JOURNAL OF EXPERIMENTAL CHILD PSYCHOLOGY **59**, 419–456 (1995)

Evidence of Robust Recognition Memory Early in Life Even When Assessed by Reaching Behavior

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Infants of only 5–6 months prefer to look at something new when given the choice of looking at a stimulus shown earlier or something new, even after a long delay (the visual paired comparison task). However, if infants must *reach* and displace a stimulus to retrieve a reward, even 18-month-olds respond randomly when given the choice of reaching to the stimulus shown earlier or to something new, even after a brief delay (the delayed nonmatching to sample task). To investigate this paradox we modified the delayed nonmatching to sample task to make it more similar to visual paired comparison. Each stimulus served as its own reward; no rewards were hidden under any stimuli. Infants were habituated to a sample object, a delay was imposed, and then the sample and a new object were presented. Infants could choose to look at (in visual paired comparison) or reach for (in delayed nonmatching to sample (stimulus = reward)) either object. One hundred twenty infants were tested: 60 (20 each at 4, 6, and 9 months) on visual paired comparison and 60 (20 each at 6, 9, and 12 months) on delayed nonmatching to sample (stimulus = reward). The same 10 pairs of stimuli were used on both tasks. Each subject was tested twice at all five delays (10, 15, 60, 180, and 600 s). At even the youngest age that reaching was tested (6 months), infants showed evidence of recognition memory on the reaching task at delays at least as long as those at which they demonstrated recognition memory on the looking task. Indeed, when subjects reached, not in order to obtain something else, but to obtain the stimulus itself, they succeeded on a recognition memory task even at delays 10 min long very early in life. © 1995 Academic Press, Inc.

This paper summarizes the work reported in Technical Report IRCS-92-11 of the Institute for Research in Cognitive Science, University of Pennsylvania (Diamond, 1992). The research was supported by the National Institute of Mental Health (R01 MH-41842). This work was reported earlier at a meeting on "The Development and Neural Bases of Higher Cognitive Functions" (Diamond, 1990). I thank Bertha Doar for conducting most of the visual paired comparison testing, Greer Richardson for conducting most of the delayed nonmatching to sample testing, Judy Chasin for helping in all phases of the research from data collection to data analysis, and Don Ernst for help with the statistical analyses. I also thank Nora Newcombe and the two reviewers for their very helpful comments. Finally, my sincere thanks to all the parents and infants who participated in this study. Correspondence and reprint requests should be addressed to Adele Diamond, Department of Brain and Cognitive Sciences, MIT, Building E10, 77 Massachusetts Avenue, Cambridge, MA 02142. E-mail: diamond@psyche.mit.edu.

0022-0965/95 $6.00

Cognitive abilities appear to be present earlier when assessed by where infants look than when assessed by where they reach. For example, infants show evidence of recognition memory on visual habituation and visual paired comparison measures by the age of 2–5 months (e.g., Fagan, 1970, 1990; Welch, 1974; Caron, Caron, Minichello, Weiss, & Friedman, 1977). However, on a recognition memory task closely analogous to visual paired comparison that requires subjects to *reach* and not just look (delayed nonmatching to sample) infants do not show evidence of recognition memory until $1\frac{1}{2}$–2 years of age (Diamond, 1990; Overman, 1990; Overman, Bachevalier, Turner, & Peuster, 1992; Diamond, Towle, & Boyer, 1994). Why is it that infants of only 2–5 months can demonstrate that they remember a stimulus by where they look (in the visual paired comparison task), but cannot demonstrate that they remember a stimulus by where they reach (in the delayed nonmatching to sample task) until at least 19–21 months?

Similarly, why should it be that infants seem to remember that an object is behind a screen at $3\frac{1}{2}$–5 months when judged by where they look, but do not seem to remember this until $7\frac{1}{2}$–8 months when judged by where they reach? Infants will not reach for an object hidden behind a screen or under a cover until $7\frac{1}{2}$–8 months of age (e.g., Gratch & Landers, 1971; Fox, Kagan, & Weiskopf, 1979; Wishart & Bower, 1984; Diamond, 1985), even though they will readily reach for the same object when it is visible. Indeed, infants of 6 months can be stopped in midreach by covering the object they are pursuing (Piaget, 1954 [1937]; Bruner, 1969; Gratch, 1972). They seem to act as if they do not know the object is still there once it is hidden. However, infants of only $3\frac{1}{2}$–5 months seem to demonstrate by their looking behavior in visual habituation paradigms that they do, in fact, know that an occluded object is still there (e.g., Baillargeon, Spelke, & Wasserman, 1985; Baillargeon, 1987). For example, they will look longer (as if surprised) when a screen falls backward without the object hidden behind it breaking its fall, as if they know the object behind the screen is still there. Why should there be this difference in what infants' looking and reaching behaviors reveal?

One possibility is that since vision matures earlier than reaching (and since reaching requires both the visual system and the arm movement system), cognitive abilities might become integrated with the visual system before they become integrated with reaching. Perhaps when a cognitive competence appears it is not generally accessible, but becomes incorporated first into one response system and then another. Cognitive capacities can appear in a narrow context to begin with, and then become progressively generalized with time (e.g., Rozin, 1976). This kind of reasoning is consistent with the plethora of findings in neuropsychology showing that whether or not a brain-damaged patient is judged to have certain cognitive abilities often depends on which response system is used to measure those abilities (e.g., explicit verbal recognition or recall vs implicit demonstration in behavior (Schacter, 1987, 1990; Squire & Cohen, 1984); response of left or right hand to information shown to only one eye in split-brain patients (Gazzaniga, 1970, 1985)). However, note that this also suggests that "I" (as an infant) do not know or remember something. Rather, early in development, my eyes may know it but my hands may not.

Alternatively, perhaps the paradigms that use reaching as the dependent measure make greater cognitive demands than do looking paradigms. When visual fixation is the dependent measure, subjects need only look at what interests them. This is a simple, direct response; subjects do not look at something in order to obtain anything else. They look at something because it is intrinsically interesting.

When reaching is the dependent measure, however, studies have required subjects to act on one object to obtain another. Thus, subjects remove a cover, or detour around a screen, to obtain a hidden toy, or they displace an object to obtain the reward underneath it (as in delayed nonmatching to sample). This is a more complicated, indirect response; subjects must act on one object to obtain another, rather than acting on an object to obtain that object itself. They must act on an object *not* because it is intrinsically interesting, but because of its relationship to something else.

This would suggest that the critical variable might not be looking versus reaching, but whether the stimulus presented to subjects is itself the reward or is simply a means to obtaining the reward. When the stimulus is itself the reward, a simple, direct, single-action response is possible. However, when the stimulus stands for the reward, or is only a means to obtaining the reward, a more complicated, two-action response has been required. Here, the subject must appreciate the relationship between the visible object and the reward and must exercise the planning and forethought necessary to string two actions together into a means–end sequence (e.g., displace covering object, retrieve reward).

In the past, all studies using looking as their dependent measure have also had the stimulus serve as its own reward, while all studies using reaching as the dependent measure have required that subjects act on the stimulus to obtain something else as the reward. Looking versus reaching has been confounded with whether or not the stimulus itself is the reward.

DELAYED NONMATCHING TO SAMPLE TASK MODIFIED SO THAT STIMULUS = REWARD

To test between these two interpretations, that the critical variable is (1) looking versus reaching or (2) whether the stimulus itself is the reward or not, we modified the delayed nonmatching to sample task so that instead of subjects displacing a stimulus object to obtain the reward beneath it, subjects were allowed to have the object they reached for as the reward.

In this way we tested infants on two versions of the same task. In one version (visual paired comparison) the response was made by looking; in the other version (delayed nonmatching to sample modified) the response was made by reaching. In *both* versions the stimulus served as its own reward; no reward was hidden under any stimulus in either version of the task. In both versions, infants were presented with a sample object until they habituated; a delay ensued, and then the sample object was presented again paired with an object that the infants had never seen before. New objects were used on every trial, and the same objects were used on the looking and reaching versions of the task. The primary difference between the tasks was that in delayed nonmatching to sample (stimulus = reward) infants reached for an object during familiarization and test while in visual paired comparison infants only looked at the object(s) during familiarization and test.

We hypothesized that the reason that previous studies had demonstrated recognition memory so much later on delayed nonmatching to sample than on visual paired comparison was the additional cognitive requirements of the delayed nonmatching to sample task. Therefore, we predicted that when these additional requirements were removed from the task, the developmental progression on delayed nonmatching to sample (stimulus = reward) would be comparable to that for visual paired comparison. If, on the other hand, recognition memory becomes integrated with the visual system before it becomes integrated with reaching, then infants should indicate that they recognize the sample object after longer delays at younger ages on visual paired comparison than on even our modified version of delayed nonmatching to sample with the stimulus as its own reward.

BACKGROUND

The Standard Delayed Nonmatching to Sample Task

The delayed nonmatching to sample task was developed to determine the neural system underlying recognition memory for objects in monkeys (e.g., Gaffan, 1974; Mishkin & Delacour, 1975; Zola-Morgan, Squire, & Mishkin, 1982). A reward is first hidden under a single, sample object out of view behind an opaque screen. The screen is raised revealing the sample object at the midline, and the subject is to displace this object to retrieve the reward. That concludes part one of the trial. The opaque screen is again lowered, and a delay is imposed (typically 5 s to 1 min). The purpose of part one is to expose subjects to the sample. The reason for having subjects displace the sample is only to ensure that subjects have, in fact, seen the sample.

During the delay, one object is positioned to the left of the midline and one to the right. One is a new object and one is the now familiar sample. The reward is hidden under the object that does *not* match the sample (the new object). After the delay, the screen is raised and the subject is allowed to reach. If the subject displaces the nonmatching object, the reward is thereby revealed and the subject can retrieve it. If the subject displaces the familiar object, an empty well is revealed beneath it, and the subject receives no reward on that trial. The left–right position of the new object is varied randomly over trials. The testing procedure currently used, with different objects on every trial ("trial-unique objects"), was independently devised by Gaffan (1974) and by Mishkin and Delacour (1975).

Delayed nonmatching (reward under new object) is used rather than delayed matching (reward under familiar object) because monkeys (Harlow, 1950; Brush, Mishkin, & Rosvold, 1961; Mishkin, Prockop, & Rosvold, 1962; Gaffan, Gaffan, & Harrison, 1984), like children (e.g., Fantz, 1964; Fagan, 1970, 1973; Fisher & Zeaman, 1973; Cohen & Gelber, 1975), have a natural preference for novelty and so delayed nonmatching to sample (where subjects must reach to the novel stimulus) is far easier for them than delayed matching to sample (where subjects must reach to the familiar stimulus).

The Standard Visual Paired Comparison Task

The visual paired comparison task (also called "preferential looking") was originally developed to study recognition memory in infants (Fagan, 1970, 1990). In broad outline, it is quite similar to delayed nonmatching to sample. Here, as in delayed nonmatching to sample, a sample is presented during part one of the trial (called the "familiarization phase"). Following a delay, the sample stimulus is presented again paired with a novel stimulus (one stimulus is presented to the left and the other to the right). When given a choice between an old, familiar stimulus and something new, infants and monkeys tend to choose something new. Memory of the previously presented stimuli (the samples) is, therefore, inferred from consistent choice of the new (nonmatching) stimuli.[1]

Visual paired comparison requires only looking, however, unlike delayed nonmatching to sample. Typically, two-dimensional stimuli are used, such as colored slides, black-and-white designs, or photographs of faces. During the familiarization phase, the sample stimulus is presented for the subject to look at, either at the midline or, more commonly, at both the left and right, until either the subject habituates to the stimulus or a set time of presentation has elapsed. After a delay, the familiar sample is presented again along with a new stimulus; how much time the subject looks at each stimulus is monitored. This is called the "test phase." Midway through the test phase of each trial, the left–right placement of the familiar and novel stimuli are reversed (e.g., the sample may be presented to the right during the first 10 s, and presented to the left during the second 10 s). Preference for one stimulus or the other is inferred from the percentage of time that the infant fixates each stimulus.

[1] "Choice" in delayed nonmatching to sample is indicated by the subject reaching to, and displacing, one of the stimuli. "Choice" in visual paired comparison is inferred from the subject's looking more at one of the stimuli.

Pretesting

Pretesting was conducted to find pairs of objects of roughly equal interest to infants of 6–12 months (see Diamond, 1992, for a detailed discussion of the pretesting methods and results). Objects were selected to meet the following criteria: (1) infants up to 1 year of age had never seen them before (so the objects would be truly novel), (2) sufficiently interesting that infants would reach for or look at them, and (3) sufficiently boring that when given another chance infants would reach for or look at something else. The purpose of Study 1 was to determine which pairs of these objects were most appropriate for use in later testing. We wanted the two objects in each pair to be roughly equal in interest to infants because if infants greatly preferred one of the objects, and that object served as the sample during later testing, infants might still reach for, or look at, that object during the test phase.

Many objects in many different pairings were tried before 15 promising object pairs were found. A total of 143 infants (38 at 6 months, 36 at 8 months, 39 at 10 months, and 30 at 12 months) were presented with each pair of objects, one pair at a time. The objects were presented equidistant from the midline, and the experimenter made sure that the infant saw both before they were pushed just within reach. Half of the infants in each age × sex group saw object A of each pair on the left, and half saw object B on the left. The dependent measure was which object the infant reached for in each pair. The 10 object pairs most closely matched in infants' preferences were retained. For 9 of these 10 pairs, the percentage of infants reaching for one or the other object was between 47 and 53%. For one of the object pairs, a significant preference was evident, with 66% of the infants selecting the same member of the pair. No systematic sex differences were found.

Pretesting was also conducted to determine if infants would demonstrate a preference for novelty in their reaching. After 9 months of age, infants often show a longer latency to reach for novel than familiar objects, which could have shown up here as preference for the familiar, and under 9 months they often reach impulsively for whatever object they see first, which could have shown up here as no effect of familiarization (e.g., Schaffer & Parry, 1970; Schaffer, Greenwood & Parry, 1972). Other studies, however, have found a preference for novelty in infants' reaching behavior as indicated by total time exploring novel stimuli as compared with total time exploring a familiar stimulus (Rubenstein, 1967), percentage of time manipulating the novel stimulus (Ruff, 1976), and the number and percentage of reaches to the novel stimulus (Gottfried, Rose, & Bridger, 1977). Thus, as the second pretest study (see Diamond, 1992, for detailed description of methods and results) we administered delayed nonmatching to sample (stimulus = reward) without any delay between familiarization and test to determine if, indeed, infants would show a preference for novelty when assessed by which object they reached for, rather than by which object they looked at more. The 10 most equally matched object pairs from the earlier pretesting were used. Thirty infants were tested; 5 female and 5 male at 6, 9, and 12 months of age. Infants at each age showed a robust novelty preference in their reaching across the pairs of objects. A significant tendency to reach to the novel object was found for every one of the 10 pairs of objects (range in percentage of infants reaching to novel object was 83–90%). Even for object pair 1, the pair last well-matched in interest, 27 of 30 infants (90%) still reached for the new member of the pair when familiarized first with the other pair member. Of these 27 infants, 13 reached for the new object when the sample was object A and 14 did so when the sample was object B. No significant sex or age differences were found. Because infants preferentially reached to the novel object in the delayed nonmatching to sample (stimulus = reward) paradigm with a 0-s delay, a failure to demonstrate this novelty preference after a delay can be attributed to forgetting.

These two pretesting studies provided us with pairs of objects that were roughly of equal interest to infants and with evidence that infants show a novelty preference in reaching, seemingly comparable to that previously shown in their looking, at least under the conditions investigated (i.e., when allowed to look at and manipulate one object until habituated, when no delay between familiarization and test, and when the choice is between two stimuli roughly equal in interest).

VISUAL PAIRED COMPARISON AND DELAYED NONMATCHING TO SAMPLE (STIMULUS = REWARD)

Subjects

We tested 120 human infants: 20 infants (10 male and 10 female) × 2 tasks × 3 ages per task. All infants were healthy and full-term. Their names were obtained through the birth records and through birth announcements in the local papers. On both visual paired comparison and delayed nonmatching to sample (stimulus = reward), 20 infants were tested at the age of 6 months and at the age of 9 months. In addition, 20 4-month-old infants were tested on visual paired comparison to establish comparability with other studies using that task. Infants of 4 months cannot retrieve free-standing objects and so could not be tested on delayed nonmatching to sample (stimulus = reward). Twenty infants were tested on delayed nonmatching to sample (stimulus = reward) at 12 months of age in case performance on this task lagged behind performance on visual paired comparison. In sum, a total of 60 infants at three different ages were tested on each task (4, 6, and 9 months of age for visual paired comparison; 6, 9, and 12 months of age for delayed nonmatching to sample (stimulus = reward)). Their exact ages in weeks and days are provided in Table 1. Most

TABLE 1
Mean Age and Age Ranges of the Subjects under the Two Experimental Conditions

	Subjects tested on the visual paired comparison task			Subjects tested on delayed nonmatching to sample (stimulus = reward)		
	4 Months	6 Months	9 Months	6 Months	9 Months	12 Months
Mean age in weeks (and days)	19 (8)	27 (2)	40 (4)	27 (4)	40 (5)	53 (5)
Age range in weeks (and days)	17 (1)– 21 (0)	25 (5)– 29 (0)	39 (0)– 42 (3)	26 (0)– 29 (0)	39 (1)– 43 (0)	52 (0)– 55 (6)

children were Caucasian and most were from middle to upper-middle class homes. Most parents were college graduates. The mean age of the mothers was 30 years, and the mean age of the fathers was 32 years. Most of the infants had one older sibling. (For detailed demographic information on the subjects, see Diamond, 1992.)

Subjects were fussier during visual paired comparison than during delayed nonmatching to sample (stimulus = reward), as they were only allowed to look at the objects in the visual paired comparison task, while in the other task they could handle the objects as well. Subject attrition was, therefore, higher for visual paired comparison than for delayed nonmatching to sample (stimulus = reward). In addition to the 60 subjects whose performance on visual paired comparison is reported here, another 22 were tested but were excluded from subsequent analyses. Of these, 8 infants of 4 months were too fussy during testing and 2 fell asleep; 4 infants of 6 months were too fussy, 2 fell asleep, and the experimenter erred in testing 1 other; 4 infants of 9 months were too fussy and the experimenter erred in testing 1 other. In addition to the 60 subjects whose performance on delayed nonmatching to sample (stimulus = reward) is reported here, only 3 more were tested. These 3 infants (2 at 6 months and 1 at 12 months) were excluded from subsequent analyses because they were too fussy during testing.

Testing Procedure

All subjects were tested in the infant laboratory, seated on their parent's lap. Regardless of the task, each infant received 10 trials, 2 trials each at delays of 10 s, 15 s, 1 min, 3 min, and 10 min.[2] Each of the first 5 trials was at a different delay, counterbalanced across infants within experimen-

[2] It had been intended that the two shortest delays be 0 and 10 s. However, analysis of the videotape records revealed that the delays actually used were longer than intended. The actual delays were 10 and 15 s.

tal condition (Latin square design). The delays were presented in reverse order over the last 5 trials. Which member of an object pair served as the sample was counterbalanced across order of delay presentation and sex within all ages for each task. The test pairs were always presented as pictured in Fig. 1. In half the sessions, the object serving as the sample was: R (object on the right on trial 1), R, L, L, R, L, L, R, L, R. Thus, there were five orders of delay × left or right object defined as the familiar object × 2 tasks × 2 sexes, at each of 3 ages. All infants were tested twice at all five delays (10 s, 15 s, 1 min, 3 min, and 10 min). To minimize differences between the testing procedures for visual paired comparison and delayed nonmatching to sample (stimulus = reward), the same pairs of trial-unique objects were used for both tasks. This meant that visual paired comparison was administered using three-dimensional objects, rather than the more typically used two-dimensional stimuli (such as black-and-white abstract designs or photos of faces).

An infant-controlled procedure was used to determine habituation during the familiarization period of each trial.[3] That is, we presented the sample until a standard level of habituation was reached rather than for a standard length of time. We did this to reduce subject attrition and because we were interested in memory once the subject had processed the stimulus.

Each trial consisted of two parts separated by a delay:

Sample presentation (familiarization period). The experimenter presented an object for the infant to play with (delayed nonmatching to sample (stimulus = reward)) or look at (visual paired comparison) until the infant tired of the object (reached the habituation criterion).

For visual paired comparison, the object was 46 cm from the child (i.e., out of reach) and was moved slowly and continually from left to right (to keep the infants' attention longer) between two markers, each 20.5 cm from midline, until the infant looked away from the sample three times for periods of at least 3 s each. Only the object was visible to the infant, not the experimenter, who controlled the movement of the object from a position underneath the table. Each time, if the infant did not look back at the object after 3 s, the infant's attention was redirected back to the object by calling to the infant and jostling the object. Visual fixation was monitored by an observer looking at the session on a television screen and seated at a computer keyboard. The duration of each "look away" was timed by computer. The experimenter wore a headset through which the observer could is-

[3] Research on visual paired comparison and visual habituation has shown the importance of infant controlled procedures (e.g., Horowitz et al., 1972; Rose et al., 1982). If the sample is presented for a standard amount of time, that time will be too short for some children to have habituated and too long for others so that they become cranky and fidgety. With an infant controlled procedure, the sample is presented until each child has reached the habituation criterion (e.g., looked away three times for at least 3 s each time).

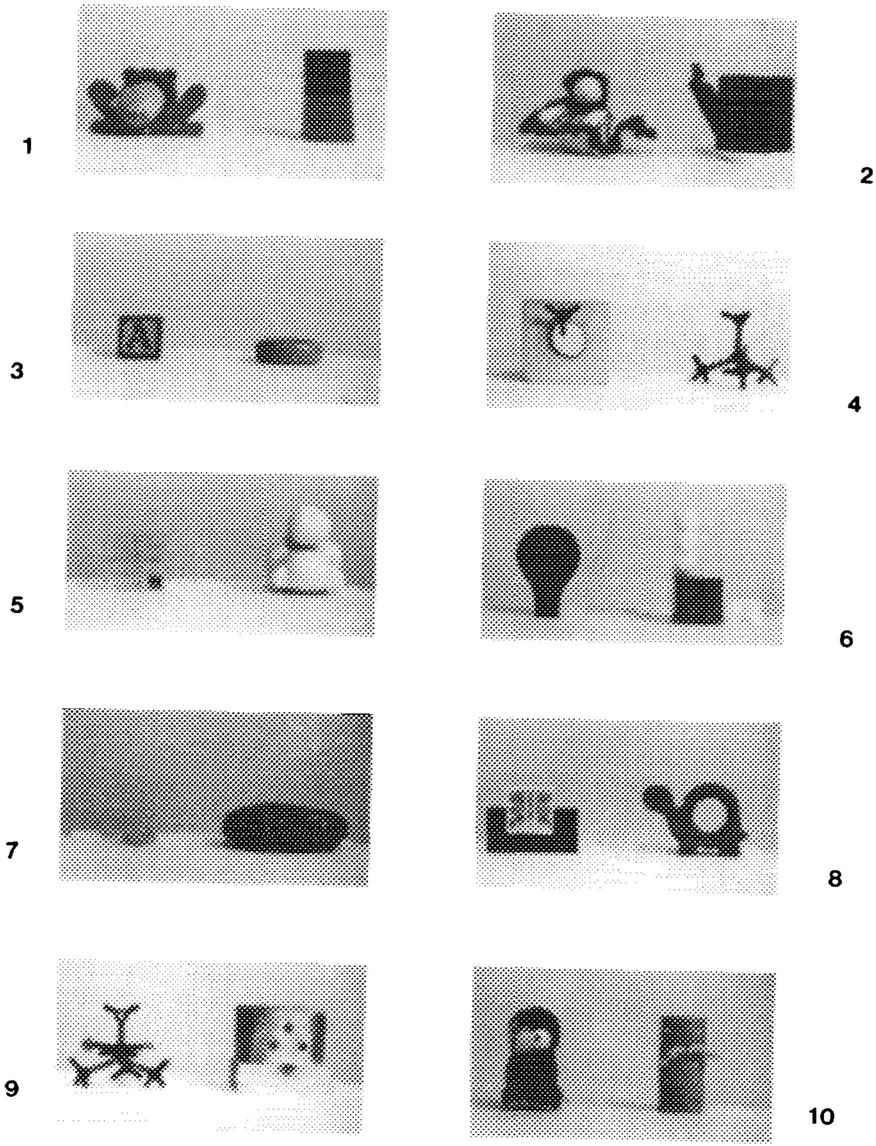

FIG. 1. The pairs of stimuli used for testing both delayed nonmatching to sample (stimulus = reward) and visual paired comparison. The two objects in each pair were always highly discriminable from one another. For example, the objects in pair 1 are (a) a wooden napkin holder (brown) in the shape of a frog with a terry cloth cushion sewn into the napkin hole, and (b) two plastic lego building blocks, one blue and one red, glued together.

sue instructions about when to redirect the infant's gaze back to the object or when to terminate the familiarization period.

For delayed nonmatching to sample (stimulus = reward), the same procedure for determining habituation was used, except that here the experimenter sat opposite parent and child, and infants could indicate boredom not only by looking away but by discarding the object as well. The discarded object was returned to the infant each time until the habituation criterion was met. The habituation criterion consisted of any combination of four instances of (a) looking away for 3 s + (b) discarding the stimulus (e.g., 2 look aways + 2 discards, 1 look away + 3 discards, etc.). We wanted the child to have visual, as well as tactile, contact with the object during familiarization because choice of the stimulus during the test phase would be based on the visual appearance of the objects; therefore infants were discouraged from putting the object in their mouth during familiarization.

Delay period. Immediately following familiarization, the delay began and the sample object was removed from view. During the delay period, infants were allowed to crawl around the room, climb onto the testing table, feed, interact with parent or experimenter, or play with two large toys that were introduced before testing and that were very different from the small stimulus objects. At the end of the delay, the experimenter held a white card in front of the videocamera to aid in locating the test phase of the trial on the videotape. The length of each delay was verified from the videotape during data analysis and was found to be slightly longer than intended. The lengths of the delays actually used are summarized in Table 2.

Test phase (paired presentation). After the delay, the experimenter asked the parent to again center the child at the center marker on the table and to close his or her own eyes (to avoid biasing the infant's response). The pair of objects was then presented.

For visual paired comparison, the objects were presented out of reach, 46 cm from the infant, one to the left and one to the right, and moved back and forth at the same speed along the horizontal plane from 20.5 cm from the midline to 46 cm from the midline on their respective sides, both beginning at 20.5 cm from the midline and moving outward and then back in and then out, etc. The objects were presented for a total of 20 s, with their left–right placement reversed after 10 s. Timing of each 10-s period began when the infant first looked to one of the stimuli.

For delayed nonmatching to sample (stimulus = reward), the objects were presented out of reach side by side at the midline to ensure that the infant saw both objects. Movement of each object along the horizontal plane encouraged the infant to visually track each object. Once the infant had clear-

TABLE 2
Actual Mean Length of Delays (in Seconds) Used under the Two Experimental Conditions

	Intended delay length (in seconds)				
	0	10	60	180	600
Visual paired comparison	10	15	70	195	611
Delayed nonmatching to sample (stimulus = reward)	6	13	75	200	620

ly seen both objects, the objects were moved forward at a uniform rate and placed at the boundary of the infant's reach and 20.5 cm from the midline. Placing the objects just barely within reach forced the infant to stretch to grasp an object, and so discouraged reaching simultaneously for both objects. Once the infant had touched an object, the other object was removed. Infants were allowed to play with the object they had selected for 15 s. An intertrial interval of 20 s was intended for both studies, but was achieved only for delayed nonmatching to sample (stimulus = reward); for visual paired comparison the ITI actually used was closer to 15 s.

The procedure for ensuring that infants had seen both objects before reaching was quite successful. Sixty infants were each tested for 10 trials on the delayed nonmatching to sample (stimulus = reward) task for a total of 600 trials. Of these, 598 trials were recorded on videotape. Coding of the infants' visual fixations from the videotape revealed that on 597 of these 598 trials the infant had, in fact, clearly looked to each of the two objects before the objects were moved forward within the infants' reach.

A videocamera was positioned directly behind the stimuli at the midline. The stimuli were sufficiently far apart that which object the infant was fixating could be accurately determined from the infant's lateral eye and head movements. Visual fixation was coded from the videotape by a coder who did not watch any of the test sessions and did not know which objects served as samples for any infant. For coding fixation during the test phase of each trial, an occluder was placed in front of the bottom two-thirds of the TV monitor. The coder fast-forwarded the videotape until the image on the TV screen was white (indicating the beginning of a trial's test phase). Then the coder removed the occluder and coded visual fixation during the test phase using slow-motion and freeze-frame analysis, replacing the occluder when the test phase was over and repeating this procedure for all trials.

The work of monitoring visual fixation during the familiarization period as testing was in progress (to determine each time an infant had looked away for 3 s and to determine when the habituation criterion had been met) was divided between two people. Similarly, the work of coding visual fixation during the test phase from the videotape was divided among two other people. All four people received extensive training and the judgments regarding visual fixation were quite straightforward and easy to make; the intracoder reliability for each person and intercoder reliability between the two sets of coders was consistently $\geqslant .95$ (alpha coefficient). The calculation of intercoder reliability was based on the six sessions (two at each age) that both videocoders coded independently. The calculation of intracoder reliability was based on the three sessions coded two times by the same videocoder, once early in the study and again after roughly half the videocoding had been completed.

No significant sex difference was found at any age at any delay for either task as measured by any of several dependent measures, such as percentage of time fixating the novel stimulus, percentage of subjects reaching to the novel stimulus, or whether the longest look when the stimuli were first presented was to the novel or the familiar stimulus. Therefore, the results for males and females are combined in all analyses reported below.

Infants received one trial at each of the five delays during the first half of the session, and again during the second half of the session, for a total of 10 trials per subject. There was no overall difference in performance during the first half of the session as compared with performance during the second half, so results for the two trials at each delay are generally combined in the analyses below. Similarly, time to habituation did not differ significantly at any age on either task for the first 5 trials versus the second 5 trials.

RESULTS

Comparison of Performance on Visual Paired Comparison and Delayed Nonmatching to Sample (Stimulus = Reward) in the Delays Infants Could Tolerate at Each Age

Infants were able to succeed on delayed nonmatching to sample (stimulus = reward) and to withstand delays fully as long on this task as on visual paired comparison from the youngest age at which they could be tested. "Success" on a task was defined as a significant tendency to reach for, or look at, the novel (nonmatching) object. We judged success on delayed nonmatching to sample (stimulus = reward) by the percentage of trials on which infants reached for the novel object. We judged success on visual paired comparison by (a) the difference in fixation time to the novel and familiar objects (percentage of time fixating the novel object out of the total time fixating either object) and (b) the percentage of trials on which infants fixated the novel object at least 67% of the time (to yield a measure of percentage of trials on which infants chose the novel object to compare with the percentage of trials on which infants chose the novel object in delayed nonmatching to sample (stimulus = reward)). Sixty-seven percent was chosen because it is the lowest level at which the binomial distribution would still yield significance, but results differ little if percentage of infants fixating the novel object only 55% of the time is used as the dependent measure instead. Most visual paired comparison studies have used percentage of fixation to the novel object as the dependent measure. When we use that measure, our results are similar to those when the dependent measure is percentage of infants fixating the novel object ≥67% of the time (compare Tables 3 and 4).

Using percentage of infants fixating the novel object ≥67% of the time, infants of 4 months succeeded on visual paired comparison *only* at the shortest delay (10 s). They did not show a significant novelty preference at any delay longer than that, including the 15-s delay (see Table 3). Using per-

TABLE 3
Percentage of Infants Choosing the Nonmatching (Novel) Object by Age, Task, and Delay

Delays	4 Months old		6 Months old		9 Months old		12 Months old	
	VPC	DNMS	VPC	DNMS	VPC	DNMS	VPC	DNMS
			A. Entire testing session[a]					
10 s	70*		90***	85***	80**	85***		90***
15 s	55		60	80**	80**	85***		85***
1 min	60		75*	70*	80**	90***		85***
3 min	50		70*	65†	65†	85***		90***
10 min	50		60	70*	70*	80**		85***
			B. First half of the session					
10 s	65†		85***	75*	80**	90***		85***
15 s	60		65†	75*	85***	90***		80**
1 min	65†		65†	60	80**	90***		74*[b]
3 min	50		70*	53[b]	65†	100***		85***
10 min	45		60	55	70*	75*		85***
			C. Second half of the session					
10 s	70*		95***	95***	80**	65†		90***
15 s	55		60	85***	75*	80**		85***
1 min	60		85***	80**	75*	90***		85***
3 min	50		70*	75*	65†	60		95***
10 min	55		60	85***	65†	70*		80**

Note. VPC, visual paired comparison; DNMS, delayed nonmatching sample. Choice of nonmatching (novel) object in VPC = looked at novel object ≥67% of the time during the 20-s paired presentation. Choice of nonmatching (novel) object in DNMS = reached for novel object. Each subject was tested on only one task and at only one age. All received two trials at each delay; one trial at each delay in the first half of the session and one at each delay in the second half.

[a] The two scores at each delay are averaged for each subject in Section A. All *N*'s = 20 unless otherwise specified.

[b] $N = 19$

†Percentages ≥65% are significiant at ≤.10 level (binomial distribution).

*Percentages ≥70% are significiant at <.05 level (binomial distribution).

**Percentages ≥80% are significiant at <.005 level (binomial distribution).

***Percentages ≥85% are significiant at <.001 level (binomial distribution).

centage of time fixating the novel object, 4-month-old infants never showed a significant novelty preference, even at the 10-s delay (see Table 4).

At 6 months of age, infants succeeded on the visual paired comparison task at delays of 10 s and 1 min, but failed with delays of 15 s and 10 min (see Tables 3 and 4). Judging by percentage of fixation to the novel object they failed at the 3-min delay, although judging by percentage of infants meeting the 67% fixation criterion, they just barely passed at the 3-min delay. Infants of 6 months succeeded on delayed nonmatching to sample (stimulus = reward) *at all delays,* although the percentage of infants reaching for the novel object at the longer delays (1, 3, and 10 min) was just bare-

TABLE 4
Fixation Times to Nonmatching (Novel) and Matching (Familiar) Objects in the Visual Paired Comparison Task by Age and Delay

	4 Months old	6 Months old	9 Months old
Delay of 10 s			
Mean fixation time to novel object	10.33	10.11	10.79
Mean fixation time to familiar object	7.92	6.48	6.48
Percentage of time fixating novel[a]	57%	63%	62%
Significance of difference in fixation	$t = 2.22$	$t = 4.96$	$t = 3.97$
	$p = .03$[b]	$p < .0001$	$p = .0008$
Delay of 15 s			
Mean fixation time to novel object	9.98	10.17	10.63
Mean fixation time to familiar object	8.72	8.42	7.22
Percentage of time fixating novel	53%	54%	59%
Significance of difference in fixation	$t = 1.07$	$t = 1.57$	$t = 3.81$
	ns	ns	$p = .001$
Delay of 1 min			
Mean fixation time to novel object	11.29	11.03	10.81
Mean fixation time to familiar object	8.48	7.13	8.02
Percentage of time fixating novel	55%	60%	57%
Significance of difference in fixation	$t = 1.85$	$t = 3.10$	$t = 2.78$
	$p = .08$	$p = .006$	$p = .01$
Delay of 3 min			
Mean fixation time to novel object	10.06	10.01	10.06
Mean fixation time to familiar object	9.41	8.25	7.69
Percentage of time fixating novel	51%	55%	57%
Significance of difference in fixation	$t = 0.57$	$t = 1.32$	$t = 2.32$
	ns	ns	$p = .03$[b]
Delay of 10 min			
Mean fixation time to novel object	10.29	9.66	10.99
Mean fixation time to familiar object	8.98	8.09	8.21
Percentage of time fixating novel	53%	54%	57%
Significance of difference in fixation	$t = 1.40$	$t = 1.37$	$t = 2.68$
	ns	ns	$p = .01$

[a] Percentage of time fixating novel = (mean fixation time to novel) divided by (mean fixation time to novel + mean fixation time to familiar). Total presentation time was 20 s (with left–right position of objects reversed after 10 s).

[b] Not significant using the Bonferroni correction. If you use the Bonferroni correction for multiple comparisons, then since there are 15 comparisons here, only those significant at $p \leq .013$ should be considered significant. A significance level of .013 for 15 independent comparisons is considered equivalent to a significance level of .05 for a single comparison (Keppel, 1982).

ly significant (see Table 3). Thus, using these dependent measures, performance of 6-month-old infants on delayed nonmatching to sample (stimulus = reward) was at least as good as their performance on visual paired comparison, and there is some suggestion that their performance was better. At roughly the earliest age when infants can reach for free-standing objects, they succeeded at delayed nonmatching to sample (stimulus = reward) at quite long delays (including the longest delay tested, 10 min). At 9 months of age, infants succeeded on both tasks at all delays. The single exception to this was that 9-month-old infants did not fixate the novel object significantly more than the familiar object when the delay was 3 min (see Tables 3 and 4).

Thus, allowing the stimulus object to serve as its own reward eliminated any suggestion that infants succeed earlier on visual paired comparison than on delayed nonmatching to sample, regardless of whether percentage of infants or percentage of fixation time was the dependent measure. We had not expected that simply making the stimulus its own reward on delayed nonmatching to sample would so effectively eliminate developmental differences in when infants succeed on the two tasks. Had we expected this, we would (a) have used longer delays (as there was probably a ceiling effect at 9 months) and (b) we would not have tested subjects at 12 months of age. Predictably, given the success of the 9-month-old infants, infants of 12 months succeeded at all delays on delayed nonmatching to sample (stimulus = reward) (see Table 3).

The correlation between where infants were looking as they reached and where they reached in the delayed nonmatching to sample task (stimulus = reward) was .98. Results for which object infants looked at while reaching are the same as the results for where they reached.

There is little indication that a preference to reach to one side or the other can account for any of the delayed nonmatching to sample (stimulus = reward) results. The mean percent of times infants reached for the object on the left during the test phase was 40, 55, and 47% for the ages of 6, 9, and 12 months, respectively. (The novel object appeared on the left for 50% of the trials for each infant.)

There was no overall difference in performance during the first half of the session as compared with performance during the second half. However, on delayed nonmatching to sample (stimulus = reward) infants of 6 months performed better during block 2 (see Table 3). During visual paired comparison testing infants of 6 months showed a significant novelty preference at more delays during the first half of the session than during the second half, but when they did show a novelty preference during the second half it was generally more pronounced than during the first half.

Performance on the Visual Paired Comparison Task as Revealed by Another Dependent Measure

Infants might indicate that they notice that an object is novel by staring at it longer when both objects are first presented, rather than by looking at it longer over the entire test phase. To investigate this we compared the length of the longest uninterrupted look (longest individual fixation) at the novel object during the first 10 s of presentation to the length of the longest individual look at the familiar object during the same period. The results are striking. Judged by longest individual fixation, infants at all ages succeeded at all delays with only two exceptions (4-month-olds at 10 s and 9-month-olds at 3 min) (see Table 5). Thus, although 4-month-olds failed all but the very shortest delay and 6-month-olds failed with a 10-min delay and performed marginally at the 15-s and 3-min delays when this was assessed by percentage of total fixation time, 4- and 6-month-olds succeeded at the full range of delays when assessed by longest individual fixation during initial presentation. Apparently, some retention of the sample can still be detected by longest individual fixation when it can no longer be detected by percentage of total fixation. To my knowledge, "longest look" (duration of longest look at the novel stimulus versus duration of longest look at the familiar stimulus during initial presentation) as a measure of novelty detec-

TABLE 5
Longest Single Fixation of the Nonmatching (Novel) and Matching (Familiar) Objects during the First 10 s of the Test Phase in Visual Paired Comparison by Age and Delay

	4 Months old	6 Months old	9 Months old
Delay of 10 s			
Mean length of longest look at novel	4.67	3.76	4.14
Mean length of longest look at familiar	4.04	1.77	2.22
Significance of difference in length of longest look novel vs familiar	$t = 0.33$ ns	$t = 5.81$ $p < .0001$	$t = 4.45$ $p < .0003$
Delay of 15 s			
Mean length of longest look at novel	4.84	3.83	4.19
Mean length of longest look at familiar	2.56	2.11	2.25
Significance of difference in length of longest look novel vs familiar	$t = 3.43$ $p = .003$	$t= 3.06$ $p = .006$	$t = 3.87$ $p = .001$
Delay of 1 min			
Mean length of longest look at novel	5.29	4.09	3.57
Mean length of longest look at familiar	2.44	2.23	1.88
Significance of difference in length of longest look novel vs familiar	$t = 3.76$ $p = .001$	$t = 3.38$ $p = .003$	$t = 6.58$ $p < .0001$
Delay of 3 min			
Mean length of longest look at novel	4.43	3.78	3.34
Mean length of longest look at familiar	3.24	2.45	3.09
Significance of difference in length of longest look novel vs familiar	$t = 2.54$ $p = .01$	$t = 2.65$ $p = .01$	$t = 0.37$ ns
Delay of 10 min			
Mean length of longest look at novel	4.50	3.93	3.57
Mean length of longest look at familiar	2.72	2.33	2.22
Significance of difference in length of longest look novel vs familiar	$t = 3.89$ $p = .001$	$t = 3.78$ $p = .001$	$t = 3.22$ $p = .004$

Note. Using the Bonferroni correction for multiple comparisons, p values $\leq .013$ are considered significant.

tion has not previously been investigated in studies of visual paired comparison.

Results for total fixation (or percentage of time fixating the novel object) are essentially the same for the first 10 s of presentation, second 10 s, and total presentation time. Results for longest look during the second 10 s or over total presentation time do not yield the dramatic effects found with longest look during the first 10 s. A measure somewhat similar to "longest look during first 10 s," length of first fixation has been previously used (e.g., Kagan, Henker, Hen-Tov, Levine, & Lewis, 1966; Lewis, Kagan, & Kalafat, 1966). However, which stimulus the subject looks at first might be due to chance, whereas the longest look during the initial period might reflect more of a selection process, perhaps akin to the selection involved in reaching for an object in delayed nonmatching to sample (stimulus = reward). Similarly, "longest look" during habituation to a single stimulus has also been assessed by previous investigators (see, e.g., Bornstein, 1985), but I am aware of no previous work comparing length of the longest fixation during the *initial* period of stimulus presentation when there is a *choice* of stimuli at which to look.

If performance on visual paired comparison using this dependent measure is compared with performance on delayed nonmatching to sample (stimulus = reward), the conclusions vary little from those stated above. If anything, now performance is even more comparable on the two tasks (whereas in Table 3 there was a hint of better performance by infants of 6 months on delayed nonmatching to sample [stimulus = reward] than on visual paired comparison). The big difference is in the conclusions one draws about age-related improvements in recognition memory as indicated by performance on the visual paired comparison task. If percentage of time fixating the novel object is used as the dependent measure then performance appears to improve over age from 4 to 9 months. However, if longest individual fixation during the first 10 s of test is used, then infants appear to be at ceiling even at the youngest age (4 months) and at the longest delay (10 min). The latter measure suggests that robust recognition memory is present very early indeed, and perhaps does not improve further with age.

Comparison of Performance on Visual Paired Comparison and Delayed Nonmatching to Sample (Stimulus = Reward) during Familiarization

Infants seemed more interested in the task, and in the specific object presented, when they could manipulate the object rather than just look at it:

(1) Infants maintained their interest in the sample object significantly longer when they could manipulate it as well as look at it (delayed nonmatching to sample (stimulus = reward)) than when they could only look at the object (visual paired comparison). This can be seen in the mean times to habituation on the two tasks (Table 6). Infants took significantly longer to habituate to the sample object in delayed nonmatching to sample (stim-

TABLE 6
Time to Habituation in Seconds by Age and Task

	Age in months			
	4	6	9	12
Visual paired comparison task				
Mean	53.0	34.5	31.5	
Standard deviation	22.9	9.1	6.1	
Range	30.7–126.1	21.7–51.5	20.0–42.9	
Delayed nonmatching to sample task				
Mean		53.8	43.3	40.3
Standard deviation		12.4	13.6	10.0
Range		35.6–75.1	22.9–66.9	26.3–61.1

Note. Time to habituation is the accumulated time actually attending to the stimulus, not the total time the stimulus was presented. Mean presentation time in seconds (mean of the total time the sample was present) at each age was 76.2 (4 months; VPC), 56.1 (6 months; VPC), 73.6 (6 months; DNMS), 48.9 (9 months; VPC), 65.6 (9 months; DNMS), and 61.3 (12 months; DNMS).

ulus = reward) than in visual paired comparison at both 6 months ($t = 5.93$, $df = 38$, $p < 0.0001$) and 9 months ($t = 4.10$, $df = 38$, $p = .0003$)—even though the exact same objects were used on both tasks.

Time to habituation connotes total time attending to the stimulus until the habituation criterion was reached. Results are similar if total presentation time is analyzed instead. Mean presentation time at 6 months was 56.1 s for visual paired comparison and 83.6 s for delayed nonmatching to sample (stimulus = reward). At 9 months, mean presentation time was 48.9 s for visual paired comparison and 65.9 s for delayed nonmatching to sample (stimulus = reward).

(2) Infants were more likely to become fussy during visual paired comparison (at 6 and 9 months of age, eight infants became too fussy during visual paired comparison testing to permit completion of the session) than during delayed nonmatching to sample (stimulus = reward) (at 6 and 9 months of age, only two infants became fussy during delayed nonmatching to sample testing).

Relation of Performance during the Familiarization Period to Performance during Test

Baillargeon (1987) has found that infants who habituated quickly to her displays seemed to indicate by their looking behavior that they knew an object they could no longer see was still there by 3 months of age; however, infants who habituated slowly did not show that they knew the hidden object was still there until 4 months of age. It seemed reasonable, therefore, that infants who habituated more quickly might succeed (i.e., show a preference for the novel object) at a younger age on visual paired comparison or delayed nonmatching to sample (stimulus = reward) than infants who habituated more slowly. To investigate this we looked at the relationship between habituation variables and preference for novelty within each age on both tasks.

In general, we found that neither time to habituation, presentation time of the sample, number of "look aways," nor total time spent looking away was predictive of preference for the novel object within age and delay on either task. This accords well with DeLoache's finding that once infants have habituated to a stimulus, memory of that stimulus and the preference to look at something else appears to be comparable in fast and slow habituators (DeLoache, 1976). It also agrees with Fagan's observations that habituation variables do not predict subsequent novelty preference (Fagan, 1973, 1990). Indeed, in general we found these correlations to be less than .10.

The only exception to this is that at delays at the border of what infants at a given age could tolerate, habituation variables sometimes seemed to matter. Variations in behavior during habituation never seem to matter for delays well within or well beyond the levels that infants at a given age could tolerate. Thus, for infants of 6 months tested on visual paired comparison, habituation variables were unrelated to performance during the test phase except at the 3-min delay, which seemed to be the very longest delay that these infants could tolerate. Those 6-month-old infants who habituated more quickly showed a significantly stronger tendency to look at the novel object during test than those 6-month-olds who took longer to habituate (pearson correlation of time to habituation with percentage fixation of the novel object at 6 months = $-.48$, $p = .03$). On the other hand, however, no habituation variables were significantly related to any performance variables for infants of 4 months on visual paired comparison at any delay, even though the 10-s delay seemed to be just inside the limit of their ability and the 15-s delay seemed to be just beyond the border of their ability.

Infants at all ages performed very well on delayed nonmatching to sample (stimulus = reward) at all delays, except for infants of 6 months during the first half of the session. In delayed nonmatching to sample (stimulus = reward), habituation variables were significantly related to test performance only for 6-month-old infants and only for the first half of the session (mean time to habituation on those trials where the infant reached to the novel object vs mean time to habituation on those trials where the infant reached to the familiar object, during the first five trials for infants of 6 months: within-subjects $t = 3.87$, $p < .05$).

Age Differences in Performance during Familiarization

Younger infants took significantly longer to habituate to the sample object than did older infants. This can be seen, for example, in the significant main effect for age on both tasks: ANOVA for time to habituation for the three ages tested on visual paired comparison was $F(2,55) = 13.66$, $p < .0001$.

ANOVA for time to habituation for the three ages tested on delayed nonmatching to sample (stimulus = reward) was $F(2,57) = 6.55, p = .002$. This is consistent with numerous findings of slower speed of processing at younger ages. The most dramatic age difference in habituation time, however, is in the range of times for 4-month-olds versus any of the older age groups on either task. The individual differences among 4-month-olds in how long they looked at the sample before they habituated to it are striking (see Table 6 and Fig 2).

These age differences decreased with increasing age so that by 9–12 months the age difference in habituation time was very minimal indeed. Orthogonal linear contrasts for the difference in habituation time at the individual age during visual paired comparison testing: 4 months vs 6 months = 15.39, $p = .0003$; 4 months vs 9 months = 25.16, $p < .0001$; 6 months vs 9 months = 1.16, ns. Orthogonal linear contrasts for the difference in habituation time at the individual ages during delayed nonmatching to sample (stimulus = reward testing): 6 months vs 9 months = 8.98, $p = .03$; 6 months vs 12 months = 11.84, $p = .001$; 9 months vs 12 months = 0.60, ns.

The number of times infants looked away from the sample object during the familiarization period decreased with age. In particular, the number of

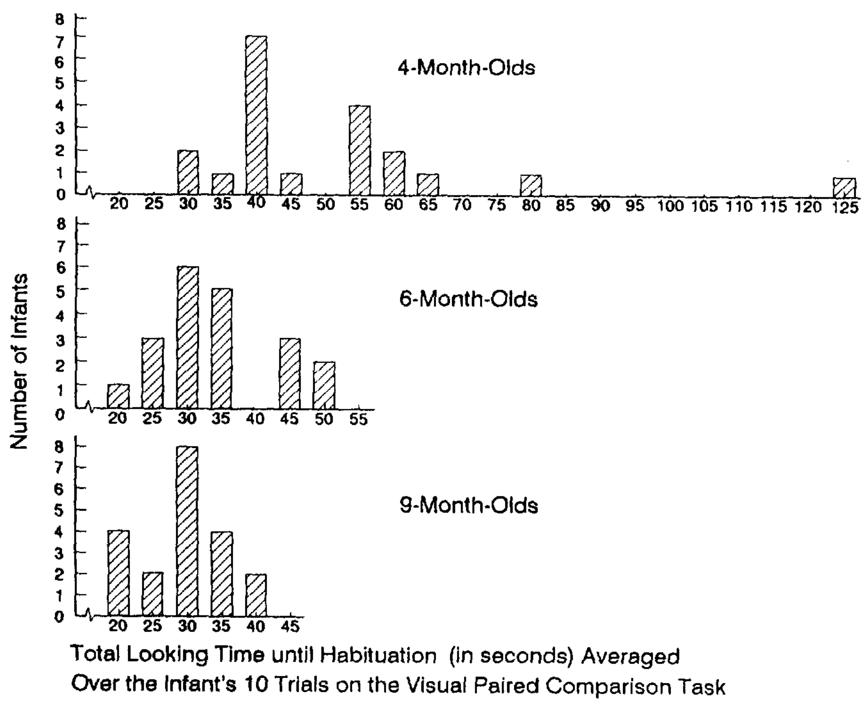

FIG. 2. Mean time each infant tested on the visual paired comparison task looked at the sample stimulus until the habituation criterion was reached (averaged over that infant's 10 trials on the task).

look aways by infants of 4 months was much greater than at any of the older ages. The decrease from 6 to 12 months was small. (ANOVA for number of times infants looked away from the sample for the three ages tested on visual paired comparison: $F[2,57] = 8.68$, $p = .0005$. Orthogonal linear contrasts: 4-month-olds vs 6-month-olds = 8.06, $p = .006$; 4-month-olds vs 9-month-olds = 16.47, $p = .0002$; 6-month-olds vs 9-month-olds = 1.48, ns.) (ANOVA for number of times infants looked away from the sample for the three ages tested on delayed nonmatching to sample [stimulus = reward]: $F[2,57] = 2.78$, $p = .07$. Orthogonal linear contrasts: 6-month-olds vs 9-month-olds = 2.43, ns; 6-month-olds vs 12-month-olds = 5.34, $p = .02$; 9-month-olds vs 12-month-olds = 0.57, ns.)

The inordinately large number of instances of looking away from the sample by infants of 4 months appears to reflect the inability of 4-month-olds to inhibit the pull to look back at the object. We had the very strong impression during testing that the 4-month-olds were bored with the sample long before they reached the habituation criterion. They reached the habituation criterion long after they appeared to be bored, because they were not able to sustain looking away from the object for a full 3 s. This is consistent with the greater distractibility of younger infants (their reduced ability to control their attention).

DISCUSSION

From the earliest age that reaching was tested (6 months), infants showed evidence of memory on delayed nonmatching to sample (stimulus = reward) (a recognition memory task where subjects respond by reaching) at delays as long as those that they could tolerate on a comparable recognition memory task requiring only looking (visual paired comparison). Children normally do not succeed on delayed nonmatching to sample until at least 20–21 months of age even at delays of only 5–10 s (Diamond, 1990; Overman, 1990; Overman et al., 1992; Diamond et al., 1994). We modified the delayed nonmatching to sample task by placing no reward under any stimulus; instead the stimulus served as its own reward. When the sample was presented, subjects did not displace it to retrieve a reward underneath (as in the standard procedure), but instead were allowed to explore and manipulate the sample itself. After the delay, no reward was hidden under either the familiar sample or the new object (a reward is hidden under the new object in the standard procedure), but again subjects were allowed to play with whichever stimulus they reached for. In this modified version of the task, 6-month-old infants succeeded (i.e., consistently chose the nonmatching object) at delays as long as 10 min. This is at least as good as the performance of infants of the same age on the visual paired comparison task. Infants of 6 months consistently spent proportionately more time looking at the nonmatching object at delays up to 3 min long; their longest initial look was consistently at the nonmatching object at delays as long as 10 min. In the visual paired comparison task, subjects respond by looking at the stimulus that interests them, rather than by reaching for it, but otherwise it is much the same task as delayed nonmatching to sample.

Thus, we seem to have created a measure requiring reaching on which infants perform at least as well as they do on a comparable measure requiring looking, from roughly the earliest age infants can retrieve free-standing objects. Indeed, researchers might consider using delayed nonmatching to sample (stimulus = reward) instead of visual paired comparison, since delayed nonmatching to sample (stimulus = reward) is so much easier to administer. The attrition rate is markedly lower, and performance on the dependent measure is much easier to determine. It is easier to judge which stimulus a subject has reached for than to judge the percentage of total looking time directed toward one stimulus or the other. Neither videotaping of visual fixation nor an observer peering at the infant's eyes through a peephole is necessary for delayed nonmatching to sample (stimulus = reward). In any case, the present results would seem to eliminate the possibility that recognition memory might first become available to the visual system and only later to reaching. Here is evidence of early memory at long delays using reaching as the dependent measure.

Comparison of Our Visual Paired Comparison Procedures and Results with Those from Other Studies

Our procedure for testing visual paired comparison differed in some ways from the procedures most commonly used for the task, but our results are quite comparable to the results obtained in other studies. (1) Visual paired comparison is usually tested using two-dimensional stimuli; our stimuli were three-dimensional so that the same stimuli could be used for delayed nonmatching to sample (stimulus = reward) and for visual paired comparison. (2) During familiarization, the sample stimulus is often presented simultaneously at both the right and the left. We presented the sample only at the midline. Since we created novel three-dimensional objects as our stimuli it would have been burdensome to produce two copies of each sample, and it would have been difficult to make both copies absolutely identical. (3) We moved our sample slowly to the right and left to keep the infant's attention. Usually, the sample is stationary, although usually whether the infant looks right or left there is a copy of the sample to look at. There are precedents for (1)–(3), however, as in Gottfried et al. (1977) for example, where three-dimensional objects were used as the stimuli, a single sample stimulus was presented during familiarization, and the sample stimulus was moved back and forth to maintain the infants' attention to the stimulus, much as we have done here. (4) Many studies display the sample stimulus for a briefer time and for a set period of time, whereas we displayed the sample until the infant met the habituation criterion. This, too, has several precedents, however. (5) Other investigators often use only one trial at each delay; we have used two.

Despite these differences in procedure, our results are similar to those obtained in other investigations. For example, we found that infants of 4 months showed preferential looking to the novel stimulus *only* at the shortest delay (10 s), failing even at the 15-s delay. This accords well with the results from other studies. Pancratz and Cohen (1970) report that 4-month-old infants showed a significant recovery of looking time to novel stimuli after a delay of 15 s but not after 5 min (no intermediate delays tried). Stinson (1971) found that 4-month-olds showed recognition memory of a visual stimulus after 15 s, but not at the next longer delay (30 s). Finally, Albarran (1987), in a study using 3-dimensional objects such as were used here, found that 4-month-olds succeeded on the visual paired comparison task after a delay of 10 s but not at the next longer delay (1 min).

In agreement with the results reported by Caron et al. (1977), we found that even though our younger subjects were given longer with the sample (because they took more time to habituate) they still failed to show a significant novelty preference at the longer delays. Finally, our attrition rate on the visual paired comparison task is fully comparable to that found in other studies using the task.

Comparison of Our Delayed Nonmatching to Sample (Stimulus = Reward) Results with Those from Other Studies

Kates and Moscovitch (1990) have been testing 8- and 12-month-old infants on delayed nonmatching to sample (stimulus = reward). They are finding that when the sample is presented for 40 s, 8-month-olds reach preferentially to the new stimulus after delays of 40–80 s, and 12-month-old infants show a novelty preference even after the longest delay (3 min (200 s)). These results agree well with our own. That 12-month-olds could tolerate longer delays on the task than 8-month-olds agrees with our finding that infants of 6 months could not succeed at delays as long as could infants of 9 months (although there was no significant difference between the performance of 9- and 12-month-old infants within the range of delays we tested (10 s–10 min)). That 12-month-olds continued to succeed even at the longest delay tested (200 s) is consistent with our finding that 12-month-olds succeeded at the longest delay we tested (620 s). Given the performance of our 6- and 9-month-old subjects, however, we would have expected the 8-month-old infants tested by Kates and Moscovitch to succeed at delays longer than 40–80 s. Perhaps if the sample presentation time had been longer, performance would have been more comparable to that of our subjects.

Oakes, Madole, and Cohen (1990) allowed infants to reach for and play with a three-dimensional stimulus object during familiarization, just as we have done. They used a habituation-dishabituation procedure, and found results similar to those found in traditional visual habituation–dishabituation tasks. This is consistent with our conclusion that reaching versus looking is not a critical difference.

Several studies have found fear or wariness of novelty as indicated by a longer latency to reach to novel stimuli in infants of 9 months or more (e.g., Schaffer & Parry, 1970; Schaffer, Greenwood, & Parry, 1972; Rothbart, 1988). How does this compare with the present demonstration of infants 6, 9, and 12 months reaching preferentially to the novel stimulus? There is no inconsistency because the dependent measures are different. We did not study latency; indeed, we revealed the objects for a few seconds before the infant was allowed to reach because we wanted to make sure the infant had seen both objects before reaching. We measured choice, regardless of how much time it took the infant to reach.

Procedural Differences between Delayed Nonmatching to Sample (Stimulus = Reward) and the Visual Paired Comparison Task

Perhaps the most serious difference in procedure in the two tasks was in presentation time. Because infants are more interested in stimuli that they can touch and play with than in stimuli that they can only look at, subjects took longer to habituate in delayed nonmatching to sample (stimulus = reward) than in visual paired comparison. While this is understandable, it meant that infants had more time to familiarize themselves with the sample during delayed nonmatching to sample (stimulus = reward) than during visual paired comparison. Infants are more likely to show a novelty preference the longer the familiarization time (e.g., Hunter & Ames, 1988; Caron et al., 1977; Lasky, 1980; Rose, Gottfried, Melloy-Carminar, & Bridger, 1982). It remains to be seen whether performance on delayed nonmatching to sample (stimulus = reward) would be fully comparable to visual paired comparison performance if presentation time, rather than level of habituation, were equated on the two tasks.

The interstimulus intervals, which we had intended to keep constant, were actually 20 s for delayed nonmatching to sample (stimulus = reward) but 15 s for the visual paired comparison task. Finally, the delays should have been the same for the two tasks, but delays ≥ 1 min were actually slightly longer in delayed nonmatching to sample (stimulus = reward) than in visual paired comparison (see Table 2). Despite this, however, performance was at least as good on delayed nonmatching to sample (stimulus = reward) as it was on visual paired comparison at all ages and delays.

It should also be mentioned that the stimulus pairs were pretested for preference in reaching but not for preference in looking. It is possible, though we think unlikely, that the pairs of objects were not as equally matched for looking as they were for reaching. If object preferences existed they would have created some noise in the data.

We asked the parent on whose lap the infant was seated to close his or her eyes during the test period of each trial, when the sample and a new object were presented to the infant. This was done to minimize the possibility of the parent affecting where the infant looked or reached. Other researchers have used this procedure, too, whereas still others have placed a covering over the parent's eyes. We decided not to blindfold the parent for the entire testing session because of the length of our sessions and the desire to have the parent available to play with the infant during long delays. It would have been difficult to put the blindfold on before the test period of each trial because we were aiming for the shortest delays to be 0 and 10 s long. We felt that if any parents were tempted to peek and thus influence the results, this would work against our prediction of early competence. That is, until we explained our hypotheses and their rationale to parents after the testing session, most parents assumed that recognition memory would be indicated by the infant choosing (i.e., reaching to or looking longer at) the familiar sample. We found a novelty preference despite any possible bias parents might have been tempted to introduce.

If reaching versus looking is not the critical variable, what is? What critical late-developing ability or abilities are required for the standard delayed nonmatching to sample task, but not required for the visual paired comparison task or for our modified version of delayed nonmatching to sample (stimulus = reward)?

1. Ability to execute a means–end action sequence. One such ability might be motor planning, required to execute means-end action sequences. A means-end sequence involves first acting on, or in relation to, one object (e.g., removing a cover, displacing a stimulus, detouring around a barrier), and then acting on another object (e.g., retrieving a reward). The standard delayed nonmatching to sample task requires such a means-end sequence (displace an object and then retrieve the reward). This is a more complicated response than that required by either visual paired comparison (where subjects simply look at what interests them) or delayed nonmatching to sample (stimulus = reward) (where subjects simply reach to what interests them). Perhaps the additional requirement in the standard delayed nonmatching to sample task of executing a sequence of actions can account for why children succeed later on that task than on visual paired comparison or delayed nonmatching to sample (stimulus = reward).[4] It is certainly reasonable to suppose that the need to string two responses together might complicate things, requiring as it does a certain degree of planning and temporal organization in behavior, as well as keeping the goal in mind over a longer period and in the face of possible distraction.

[4] The reader is reminded that "success" on either task is defined here as consistent choice of the nonmatching stimulus indicated by looking more at that stimulus (in the visual paired comparison task) or by reaching for that stimulus (in delayed nonmatching to sample).

The difficulty of planning and executing a two-action means–end sequence might also account for why infants will not reach around a screen, or pull off a cover, to retrieve a hidden object until roughly 8 months of age, although at only 4 or 5 months they indicate that they know that a hidden object is still there on visual habituation tasks (e.g., Baillargeon et al., 1985). Evidence consistent with a means–end interpretation is that infants of only $6\frac{1}{2}$ months will reach in the dark for an object they cannot see and will adjust this reach in advance of contacting the object based on their memory of the object's size (Clifton, Rochat, Litovsky, & Perris, 1991). Here is success in reaching for an unseen object at least 1 month before reaching for unseen objects is shown in the light. Infants might be able to succeed at a younger age in the dark because there they can reach directly for the object, without first acting on anything else.

Other evidence that the barrier to infants retrieving hidden objects at a younger age is their inability to execute means–end action sequences is that no means–end sequences are seen in infants' behavior before infants can uncover hidden objects. As soon as infants can execute other means–end sequences (e.g., pulling a cloth closer to retrieve a distant toy on the cloth) (Piaget, 1954 [1937]; Willatts, 1987), they also begin to retrieve hidden objects. In addition, the ability to uncover a hidden object comes in at roughly the same age as the ability to retrieve a contiguous object from directly behind a neighboring object. Retrieval of a contiguous object from this position requires linking two actions together in a sequence (reaching over the barrier and then reaching back for the toy) (Diamond & Gilbert, 1989). Even when the neighboring object is transparent, retrieval is not seen at younger ages.

It is very likely that the difficulty in executing a means–end sequence might account for why infants cannot uncover a hidden object until about 8 months. It is much less likely, however, that problems in executing means–end action sequences could account for why the standard delayed nonmatching to sample task is not solved until 20–21 months of age although infants of only 6–9 months perform so well on our modified version of delayed nonmatching to sample (stimulus = reward). This is a lag of roughly 1 full year, and infants can certainly perform all manner of means–end tasks months before they succeed on the standard version of delayed nonmatching to sample. Why, too, should success on delayed nonmatching to sample appear so much later than success in retrieving a hidden object (21 months vs 8 months) if the main problem for each is the same (executing a means–end sequence)?

Yet, on the other hand, there is at least one piece of evidence that the need to execute a means–end sequence might pose a significant problem for even older children. In a form discrimination task with $3\frac{1}{2}$ to $4\frac{1}{2}$-year-old children, Blank and Rose (1975) required half the children to displace the correct stimulus to retrieve the reward (i.e., two actions: displace stimulus, retrieve reward), while half the children were handed the reward if they reached to the correct stimulus (i.e., 1 action: displace stimulus); otherwise the testing conditions were identical. This difference in testing procedure produced a dramatic difference in performance. The children rapidly learned the task when handed the reward, but required twice as many trials when they had to retrieve the reward themselves. Indeed, half the children in the two-action condition never succeeded at the task.

2. *Relational skills.* The stimulus one sees and initially acts upon in most reaching tasks is not the reward, but only stands for the reward. In delayed nonmatching to sample, for example, an object must be displaced to retrieve the reward underneath it. This is more abstract than if the stimulus itself is the reward. Similarly, when infants uncover a cloth to retrieve the object beneath, the thing they initially see and reach for (the cloth) is not the reward. In visual paired comparison and visual habituation paradigms, on the other hand, subjects look at something because it is intrinsically interesting, not because of its relationship to anything else. Perhaps problems in understanding the relationship between the stimulus object and the reward is what makes the standard delayed nonmatching to sample task so difficult for infants. See an interesting discussion of a related issue in Asch (1969).

There is evidence that the more remote the connection between the stimulus and the reward, the more difficult the task. The closest connection, of course, is when the stimulus is also the reward, as in visual paired comparison and in our modified version of delayed nonmatching to sample (stimulus = reward). Jarvik (1953) investigated why it takes monkeys hundreds of trials to learn a simple color discrimination. He tested monkeys the traditional way with two baited foodwells, one covered by a green plaque and one covered by a red plaque, but also tested monkeys with bread colored red or green (the bread of one color was treated with a disagreeable flavor; monkeys enjoy the taste of unflavored bread). The bread did not cover a foodwell; the piece of bread the subject reached for was what the subject got to eat. Otherwise the testing conditions were identical in the two conditions: the left–right placement of the red and green stimuli were varied randomly over trials, but the same color was consistently associated with the reward. In the standard condition, Jarvik replicated the standard results: after 75 trials, the monkeys were still performing at chance. However, in the colored bread condition, all monkeys learned in *1 trial.*

When the stimulus and reward are identical, however, one cannot distinguish problems in means–end actions from problems in understanding the relationship between the stimulus and reward. Therefore, studies that have varied the directness of the relationship between stimulus and reward are particularly informative here. Continuing his investigation of the color discrimination paradigm with chimpanzees, Jarvik (1956) varied whether the reward was hidden *under* a plaque or *inside* the plaque (taped to a depression in the underside of the plaque). The standard technique is to hide the reward under the plaque, and Jarvik again found the standard result; mean number of trials to criterion was 131. However, when the reward was attached to the plaque the mean number of trials to criterion was 1.

Although this has not yet been investigated directly with children, Rudel (1955) found that when the reward was placed inside the stimulus (boxes served as the stimuli), children of $1\frac{1}{2}$–$3\frac{1}{2}$ years learned to choose on the basis of relative size in far fewer trials than have even older children when tested with the reward underneath the stimulus (Kuene, 1946; Alberts & Ehrenfruend, 1951).

More recent work by DeLoache might also be relevant here. In one experiment, DeLoache and Brown (1983) varied whether toys were hidden in a piece of furniture or in a plain box on or near the piece of furniture. In another experiment, DeLoache (1986) varied whether a small object was hidden in a distinctive container or whether the distinctive container was attached to the top of the plain box in which the object was hidden. In both experiments, 21-month-olds performed significantly better when the connection between stimulus and reward was more direct. That is, they performed much better when the reward was hidden in the piece of furniture rather than near it and much better when the reward was hidden in the distinctive container rather than in a box under the distinctive container. DeLoache (1986, p. 123) summarizes the findings thusly:

> [W]hen the same distinctive visual information was a less integral aspect of the hiding location, age differences appeared; older children [27 months] were more successful than younger ones [21 months] at using the distinctive cues that were associated with (but not intrinsic to) the hiding place. . . . Information that is successfully exploited when it is intrinsic to the hiding place of an object may be ineffective when it is not intrinsic. . . .

Passingham and Halsband (1982, 1985; Passingham, 1985a; 1985b) have found similar results in monkeys, especially following lesions of premotor cortex. They trained subjects on conditional tasks, such as (a) pull the handle if it is blue, turn the handle if it is red, (b) pull the handle if the background is blue, turn the handle if the background is red, or (c) displace the panel in front of the handle and then act on the handle; pull the handle if the panel was blue, turn the handle if the panel was red. Subjects performed much better when the handle itself contained the color cue rather than the background or the front panel. Indeed, monkeys with premotor lesions never learned the task under conditions (b) or (c).

Our own results are equally compatible with interpretation 1 (which hypothesizes that the standard delayed nonmatching to sample task is solved much later than visual paired comparison and delayed nonmatching to sample (stimulus = reward) because the former requires a two-action means–end sequence, while the latter two tasks do not) and interpretation 2 (which hypothesizes that the standard delayed nonmatching to sample task is solved much later because it requires subjects to act on one thing to obtain another, while in the other two tasks subjects act directly on the reward). To test between these two interpretations, we have constructed a jack-in-the-box apparatus for testing delayed nonmatching to sample. Here, the objects are affixed to trays on the top of the apparatus and cannot be removed. However, in reaching for the object, if the object is moved at all, a jack-in-the-box pops up behind it. The jack-in-the-box is the reward, not the object for which the infant reaches, but only one action is required—the act of starting to retrieve the object causes the jack-in-the-box to spring up. Infants appear to succeed on this at the earliest age we have been able to test them, 9 months.

3. Speed of processing. In the standard delayed nonmatching to sample task, the sample is presented only briefly (until it is displaced and the reward retrieved (about 2–5 s)). Perhaps infants need more time than this to process the visual information about the sample. In our version of delayed nonmatching to sample (stimulus = reward), the sample was typically present for about 70 s, and infants typically looked at it for 40–50 s before reaching the habituation criterion (see Table 6). We found long looking times at the sample in the visual paired comparison task as well (Table 6). In other studies using visual paired comparisons, the sample has been presented for anywhere from 10 s to 2 min (see Fagan, 1990).

We know that information processing time decreases dramatically with age; younger children need longer to process a stimulus than do older children. Perhaps infants fail the standard delayed nonmatching to sample task until roughly 21 months because the sample is presented too briefly for them. Perhaps infants in the first year succeed on the visual paired comparison task and delayed nonmatching to sample (stimulus = reward) because they are given enough time to process the sample stimulus on these tasks. Similarly, when an object is hidden in an object permanence study, the infant sees the object and hiding procedure for only a few seconds. In Baillargeon's visual habituation procedures, however, the infant sees this repeated over and over again many times. Differences in the time available to process what is happening might be important in understanding why infants show that they know that the hidden object is there earlier in Baillargeon's tasks than when they are required to uncover a hidden object. Evidence consistent with this interpretation is that studies of visual paired comparison have often found that if the sample is only presented briefly no novelty preference is shown (e.g., Hunter & Ames, 1988; Caron et al., 1977; Lasky, 1980; Rose et al., 1982). Moreover, the time needed to encode the sample decreases with age during infancy (e.g., Caron et al., 1977; Werner & Perlmutter, 1979; Rose et al., 1982), so if the sample is presented only briefly, younger children would be more adversely affected by this than older children.

Yet, there are already indications that length of presentation time may not be the critical variable either. (1) Fagan (1974) found that infants as young as 5 months can succeed on the visual paired comparison task even after minimal exposure to the stimulus and in the absence of overt habituation. (2) Bachevalier (1990) reports that even though the sample stimulus was present for 30 s during visual paired comparison testing, infant monkeys generally looked at it for only about 2–5 s.[5] This is about as long as they saw the sample during delayed nonmatching to sample testing. Yet, she found that infant monkeys could succeed on visual paired comparison as early as at least 2 weeks of age, but could not succeed on delayed nonmatching to sample until about 4 months of age. (3) In our own work, 4-month-old human infants looked at the sample longer during familiarization than did older infants (53 s vs 35 s; see Table 6 above), and all were equated on level of habituation before the sample object was removed, yet the 4-month-old infants still failed the visual paired comparison task at all delays except perhaps the very briefest, whereas the older infants looked significantly longer at the novel, rather than the familiar, stimulus at quite long delays (see Tables 3 and 4 above). Earlier, Caron et al. (1977) had found that giving $3\frac{1}{2}$-month-old subjects more time to become familiar with the sample did not increase the likelihood of these infants looking preferentially to the new stimulus. These infants had not habituated to the sample, however, even though given a longer presentation time. The present results confirm and extend the conclusion reached by Caron et al., for even when infants of 4 months had been habituated to the sample here, they still failed to look preferentially to the new stimulus except perhaps at the very shortest delay. (4) We found that presenting the sample for a long time in the standard delayed nonmatching to sample task was of little help to infants 12–15 months of age (Diamond et al., 1994) and that varying the presentation time in our jack-in-the-box version of the task had little effect on the performance of infants 9–12 months of age (Diamond & Lee, in preparation).

4. Explicit versus implicit processing: Work versus play. Perhaps when there is a formal testing situation, where it is possible to be wrong, the performance of infants deteriorates. On visual paired comparison and delayed nonmatching to sample (stimulus = reward), there is no wrong answer. The subject can look at, or have, whichever stimulus he or she chooses. It feels more like a play situation than a test. In the standard delayed nonmatching to sample procedure, subjects are rewarded only when they reach to the novel stimulus. It is clear that they are being tested, and that there are right and wrong answers.

[5] Bachevalier's looking times for infant monkeys are much shorter than ours for human infants. That may be because, until our habituation criterion was met, we redirected subjects' attention back to the sample stimulus if they looked away for more than 3 s, whereas Bachevalier did not bring subjects' attention back to the stimulus if they looked away.

Consider that amnesic patients often cannot recall information when explicitly tested, but can show that they have some memory of that information on subtle measures where they do not know they are being tested. Rats will alternately enter one arm of a t-maze and then the other if allowed free access to explore the maze ("spontaneous alternation"); however, a great many trials are required to explicitly train a rat to alternately enter one arm of the maze and then the other ("single alternation task"). Although infants' spontaneous preference might lead them to choose the new object most of the time, perhaps trying to "think about" what they are doing, or what they are supposed to be doing, makes the task much harder than when they just respond automatically.

This point might be similar to the interpretation proposed by Mishkin. Mishkin has proposed that delayed nonmatching to sample is more difficult than visual paired comparison because the former requires attending to the abstract quality of novelty and learning an abstract rule ("reach to the stimulus that does not match the sample"), whereas the latter requires doing only what comes naturally.

Looking at the tasks, it might appear that visual paired comparison and delayed nonmatching to sample (stimulus = reward) might require only implicit memory, whereas delayed nonmatching to sample requires explicit memory. Certainly, adult patients (Squire, Zola-Morgan, & Chen, 1988) and monkeys (Mishkin, 1978; Murray, Bachevalier, & Mishkin, 1989; Zola-Morgan & Squire, 1986; Zola-Morgan, Squire, & Amaral, 1989a, 1989b) who have damage to the medial temporal lobe structures thought to underlie explicit memory fail the standard delayed nonmatching to sample task. The problem for this interpretation is that lesions to the hippocampus + amygdala + rhinal cortex also impair performance on the visual paired comparison task in infant monkeys (Bachevalier, Brickson, & Hagger, 1993) and in adult monkeys (Saunders, 1990), and patients amnesic due to damage to the medial temporal lobe also fail the visual paired comparison task (McKee & Squire, 1993). Either medial temporal lobe structures are also important for nonexplicit memory tasks or visual paired comparison requires explicit memory.

5. *Resistance to interference.* Perhaps children do not succeed on the delayed nonmatching to sample task until relatively late because retrieval of the reward after displacing the sample interferes with, or masks, memory of the sample. Gaffan, Shields, and Harrison (1984) found that monkeys performed better on the delayed matching to sample task when they received no reward during initial sample presentation. Perhaps the reason performance was so much better here was because the last thing subjects saw before the delay was the sample, rather than having their attention drawn away from the sample to the reward.

There is a body of literature demonstrating that monkeys perform substantially better on delayed matching to sample (D'Amato & O'Neill, 1971; Etkin, 1972; D'Amato, 1973) and on the delayed response task (Malmo, 1942) if the experimenter simply turns the lights off during the delay. Etkin checked to see if monkeys were perhaps less active in the dark, but he found no activity reduction at all. These results suggest that any interference, such as looking around at things in the testing room, might make it more difficult to remember what the stimulus had been before the delay. There is also evidence, however, that recognition memory on visual measures is quite robust despite the presence of stimuli interspersed between sample and test even in very young infants (e.g., Caron & Caron, 1968; Fagan, 1971; Martin, 1975; Bornstein, 1976).

If interference is a problem, children should fail the jack-in-the-box condition, for here, too, a reward is interposed after the sample; yet performance is quite good here (Diamond & Lee, in preparation). However, we did find that when the sample was presented with no reward underneath it during familiarization, toddlers succeeded on the standard delayed nonmatching to sample task at a younger age than when the sample was presented with a reward (Diamond et al., 1994). In the no-reward-during-familiarization condition, 15-month-old infants performed as well as do 21-month-old infants in the standard condition.

6. Where does a trial begin and end? Perhaps a reward denotes the end of a trial for infants. Then, allowing subjects to retrieve a reward after familiarization as well as after the test phase might confuse them. They might see this as single stimulus trials alternating with two stimuli trials, without perceiving the connection between the single and paired presentations. Not placing a reward under the sample during familiarization should help make the trial boundaries clear, as a reward would be available only at the end of a trial. However, if ambiguity about the boundary between trials is the problem, then it should be possible to demarcate trials more clearly and thereby improve performance even if infants receive a reward during both familiarization and test.

Although the present study allows us to eliminate response modality (reaching vs looking) as the critical variable, and it indicates that other studies requiring a reaching response may have underestimated the memory abilities of infants because of nonmemory requirements of the tasks, several hypotheses concerning the critical difference between the visual paired comparison and the standard delayed nonmatching to sample tasks are still compatible with our results. Using the stimulus as its own reward may have made it possible for young infants to succeed on delayed nonmatching to sample because it removed the need to plan and execute a means–end sequence, it made the relationship between the stimulus and response direct, it was associated with a much longer stimulus presentation time, it was not an explicit testing situation, it eliminated a salient stimulus (the reward) from intervening between sample and test, and/or because it made more clear the beginning and end of a trial.

In summary, although children cannot succeed on the standard delayed nonmatching to sample task until 20–21 months of age even at delays as brief as 5–10 s, when we modified the task by removing all extrinsic rewards, infants of only 6 months were able to succeed at the task at delays as long as 10 min. Moreover, their performance on this modified version of delayed nonmatching to sample (stimulus = reward) was at least as good as their performance on the visual paired comparison task, a comparable test which requires no reaching but only looking. These results suggest that when tasks are equated on other dimensions, infants can indicate the presence of cognitive abilities at least as early on reaching tasks as on tasks requiring only looking. These results also suggest that infants can remember for quite long periods by at least 6 months of age, and so their failure to succeed on the standard delayed nonmatching to sample task at short delays until almost 2 years of age is probably not due to a lack of memory, but rather to some other cognitive requirement of the task.

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RECEIVED: March 22, 1994; REVISED: January 26, 1995