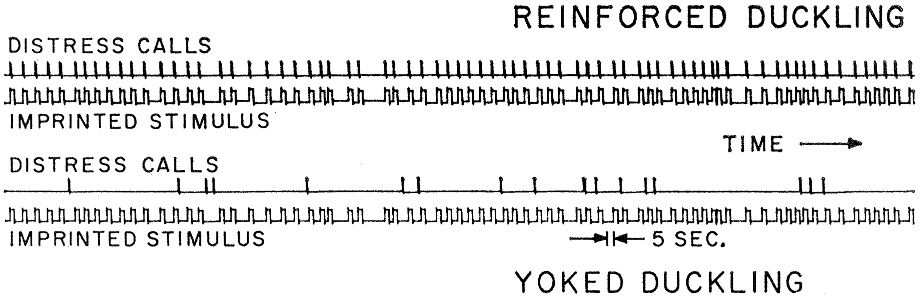

Fig. 3. Sample record illustrating performance differences between the reinforced ducklings and their yoked partners. In this condition presentation of the imprinted stimulus to both ducklings was determined by the distress vocalizations of the reinforced subject.

ment insured that both members of each pair received exactly the same number of stimulus presentations in the same temporal sequence, but, for the experimental subject, presentation of the imprinted stimulus was contingent upon distress calls, whereas for its control (yoked) partner no response contingency existed. On day 5, subjects were run for a 40-minute session and the presence of the imprinted stimulus for both subjects was dependent upon whether or not the experimental subject emitted a distress call. On the following day (day 6), the contingency was reversed for each member of a pair, and now the presence of the imprinted stimulus for both subjects was determined by the emission of distress calls by the previously yoked subject.

Figure 2 shows the mean number of distress calls under each of the several conditions. On day 5, reinforced subjects emitted a greater number of distress calls than their yoked partners. A similar effect is seen on day 6 when the conditions for the members of each pair were reversed, but the observed difference is small.

A test for related measures of the difference in total number of distress calls emitted by the reinforced versus yoked subjects for days 5 and 6 separately yielded a significant value for day 5 ($t = 6.21$, df $= 8$, $p < .005$) but not for day 6 ($t = 0.16$, df $= 8$, $p > .05$). In addition, tests for related measures comparing the total number of distress calls emitted by each subject in each of the two conditions show that subjects who were initially yoked (day 5) and subsequently reinforced (day 6) exhibited a significant increase in the number of distress calls emitted ($t = 2.5$, df $= 8$, $p < .05$). However, subjects going from the reinforced condition to the yoked condition did not show a significant decrease in the number of emitted distress calls ($t = 1.42$, df $= 8$, $p > .05$).

Figure 3 shows a sample record from day 5. It illustrates the details of the performance difference between reinforced and yoked subjects and provides a basis for interpreting the data in Fig. 2. For the reinforced duckling, the frequency of distress vocalization is relatively high. As a result, the imprinted stimulus seldom is absent for more than a few seconds. When, however, the yoked subject is exposed to the same sequence of stimulus presentations (by means of the distress calls of its reinforced partner) few distress calls are emitted. Apparently, as seen in the performance of the yoked subject (and summarized in Fig. 2), when the imprinted stimulus is presented regularly without regard to subject's vocalization, few distress calls occur (*5*). If, however, stimulus presentations are equated, but stimulus presentation is contingent upon distress calls, the tendency to emit distress calls is enhanced. Since response facilitation of this sort is the expected effect of reinforcement, and since all other factors are equated, it is concluded that distress vocalization is reinforced when the return of the imprinted stimulus is solely determined by the emission of distress calls.

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3. In order to insure that the voice keys would selectively respond to distress calls and not to other sounds, several pilot subjects were placed in the apparatus and repeatedly captured and released. During capture subjects typically emitted a constant stream of distress calls and the voice key consistently responded to them. Movements of the imprinted stimulus, however, and other sounds of the subject (for example, the low-intensity contentment cheep) never activated the voice key.
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5. Figure 1 provides the clue to why short-exposure cycles yield so few distress calls. As seen in Fig. 1, the emission of distress calls does not typically begin until several seconds after stimulus withdrawal. Short cycles of stimulus exposure yield relatively few distress calls because the stimulus often returns before the subject ordinarily begins to vocalize. A process of this sort can explain the large reduction in overall frequency of distress vocalization in going from days 3 and 4 to days 5 and 6. On days 3 and 4 the stimulus was presented and withdrawn in 1-minute cycles, whereas on days 5 and 6 (because of the performance of the reinforced subjects) the average cycle length was only a few seconds.
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Age Differences in Infants' Attention to Patterns of Different Complexities

Abstract. *Infants 3 weeks, 8 weeks, and 14 weeks old were presented with checkerboard patterns which differed in the number of squares they contained. The older the infants, the more complex was the checkerboard that they looked at longest. This result does not appear to depend on changes in visual acuity or accommodation related to age.*

Until recently, results of studies of infants' attention to visual patterns of different complexities seemed remarkably consistent. In spite of the fact that the studies were not directly comparable because they used different stimuli and infants were of different ages, they agreed in finding evidence for the hypothesis that infants prefer to look at more complex rather than less complex patterns (*1*). It is not surprising then to find that this hypothesis has sometimes been used as a *post hoc* explanation for results in other studies. For example, when Stechler found that infants 2 to 4 days old looked more at a face pattern than at a die pattern and more at the die than at a blank card (*2*), he noted that differences in complexity alone would suffice to explain his results.

The consistency of results has recently been destroyed by Hershenson, who found that newborns preferred the least complex of three black and white checkerboard patterns (*3*). Hershenson's subjects looked most at a checkerboard with 2 squares on each side and least at one with 12 on each side. It seems noteworthy that these subjects were newborn infants, whereas subjects who have given the greatest preference to the most complex patterns of a set were infants 2 months old and more.

We investigated the effect of age on infant preferences for complexity. The subjects were 30 infants, 10 ranging in age from 21 to 25 days (3-week age group), 10 ranging from 51 to 61 days (8-week age group), and 10 ranging from 93 to 103 days (14-week age group). Subjects were brought individually to the laboratory by their parents and each was placed in a mobile cradle. The base of the cradle was concave along its length and prevented gross body movements. Sponges placed at the sides of the infant's head reduced head movements.

The cradle holding the supine baby was rolled into an experimental chamber lined with navy blue felt. In the ceiling of the chamber was a hinged door containing a holder into which a stimulus card 22.2 by 29.0 cm could be slid. The infant's eyes were 45.7 cm below the center of the card. Illumination was provided by two 40-watt light bulbs placed below and at the sides of the infant's head. A blind below the chamber ceiling was drawn to hide the patterns between trials.

A peephole 0.6 cm in diameter was situated in the ceiling door 1.3 cm to one side of the edge of the stimulus card. The observer watched the infant's eyes through the peephole and pushed a button attached to a Rustrak event recorder to record the number and duration of the infant's visual fixations on the stimulus. The criterion of fixation was the reflection of the pattern over the infant's pupil.

The patterns were three black and white 15.2-cm-square checkerboards. Pattern A had four squares, each 7.6 cm on a side; pattern B had 64, each 1.9 cm on a side; and pattern C had 576, each 0.6 cm on a side. To test whether pattern C was below the visual acuity threshold of younger infants, the 3-week and 8-week age groups were also shown a plain gray square of the same size and overall reflectance as the checkerboards. It was reasoned that if subjects looked longer at pattern C than at the gray square, its pattern must be perceptible to them.

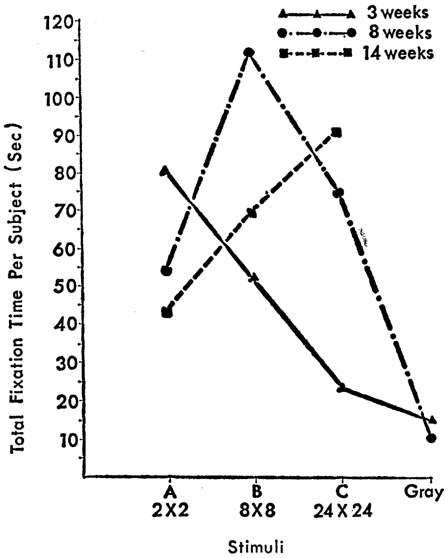

Fig. 1. Total time per subject spent by infants 3, 8, and 14 weeks of age looking at different patterns.

Each pattern was presented for four 30-second trials. For the first half of the series of trials the order of presentation was randomized individually for each subject. The randomized order was reversed in the second half of the trial series. The 14-week age group had 12 trials, while the 8-week and 3-week groups had 16 trials because they were also shown the gray square.

Agreement between observers was determined by comparing observations from two independent observers on three of the 3-week-old subjects and six of the 14-week-old subjects. The observers simultaneously recorded visual fixations while they looked through separate peepholes on either side of the subject. The Pearson correlation between the fixation times recorded for each trial by the two observers was +0.94.

A two-way analysis of variance of the data in Fig. 1 (excluding those from the gray square) shows that the effects of age, pattern, and of the interaction of age and pattern are all significant (all p's $< .005$). To investigate the interaction effect, one-way analyses of variance were performed separately for each age group. Analyses for the 3-week and 8-week age groups included the gray square. In each group the effect of pattern was significant (all p's $< .005$). For each of the analyses a Newman-Keuls test was performed on the differences between the effects of any two patterns. For all age groups differences between patterns in all possible pairings were significant (all p's $< .02$) except the difference between pattern C (the most complex) and the gray square for the 3-week-old group. The 3-week age group preferred the patterns in decreasing order of complexity; the 8-week group preferred the pattern of intermediate complexity (pattern B) most; and the 14-week group preferred the patterns in increasing order of complexity.

Although the 8-week-old infants looked significantly longer at pattern C than at the gray square, those 3 weeks old did not; this finding suggests that they could not distinguish the most complex checkerboard from a uniformly gray square. This inability could be due either to the younger infants' poorer visual acuity, demonstrated by Fantz, Ordy, and Udelf (*4*), or to their poorer visual accommodation. Haynes, White, and Held (*5*) found that the accommodative responses of infants less than 1 month old do not adjust to changes in target distance, but remain locked at an average focal distance of approximately 19 cm. Since the patterns in the present study were presented at a distance of 45.7 cm, it is probable that the 3-week-old infants could not accommodate well enough to allow them to distinguish the pattern in the most complex checkerboard. If this was the case, a part of their supposed preference for less complex patterns could simply be a preference for pattern over non-pattern, a preference already well-documented by Fantz (*6*).

To investigate this possibility a second group of infants 3 weeks old was tested with the patterns at 19 cm. These subjects were ten infants ranging in age from 22 to 25 days. The apparatus, method and procedure remained unchanged from the earlier tests except that the change of distance required changes in the size of the patterns and in the position of the observation hole. Patterns were reduced to present the same size retinal image as they had when further away. They were 6.26-cm-square checkerboards on cards 9.2 cm by 12.1 cm. The numbers of individual squares in these checkerboards were the same as in the larger ones, but their size was proportionally reduced. Because of the reduced distance the observer could not get a good view of the infant's eyes through a peephole at the side of the stimulus card. A pinhole was therefore punched in the center of the card itself, and the observer looked directly through this hole.

The results of this test were similar to those of the earlier ones at the longer distance, and this similarity shows that our results cannot be attributed merely to inadequacy of visual acuity or accommodation among infants 3 weeks old. With the shorter distance, infants looked at all patterns longer (total looking time per subject for pattern A, 101 seconds; for pattern B, 86 seconds; for pattern C, 67 seconds; and for the gray square, 43 seconds). A two-way analysis (excluding the gray square) of the results of tests on the 8- and 14-week-old infants, run at 45.7 cm, and on 3-week-old infants, run at 19 cm, reveals the significance of age ($p < .05$), pattern ($p < .01$), and of the interaction of age and pattern ($p < .01$). The decrease in total looking time with age is consistent with other results found in our laboratory.

A one-way analysis of variance of the second group of infants 3 weeks old shows that they preferred the patterns, as did the first group, in decreasing order of complexity ($p < .01$, including the gray square). A Newman-Keuls test revealed that differences between patterns in all possible pairings were significant (all p's $< .01$, except the difference between pattern A and pattern B, for which $p < .05$). Thus, at the shorter distance infants looked at the most complex pattern, C, more than at the gray square. Subjects 3 weeks old distinguished the pattern in C at this distance, but they still showed no preference for its greater complexity.

Thomas has also studied the effect of age on infants' preferences for complexity (*7*). He ranked his patterns in complexity according to the ratings given them by college students. In order of increasing complexity, the oval achromatic patterns were two broad, horizontal stripes, a type of checkerboard, a face, and a clothed female figure. Thomas compared the preferences of one group of babies, aged 2 to 14 weeks, to those of an older group, aged 15 to 26 weeks. The younger infants showed greatest preference for the checkerboard, while the older infants looked at the face most. Assuming that the rated complexities of the patterns are correct, these results also indicate a preference for greater complexity at older ages.

Recently Salapatek and Kessen (*8*), using photographic records of eye movement, have found that human neonates presented with a large black triangle on a white field direct their eyes mainly towards one vertex and spend little time looking at other parts of the triangle. If infants do not look at the whole figure, then the determination of the effective stimulus becomes a difficult task. It seems possible that part of the age-related changes in response to complexity, as defined in our research, may be attributable to changes in patterns of scanning. Whatever the underlying mechanism may be, our results are clear in showing that infants' visual fixation preferences for complexity change with age. The results suggest that caution should be used in generalizing about results in an area of behavioral development in which response changes take place within such short periods.

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