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Long- and Short-Looking Infants' Recognition of Symmetrical and Asymmetrical Forms

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Adults process symmetrical visual forms more rapidly than asymmetrical visual forms, presumably because symmetrical forms are amenable to a global visual encoding strategy. Individual differences in look duration during infancy have been hypothesized to covary with different modes of visual intake and encoding, with longer look durations reflecting encoding based on prolonged inspection of local visual properties, and briefer look durations reflecting encoding based on more of a global, or global-to-local processing sequence. This hypothesis predicts that short-looking infants would process symmetrical stimuli faster than asymmetrical stimuli, but that long-looking infants would not. Three experiments are described here in which this prediction is tested. Results were in general accord with the prediction, and provide further support for the hypothesis that individual differences in look duration may reflect different modes of visual encoding or inspection.

For the past four decades, the development of perceptual–cognitive processes during infancy has been studied using the visual habituation and paired-compar-

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ison techniques. Much of this work has focused on the documentation of normative developmental trends in emergent cognitive function.

Research over the past decade, however, has also examined individual differences in infants' performance on these two paradigms, and the relation of such individual differences to cognitive performance later in childhood (e.g., Bornstein & Sigman, 1986; Colombo, 1993; McCall & Carriger, 1993). Recent research in this area has attempted to enumerate those processes that may underlie early individual differences (Colombo, 1995; Colombo & Frick, in press; Colombo & Janowsky, 1998). This is particularly true of individual differences in look duration, a measure that has been reported to be modestly predictive of cognitive performance into late adolescence (Jacobson, Chiodo, & Jacobson, 1996; Mitchell, McCollam, Horowitz, Embretson, & O'Brien, 1991; Sigman, 1983; Sigman, Cohen, & Beckwith, 1996; Sigman, Cohen, Beckwith, Asarnow, & Parmelee, 1991; Sigman, Cohen, Beckwith, & Parmelee, 1985; Sigman, Cohen, Beckwith, & Parmelee, 1986; Rose, Slater, & Perry, 1986; Tamis-LeMonda & Bornstein, 1989; Slater, Cooper, Rose, & Morison, 1989). The reported valence of this correlation is negative; that is, prolonged looking at static, two-dimensional stimuli during early to mid-infancy has been associated with less optimal cognitive outcomes. Given that the developmental course of look duration declines across a substantial portion of the first postnatal year, prolonged look durations have been hypothesized to reflect what may be "less mature" modes of visual encoding (Colombo & Mitchell, 1990).[1]

Infant Look Duration and Visual Encoding

To some degree, this hypothesis has been substantiated by recent research. The visual scanning patterns of very young infants tend to be tightly clustered around specific ("local") elements in stimuli such as contours and vertices (Bronson, 1982; Salapatek, 1968, 1975; Salapatek & Kessen, 1966); older infants tend to initially distribute their fixations across larger portions of stimuli ("globally") as do children and adults (Findlay, 1982). This has led to the suggestion that the attentional profiles of older infants (i.e., briefer look durations) may indicate a more "adult-like" global-to-local visual processing sequence (e.g., Navon, 1977, 1983), while those of younger infants (i.e., prolonged look durations) may indicate a reliance on local features for visual encoding (Colombo, Freeseman, Coldren, & Frick, 1995).

Research on individual differences in scanning and look duration has supported the notion of covariance between such patterns within ages as well (Bronson, 1990, 1991, 1994, 1997; Jankowsky & Rose, 1997; Krinsky-McHale

[1] It is worth emphasizing that these points about developmental and individual differences in look duration may be relevant only to a limited portion of the first postnatal year, and only to looking at static, two-dimensional visual stimuli. Generalization beyond these constraints may be unadvisable, as length of looking may reflect different cognitive processes when measured at different ages (Ruff & Rothbart, 1996) or when observed under different stimulus conditions (e.g., dynamic stimuli; see Frick & Richards, 1998).

& Hainline, 1996). Infants whose attentional patterns are characterized by longer look durations have also been reported to attend selectively to local elements in hierarchical visual displays (Colombo et al., 1995) and to rely on particular visual features or contours for recognition (Colombo, Frick, Ryther, & Gifford, 1996; Frick & Colombo, 1996). Orlian and Rose (1997) have recently reported superiority in long-looking infants for recognizing subtle changes in local features. Although these previous results are suggestive, the question regarding whether individual differences in look duration covary with the use of different modes of visual encoding has not been decisively answered. Therefore, the current study is intended to contribute to the body of literature concerning this question with a convergent test of this hypothesis.

The Encoding of Visual Symmetry

Symmetry in the structure of forms has long been considered to be a component in "goodness" of patterns (see Attneave, 1954; Garner, 1970; Szilagyi & Baird, 1977). Pattern "goodness" is thought to make a stimulus easier to encode. Symmetry facilitates visual processing in adults; it is detected quickly by adults (Corballis & Roldan, 1975; Barlow & Reeves, 1979; Royer, 1981; Palmer & Hemenway, 1978) and is correlated positively with reproduction, learning, and memory for shapes (Howe, 1980). It has been suggested that the facility of adults' processing of visual symmetry may be attributable to the use of a global scan in analyzing visual information (Bruce & Morgan, 1975). This possibility was supported by Locher and Nodine (1973), who monitored subjects' eye movements while they performed a complexity-rating task with visual stimuli that varied in symmetry, number of sides, and structural angularity. Locher and Nodine (1973) concluded that subjects tended to scan only one-half of the symmetrical shapes, but scanned the entirety of the asymmetrical ones. In a follow-up study, Locher and Nodine (1987) found that adults concentrated their eye movements along the axis of vertically symmetrical stimuli, but evenly distributed eye movements over asymmetrical stimuli. They suggested a two-step process in which the axis of symmetry is initially sought and detected, followed by the exploration of local details.

Infants' perception of symmetry has also been a topic of study. Bornstein, Ferdinandsen, and Gross (1981) found that 4-month-old infants showed greater and faster habituation to stimuli that were symmetrical about a vertical axis ("vertically symmetrical") stimuli than they did to stimuli that were symmetrical about a horizontal axis ("horizontally symmetrical"), and found 12 month-olds to prefer vertically symmetrical stimuli over horizontally symmetrical or asymmetrical stimuli. Finally, Fisher, Ferdinandsen, and Bornstein (1981) found that 4-month-old infants could discriminate vertically symmetrical forms from asymmetrical and horizontally symmetrical forms, but could not discriminate at all between asymmetrical and horizontally symmetrical forms, or between two asymmetrical forms. The authors suggested that the perceptual discrimination of vertical symmetry was promoted by its inherent global organization. Taken together, these studies indicate a general advantage for processing symmetrical stimuli over asymmetrical stimuli by 4 months of age (see, however, Humphrey & Humphrey, 1989).

Aims and Rationale of the Present Experiments

If, like adults, infants' facility for processing visual symmetry is mediated by a global visual scanning strategy, then an advantage in processing (for example) vertically symmetrical over asymmetrical stimuli could be taken as an indirect measure of a propensity toward global scanning strategies. In the studies described below, short- and long-looking infants were presented with familiarization-novelty/paired-comparison tasks that tested for recognition of vertically symmetrical and asymmetrical stimuli; the amount of familiarization was systematically varied across experiments. If short-looking infants encode visual stimuli by first processing global configurations, then these infants should show recognition of vertically symmetrical stimuli at briefer familiarization than necessary for asymmetrical stimuli. However, if long-looking infants encode visual stimuli through the inspection strategies that emphasize or focus on local features, then asymmetrical stimuli should be recognized at levels of familiarization at least equal to that required for recognizing vertically symmetrical stimuli.

EXPERIMENT 1

Method

Subjects. Sixty 4-month-old infants (M = 126.7 days, SD = 5.48) were recruited by mail and telephone from the suburban Kansas City area. Demographic data for this experiment (and all those that follow) are listed in Table 1. Twenty subjects were excluded due to experimenter error (n = 4), fussiness (n = 8), prematurity (gestational length of less than 37 weeks; n = 4), sleepiness (n = 3), or age of over 135 days at testing (n = 1). Males and females were represented equally among the remaining 40 infants. Four-month-old infants were chosen for this study because this is the age with which much of the prior work in individual differences has been conducted, and because of previous reports of advantages in the processing of symmetry at this age.

Apparatus

Infants were tested in a room with black walls and ceiling. A 1.0 m × 0.7 m translucent rear-projection screen was positioned in the center of the wall opposite the door. Infants were placed in an infant car seat strapped to a table placed 32cm from the screen. Stimuli were slides showing black figures on a white background; slides subtended a total visual angle of 33° high by 24° wide when projected and were presented to the infant by three Kodak Carousel projectors. Single stimuli were presented at the midline. Paired stimuli were

TABLE 1
Demographic Characteristics: Experiments 1–3

	Experiment				
	1	2a	2b	3a	3b
Infant characteristics					
Age at testing (days)	126.7 (5.48)	126.9 (4.57)	128.0 (8.48)	127.1 (7.18)	128.2 (7.02)
Gestation length (weeks)	39.9 (1.29)	39.9 (1.48)	40.1 (0.94)	39.8 (0.97)	39.7 (0.71)
Birthweight (g)	2970 (297.9)	3076 (437.1)	2930 (452.3)	3209 (373.6)	2914 (375.0)
Family characteristics					
Maternal age (years)	30.9 (4.06)	30.5 (4.31)	29.4 (4.21)	30.9 (5.06)	27.3 (3.40)
Maternal education (years)	15.5 (1.54)	15.7 (1.26)	15.6 (2.36)	14.9 (3.52)	15.6 (2.41)
Paternal age (years)	32.9 (4.88)	31.8 (4.46)	32.8 (5.11)	32.5 (4.93)	29.5 (4.35)
Paternal education (years)	16.1 (2.21)	16.4 (1.35)	16.3 (2.77)	15.5 (3.79)	15.4 (1.58)
Number of siblings	1.5 (1.91)	1.2 (1.01)	0.9 (1.07)	0.6 (0.78)	0.9 (1.29)

Note. Table entries are mean values, standard deviations in parentheses.

presented to the left and right of the infant's midline, with slide borders separated by 12° edge-to-edge.

Infants' looks were coded by an observer blind to stimulus identity. The observer watched subjects' corneal reflections on a monitor, as a VHS video camera placed below the projection screen recorded the sessions. The duration and direction of looks were recorded by an observer who coded infants' looking online (i.e., "live") using buttons interfaced with a Zenith microcomputer. In addition, the entire session was videotaped, and we were able to obtain interobserver reliabilities by having a second observer code the session from the videotape. Pearson correlations computed between the "live" and "taped" observers' records on 27 subjects in Experiment 1 yielded coefficients of +.93 for peak look during the pretest, +.94 for peak look during familiarization, and +.96 for novelty preferences.

Stimuli. Four different stimuli were used in this study. The first was a color photograph of an adult female face (e.g., Colombo, Mitchell, Coldren, & Freeseman, 1991; Frick & Colombo, 1996). The remaining three stimuli were black and white abstract shapes (See Figure 1). One of these shapes was bilaterally symmetrical around the vertical axis while the other two were completely asymmetrical. Stimuli were created using procedures described by Palmer and Hemenway (1978).

Design and Procedure

A between-subject factorial design was used for this study, with factors of Looking Profile (2: Long vs Short) × Discrimination Type (2: vertically symmetrical/asymmetrical vs asymmetrical/asymmetrical). Upon arrival at the infant laboratory, the purpose of the study was briefly explained to parents and in-

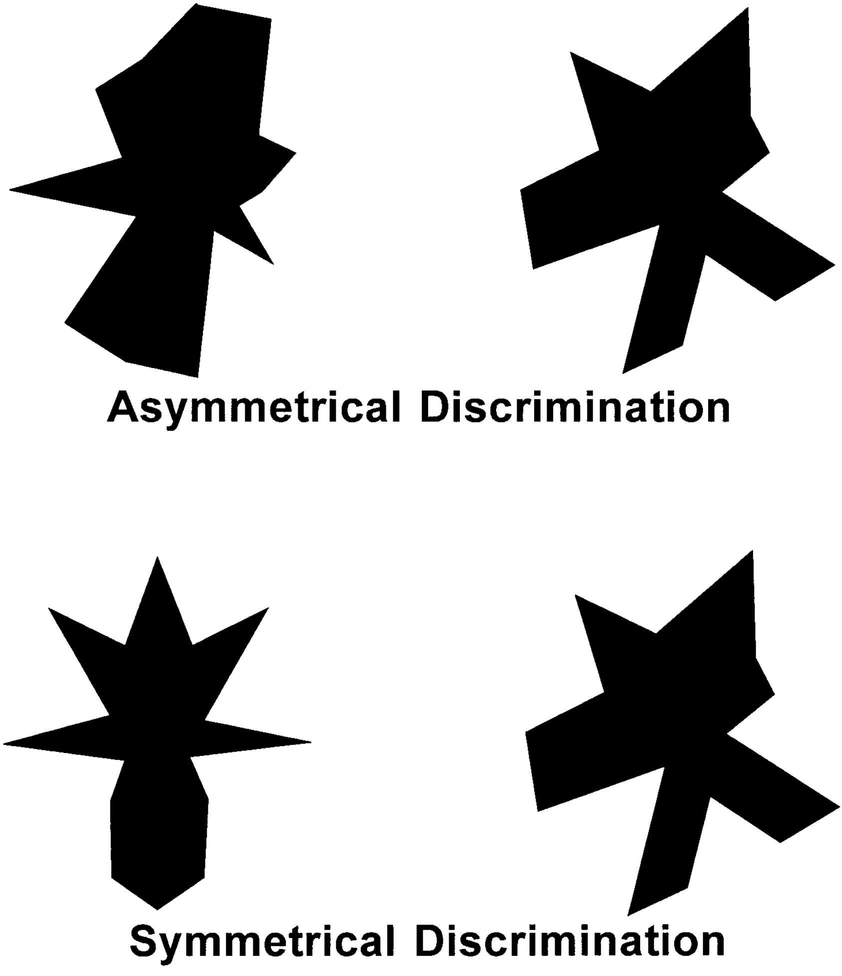

FIG. 1. Stimulus pairings for discrimination/recognition tasks used in Experiments 1–3.

formed consent was obtained. Infants were secured in the car seat, the lights were turned out and the session began immediately.

Look duration pretest. Infants were first shown the photograph of a woman's face until they had accumulated 20 s of looking. Infants were classified either as "long-" or "short-looking," based on the length of their peak look to this stimulus. A large normative study of 4-month-olds (Colombo, Freeseman, Mitchell, & Coldren, 1990) found the median peak look to this stimulus under these conditions to be 9 s; infants whose peak looks fell above 9 s were thus classified as "long-looking" while those whose peak looks fell below 9 s were classified to be "short-looking." This same method and metric for classification was used in all of the experiments that follow.

Paired-comparison task. After the look duration pretest, infants were randomly assigned to conditions in which they were familiarized to a stimulus that was either vertically or symmetrical or asymmetrical. To begin the task, both groups were shown the familiarization stimulus at midline until they had accumulated 20 s of looking time to it. After this criterion was met, the stimulus was removed and then presented simultaneously alongside a novel asymmetrical stimulus. Both stimuli remained on the screen until the infant had accumulated 5 s of looking. The slides were then reversed for another 5 s of accumulated looking to control for lateral bias (Fagan, 1971). Infants who looked to only one lateral position across both paired-comparison trials were excluded from final analyses; such responding yields chance-level performance under conditions where no direct comparison of the novel and familiar stimuli occur (Freeseman, Colombo, & Coldren, 1993).

From the choice trials, novelty preferences were calculated by dividing the amount of time spent looking at the novel stimulus (collapsed across choice trials) and by the total amount of looking to both stimuli during the choice trials.

Results and Discussion

Novelty preferences were analyzed using an ANOVA with between-subjects factors of Looking Profile (2: Long vs Short) and Task Type (2: vertically symmetrical/asymmetrical vs asymmetrical/asymmetrical). This analysis yielded a significant main effect for Looking Profile, $F(1,36) = 8.76$, $p < .005$, but no other significant terms.

Novelty preferences of long- and short-looking infants therefore varied significantly from one another. A *t*-test was then conducted to compare these novelty preferences against chance (.50), in order to determine whether either of the two groups successfully discriminated between the two types of stimuli. Short-looking infants' novelty preferences ($M = .611$, $SD = .147$) were significantly above chance ($t(19) = 3.37$, $p < .003$), but long-looking infants' novelty preferences ($M = .474$, $SD = .139$) were not ($t(19) = .84$, *ns*).

Finally, the correlation between peak look at the face stimulus and peak look at the familiarization stimulus was +.41 ($n = 40$, $p < .01$). This finding concurs with previous findings (e.g., Mitchell & Steiner, 1984) that look duration shows moderate test-retest reliability.

These results indicate that short-looking infants successfully encoded both vertically symmetrical and asymmetrical stimuli after 20 s of familiarization, but that long-looking infants probably needed more extended familiarization to encode either stimulus. Given that previous work has shown that long-looking infants may require up to 30 s more familiarization than short-looking infants to encode stimuli (Freeseman et al., 1993; Frick & Colombo, 1996), we increased familiarization time for this group in experiments that follow (2a and 3a).

Following from the same line of reasoning, since short-looking infants encoded both stimuli at 20 s, we decreased their familiarization times in following experiments (2b and 3b) to determine if one type of stimulus (vertically symmetrical or asymmetrical) was more quickly encoded than the other.

EXPERIMENT 2

For Experiment 2, 53 four-month-old infants were recruited and administered the look duration pretest. Of these infants, 29 were classified as long-looking based on the use of the 9-s median peak look duration, and were assigned to Experiment 2a. Another 24 were classified as short-looking, and assigned to Experiment 2b.[2]

Experiment 2a

Experiment 2a included only long-looking infants, and was conducted in order to determine whether a novelty preference would emerge for either of the two tasks following 40 s of familiarization.

Method

Subjects. The 29 four-month-old-infants (*M* = 126.85, *SD* = 4.57 days) assigned to this study were recruited in the same manner as were subjects in Experiment 1 (see demographic characteristics in Table 1). Nine subjects from this study were excluded from final analyses due to either fussiness (*n* = 3), reported visual problems (*n* = 2), prematurity (*n* = 2), complete lateral bias (*n* = 1), or experimenter error (*n* = 1), leaving a final sample of 20 infants.

Apparatus, stimuli, procedure, and design. The apparatus, stimuli, procedure, and design for Experiment 2 were identical to those in Experiment 1, except that familiarization time for the recognition task was increased to 40 s. Those infants classified as long-looking infants were then familiarized to either the vertically symmetrical or asymmetrical stimulus for 40 s of accumulated looking time (infants classified as short-looking infants were assigned to Experiment 2b). After accumulating this familiarization, the familiarization stimulus was paired with the novel asymmetrical stimulus for a combined looking time of 5 s, and then the slides were reversed for another 5 s of accumulated looking time.

[2] For both Experiments 2 and 3, it would appear that more infants are classified as long-looking (*n* = 56) than are classified as short-looking (*n* = 39). At face value, one might therefore question whether the 9 s median used for classification was valid. However, the reader should note that all experiments involving long-looking infants included tests on both stimulus conditions, while in Experiment 3b (run with short-looking infants), only one such condition was run. In addition, familiarization was being increased to higher levels across these experiments for long-looking infants (40 and 50 s), but systematically decreased for short-looking infants (10 and 5 s). As one might expect in such a situation, loss/attrition across both experiments for long-looking infants (33%) was more than twice that observed for short-looking infants (15%). Thus, conditions involving long-looking infants took longer to complete, and more long-looking infants were required to complete these cells; short-looking infants encountered during such testing were assigned to other studies being run in the laboratory.

Interobserver reliabilities for 11 subjects averaged +.99 for peak look during the pretest, +.97 for peak look during familiarization, and +.93 for novelty preference during the paired-comparison phase.

Results and Discussion

T-tests were performed to determine whether long-looking infants' novelty preferences differed significantly from chance as a function of discrimination condition. Preferences in neither the vertically symmetrical–asymmetrical condition ($M = .531$, $SD = .187$, $t(9) = .52$, *ns*) nor in the asymmetrical–asymmetrical condition ($M = .539$, $SD = .131$, $t(9) = .95$, *ns*) attained significance, suggesting that long-looking infants did not successfully recognize either the vertically symmetrical or the asymmetrical stimulus. In Experiment 3a, familiarization for long-looking infants was thus increased even further to facilitate their discrimination between the two types of stimuli.

Experiment 2b

Only short-looking infants were included in experiment 2b, which was identical to the first two experiments reported. Here, however, the length of familiarization was *decreased* to 10 s, in an effort to determine whether infants' novelty preferences would differ for the two discrimination tasks (vertically symmetrical/asymmetrical or asymmetrical/asymmetrical) when familiarization time was decreased.

Method

Subjects. Twenty-four four-month-olds ($M = 128.00$, $SD = 8.48$ days) were recruited for this study (see Table 1). Four were excluded due to either fussiness ($n = 1$), gestational length of under 37 weeks ($n = 1$), or experimenter error ($n = 2$), leaving a final sample of 20.

Apparatus, stimuli, procedure, and design. Once again, the apparatus, stimuli, procedure, and design was essentially the same for the previous experiments, except that familiarization was decreased to 10 s. Interobserver reliabilities for 14 subjects were +.85 for peak look during the pretest, +.93 for peak look during familiarization, and +.92 for novelty preferences.

Results and Discussion

At 10 s of familiarization, short-looking infants' novelty preferences were different from chance in the vertically symmetrical/asymmetrical condition ($M = .608$, $SD = .105$, $t(9) = 3.24$, $p < .01$) but not in the asymmetrical/asymmetrical condition ($M = .481$, $SD = .138$, $t(9) = .43$, *ns*). Novelty preferences of infants in the two conditions differed significantly from one another ($t(18) = 2.30$, $p < .05$).

Thus, after 10 s of familiarization, short-looking infants successfully performed the vertically symmetrical/asymmetrical discrimination, but not the asymmetrical/asymmetrical discrimination. This finding is consistent with the expectation that symmetry promotes the encoding of visual information. The pattern of findings from this experiment and those from Experiment 1 are also consistent with the hypothesis that short-looking infants process global information before local information, as the vertically symmetrical/asymmetrical discrimination is obtained at briefer levels of familiarization than the asymmetrical/asymmetrical discrimination.

EXPERIMENT 3

A total of 37 infants were recruited for Experiment 3, and to whom the look duration pretest was administered. Of these infants, 27 were classified as long-looking and assigned to Experiment 3a, and 10 were classified as short-looking and assigned to Experiment 3b.

Experiment 3a

As in Experiment 2a, Experiment 3a included only long-looking infants. Familiarization time was increased to 50 s, in an effort to facilitate long-looking infants' differentiation between the two stimulus pairs.

Method

Subjects. Infants classified as long-looking were placed in Experiment 3a. Of the 27 infants fitting this classification (again, see demographic characteristics in Table 1), 9 were excluded because of either fussiness ($n = 6$), complete lateral bias ($n = 1$), experimenter error ($n = 1$), or prematurity ($n = 1$); this left a final sample of 18 ($M = 127.06$, $SD = 7.18$ days).

Stimuli, apparatus, procedure, and design. The stimuli, apparatus, procedure, and design of this study were the same as before, but infants accumulated 50 s of looking to the initial stimulus during familiarization. Interobserver reliabilities were recorded for 15 subjects in this experiment. Reliability was +.96 for look duration during the pretest, +.70 for peak look during the familiarization phase, and +.93 for novelty preferences.

Results and Discussion

After 50 s of familiarization, long-looking infants discriminated the asymmetrical-asymmetrical stimuli ($M = .333$, $SD = .062$, $t(8) = 8.07$, $p < .001$), but not the vertically symmetrical/asymmetrical stimuli ($M = .510$, $SD = .105$, $t(8) = .28$, *ns*). The preferences of infants in these two conditions differed significantly from one another ($t = 4.33$, $p < .001$). At 50 s of familiarization time, then, long-looking infants actually preferred the familiar asymmetrical stimulus. Such familiarity preferences are commonly seen in younger infants, and are thought to indicate that a stimulus has been incompletely processed (Colombo, 1993; Wagner & Sakovitz, 1986). Irrespective of the direction of the preference, the systematic attention indicates discrimination of the asymmetrical/asymmetrical pair; what is somewhat surprising is that it emerged while the vertically symmetrical/asymmetrical discrimination did not.

Experiment 3b

Only short-looking infants were included in Experiment 3b, with familiarization time decreased to 5 s. Infants in this experiment were only given the vertically symmetrical/asymmetrical task, since their novelty preferences in the asymmetrical/asymmetrical condition did not differ significantly from chance after having been given 10 s of familiarization, indicating that they could not make the asymmetrical/asymmetrical discrimination given this amount of time.

Method

Subjects. Ten 4-month-olds were recruited for this study. Demographic characteristics of infants included in this experiment can be found in Table 1. Only two infants were excluded from this experiment, both due to fussiness, leaving a final sample of eight (M = 128.20, SD = 7.02 days).

Stimuli, apparatus, procedure, and design. All were the same as the four previous experiments, except that infants were given only the vertically symmetrical/asymmetrical discrimination task, at only 5 s of familiarization. Interobserver reliabilities for 5 subjects were +.99 for peak look during pretest, +.85 for peak look during familiarization, and +.92 for novelty preference.

Results and Discussion

After 5 s of familiarization, short-looking infants' novelty preference in the vertically symmetrical/asymmetrical task (M = .554, SD = .160) was not significantly different from chance ($t(9) = 1.06$, *ns*). Thus, when familiarization time was reduced to 5 s, short-looking infants were unable to make the vertically symmetrical/asymmetrical discrimination.

GENERAL DISCUSSION

The results from this series of experiments are laid out in Table 2. The finding that long-looking infants did not show an advantage in performing vertically symmetrical/asymmetrical discriminations over asymmetrical/asymmetrical discriminations (while short-looking infants did) indicates that differences may exist in infants' visual processing as a function of characteristic look durations. Evidence from the adult literature (e.g., Howe, 1980; Bruce & Morgan, 1975) strongly suggests that the property of symmetry in visual stimuli facilitates adults' processing of those stimuli. It has been proposed that this finding may be attributable to adults' use of an initial global scan in encoding visual information. This, in turn, suggests that short-looking infants, who showed a greater ability to process symmetrical stimuli in this study, may have employed a global-to-local sequence in processing these stimuli, while long-looking infants may have implemented an alternate, less efficient scanning strategy, such as a local-to-

TABLE 2
Summary of Results from Experiments 1–3[a]

Looking profile	Task type	Familiarization time (s) 5	10	20	40	50
Short-Looking	Vertically symmetrical	55	61**	63**	—[b]	—
	Asymmetrical	—	48	59*	—	—
Long-Looking	Vertically symmetrical	—	—	48	53	51
	Asymmetrical	—	—	47	54	33***

[a] Table entries are novelty preferences, rounded to the nearest percent. Superscripts denote significance of *t* value of novelty preference against chance (.50) responding (*$p < .05$, **$p < .01$, ***$p < .001$)
[b] Dashes indicate conditions not tested in the sequence of Experiments.

global scan. This would be in accord with other studies which have compared the visual processing performances of long- and short-looking infants (e.g. Colombo et al., 1996).

We were surprised by the fact that long-looking infants recognized the asymmetrical stimulus at 50 s of familiarization, but did not recognize the vertically symmetrical stimulus at that same level of familiarization. This result was not explicitly predicted by our general hypothesis; indeed, we would have thought that recognition of the two tasks would have occurred at the same level of familiarization. We do not believe that this finding reflects a generalized advantage in the processing of asymmetrical stimuli for long-looking infants *per se*. Rather, because the method for constructing these stimuli produces variation in symmetry but constancy on many other visual properties (Palmer & Hemenway, 1978), we view this as a function of some idiosyncratic feature(s) of the asymmetrical stimulus that allowed long-looking infants to recognize it more readily than the vertically symmetrical one. If this is indeed the case, then this findings would not be inconsistent with the hypothesized bias for processing local elements on the part of long-looking infants. In any case, this finding may well be a topic for future investigation; the current study is based only a limited set of stimuli, and the generality of this finding will obviously await tests with a more extensive set of stimuli.

The fact that long-looking infants showed asymmetrical–asymmetrical discrimination via a familiarity preference indicates that even at 50 s, stimuli may still have been only partially encoded (Colombo & Bundy, 1983; Rose, Gottfried, & Bridger, 1978; Rose, Gottfried, Melloy-Carminar, & Bridger, 1982; Rose & Wallace, 1985; Uzgiris & Hunt, 1970). However, the systematic discrimination nevertheless does signify recognition of the stimuli. Although it might have been interesting to increase familiarization time beyond 50 s, we chose not to do this because of the problems engendered by such long sessions; indeed, subject loss due to fussiness was 8% at 5 s familiarization, but 33% at 50 s.

It is worth noting that the qualitative differences in encoding that have been observed between long- and short-looking infants are superimposed on quantitative differences that have been observed previously in our laboratory (e.g., Colombo, Mitchell, & Horowitz, 1988; Colombo et al., 1991; Mitchell & Colombo, 1989; Mitchell & Horowitz, 1988) and others' (Jankowsky & Rose, 1997; Miceli, Whitman, Borkowski, Braungart-Reiker, & Mitchell, 1998). In each of the sets of studies where qualitative differences between long- and short-looking infants have been observed (Colombo et al., 1995; Colombo et al., 1996; Frick & Colombo, 1996, and including this set of studies), qualitative differences in response are accompanied by differences in length of time needed for the two groups to process stimuli. It is unclear whether these two aspects of the groups' performance are independent and additive factors (i.e., the groups vary on both rapidity and quality of encoding), or whether the two factors are related (i.e., differences in rapidity are a function of the qualitative differences in encoding). The latter is clearly a more parsimonious account, but it has not yet been tested definitively. Recent data from our laboratory (Frick, Colombo, & Saxon, in press) suggest that prolonged looking at 3 and 4 months may be related to an inability to disengage, or "inhibit" looking. Thus, long-looking infants may not only rely on particular local features for encoding, but may also tend to get "stuck" (Hood, 1995) or "perseverate" (Krinsky-McHale & Hainline, 1996) on such local features. Such a scenario might explain why the performance of long-looking infants on a discrimination where no advantage for symmetry was involved (i.e., the asymmetrical–asymmetrical discrimination) still lagged behind that of short-looking infants in terms of familiarization time.

In summary, this study lends further support to findings that suggest differences in the visual encoding of long and short-looking infants. Although it suggests specific differences in visual processing that covary with individual differences in look duration, the current study does not directly address the questions of (a) why they are different or (b) whether those differences in processing are related to the predictive validity of individual differences in look duration. Such issues should obviously be considered for future research.

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