FACE PERCEPTION DURING EARLY INFANCY

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Abstract—*Previous studies of face perception during early infancy are difficult to interpret because of discrepant results and procedural differences. We used a standardized method based on the Teller acuity card procedure to test newborns, 6-week-olds, and 12-week-olds with three pairs of face and nonface stimuli modified from previous studies. Newborns' preferences were influenced both by the visibility of the stimuli and by their resemblance to a human face. There appears to be a mechanism, likely subcortical, predisposing newborns to look toward faces. Changes in preferences at 6 and 12 weeks of age suggest increasing cortical influence over infants' preferences for faces.*

Studies investigating the development of face perception during early infancy have yielded inconsistent results. Some studies indicate that even newborns prefer facelike over nonfacelike stimuli (e.g., Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991; Valenza, Simion, Cassia, & Umiltà, 1996); other studies indicate that preferences for facelike stimuli first emerge between 2 and 4 months of age (Dannemiller & Stephens, 1988; Kleiner & Banks, 1987; Maurer & Barrera, 1981; Wilcox, 1969).

Two types of hypothesis have been proposed to reconcile these findings. One proposes that newborns' preferences for faces over nonfaces depend on the visibility of the stimuli. For example, Kleiner (1987; Kleiner & Banks, 1987) argued that such preferences depend on the amplitude spectra of the stimuli, which represent the amplitudes and orientations of the sine-wave components at different spatial frequencies. Not until the 2nd month of life are preferences based on differences in the organization of the energy or, in Kleiner's version, on the phase spectra, which represent the phases and orientations of the sine-wave components at different frequencies. According to Kleiner, a newborn will show a preference for a facelike stimulus over another stimulus with which it is paired only if the facelike stimulus has an amplitude spectrum that matches the infant's contrast-sensitivity function better than the second stimulus.

The second type of hypothesis proposes that newborns have an innate preference for facelike stimuli. For example, Johnson and Morton (1991; Morton & Johnson, 1991) proposed that an innate subcortical mechanism, Conspec, causes newborns to orient toward stimuli with high-contrast elements in the configuration of facial features. Conspec declines during the 2nd month of life and is later replaced by a cortical mechanism, Conlern. According to this hypothesis, newborns should show preferences for faces under conditions most likely to activate Conspec. The structures likely to be involved (e.g., the superior colliculus, the pulvinar, or both) are more sensitive to moving than to static stimuli and are active before eye movements toward peripheral stimuli (for reviews, see Johnson, 1995, and Maurer & Lewis, 1998). Consequently, newborns should prefer facelike stimuli when stimuli are either moving, as in a tracking procedure, or presented in the periphery.

Each of these hypotheses can explain many, but not all, of the discrepant findings. For example, Johnson and Morton's (1991) hypothesis cannot explain why newborns do not track the stimulus called *config*—a head outline with three unpatterned blobs in the locations of eyes and a mouth—farther than its inverted version (Johnson et al., 1991). Likewise, Kleiner's (1987) model cannot explain why newborns look preferentially toward a schematic face, with both the phase and amplitude spectra of a face, over a hybrid stimulus with the amplitude spectrum of the face and the phase spectrum of a lattice (Morton, Johnson, & Maurer, 1990). Kleiner (1990, 1993) subsequently developed a hierarchical model in which newborns' preferences are determined by the degree to which the phase spectra are facelike if and only if the two members of a pair of stimuli have the same amplitude spectrum.

It is difficult to form a unified theory of early face perception because the parameters have varied widely. Across studies, stimuli have ranged from the very simple (e.g., Johnson et al., 1991) to the very complex (e.g., Kleiner, 1987), and facelike stimuli have been presented with scrambled features (e.g., Goren et al., 1975), inverted features (e.g., Johnson et al., 1991), reversed phase and amplitude spectra (e.g., Kleiner, 1987), or simply a reversed phase spectrum (e.g., Dannemiller & Stephens, 1988). Although comparisons across studies are potentially informative about underlying mechanisms, stimulus differences have been confounded with procedural differences. Stimuli have been moving (e.g., Goren et al., 1975) or stationary, and stationary stimuli have been presented either singly in the center of the visual field (e.g., Fantz, 1966) or in pairs at various distances from center (cf. Dannemiller & Stephens, 1988; Valenza et al., 1996). Measures have included extent of tracking (e.g., Goren et al., 1975), total fixation time (e.g., Dannemiller & Stephens, 1988), and duration of first look (e.g., Valenza et al., 1996). The age of the infants has varied as well. Newborns, for example, have ranged from a mean age of 37 min (Johnson et al., 1991) to a mean age of a few days (Maurer & Young, 1983).

The purpose of the present study was to reconcile the inconsistent results by using a standardized method to test three pairs of stimuli that have led to different conclusions in the past (Dannemiller & Stephens, 1988; Johnson et al., 1991; Kleiner, 1987; Kleiner & Banks, 1987). We modeled the test on the Teller acuity card procedure (Teller, McDonald, Preston, Sebris, & Dobson, 1986), in which an observer, unaware of the exact stimuli presented during each trial, can use any cues to decide whether or not an individual infant can see the stimulus (or, in this case, prefers one of the two stimuli in a pair). We studied newborns within 2 hr of birth in order to measure preferences after minimal experience with faces. We also tested 6-week-olds and 12-week-olds because previous studies suggested that developmental changes occur by 6 weeks of age for some stimuli (Johnson et al.,

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1991), but not until 12 weeks of age for others (Dannemiller & Stephens, 1988).

METHOD

Participants

The participants consisted of three groups of 12 full-term infants: newborns (mean age = 53 min, range: 17–82 min), 6-week-olds (mean age = 43.7 days, range: 39–48 days), and 12-week-olds (mean age = 84.6 days, range: 77–88 days). One additional baby was tested but excluded from the study because the observer failed to obtain the expected result on a control card (see Results).

Stimuli and Apparatus

The stimuli consisted of five cards and their left-to-right reversals (see Fig. 1). Four of the cards had two black-and-white photographs centered 19 cm (30º of visual angle when viewed from 33 cm) to the left and right of center. The remaining card had one black-and-white photograph centered 19 cm off to the side. The three experimental cards (see Figs. 1a, 1b, and 1c) were versions of stimuli used in previous studies, modified so that the face portion (outer cheek to outer cheek) measured 16 cm (27.5º). Because stimuli varied in the amount of pattern outside the face region (e.g., hair), the size of the entire stimulus and the distance from center to the nearest edge varied across pairs. The two control cards (see Figs. 1d and 1e) were designed to assess the validity of the test and to ensure that at each age tested, there was at least one card that should not elicit a visual preference (Fig. 1d) and one card that should (Fig. 1e). The test was designed so that an infant could be excluded from the final sample if the observer failed to record the expected preference for either of the control cards. We also included one anchor card with stripes on only one side, identical to the card shown in Figure 1e.

The cards were 74.0 cm wide by 50.7 cm high; the observer watched the infant's eye movements through a 6-mm hole punched in the center. The background of the cards was gray, with a luminance equal to the mean luminance of the stimuli shown in Figure 1c. If the baby appeared to be distracted by extraneous stimuli, the cards were presented through a 74-cm × 50-cm porthole in a three-sided gray stage (1.75 m high by 2.30 m wide).

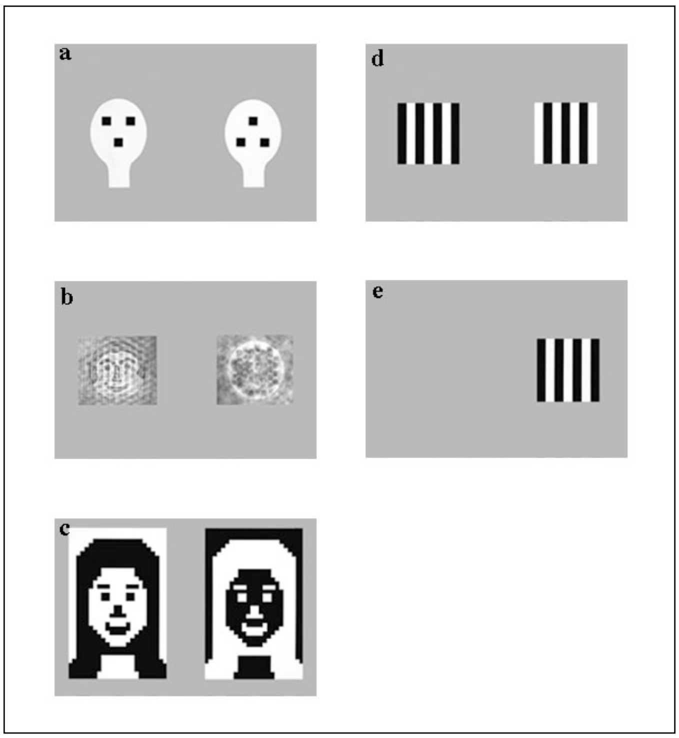


Fig. 1. The three face-nonface stimulus pairs and two control stimuli. Shown in (a) are *config* and its inversion (Johnson, Dziurawiec, Ellis, & Morton, 1991). The left side of (b) shows a stimulus with the phase spectrum of a face but the amplitude spectrum of a lattice. The right side of (b) shows a stimulus with the amplitude spectrum of a face but the phase spectrum of a lattice (Kleiner, 1987). A positive-contrast face and negative-contrast face (Dannemiller & Stephens, 1988) are shown in (c). The control stimuli consisted of 2.5-cm-wide black and white stripes on both sides (d) or on one side (e) of center. There were five additional stimulus cards with the stimuli reversed left-to-right.

Procedure

We began by describing the study to the parent (or parents) and obtaining informed consent. The infant was placed in a position in which he or she was quiet and alert, with the eyes 33 cm from the stimuli. If a person was holding the baby and would be able to see the cards, the person either wore opaque glasses or kept his or her eyes closed during testing. For 12-week-olds, and when necessary for 6-week-olds, the cards were presented through the porthole in the stage. The observer first presented the anchor card several times to be sure that the baby chose the stripes whether they were on the left or right. For the remaining 10 cards, the observer knew only that the cards were arranged in pairs, so that each card was followed by its left-to-right reversal, but did not know what the stimuli were.

Visual preferences were determined subjectively using any behavioral indicators, but primarily direction of first look and duration of looking. The observer showed the baby the first card of a pair as many times as necessary to form a hypothesis about whether the baby preferred the stimulus on the left, preferred the stimulus on the right, or had no preference. The observer then showed the baby the second card, with the stimuli reversed left-to-right, to confirm the hypothesis and retested each card as many times as necessary to reach a decision for that pair. Before deciding that an infant had no preference with a particular pair of stimuli, the observer returned to the anchor card to verify that the baby still looked toward the side with the stripes. For eight 6-week-olds and eight 12-week-olds, we reordered the cards, and an independent observer tested the infants a second time.

RESULTS

The procedure was valid: For every 6-week-old, every 12-week-old, and all but 1 newborn, the testers came to the expected conclusion on control cards, that is, the testers decided that the infants had no preference for the pair shown in Figure 1d and chose the side with the stripes for the pair shown in Figure 1e. The procedure was also reliable: The two observers agreed on 78 of the 80 reliability trials (5 stimuli × 8 babies × 2 ages).

We analyzed visual preferences for each of the three pairs of experimental patterns using a two-tailed binomial test. (When babies showed no preference on a pair, we assigned half of them a preference for the face stimulus, and half a preference for the nonface stimulus. When an odd number of babies showed no preference, we used the more conservative assignment.)

Table 1 summarizes the results. Newborns preferred *config* over its inversion, and amplitude of face over phase of face, but showed no preference for the positive-contrast face over the negative-contrast face. In contrast, 6-week-olds did not prefer *config* over its inversion and preferred phase of face over amplitude of face. Like newborns, they showed no preference for the positive-contrast face over the negative-contrast face. Twelve-week-olds preferred the positive-contrast face over the negative-contrast face. They showed no preference for *config* over its inversion and preferred phase of face over amplitude of face.

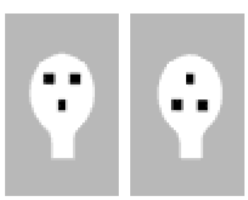
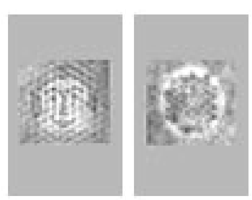
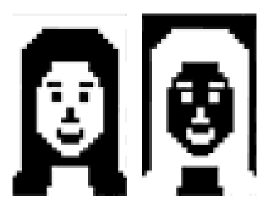
DISCUSSION

The results demonstrate that newborns' preferences are influenced both by the visibility of the stimuli and by their resemblance to a human face. When shown the pair pitting the amplitude of a face against the phase of a face, newborns preferred the amplitude of a face. However, when shown two stimuli with essentially equal amplitude spectra but differing resemblance to a face, they preferred *config* over its inversion. When both stimuli had the same features in the same facelike arrangement (positive-contrast face vs. negative-contrast face), the newborns had no preference. Thus, there appears to be a mechanism predisposing newborns to look toward faces. That mechanism is likely to be innate, although we cannot rule out an influence from the approximately 1 hr of visual input the newborns had received. The mechanism likely contains only a crude representation of a face, because the *config* stimulus was adequate to activate it and it was indifferent to the luminance of the face when contrast was reversed. In fact, the representation might not even look facelike to a normal adult yet, nevertheless, serve the function of directing newborns' attention toward faces. Face preferences at birth could be mediated by an immature cortical mechanism that responds to both central and peripheral stimuli or by a subcortical structure, such as the superior colliculus or pulvinar, that favors peripheral stimuli. The fact that the preference for *config* disappeared by 6 weeks of age favors the subcortical explanation for newborns' preferences because cortical influences are known to increase with age whereas subcortical influences sometimes wane (e.g., Braddick, Atkinson, & Hood, 1996; Johnson & Morton, 1991; Muir & Clifton, 1985).

Unlike newborns, both 6- and 12-week-olds preferred the stimulus with the phase spectrum of a face over the stimulus with the amplitude spectrum of a face. These results suggest that by 6 weeks of age, the developing cortex directs infants' attention toward faces, a hypothesis that is consistent with other evidence of increased cortical influence at about 6 weeks of age (Atkinson, Hood, Wattam-Bell, Anker, & Tricklebank, 1988). The preference may be based on experience with faces during the first 6 weeks of life—experience that is not sufficient for differentiation of a positive-contrast schematic face from a negative-contrast schematic face. Unlike 6-week-olds, 12-week-olds did show a preference for the positive-contrast schematic face (consistent with Dannemiller & Stephens, 1988). Like adults (Kemp, Pike, White, & Musselman, 1996), 12-week-olds may have difficulty recognizing a negative-contrast face because they rely on shading when processing shape. Although adults recognize *config* as facelike, neither 6- nor 12-week-olds preferred *config* over its inversion. It is likely to require more than 12 weeks of experience with faces before babies can use top-down processing to recognize very crude stimulus representations, such as *config*, as facelike.

Hypotheses that focus on either a shift from amplitude to phase (e.g., Kleiner, 1987) or a shift from subcortical to cortical mechanisms (e.g., Johnson et al., 1991) can explain only a portion of our data. Although the results for amplitude versus phase of a face are as Kleiner predicted, the original model (Kleiner, 1987) cannot explain why newborns showed a preference for *config* over its inversion, and the modified hierarchical model (Kleiner, 1990, 1993) cannot account for the disappearance of the preference in older babies. These findings are consistent with Morton and Johnson's (1991) hypothesis that a subcortical mechanism influences preferences for faces at birth but wanes by 6 weeks. However, Morton and Johnson predicted that a cortical face-processing mechanism, Conlern, first emerges between 2 and 3 months. Our finding that the preference for phase of a face over amplitude of a face emerges between birth and 6 weeks suggests that the learning mechanism is functional earlier.

Table 1. *Number of babies who preferred each stimulus over its paired stimulus*

	Feature inversion			Phase and amplitude reversal			Contrast reversal		
Age	*Config*	Inversion	Neither	Phase of face	Amplitude of face	Neither	Positive contrast	Negative contrast	Neither
Newborns	9*	1	2	0	9*	3	0	0	12
6-week-olds	0	0	12	12**	0	0	3	0	9
12-week-olds	0	1	11	12**	0	0	12**	0	0

*$p < .05$, two-tailed binomial test. **$p < .001$, two-tailed binomial test. All other *p*s > .1.

The acuity card procedure proved to be ideal for testing face preferences in young infants: All babies completed the test, independent testers agreed on almost all visual preferences, and only 1 baby was excluded because of an unexpected result for a control card. This method can be adapted to infants of varying ages. The behavioral measure that was most useful differed for newborns and 6-week-olds (direction of first look) versus 12-week-olds (direction of first look and duration of looking), but the test was equally sensitive for all ages tested. Presenting newborns with pairs of stimuli may be more sensitive than visual tracking: Newborns do not track *config* farther than its inverted version (Johnson et al., 1991), but show a preference for *config* when presented with pairs of stimuli in the periphery (the present study; Valenza et al., 1996). The acuity card procedure has the added advantage of allowing the experimenter to measure visual preferences in individual infants for several pairs of stimuli, each of which may tap a different mechanism. These characteristics make the test particularly useful for investigating the development of face perception during early infancy. Future studies using our method could include more realistic images that might better tap young infants' face-processing abilities. Future studies should also test special populations of infants who differ in their experience with faces, such as preterm babies and infants treated for bilateral congenital cataracts. Results from such studies will be useful for further refining hypotheses about the development of face perception during infancy.

Acknowledgments—We thank Marty Banks for verifying the phase and amplitude spectra of the stimuli shown in Figure 1b. We also thank the staff in Labour and Delivery at McMaster University Medical Centre, Hamilton, Ontario, Canada, for facilitating the testing of newborns. This research was funded primarily by Human Frontiers Scientific Foundation Grant 33/95B. J.L.D. was supported partially by funds from the National Institutes of Health, National Institute of Child Health and Human Development (HD32927). These data were presented as a poster at the International Conference on Infant Studies in Atlanta, Georgia, April 1998.

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(Received 7/27/98; Accepted 12/8/98)