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Research Report

The Origin of Biases in Face Perception

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ABSTRACT—*Experience with certain types of faces during the first year of development defines which types of faces are more efficiently recognized later in life. In work described here, we found that infants who learned to recognize six monkey faces individually (i.e., each face was individually labeled) over a 3-month period maintained the ability to discriminate monkey faces. However, infants who learned these same six faces categorically (i.e., all faces were labeled "monkey") or were simply exposed to these faces (i.e., faces were not labeled) showed a decline in the ability to discriminate monkey faces. These results suggest that experience individuating faces from 6 to 9 months of age, via labeling, critically shapes the perceptual representation that is responsible for later recognition and discrimination of faces.*

Perceptual narrowing is thought to be a domain-general developmental phenomenon that occurs in face perception, speech perception, cross-modal perception, and the perception of musical rhythms (Scott, Pascalis, & Nelson, 2007). Perceptual narrowing is a decline in the ability, during the 1st year of life, to discriminate unfamiliar types of perceptual stimuli, such as two faces of another race or species or two phonemes from a nonnative language.

The development of the ability to tell the difference between two faces within an uncommonly experienced face category declines in infants from 6 to 9 months of age (Kelly et al., 2007; Pascalis, de Haan, & Nelson, 2002; Pascalis et al., 2005). It is during this brief time in development that perceptual biases are formed, leading to long-lasting deficits in recognizing and identifying individuals of other races and species, relative to individuals of one's own race or species. For example, using measures of preferential looking time, Pascalis et al. (2002) found that 6-month-old infants looked longer at novel monkey faces than at recently familiarized monkey faces, which indicated discrimination between these faces. However, neither adults nor 9-month-old infants showed discrimination of recently familiarized and novel monkey faces. Results from training tasks indicate that this decline in other-species face discrimination depends on experience viewing monkey faces during the 1st year of life (Pascalis et al., 2005).

A decline in the ability to discriminate between vocalizing monkeys (Lewkowicz & Ghazanfar, 2006) and between silently articulating human faces (Weikum et al., 2007) has also been reported. Infants younger than 6 months of age can more accurately match the appropriate vocalization with a movie of a monkey making that vocalization than 8- and 10-month-old infants (Lewkowicz & Ghazanfar, 2006). Younger infants (4 and 6 months old) are also better able to visually discriminate their native language from a nonnative language in silently articulating faces than are older infants (8 months old). However, bilingual infants, unlike their monolingual counterparts, maintain the ability to visually discriminate both languages at 8 months of age (Weikum et al., 2007). These examples provide evidence of a strong link between visual and auditory information originating from the face, and suggest that experience with faces influences perceptual narrowing in both the auditory and visual domains. However, neither the specific nature of this critical experience nor the mechanisms responsible for perceptual narrowing have been investigated directly.

When adults categorize objects at more specific levels, they extract different perceptual information about these objects than when they categorize them at more general levels. For example, using a change-detection task, Archambault, O'Donnell, and Schyns (1999) found an increased ability to detect object change or disappearance across visual scenes in participants who learned object-label pairings at a more specific level. In addition, prior research investigating the acquisition of perceptual expertise in adults suggested that increased expertise is only exhibited by those who were trained to discriminate cars or birds at more specific levels (i.e., they learn to identify multiple species of owls). Neither category (i.e., learning that several species of owls all belong to the "owl" category) nor exposure (i.e., passive viewing) training led to an increased ability to distinguish individuals within a species or individual cars

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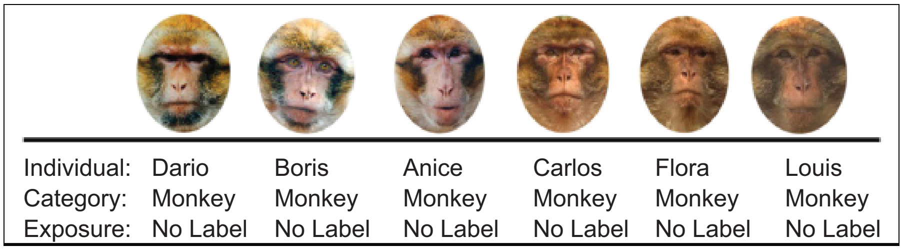

Fig. 1. Examples of six monkey faces and how they were labeled for individual, category, and exposure training.

within a specific model (Scott, Tanaka, Sheinberg, & Curran, 2006, 2008). It is possible that the manner in which perceptual expertise is acquired in adults is similar to the manner in which face expertise is acquired through experience in the course of normal development (Gauthier & Nelson, 2001). We predicted that, in infancy, experience discriminating novel types of faces at the individual level, but not at the category level or through exposure, would lead to specialized processing for those trained types of faces; if our prediction is correct, this specialization would be similar to the acquisition of perceptual expertise in adults. More specifically, we hypothesized that 3 months of experience with monkey faces labeled at the individual level would lead to maintenance of the ability to discriminate among individual monkey faces between 6 and 9 months of age. However, we predicted that category and exposure training would fail to prevent the decline in the ability to discriminate among other-race and other-species faces.

METHOD

Participants

Participants were forty 6-month-old infants (22 males, 18 females; 35 Caucasian, 2 Asian, 2 African American, and 1 American Indian), who were randomly assigned to the individual-, category-, or exposure-training groups. Fourteen infants completed individual-level training, 18 infants completed category-level training, and 8 infants completed exposure training. An additional 21 participants were excluded because they never returned for the posttest or were noncompliant with the training ($n = 14$), became fussy during testing at either session ($n = 2$), or exhibited a bias to look toward only one side of the screen during the test ($n = 5$). All infants were born full term and had no visual or neurological abnormalities. Participants were tested first at 6 months of age (mean age = 186 days, $SD = 9$ days) and then at 9 months of age (mean age = 276 days, $SD = 9$ days). The families of participants were paid $10 and given a small toy for their participation at each session.

Stimuli and Apparatus

Twelve digitized color photographs of Barbary macaques (*Macaca sylvanus*) were used as stimuli in the pre- and posttest assessments. Images were presented on a dark-gray background at a visual angle of approximately 13.6° (see Fig. 1).

Training stimuli were presented to the infant in a picture book. Participants in the individual-training group were sent home with books in which six images of monkey faces were labeled at the individual level (e.g., "Carlos," "Iona"). Participants in the category-training group were sent home with books in which the six images of monkey faces were labeled at the category level (i.e., all were labeled "monkey"). Participants in the exposure-training group were sent home with books in which the six images of monkey faces were not labeled. For each group (individual, category, and exposure training), there were two different training books containing six different monkey faces (Book 1 and Book 2). The training books were randomly assigned within each group. Participants who were trained with Book 1 were tested with novel images from Book 2, and vice versa. The same training and testing images were used for all three training conditions.

Procedure

We assessed infants' ability to discriminate monkey faces before and after a 3-month training period. Infants were tested at 6 and 9 months of age using the visual paired-comparison (VPC) procedure. At 6 months of age, infants were randomly assigned to one of the three training groups. Following the same procedures used previously (Pascalis et al., 2005), we sent the infants home with the training books for 3 months. At 9 months of age, infants returned to the laboratory and completed the posttraining VPC task.

The VPC procedure relies on infants' relative interest in novelty and indexes their ability to discriminate a recently familiarized stimulus from a new stimulus. Discrimination is inferred if, after the familiarization period, infants look at the novel stimulus significantly longer than the familiar stimulus. Infants were familiarized to a single monkey face for an accumulated looking time of 30 s. After the familiarization period, the familiarized face was presented along with a novel monkey face for 10 s (each stimulus was presented on each side of the screen for 5 s). A digital video camera recorded infants while they completed the VPC task. Two separate observers (85% interobserver agreement), blind to the conditions, coded the proportion of time spent looking toward the familiar and novel images. Measures of looking time were averaged across the two 5-s test trials and then converted into the percentage of time spent fixated on the novel stimuli.

After the pretraining assessment, parents were given the training books, a schedule, and a diary, and asked to "read" the book for 10 min with their infant on each of the days indicated. The training schedule required parents to read the book every day for the first 2 weeks, every other day for the following 2 weeks, every 3rd day for the next 2 weeks, and then every 4th day until their 9-month visit. Parents of infants in the individual- and category-training condition were instructed to use only the provided labels when referring to the images. Parents of infants in the exposure-training condition were instructed to not use any labels. Parents of infants in all three training conditions were instructed to record their training efforts in the diary, and were considered compliant with the training if they followed the schedule for 75% of the time.

RESULTS

The data were first analyzed by using one-tailed t tests that compared the percentage of time spent fixated on the novel stimulus with chance (50%). At 6 months of age, before training, infants exhibited novelty preferences in the individual-training group ($M = 63.9\%$, $SE = 2.7\%$), $t(13) = 5.08$, $p = .001$; in the category-training group ($M = 59.4\%$, $SE = 3.4\%$), $t(17) = 2.80$, $p = .013$; and in the exposure-training group ($M = 65.6\%$, $SE = 3.9\%$), $t(7) = 3.98$, $p = .005$ (see Fig. 2). These results are consistent with previous reports of infants' discrimination abilities at 6 months of age (Pascalis et al., 2002, 2005). After 3 months of training, only infants in the individual-training condition continued to exhibit a significant novelty preference for previously unseen monkey faces ($M = 61.3\%$, $SE = 4.1\%$), $t(13) = 2.70$, $p = .018$ (see Fig. 2). Infants in the category-training condition ($M = 49.89\%$, $SE = 4.5\%$), $t(17) = -0.025$, $p = .980$, and in the exposure-training condition ($M = 49.5\%$, $SE = 4.0\%$), $t(7) = -0.112$, $p = .914$, did not exhibit a significant novelty preference for unseen monkey faces (see Fig. 2).

Within each training group, planned paired t tests were also conducted to determine whether the percentage of time spent looking toward the novel stimulus was maintained from pre- to posttraining. The results of these analyses revealed no change in novelty preference after individual training, $t(13) = 0.581$, $p = .571$, and a significant decrease in novelty preference after category training, $t(17) = 2.36$, $p = .031$, and after exposure training, $t(7) = 2.43$, $p = .045$. These results suggest that individuating multiple exemplars of monkey faces was necessary in order to maintain the ability to discriminate monkey faces between 6 and 9 months of age.

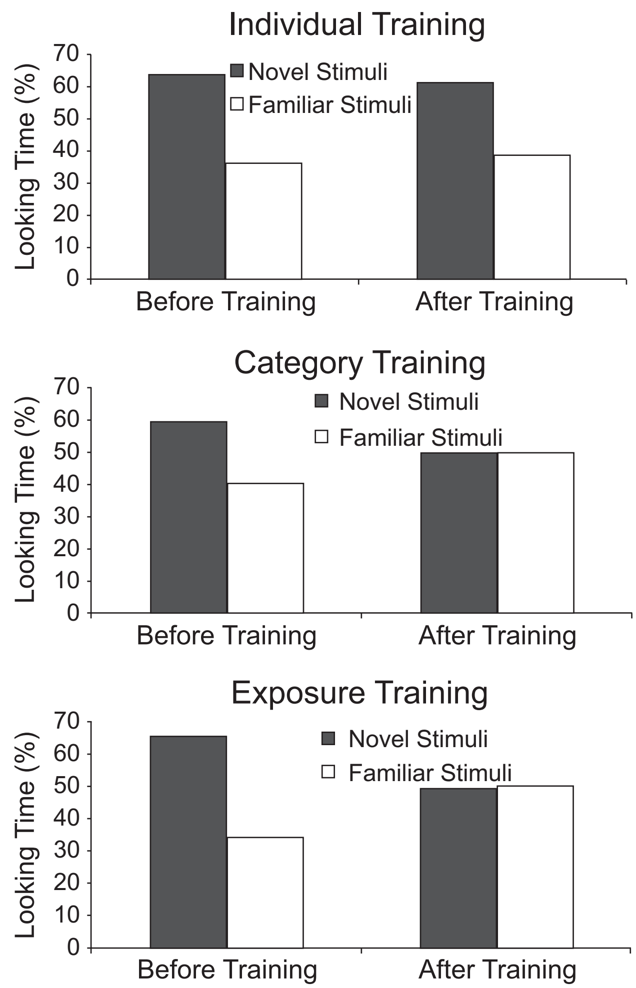

Fig. 2. Mean percentage of time spent looking toward the novel and familiar stimuli before and after 3 months of individual, category, or exposure training with monkey faces.

DISCUSSION

These findings provide direct evidence of the importance of individuation learning in the development of face processing. Moreover, it appears that infants who learned multiple exemplars at specific levels treated faces differently than they treated everyday categories of objects or animals. This finding is consistent with previous work on the acquisition of perceptual expertise with nonface visual categories in adults (Scott et al., 2006, 2008).

Individuation training may have led infants to attend to the unique features of individual monkey faces, whereas category and exposure training led infants to focus on what the monkey faces have in common. This explanation is consistent with previous findings that 12-month-old infants readily form categories when provided with consistent and novel labels for distinct sets of objects (Waxman & Braun, 2005). Here, we have shown that the opposite experience is necessary in order to distinguish between face exemplars within a category. Thus, when confronted with the need to individuate and recognize faces, infants maintain the ability to distinguish among similar faces with which they are familiar. However, unfamiliar types of faces, such as monkey faces, are typically categorized but not individuated, leading to a decline in ability to distinguish between exemplars within the unfamiliar category.

We argue that individuation training, but not category or exposure training, led infants in our study to maintain their ability to distinguish among monkey faces. Alternate interpretations of the present results exist. For example, category training, not individuation training, could lead to a decline in ability to discriminate individual exemplars between 6 and 9 months of age. However, as with adults (Scott et al., 2008), 3 months of categorization training offered no advantage over exposure training, which suggests that learning at the individual level drives development. Of course, it is also possible that infants in the exposure-training condition defaulted to categorizing the faces in the absence of explicit labels or instructions. Also, we did not examine the quality of interactions between infants and parents during training. As in studies suggesting that interpersonal interaction increases phonetic learning during development (Kuhl, Tsao, & Liu, 2003), parents in the individual-training group may provide more elaborate verbal information than those in the category- or exposure-training groups. Future work using multiple methodologies and more controlled training should be able to address these issues.

It is also important to note that, as is the case with all investigations using the VPC procedure, interpreting the lack of a looking preference is difficult (Snyder, 2007). For example, our results may have been due to a difference in ability, but it may also be that the infants with category and exposure training could distinguish the monkey faces but, for unknown reasons, did not. Regardless of how one interprets the lack of a looking preference after category training, these results underscore important differences between individual training and category and exposure training with sets of faces between 6 and 9 months of age.

Individuation learning may also be driving perceptual narrowing in other domains, such as phonemic discrimination in the development of language. Newborns have been found to link their mother's face (a visual stimulus) and their mother's voice (an auditory stimulus) after just 5 to 15 min of experience interacting with their mother (Sai, 2005). This link is not made when newborns have visual, but not auditory, experience with their mother. Thus, the early link between auditory and visual information serves as a guide for infants, and they are subsequently able to match their mother's voice with her face. This immediate learning at the individual level may influence subsequent auditory and visual learning. This hypothesis is consistent with the findings of Weikum et al. (2007), which suggest that visual information plays a role in the decline in ability to discriminate between native and nonnative phonemic contrasts. These previous findings, combined with the present results, suggest that individuation of faces not only drives perceptual narrowing in the domain of face perception, but may also play a key role in the decline in ability to discriminate phonemes of native versus nonnative languages.

At this time, it is unclear whether verbal labeling is necessary for individuation training to result in the development of specialized perceptual representations or whether individuation training, without labels, will lead to similar results. For example, it is possible that any correlated cue (e.g., instead of faces paired with labels, faces paired with a unique colored frame) will help infants perceive the identity of the exemplar. If verbal labels are shaping the critical perceptual representations, then these data lend support to the Whorfian hypothesis (Whorf, 1956), which suggests a direct link between the specificity of linguistic representations and conceptual and perceptual abilities. The Whorfian hypothesis also has recent support from work examining color discrimination in Russian versus English speakers (Winawer et al., 2006). In English, the word *blue* is used to describe a whole range of light and dark hues, whereas two words, *goluboy* and *siniy*, are used to distinguish lighter shades of blue from darker shades of blue in Russian. Winawer et al. reported that Russian speakers were faster to discriminate blues across the two blue categories than to discriminate blues within a category. However, there were no differences in speed of discrimination in English speakers in the same task. Combined with the present report, these results support an early link between perceptual and linguistic representations in infants, but do not rule out the possibility that other correlated cues may be as useful as verbal labels during individuation learning.

The findings reported here support our prediction that learning to individuate faces leads to the maintenance of the ability to discriminate monkey faces, whereas category learning does not. These results are consistent with previous reports of visual perceptual narrowing in infants (Kelly et al., 2007; Pascalis et al., 2002, 2005) and suggest that learning to individuate faces of one's own species (or race) more frequently than faces of other species (or races) between 6 and 9 months of age leads to difficulty in distinguishing two faces of another race or species as adults.

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