ABSTRACT

SHANEE TOLEDANO
Perceptual Narrowing in Facial Identity Perception
(Under the Direction of JANET E. FRICK)

During the first six months of life, infants are able to make fine distinctions in a broad range of stimuli. Between six and nine months of age, however, infants' abilities to identify subtle differences in irrelevant stimuli decline, while improve upon their abilities to distinguish between socially relevant stimuli. This phenomenon can be observed in regard to speech (the ability to discriminate native vs. non-native phonemes), identity discrimination (the ability to discriminate faces of one's own species and race vs. faces of other species and races), and a variety of other perceptual schemas. Following this pattern, six month old humans are able to discriminate equally among human faces and Tonkean macaque monkey (*Macaca fuscata*) faces, whereas nine month olds have reduced abilities to discriminate macaque monkey faces and enhanced abilities in discrimination of human faces. The purpose of this study was to test the same phenomenon using a phylogenetically more distant species of monkey: capuchin monkeys (*Cebus apella*). We took advantage of infants' preference for novel stimuli to determine how quickly infants are able to recognize a familiar face and distinguish it from unfamiliar faces. Our results were in agreement with the claim that younger infants are able to discriminate capuchin monkey faces more quickly than older infants and adults can.

INDEX WORDS: perceptual narrowing, development, capuchin monkey, infant, attention, discrimination, perception

PERCEPTUAL NARROWING IN FACIAL IDENTITY PERCEPTION

by

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A Thesis Submitted to the Honors Council of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

BACHELOR OF SCIENCE

in PSYCHOLOGY

with HIGH HONORS

ATHENS, GEORGIA

2008

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ACKNOWLEDGEMENTS

I am infinitely grateful to everyone in the Infant Research Lab for all of their help with this project. I would especially like to thank Tracy Bialis, Nitya Nair, Heather Beck, and Lenae Stansky for their long-term support. I would also like to extend special thanks to our more recent additions, Charlotte Bryan, Allison Buterbaugh, Lauren Doyague, Sean Johnson, and Kendra Swindler. Not only have they all shown dedication to the lab, but I have also really enjoyed working with each of my fellow research assistants. Keeping track of rambunctious siblings, enduring the sound of babies crying (daily), and staging a peaceful rebellion to keep lab meetings in room 101 would not have held the same charm without my friends.

To the grad students, I cannot even express the extent of my gratitude. Melissa Bright is a wonderful new role model from whom I have much to learn. To Melissa Dengler, I am thankful for the emotional support and for letting me tag along on coffee breaks. I have been honored to have the opportunity to work with Krisztina Varga and Elizabeth Simpson. Without them, this thesis neither would have been started, nor finished. I am thankful to Kris for telling me it is okay to quit, and I am equally thankful to Liz for pushing me to keep going.

Most of all, I am indebted to Dr. Janet Frick for being a mentor to me in more ways than one. I cannot think of a more reliable source for wisdom and advice. My experience in the lab has truly changed my outlook on research, and I feel so much more prepared for my future because of it. It is rare to meet a professor who makes the success of her students such a priority. And as far as I'm concerned, there's simply no better alternative to a research mentor who brings motivation in the form of Girl Scout cookies.

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CHAPTER 1
INTRODUCTION

Perceptual narrowing is a pattern seen in early human development whereby individuals make vast improvements in discriminating among stimuli present in their environments but lose the ability to make fine distinctions between unfamiliar stimuli. Although perceptual narrowing during infancy is a widely observed phenomenon, it is not fully understood at what point in the developmental process perception becomes more finely-tuned and to what stimuli perceptual narrowing applies. Scott, Pascalis, and Nelson (2007) have proposed a domain-general principle of perceptual development, which states that infant perception becomes more finely tuned for a wide range of stimulus types. For example, there is a decline in an infant's ability to discriminate phonemes not used in the infant's native language; an infant whose parents speak only English can initially discriminate phonemes in a non-English language (Werker & Tees, 2002). If the infant continues to be exposed only to English, however, he or she will eventually lose the ability to discriminate phonemes in non-English languages. At the same time, facilitation occurs for discrimination of speech sounds that are used in the native language (Kuhl, Stevens, Hayashi, Deguchi, Kiritani, & Iverson, 2006), indicating the development of more advanced abilities to distinguish between stimuli to which infants are regularly exposed. These shifts in processing occur between 6 and 12 months of age (Werker & Tees, 2002).

Lewkowicz and Ghanzafar (2006) demonstrated that similar effects occur for intersensory perception, namely the perception of paired vocalizations and faces. Their study indicated that older infants are less able than young infants to appropriately fixate on a face that produced the presented sound (Lewkowicz & Ghanzifar, 2006). Based on these and other data, Scott et al. (2007) claim that perceptual narrowing spans a variety of domains during development. Here we examine the mechanism by which this phenomenon extends to the perception of faces.

Due to the social implications of face recognition (Petit & Thierry, 1992), a question of how faces are processed has been addressed by many researchers. In human societies, face perception is central to the formation of relationships. Understanding the mechanism by which face processing develops in healthy individuals provides a basis for exploration of the causes of deficits in face processing, which may occur for several reasons. One such disorder is prosopagnosia, characterized by an inability to recognize familiar faces. Individuals with autism (Klin, Sparrow, de Bildt, Cicchetti, Cohen & Volkmar, 2004) and the elderly (Ferris, Crook, Clark, McCarthy, & Rae, 1980) also have difficulty with face processing.

In studying face perception, researchers commonly utilize a visual paired-comparison (VPC) paradigm, which capitalizes on a participant's tendency to fixate on novel stimuli more than familiar stimuli. When the two types of stimuli are placed side-by-side, the participant's relative interest indicates whether recognition of the familiar stimulus has taken place. Presumably, a participant will exhibit more interest in the novel stimulus, commonly measured by looking time.

Initial research suggested that an efficient system for identifying faces aids in perception of faces of one's own species. In a VPC task, adult humans exhibited a novelty preference for human faces, meaning they spent significantly more time looking at a human face that had not been previously viewed. The human participants did not show a novelty preference for monkey faces. Rhesus macaque monkeys (*Macaca mulatta*) exhibited a novelty preference for faces of their own species but not for those of humans (Pascalis & Bachevalier, 1998). Therefore, human and monkey participants demonstrated species-specific recognition of faces.

More recent research, however, has shown that experience with faces, regardless of the species to which one belongs, determines which faces are most readily recognized. Sugita (2008) found no differences between discrimination of human and monkey faces in infant monkeys that had been deprived of exposure to any type of face. After one month of exposure to either monkey faces or human faces, however, the infant monkeys were much better at discriminating only the type of face to which they had been exposed. Infant monkeys that had been exposed to human faces but not monkey faces were better at discriminating novel human faces than other monkey faces. This effect indicates that experience with certain types of face stimuli serves to narrow the perceptual abilities that are present at birth.

It may be possible that exposure to certain types of faces can inhibit some effects of perceptual narrowing. Pascalis et al. (2005) exposed human 6-month-olds to pictures of faces of barbary macaques (*Macaca sylvanus*) over a three-month training period. The infants were shown a set of six pictures for 1-2 minutes a day for the first two weeks, then less frequently over the remaining ten weeks. A VPC paradigm was used to assess infants' discrimination abilities. The 9-month-old participants with training showed longer looking times at the novel faces as compared to the familiar faces both before and after the training period. A control group of 9-month-olds with no exposure to monkey faces exhibited no difference between looking time to familiar faces and looking time to the novel faces in the VPC task. The results are in agreement with the hypothesis that perceptual narrowing is experience-dependent rather than species-specific (Pascalis et al., 2005).

Though it is possible to broaden the limits of face perception to include other species, both for infant monkeys (Sugita, 2008) and infant humans (Pascalis et al., 2005), most primates are not regularly exposed to faces of other species outside of a laboratory setting. Therefore, it is still important to study the fine-tuning of face perception that occurs in most natural settings. Pascalis, de Haan, and Nelson (2002) tested face perception among three age groups of human participants: 6-month-olds, 9-month-olds, and adults. They used the VPC procedure to examine discrimination of facial identity of human and monkey (*Macaca fascicularis*) faces. None of the participants had extraordinary exposure to monkey faces. The results showed that the 9-month-olds' ability to discriminate the monkey faces was similar to that of the adults, who showed no significant preference for the novel faces. The 6-month-olds, however, were capable of discriminating the familiar from the novel monkey faces, as evidenced by significantly greater looking times at the novel faces. This experiment provides greater insight into the progression toward a more specific face processing system that occurs in the first year of life.

Dufour, Pascalis, and Petit (2006) extended the previous research that used faces of barbary macaques (*Macaca sylvanus*; Pascalis et al., 2005) and rhesus macaques (*Macaca mulatta*; Pascalis & Bachevalier, 1998) to test face perception of two other primate species, Tonkean macaques (*Macaca tonkeana*) and brown capuchin monkeys (*Cebus apella*). Brown capuchin monkeys diverged from human ancestors earlier than any macaque species. Thus, the study included more phylogenetically distant species than had previously been studied. The participants in this study included adult humans, Tonkean macaques, and brown capuchin monkeys. No infants were tested in this experiment. All participants had been raised in primarily own-species environments with limited exposure to other species. In a VPC task, participants of all three species were better at discriminating faces from their own species than those of the other species. This study provides more evidence that experience plays an important role in influencing perceptual narrowing. However, the study is limited in its use of adult participants; the age groups tested were past the age at which perceptual narrowing occurs in many other domains. Thus, it is reasonable to expect that, in the domain of face processing, infants are also an important demographic group to consider.

The present study extended previous research to test the limits of face perception in human infants. To our knowledge, perception for faces of brown capuchin monkeys (*Cebus apella*) has only previously been tested in adults, not infants. We engaged 6-month-olds in a VPC task to determine whether they are able to discriminate faces of capuchin monkeys. We predicted that infants would be able to distinguish the familiar face from novel faces, even though adults tend to be less efficient at the same task (Dufour, Pascalis, and Petit, 2006). Our findings will provide a basis for further exploration of perceptual narrowing as it relates to face perception.

CHAPTER 2
METHODS

Participants

Twenty-six six-month-old human participants (12 males and 14 females) were recruited for the study. Infants were recruited using the local birth announcements. Additionally, some of the infant participants were recruited at a local maternity fair held in August 2008. Four infants were excluded from the final sample due to technical difficulties. At the time of testing, the mean age of the infants was 175 days (*SD*=17).

Apparatus & Stimuli

Infants sat either in an infant seat or in a parent's lap approximately 60 cm from the screen (43 cm x 58 cm), onto which images were projected by an InFocus projector (model LT755). The front and sides of the area were surrounded by a black curtain that extended from the floor to ceiling, except for a small opening for the VHS camera lens. One VHS camera (Panasonic model AG-188-Proline) was placed 91 cm behind the participant to record the stimuli on the screen, and another was placed 56 cm in front of and above the participant's face to record eye movements. The two images were combined using a Videonics digital video mixer (model MX-1). Coding was done offline using Noldus The Observer 5.0.

The stimuli presented were pictures of brown capuchin monkeys obtained from Living Links (Yerkes National Primate Research Center), Yo Mormoto (Kyoto University), and Elizabeth Simpson (University of Georgia). Pictures of adult Caucasian males were taken from the NimStim Face Stimulus Set (Tottenham, Tanaka, Leon, McCarry, Nurse, Hare, et al. in press) and the Japanese and Caucasian Neutral Faces Set (Matsumoto & Ekman, 1988). The pictures were edited using Adobe Photoshop to control for brightness, contrast, picture size (400 by 400 pixels), and orientation of the faces. Additionally, all photos were cropped evenly around the face to remove potentially distracting cues such as human hair styles and animals' ears. Two faces from each species were selected as "familiar faces" (Figure 1). Between trials, moving pictures were presented for 1500 ms to maintain the infants' focus on the screen (Figure 1.2). One of these "attention-getters" was a bulls eye that flashed in alternating colors, and the other was an array of cartoons that rotated positions on the screen. Inquisit 2.0 presented the stimuli in a randomized order.

Procedure

After parents provided informed consent, infants were brought into the testing area. One researcher operated the computer keyboard in order to advance trials. A second researcher watched the live video and operated a stopwatch, which approximated the time an infant spent looking at faces in each trial. The experiment began with a familiarization period, during which the familiar face was presented beside another image of the same face. Participants were randomly assigned to one of the four familiar faces. When the infant had accumulated 20 s of time looking at either of the two images, the first researcher initiated the appearance of the attention-getter on the screen, followed by the next trial. For subsequent trials, the familiar face was presented beside a novel face of the same species. Infants accumulated approximately 4 s of time looking to either face before the trial ended. They attempted up to 29 trials, in which the horizontal (left/right) position of the familiar face was pseudo-randomly counterbalanced. The experiment ended when the infant completed all 29 trials or if the infant became fussy. Parents filled out a health and demographic form before leaving.

Data Analysis

The videotapes of the infants' faces were analyzed frame by frame (30 frames per second). Eye movements were coded as "left," "right," or "away." The presentation of the stimuli was also coded as either "faces" or "inter-trial interval". The data were then analyzed using SPSS. To determine whether the infant had discriminated the familiar face, we calculated the amount of time spent looking at the familiar face out of the total amount of time spent looking at the faces for each trial. The criterion for discrimination of faces was said to be reached if this percentage was between 55-99% in 4 of 5 consecutive trials. Trials in which the participant looked at one face for 100% of the total looking time were excluded because the infant made no comparison of the two faces (i.e., side bias).

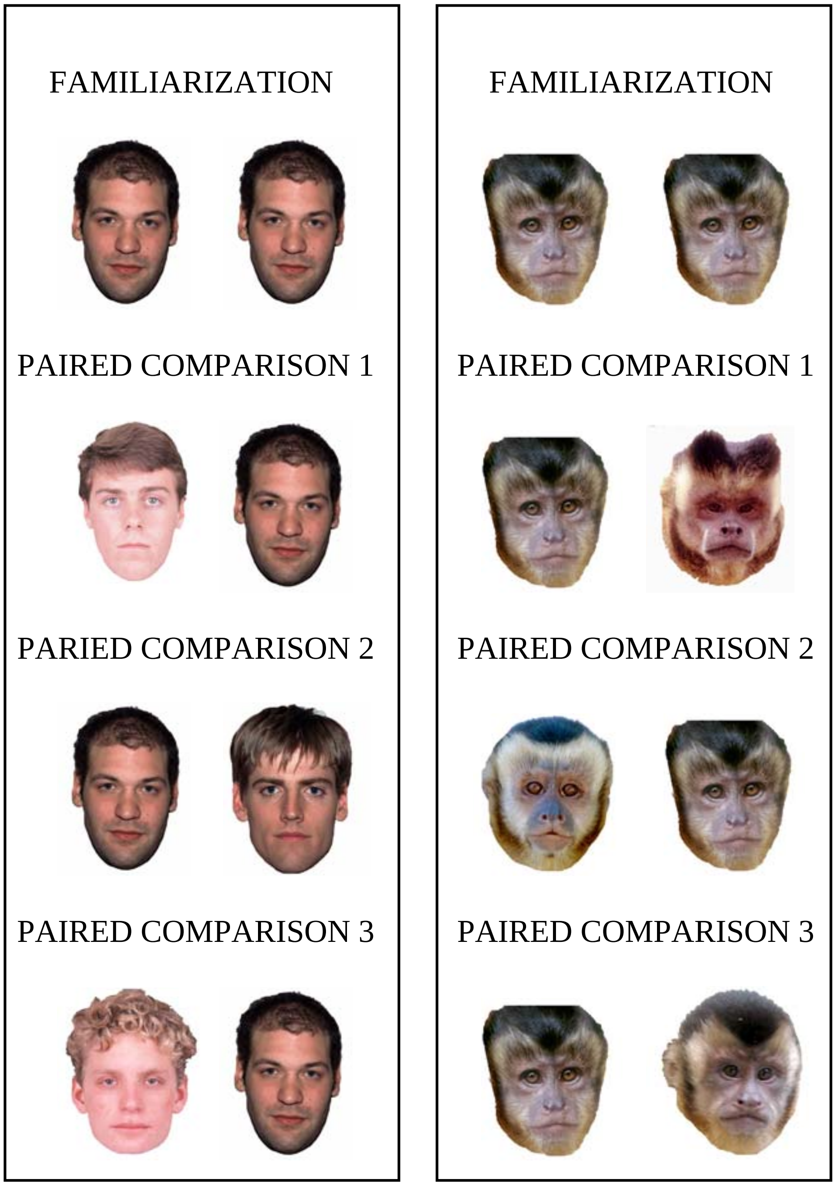

Figure 1. Sample presentation sequence for the VPC task. Participants were first familiarized with a face (*familiarization*) and then viewed a novel and familiar face on subsequent trials (*paired comparison*). Novel faces appeared randomly on either the left or right.

CHAPTER 3
RESULTS

Twenty-six six-month-olds participated in the experiment. Thirteen infants viewed monkey faces in the VPC task, and the remaining thirteen viewed human faces. Sixteen infants met discrimination criteria and ten did not. Of infants who met criteria, seven viewed human faces and the remaining nine viewed monkey faces. Of infants who did not meet criteria for discriminating, five viewed human faces and five viewed monkey faces. It took an average of seven paired comparison trials for infants to meet discrimination criteria ($SD = 7$). Infants completed an average of 20 trials ($SD = 8.3$).

We used a repeated measures analysis of variance (ANOVA) with proportion of time spent looking at the familiar face as compared to the novel face as the within subjects variable, and species (human, monkey) as the between subjects variable. The results indicate a main effect of familiarity, $F(1,25)=8.97$, $p=.006$. This indicates that 6-month-old infants had a greater proportion of looking time towards novel faces ($M=56\%$, $SD=9\%$) relative to familiar faces ($M=44\%$, $SD=9\%$). The main effect of species and interaction between species and familiarity were nonsignificant, $p>.05$. This indicates that the species viewed did not have an influence on whether infants looked more at the novel or the familiar face.

We examined the number of comparison gaze shifts (i.e., shifts of gaze between the left and right face), which are considered to be indicators of information processing speed. Infants that make more comparison gaze shifts are processing information faster and are better able to discriminate than infants with fewer shifts (Colombo, Mitchell, & Horowitz, 1988). Rose, Janjowski, and Feldman (2002) described infants who made more gaze shifts in a VPC task as having a “more mature pattern of attention.” They also found that infants who made more gaze shifts reached criterion for discrimination faster. In the present study, we found no differences in the number of comparison gaze shifts between the human (M=2.16, SD=.73) and monkey faces (M=2.15, SD=.98), t(24)=.024, p=.242. This means that the infants compared the human and monkey faces with equal processing speed.

There was also no difference between the human (M=8.36, SD=5.31) and monkey (M=8.61, SD=7.03) conditions in the time spent looking away during the paired comparison trials, t(24)=-.1, p=.921. This indicates that the infants were "on task" about the same amount, regardless of whether they viewed the human or monkey faces. Moreover, this shows that infants were equally interested in both the human and monkey faces.

CHAPTER 4
DISCUSSION

Our study examined perceptual narrowing as it relates to face processing in 6-month-old human infants. We hypothesized that 6-month-olds would be able to discriminate both human male faces and brown capuchin monkey faces with equivalent processing efficiency. We found no significant effect of the species viewed in a VPC task, supporting our hypothesis. The significant difference between the time infants spent looking at the familiar face as compared to time spent looking at the novel faces, regardless of the species presented, provided further support of the assertion that 6-month-olds can discriminate faces of both species.

The fact that human infants can discriminate the faces of brown capuchin monkeys indicates that infant perception for faces is more broad than previously known; to our knowledge, brown capuchin monkeys are the most phylogenetically distant species (in relation to humans) presented to infants in a VPC task. In conjunction with previous studies that have shown older infant and adult humans to be less adept at discriminating monkey faces (Pascalis & Bachevalier, 1997), the results provide support for the hypothesis that the perceptual window narrows with age. The age of our participants appears to be at a particular point in development before the effects of perceptual narrowing are apparent. This age is advantageous for testing the limits of perception before it becomes specified to stimuli found in an infant's environment.

Further exploration will be necessary to test the boundaries of human perception. More age groups must be tested to determine at exactly what point in development perception begins to become more fine-tuned, and at what point it is the broadest. More phylogenetically distant species, such as sheep, should also be presented in the VPC task to answer the question of whether face perception is already specified to primates at birth or if infants are equally capable of discriminating the faces of other animals.

The results are in agreement with the theory that perceptual narrowing is an experience-dependent process. None of the infants who participated were exposed to an unusually large number of monkey faces, either through personal contact or exposure to pictures. As suggested by previous research, infants who are given this type of exposure will retain or strengthen the abilities they currently possess (Pascalis et al., 2005).

Our research has implications for theories of perception as well as for the broad field of memory. The study of acquisition and decline of skills is of paramount importance in human development research. Understanding how perception develops during infancy can support research on similar processes that occur in other points in life. For example, elderly adults have trouble recognizing faces (Ferris et al., 1980). Individuals with prosopagnosia and autism also suffer from reduced capabilities in recognizing faces. Research on early perceptual development may be helpful in identifying causes of, and ultimately treatment for, deficits in face processing that occur in some individuals.

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