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Development of schematic face preference in macaque monkeys

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Abstract

This study investigated schematic face preferences in infant macaque monkeys. We also examined the roles of whole and partial features in facial recognition and related developmental change. Sixteen infant monkeys, all less than two months old, were presented with two stimulus pairs. Pair A consisted of "face" and "parts," with the components representing facial parts (i.e. eyes, mouth, and nose). Pair B consisted of "configuration" and "linear," each including three black squares. In each pair, one of two stimuli represented a facial configuration, namely "face" and "configuration." Visual following responses toward each stimulus were analyzed. The results revealed an early preference for schematic faces in these nonhuman primates. Infants less than one month of age showed a preference only for a stimulus that contained only whole facial configuration (i.e. "configuration" in Pair B). One-month-old macaque infants showed a preference only for "face" but not for "configuration." This result means that their preference at that age was affected by both the shape of the components and the overall configuration. As the developmental change and the contribution of both facial features are similar to those in human infants, it may suggest that primates share common cognitive processes in early schematic face recognition.

Keywords: Development; Face preference; Monkeys

1. Introduction

The face is one of the most important type of social stimuli for many animals living in social groups. They have to recognize faces in order to identify their group members, and communicate with each other. The importance of the face is also indicated in the literatures of human developmental psychology (Goren et al., 1975; Johnson et al., 1991; Maurer and Barrera, 1981). The studies have shown that human infants as young as one day old prefer face-like stimuli to non-face stimuli. It is also well-known that responses toward schematic faces vary as infants develop.

Until one month of age, infants show preferences for a 'face' if it contains whole facedness, or face-likeness. That is, as shown in Fig. 1, human infants younger than one month look at 'configuration' as well as 'face' more than 'parts.' Their preferences for 'face,' however, disappear in infants older than one month. Two-month-olds again show preferences for face-like stimuli, but their patterns of responses are not the same as what they were. Here they show preference for 'face' but not for 'configuration,' which means that their preferential responses are triggered by facial stimuli having both partial and whole features of a face.

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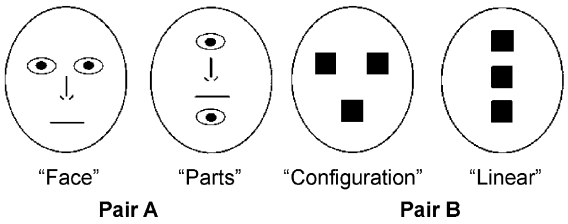

Fig. 1. The stimuli used in this experiment.

These studies suggest that humans are very sensitive to face-like patterns even in early infancy, and that infants initially respond to, or prefer stimuli with face-likeness in the form of the whole configuration. At two months after birth, preferential responses depend upon the shape of each component as well as the whole configuration.

Such preferences for faces may imply early facial recognition, and may suggest that humans are capable of this at birth. However, developmental changes support the idea that human infants possess the ability to learn to discriminate among faces as well. This ability allows us to be able to recognize increasingly greater number of faces accurately as we grow up (Johnson and Morton, 1991).

The same preference for faces has not been examined thoroughly in nonhuman primates. Myowa-Yamakoshi and Tomonaga (2001) presented a male infant gibbon (*Hylobates agilis*) with simple drawings, and used a preferential tracking procedure from 15 to 22 days after birth. The infant showed a clear preference for a schematic face, but this response depended upon the whole configuration of the stimulus. That study provides the first evidence that very young nonhuman primates respond to schematic faces in a similar way to human infants.

The main purpose of this study was to examine whether infant nonhuman primates, especially non-ape species, would also show preferences for face-like stimuli. We also aimed to clarify what was the most important feature underlying any preference. In addition, we investigated any change with development. Thus, we tested schematic face preferences in macaque monkeys, and compared the efficacy of facial features across months. Comparisons between monkeys' and human infants' responses toward schematic faces should help to reveal the common aspects as well as species-specific mechanisms in early recognition of faces.

2. Materials and methods

2.1. Subjects

We tested 16 infant macaques, all kept at the Primate Research Institute, Kyoto University, Inuyama, Japan. Thirteen individuals were Japanese monkeys (*Macaca fuscata*) raised by their mothers and living in a social group. Two of them were tested at zero month of age, four monkeys at one month of age, and five monkeys at two months of age. Each of these 11 monkeys was tested only once. The other two macaques were participated repeatedly from zero week or from one week up to three months of age.

The remaining three infants were rhesus monkeys (*Macaca mulatta*). They were also raised by their own mothers, but lived in individual monkey cages. These three infants were tested longitudinally from zero week ($N = 1$) or from one week ($N = 2$) up to three months after birth.

We completed 38 sessions in total.

2.2. Stimuli

We used four stimulus cards, "face," "parts," "configuration," and "linear" as shown in Fig. 1. Each card was stuck on the end of a 30-cm plastic rod, which an experimenter used to move the cards. The card was sized 12 cm × 10 cm in an oval shape.

"Face" was always paired with the "parts" (Pair A). Though the parts in both stimuli resembled facial parts (eyes, nose, or mouth), only "face" involved facial configuration as well. "Configuration" was always paired with "linear" (Pair B). Because both stimuli in this pair were constructed from three black squares, none of their components represented facial parts, unlike Pair A. "Linear" represented no facial features, whereas "configuration" contained of basic facial configuration.

2.3. Procedure

Each subject was brought to the experimental room and tested individually. Experimenter A held

the subject, wrapped in a towel, on his/her lap. The subject was able to move its head freely. Experimenter B stood behind Experimenter A and presented a pair of stimulus cards (Pair A or Pair B) with their back facing the subject. The distance between a subject and stimuli was about 30 cm. The cards were quickly turned 180° to face the subject when the infant oriented toward the cards. Then Experimenter B moved each stimulus slowly up to 90° to the right or left along a semicircular track for about 3 s. When the subjects were fussy or sleepy, we interrupted the experiment and waited until they were calm or alert again.

Each stimulus pair was presented four times in a session with left–right positions of the stimuli counterbalanced. For the cage-reared rhesus monkeys and two Japanese monkeys, the test sessions were repeated with a minimum interval of one week. We recorded the subject's head using a digital video camera (Sony DCR-TRV27) placed in front of the subject. The distance between the camera and the subject was about 80 cm.

2.4. Analysis

A coder rated the subjects' responses from the video records. Each looking response toward either stimulus was scored independently from 0 to 3 points by applying the criteria in the following:

- Point 0: no looking
- Point 1: following the stimulus less than 30°
- Point 2: following the stimulus more than 30°, but less than 60°
- Point 3: following the stimulus more than 60°

where "following" is defined as looking at a stimulus and turning the head and/or eyes along with the movement of the stimulus.

Each monkey was assigned a preferential looking score for each completed session as follows: preferential looking score (PLS) for Stimulus 1 = score for Stimulus 1/(score for Stimulus 1 + score for Stimulus 2). Chance level of the PLS was thus 0.5. If a subject's PLS for either stimulus was above 0.5, it means that the monkey preferred that stimulus to its counter part in that pair. We counted the number of subjects who preferred one stimulus to the other within each pair. For statistical analysis, we compared the mean scores for each stimulus in each pair using a two-tailed Wilcoxon's signed ranks test.

Our predictions were as follows: If macaque infants' preference for the face is determined only by facial configuration, we find differences in both pairs (that is, "face" as well as "configuration" will be preferred to the other stimulus in each pair).

On the other hand, if the shape of facial components is crucial, there should be no significant difference in both pairs.

If both the shape of facial components and the overall configuration determine monkeys' preferential looking toward schematic faces, we should find the appropriate difference only in Pair A but not in Pair B.

3. Results

Table 1 shows the number of subjects expressing preferences and mean score for each stimulus pair by months. We analyzed the data in each age group individually for each stimulus pair.

3.1. Pair A ("face"–"parts")

The data for Pair A was described in the upper half of Table 1. Statistical analysis with Wilcoxon's sign ranks test revealed that there was only one significant difference between "face" and "parts" in one-month-old subjects ($Z = 2.58$, $P = 0.01$), specifically nine out of 13 one-month-old infants preferred "face" to "parts. It is noteworthy that preferential responses of these nine subjects were the most remarkable at the first presentation; all nine infants looked "face" more than "parts." However, this preference toward "face" weakened across four presentations; five subjects out of nine originally showed a preference for "face," two for "parts" at the second presentation, three for "face" and three for "parts" at the third, and five for "face" and four for "parts" at the fourth, respectively. This means that the infant monkeys at one month of age familiarized to "face" after short presentation. Indeed, almost half of the subjects who preferred "face" at the first presentations, changed their looking behavior, and showed a preference for the other stimulus (i.e. "parts") at the second presentation.

Table 1
Number of subjects preferring either stimulus, and mean score for each stimulus

Age	*N*	Number of subjects			Mean scores		Wilcoxon's test (*P* value)
		F > P	F < P	F = P	F	P	
Pair A							
Zero month	15	5	5	4	3.27	3.40	N.S.
One month	13	9	1	3	4.46	2.85	F > P, $P = 0.01$
Two month	10	5	3	2	2.50	2.00	N.S.
All	38	19	9	10	3.47	2.84	
		C > L	C < L	C = L	C	L	
Pair B							
Zero month	15	11	2	1	4.27	2.80	C > L, $P = 0.04$.
One month	13	2	6	5	2.62	3.54	N.S.
Two month	10	2	5	3	2.60	2.80	N.S.
All	38	16	13	9	3.26	3.05	

F, P, C and L: "face," "parts," "configuration," and "linear," respectively.

3.2. Pair B ("configuration"–"linear")

The lower half of Table 1 showed the results of Pair B. Our analysis by months revealed the significant difference between "configuration" and "linear" at one month of age ($Z = 2.05$, $P = 0.04$), and 12 out of 15 infant monkeys preferred "configuration" to "linear." Unlike "face" preference at one month, however, they did not show a familiarization pattern; 6 out of 12 subjects showed a preference for "configuration" and 4 showed preference for "linear" at the first presentation, 6 for "configuration" and 2 for "linear" at the second, 6 for "face" and 3 for "parts" at the third, and 8 for "face" and none for "parts" at the fourth, respectively.

4. Discussion

This brief study investigated preferences for schematic faces in infants of two species of monkeys, with the aim of examining the relative roles of whole and partial features in facial recognition during early development.

We found that macaque infants less than two months of age clearly showed a preference for face-like stimulus. Moreover, the contribution of whole and partial features in face preference changed across ages. Infants under the age of one month showed a preference for the stimulus that contained only whole configuration of a face (i.e. "configuration"). One-month-old macaque infants, on the other hand, clearly showed a preference, namely for the schematic face (i.e. "face"). They showed no preference either of the stimuli belonging to Pair B at this age. This result suggests that not only facial configuration but also individual features must be face-like to trigger facial preference in one-month-old macaque infants.

Studies with human infants have shown that responses toward facial stimuli vary, and that recognition becomes more accurate during their development (see Section 1). Our data are consistent with this, showing that the developmental shift in schematic face preference; macaques prefer a pattern with facial configuration (i.e. "configuration") at first, and they come to prefer more face-like stimuli (i.e. "face"). The fact that preference diminishes as they get older is also similar to the study with human infants, which showed that five-month-olds did not show any preference for facial stimuli (Johnson and Morton, 1991).

Though we found similarities between human and macaques as described above, our data also revealed a difference between the two species. Human infants less than one month showed a preference for "face" as well as "configuration," because both contain the whole features of a face. Macaque infants, on the other hand, showed a preference only for "configuration" but not for "face" at their earliest developmental stage. To explain this difference we raise the possibility that "face" might look like a human rather than a monkey face, though each component represents facial

features shared by both species. “configuration,” on the other hand, contained no detailed features, and presented only an exaggerated form of a face. In this sense, “configuration” represents general, but not species-specific facial characteristics. In human infants, face preferences at zero month are regarded as automatic responses based on an innate “template of a face.” Maturation of the brain and experience of seeing faces lead human infants to prefer a more accurate facial representation (Johnson and Morton, 1991). If newborn macaque infants possess a “template” that matches “configuration” but not “face,” they might prefer only “configuration” as a result. Repeated exposures to real human faces possibly cause monkeys to prefer “face” at one month of age. In short, like human infants, macaques’ preferences and associated developmental changes could be the result of knowledge of a face at birth and experiences thereafter. However, we need a further study to know whether a stimulus that clearly represents an exemplar of own species’ face triggers preferential responses in younger macaque infants.

We also found that there is a difference between infants less than one month and one-month-old infants in familiarization during a session. One-month-old infants, who preferred “face,” seemed to familiarize to “face” soon after the first presentation. Younger infants, on the other hand, did not change their behaviors across four presentations. This may reflect a difference between the two age classes, for example, in terms of the ability to memorize, or other cognitive processes. Our study cannot clarify why such a difference occurred, or whether this difference is specific to face recognition or common to object recognition. Future work should be done to answer this question.

To summarize, we have shown that there exists an early preference for schematic faces in nonhuman primates. This preference was affected only by the whole at zero month of age, but changed one month after birth. One-month-old macaque infants showed a preference only for “face,” which affected by not only whole configuration but also parts of the stimuli. As the role of the two kinds of facial features (i.e. whole and parts) and the existence of developmental change were similar to findings human infants, it may be suggested that primates possess common cognitive processes in early schematic face recognition.

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References

Goren, C., Sarty, M., Wu, P., 1975. Visual following and pattern discrimination of face-like stimuli by newborn infants. Pediatrics 56, 544–549.

Johnson, M.H., Morton, J., 1991. Biology and Cognitive Development: The Case of Face Recognition. Blackwell, Cambridge.

Johnson, M.H., Dziurawiec, S., Ellis, H.D., Morton, J., 1991. Newborns preferential tracking of faces and its subsequent decline. Cognition 40, 1–19.

Maurer, D., Barrera, M., 1981. Infants’ perception of natural and distorted arrangements of a schematic face. Child Dev. 47, 523–527.

Myowa-Yamakoshi, M., Tomonaga, M., 2001. Development of face recognition in an infant gibbon (Hylobates agilis). Infant Behav. Dev. 24, 215–227.