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ORIGINAL ARTICLE

Reiko Koba · Akihiro Izumi

Sex categorization of conspecific pictures in Japanese monkeys (*Macaca fuscata*)

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Abstract We investigated whether monkeys discriminate the sex of individuals from their pictures. Whole-body pictures of adult and nonadult monkeys were used as stimuli. Two male Japanese monkeys were trained for a two-choice sex categorization task in which each of two choice pictures were assigned to male and female, respectively. Following the training, the monkeys were presented with novel monkey pictures, and whether they had acquired the categorization task was tested. The results suggested that while monkeys discriminate between the pictures of adult males and females, discrimination of nonadult pictures was difficult. Partial presentations of the pictures showed that conspicuous and sexually characteristic parts (i.e., underbellies including male scrotums or breasts including female nipples) played an important role in the sex categorization.

Keywords Japanese macaque · Sex categorization · Conspecific picture · Operant conditioning

Introduction

For nonhuman primates living in complex social groups, recognition of other members is important for survival and reproduction. It is conceivable that monkeys not only discriminate others based on individuality but also perceive various attributions of others, such as dominance, kinship, age, and sex. Primates are known to have a well-developed visual system, and visual cues seem to have important roles in perceiving others. For instance, monkeys are able to discriminate between unknown individuals of the same species by visual cues (Humphrey 1974; Parr et al. 2000). Parr et al. (2000) showed that chimpanzees and rhesus monkeys use facial cues to discriminate unfamiliar conspecifics. Bovet and Washburn (2003) suggested that rhesus monkeys are able to understand the social concept of dominance between unknown conspecifics. Parr and de Waal (1999) demonstrated that chimpanzees spontaneously match faces of unknown mothers and their male offspring. The finding showed an evidence of visual kin recognition, in which chimpanzees perceive kinship by facial similarities.

Sex categorization seems to have a fundamental role in reproductive success in primates. Humans generally demonstrate rapid and accurate gender categorization, and usually feel no difficulty in categorizing sexes of unknown people from a picture. Such categorizations do not require social or cultural cues such as clothes, hairs, or make-ups (Brown and Perrett 1993; Bruce et al. 1993). Quinn et al. (2002) revealed gender categorization of faces by infants aged 3–4 months by analyzing their looking behaviors; suggesting that the early representation of information about human faces is likely to be influenced by the gender of the primary caregiver.

Although sex categorization seems to be important for monkeys, it is unclear whether or not monkeys categorize sex of conspecifics visually as humans do. Ohshiba (1995) investigated whether Japanese monkeys discriminate the sex of individuals from pictures of conspecifics' faces using an operant conditioning task. Three Japanese monkeys were presented with faces of male and female pair pictures and trained to respond to these pictures in sequence (i.e., male first and female second). Pictures of five males and five females were used as the training stimuli. Although a monkey who succeeded in responding correctly in the training proceeded to the test with novel pictures of three male and three female monkeys' faces, the monkey did not generalize his performances based on the sex of novel individuals. Ohshiba noted that the number of training exemplars was insufficient, and that the face might not provide enough cues for monkeys to categorize sex. Mizuno (1997) trained

R. Koba · A. Izumi (✉)
Primate Research Institute, Kyoto University,
Kanrin 41, Inuyama, 484-8506 Japan
e-mail: akizumi@ncnp.go.jp
Tel.: +81-42-346-1754
Fax: +81-42-346-1754

Present address:
A. Izumi
Department of Animal Models for Human Disease,
National Institute of Neuroscience,
National Center of Neurology and Psychiatry,
4-1-1 Ogawa-Higashi, Kodaira, Tokyo 187-8502, Japan

two female rhesus monkeys to perform sex categorization with whole-body pictures of conspecifics. The monkeys were trained for a two-choice sex categorization task in which each of two bars were assigned to male and female, respectively. They were presented with pictures of novel monkeys to test whether they had acquired the categorization task. Although the author concluded that the monkeys discriminate between the pictures of males and females, the number of stimuli seemed to be insufficient. In addition, the stimuli did not appear to be well controlled because the stimulus monkeys were in various postures. To examine whether monkeys practically have the ability of sex categorization, further experiments would be needed by using enough numbers of well-controlled whole-body pictures.

In the present study, we investigated whether Japanese monkeys discriminate the sex of individuals from conspecifics' pictures using whole-body pictures as stimuli. The subject monkeys were trained to perform a two-choice sex categorization task, and were then tested with novel monkeys' pictures in probe and generalization tests to examine whether their categorization were based on the sex of individuals in pictures.

General methods

Subjects

The subjects were two 8-year-old male Japanese macaques (*Macaca fuscata*) named "Louk" and "Monkichi." They were housed in 90 cm wide × 76 cm deep × 85 cm high individual cages with water freely available. They were fed with about 200 g of monkey pellets once a day. The use of the monkeys adhered to the "Guide for the Care and Use of Laboratory Primates (Second edition, 2002)" of the Primate Research Institute, Kyoto University. Although they had previously been trained for several years to discriminate auditory stimuli (Izumi 2002, 2003), they were naïve to visual tasks.

Apparatus

The experiments were carried out in an experimental box (50 cm wide × 60 cm deep × 70 cm high) placed in a sound-attenuating chamber (RE-246A, Tracoustics). A 15-in. touch-sensitive monitor and a food tray were placed on one side of the experimental box. The food tray was connected to a universal feeder (UF-100, Davis Scientific Instruments). The resolution of the monitor was 1024 × 768 pixels (width × height). The monitor was approximately 20 cm away from the face of the subjects. A computer controlled the behavioral procedure and data collection using a customized program.

Stimuli

The stimuli were colored still pictures of 28 male and 28 female Japanese macaques (*Macaca fuscata*). Two different pictures were prepared for each stimulus monkey. Stimuli were classified into two conditions of age types (adult stimuli 7–26 years old; nonadult stimuli 3–6 years old) for each sex. Table 1 shows the age of the stimulus monkeys. The resolution of the stimuli was 500 × 500 pixels and the picture size was approximately 15 cm wide × 15 cm high. Each picture depicted clearly a frontal view of the monkey's whole body. Nipples and underbelly were easily seen in each picture as shown in Fig. 1. The stimulus monkeys were shown as just sitting down with neutral faces. The background of the stimuli was black in color. Except for four adult male monkey pictures, the images were taken in the enclosures or group cages of the Primate Research Institute, Kyoto University, Inuyama, Japan from April to July 2004. The others were of a free-ranging troop at Arashiyama, Kyoto, Japan, taken from May to July 2004. The subject monkeys were unfamiliar with the stimulus monkeys.

Table 1 Ages of stimulus monkeys used in the present experiment

Conditions	Baseline	Test (Probe, Generalization)
Male		
Adult	25, 19, 18, 17, 17, 11, 11, 9, 9, 8, 7, 7	23, 20, 19, 7
Nonadult	6, 6, 5, 5, 5, 4, 4, 3, 3, 3	5, 3
Female		
Adult	26, 19, 17, 15, 14, 13, 11, 10, 9, 8, 8, 7	21, 20, 13, 8
Nonadult	6, 6, 5, 5, 5, 4, 4, 4, 3, 3	5, 3

Note. Stimulus monkeys were classified into two age types (adult stimuli 7–26 years old: nonadult stimuli 3–6 years old) for each sex. We used 22 stimulus monkeys in baseline (training) and six stimulus monkeys in probe tests and generalization tests for each sex. Two pictures were prepared for each individual

Procedure

The task was a two-choice sex categorization in which monkeys were required to perform discrimination between male and female pictures. Initially, a start key (a yellow rectangle; 15 cm wide × 15 cm high) was displayed on the center of the monitor. The monkeys were required to respond to this key to initiate a trial. Following a response to the start key, a sample stimulus was presented for 1 s at the position of the start key. The sample stimulus was a picture of a monkey (sample individual). Following a 1-s delay, two choice keys (yellow rectangles; 8 cm wide × 15 cm high) were presented at both sides of the sample picture. Left and right choice keys were assigned for males and females, respectively. A correct response was to touch the assigned key in response to the sex of the sample picture, and an incorrect response was to touch the other key. A correct response was rewarded immediately with a small piece of sweet potato, apple, or pellet food; an intertrial interval (ITI) of 3 s then followed. An incorrect response was not rewarded and the ITI was 6 s. During each ITI,

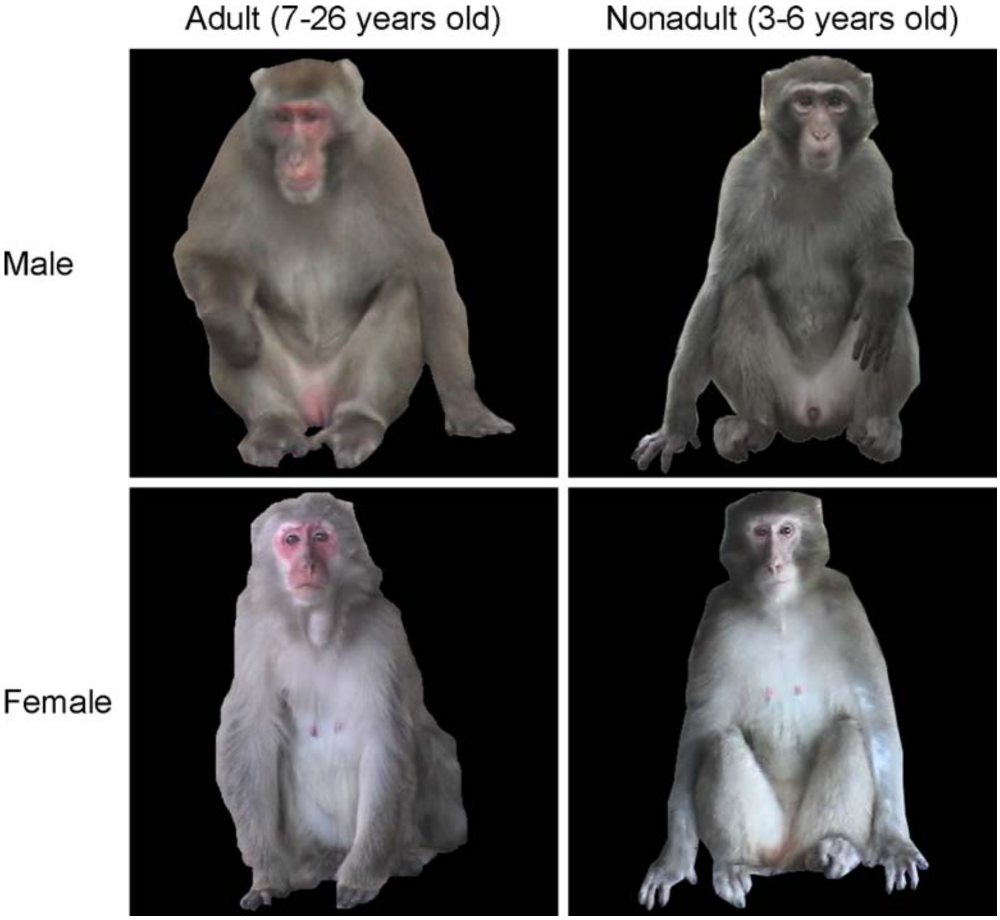


Fig. 1 Examples of four types (adult male, nonadult male, adult female, and nonadult female) of stimuli used in the present experiment. The stimuli are colored

the computer monitor was darkened. Touching the monitor during the interval was mildly punished by resetting the ITI.

The monkeys were trained to discriminate 88 pictures [22 monkeys (12 adults, 10 nonadults) × two pictures × sex (male, female)]. A training session finished when the monkey got 100 rewards. Each monkey had three to five sessions per day depend on his motivation. After the percentage of correct responses was above 85% in the training session, we proceeded to test sessions. The test sessions were designed to investigate whether the monkeys could practically perform the task based on sex of individuals in pictures.

Experiment 1: probe test

Methods

Probe test sessions included baseline and probe trials. Each session consisted of 112 trials including 88 baseline and 24 probe trials. Each monkey had five sessions. The baseline trials were identical to the trials in the training sessions, and were intended to maintain the monkeys' performances. For the probe trials, we introduced 24 pictures of novel monkeys [six monkeys (four adults, two nonadults) × two pictures × sex (male, female)]. The probe trials and baseline trials appeared randomly during each session. To prevent additional learning, any responses were not rewarded in the probe trials. If the monkeys' categorization performances were to be based on the sex of individuals in pictures, monkeys would respond to the corresponding key regardless of being rewarded or not.

Results and discussion

The numbers of training days before the performance reached 85% correct were 59 days and 55 days for Louk and Monkichi, respectively. The percentages of correct responses just before the probe test were 86% and 98% for Louk and Monkichi, respectively.

The left panels in Fig. 2 show the individual percentages of "male" responses (i.e., responses to the left key) in baseline trials from the five probe sessions. Chi-square tests demonstrated that the percentages of "male" responses were significantly higher with male pictures than with female pictures in both Louk [adult-male: 85%, adult-female: 16%, $\chi^2(1, N=240)=112.07$, $p<0.001$; nonadult-male: 76%, nonadult-female: 17%, $\chi^2(1, N=200)=67.61$, $p<0.001$] and Monkichi [adult-male: 96%, adult-female: 3%, $\chi^2(1, N=240)=201.68$, $p<0.001$; nonadult-male: 89%, nonadult-female: 4%, $\chi^2(1, N=200)=141.81$, $p<0.001$]. The performances in

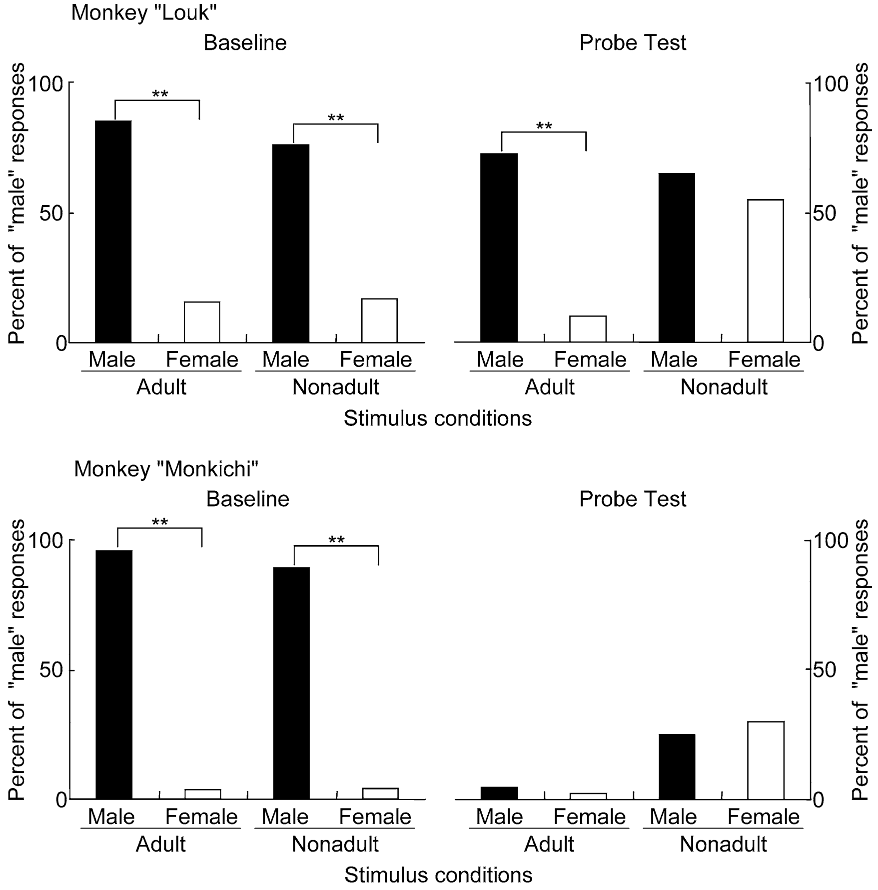


Fig. 2 Percentages of “male” responses (i.e., responses to left key) in the probe test that consisted of baseline and probe trials. $^{**}p<0.001$

baseline trials suggested that both monkeys succeeded in categorizing trained stimuli.

The upper right panel of Fig. 2 shows Louk’s percentages of “male” responses in probe trials from the five probe sessions. In the probe trials, if the monkeys’ performances with novel stimuli were to be based on the sex of individuals in pictures, the percentages of “male” responses would be higher with male pictures than with female pictures. In the conditions of adult stimuli, the percentage of “male” responses was significantly higher with male pictures than with female pictures [male: 73%, female: 10%, $\chi^2(1, N=80) = 29.70, p<0.001$]. The performances in the first two sessions had the same tendency [male: 63%, female: 19%, $\chi^2(1, N=32)=4.66$, $p=0.03$]. These results suggested that Louk succeeded in discriminating between the pictures of novel adult males and females from initial sessions. On the other hand, in the condition with nonadult stimuli, the percentages of “male” responses were not different between male and female pictures [male: 65%, female: 55%, $\chi^2(1, N=40)=0.10$, $p=0.74$]. These results suggested that Louk succeeded in sex categorization of novel adult monkeys, but he did not with nonadult monkeys.

The lower right panel of Fig. 2 shows Monkichi’s percentages of “male” responses in probe trials from the five probe sessions. The percentages of “male” responses were not different between male and female pictures in both age classes [adult-male: 5%, adult-female: 3%, $\chi^2(1, N=80)=0.00$, $p=1.00$; nonadult-male: 25%, nonadult-female: 30%, $\chi^2(1, N=40)=0.00$, $p=1.00$], and there was no evidence of sex categorization. Monkichi tended to respond to the right (“female”) key when stimuli were novel pictures in spite of sex.

The strong preference to the right key in response to novel pictures might be a reason why Monkichi did not show an evidence of the categorization based on the sex of individuals depicted. To avoid the effect of introducing novel stimuli, we conducted a generalization test in which test pictures were presented repeatedly, and responses to one of the keys were rewarded following the predetermined reinforcement contingency for each of the stimuli.

Experiment 2: generalization test

Methods

After the monkeys completed the probe test, they immediately proceeded to the generalization test. Each session consisted of 96 trials. Each monkey had five sessions per day and completed 20 sessions. Stimuli were the 24 pictures used in the probe trials and each picture appeared four times in a session.

In the generalization test, a reinforcement contingency was predetermined for each picture irrespective of the practical sex of the individual depicted. Two pictures from each

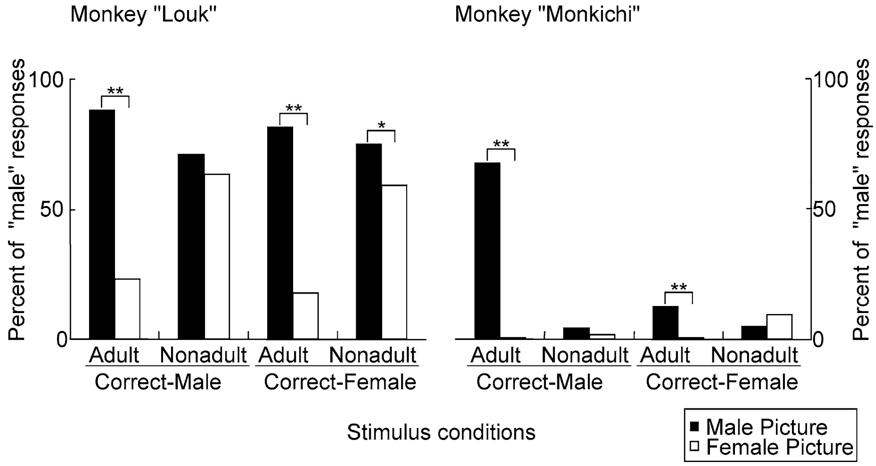


Fig. 3 Percentages of "male" responses (i.e., responses to left key) in the generalization test that consisted of Correct-Male trials and Correct-Female trials. $^{*}p<0.05$, $^{**}p<0.001$

stimulus monkeys were assigned to two types of trials, named Correct-Male and Correct-Female trials, respectively. In these trials, responses to the left ("male") and right ("female") keys were rewarded, respectively. If a male picture was assigned to Correct-Male, its reward contingency was the same as in the training. On the other hand, if it was assigned to Correct-Female, a touch to the right ("female") key was required to get reward. Such regular (i.e., trained) and reversed contingencies enabled us to examine whether or not the monkeys' performances depended on the trained sex categorization rather than the monkeys (quickly) learned about the novel reward contingencies. If the monkeys could generalize their performances irrespective of the reward contingencies, then they would be concluded to have acquired sex categorization.

Results and discussion

In the generalization test, if the monkeys' categorization performances were to be based on the sex of individuals in pictures, the percentages of "male" responses would be higher with male pictures than with female pictures regardless of the reward contingency. On the other hand, if the monkeys' categorization performance were not to be based on the sex of individuals in pictures (i.e., individual learning: based solely on recognition of the individual in pictures or recognition of the pictures themselves), the percentages of "male" responses would be high with Correct-Male (CM) conditions and low with Correct-Female (CF) conditions regardless of sex of stimuli because the responses would be based on the reward contingency.

The left panel of Fig. 3 shows Louk's percentages of "male" responses in the generalization test from the 20 generalization sessions. In the condition with adult stimuli, chi-square tests showed that the percentages of "male" responses were significantly higher with male pictures than with female pictures both in the conditions of CM [male: 88%, female: 23%, $\chi^2(1, N=640)=268.44, p<0.001$] and CF [male: 82%, female: 18%, $\chi^2(1, N=640)=260.12$, $p<0.001$]. Relatively high percentages of "male" responses with the male pictures suggested that Louk responded to the left ("male") key based on sex of the stimuli. In particular, he preferred to respond to the left ("male") key with CF male conditions although he did not get rewards. Similarly, relatively low percentages of "male" responses with the female pictures suggested that he responded to the right ("female") key regardless of reward contingencies. These results suggested that Louk succeeded in discriminating the sex of individuals from pictures of novel adult monkeys. In the condition with nonadult stimuli, the percentages of "male" responses were significantly higher with male pictures than with female pictures in CF conditions [male: 75%, female: 59%, $\chi^2(1, N=320)=8.81, p=0.003$], but such a tendency was not observed in CM conditions [male: 72%, female: 63%, $\chi^2(1, N=320)=2.04$, $p=0.153$]. These results partly supported that the idea that he discriminated between the pictures of novel nonadult males and females.

The right panel of Fig. 3 shows Monkichi's percentages of "male" responses in the generalization test from the 20 generalization sessions. Similarly to probe trials, the tendency of Monkichi, who showed the strong preference to the right key in response to novel pictures regardless of sex of stimuli, were more or less observed in the generalization test. In the condition with adult stimuli, chi-square tests showed that the percentages of "male" responses were significantly higher with male pictures than with female pictures both in the conditions of CM [male: 68%, female: 1%, $\chi^2(1, N=640)=315$, $p<0.001$] and CF [male: 13%, female: 1%, $\chi^2(1, N=640)=34.8, p<0.001$]. In contrast, in conditions with nonadult stimuli, the percentages of "male" responses were not different between male and female pictures both in the conditions of CM [male: 4%, female: 2%, $\chi^2(1, N=320)=0.929, p=0.335$] and CF [male: 5%, female: 10%, $\chi^2(1, N=320)=1.68$, $p=0.193$]. These results suggested that Monkichi succeeded in discriminating the sex of novel adult monkeys, but he did not with nonadult monkeys.

Monkichi did not show evidence of sex categorization in the probe test. In the probe test and the generalization test, the monkey strongly preferred to respond to the right ("female") key in response to novel pictures. What the monkey learned in the training might be that the trained male pictures corresponded to the left (“male”) key, and the remaining pictures (i.e., females in the training) corresponded to the right key. In the test trails with novel stimuli, the monkey basically responded to the right key because the stimuli depicted individuals other than the trained males. Certain masculine characteristics of the stimuli affected his performances because the rate of responses to the left (“male”) key was relatively high to the novel pictures of males than those of females. Although the preferences to the right key itself is evidence of individual learning in respect to the stimulus pictures or of the monkeys, the monkey seemed to perform both individual discrimination and sex categorization. It is unclear why the monkey showed preference to the right key instead of the left key. Compared to female stimuli, males might be easy for him to remember.

The results from the generalization test suggested that while monkeys discriminated between the pictures of adult males and females, discrimination of nonadult pictures was difficult. Both monkeys showed difficulty in sex categorization with nonadult pictures. In humans, sexes of children’s faces are more difficult to perceive than those of adults’ (Wild et al. 2000). It seems reasonable that the development of sexual dimorphism had some effects on the sex categorization in both humans and monkeys. In adult monkeys, female nipples and male scrotums are more conspicuous than in infants. Nipples and testis mature fully at about 10 and 7 years of ages, respectively (Hamada et al. 2005). The nonadult monkeys in our stimulus pictures were 3–6 years old, and therefore had not matured sexually.

What part is important for monkeys in sex categorization of conspecific pictures: faces, genital organs, or other global properties? In Experiment 3, we used partially-presented pictures to investigate which part is important for the monkeys in maintaining the performance on the discrimination task.

Experiment 3: partial presentation test

Methods

For the partial presentation test, we modified pictures of 20 adult monkeys [10 monkeys × sex (male, female)]. Each session consisted of five conditions: baseline, mirror image, and three types of partial presentation (face, breast, and underbelly). The stimuli of the baseline condition were the same pictures as those used in the training sessions in Experiment 1, and each of these pictures was modified into the other conditions. In the mirror image condition, the stimuli were flipped horizontally to investigate whether the monkeys discriminated the pictures based on simple cues such as contours. The face, the breast, and the underbelly pictures were upper, middle, and lower one third of the original pictures, and they presented face, nipple, and genitalia, respectively.

The monkeys were presented 100 pictures in total (five types of stimulus conditions × 10 monkeys × sex). There were 20 trials of baseline and the four conditions with modified stimuli, respectively, and a session consisted of 100 trials. The trials of these five conditions appeared randomly during each session. Each monkey had 16 sessions. As in the training sessions, the monkeys were rewarded when they made a correct response (touching the assigned key in response to the sex of the sample picture).

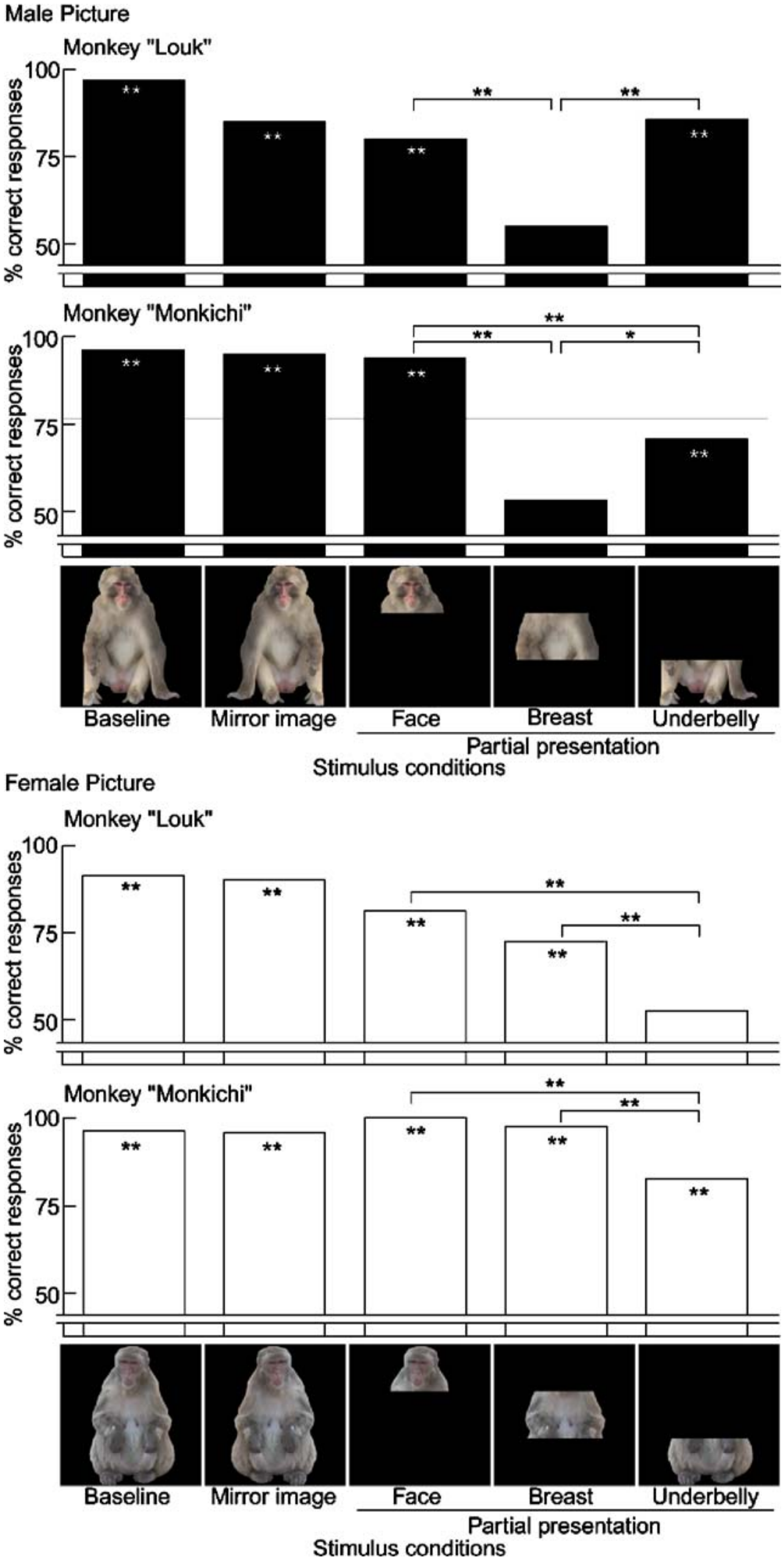
Results and discussion

The upper panel of Fig. 4 shows the individual percentages of correct responses in the trials with male pictures. Two-tailed binominal tests demonstrated that the percentages of correct responses were significantly above chance except in the breast condition (Louk’s baseline: 97%, $z = 11.78$, $p < 0.001$; mirror image: 85%, $z = 8.76$, $p < 0.001$; face: 80%, $z = 7.51$, $p < 0.001$; breast: 55% $z = 1.19$, $p = 0.236$; underbelly: 86%, $z = 8.93$, $p < 0.001$; Monkichi’s baseline: 96%, $z = 11.62$, $p < 0.001$; mirror image: 95%, $z = 11.30$, $p < 0.001$; face: 94%, $z = 10.99$, $p < 0.001$; breast: 53% $z = 0.71$, $p = 0.477$; underbelly: 70%, $z = 5.04$, $p < 0.001$). The presentations of male breasts did not give enough cues for the monkeys to perceive the sex of the depicted monkeys. In both monkeys, the percentages of correct responses with breast stimuli were significantly lower than those with face stimuli [Louk: χ^2 $(1, N = 320) = 21.67$, $p < 0.001$; Monkichi: χ^2 $(1, N = 320) = 65.62$, $p < 0.001$] and underbelly stimuli [Louk: $\chi^2(1, N = 320) = 34.49$, $p < 0.001$; Monkichi: $\chi^2(1, N = 320) = 9.66$, $p = 0.001$]. Only Monkichi showed superior performances with face stimuli than those with underbelly stimuli [$\chi^2(1, N = 320) = 27.66$, $p < 0.001$]. These results suggested that the face and the underbelly were important parts for the monkeys to categorize the male pictures.

The lower panel of Fig. 4 shows the individual percentages of correct responses in the trials with female pictures. Two-tailed binominal tests demonstrated that Louk’s percentages of correct responses were significantly above chance except in the underbelly condition (baseline: 91%, $z = 10.36$, $p < 0.001$; mirror image: 90%, $z = 10.04$, $p < 0.001$; face: 81%, $z = 7.83$, $p < 0.001$; breast: 73%, $z = 5.61$, $p < 0.001$; underbelly: 53%, $z = 0.29$, $p = 0.580$) and Louk failed to discriminate the sex of the depicted monkeys in the underbelly condition. Monkichi was able to discriminate the sex of conspecifics in all of the five conditions (baseline: 96%, $z = 11.62$, $p < 0.001$; mirror image: 96%, $z = 11.46$, $p < 0.001$; face: 100%, $z = 12.57$, $p < 0.001$; breast: 98%, $z = 11.94$, $p < 0.001$; underbelly: 83%, $z = 8.14$, $p < 0.001$). In both monkeys, the percentages of correct responses with underbelly stimuli were significantly lower than those with face stimuli [Louk: $\chi^2(1, N = 320) = 26.56$, $p < 0.001$; Monkichi: $\chi^2(1, N = 320) = 28.53$, $p < 0.001$] and breast stimuli [Louk: $\chi^2(1, N = 320) = 12.81$, $p < 0.001$; Monkichi: $\chi^2(1, N = 320) = 18.37$, $p < 0.001$]. These results suggested that the face and the breast were important parts for the monkeys to categorize the female pictures.

From the partial presentation test, we conclude that the conspicuous and sexually characteristic parts (i.e., the underbelly including male scrotum or the breast including

Fig. 4 Percentages of correct responses in the partial presentation test and examples of five types of stimuli (baseline, mirror image, face, breast, and underbelly). The stimuli are colored. $^{*}p<0.05$, $^{**}p<0.001$



female nipples) were important for the monkeys in maintaining the performance on the sex discrimination. Although the face is one of the most salient stimuli in social communication in primates (Petit and Thierry 1992; Pascalis et al. 1999; Parr et al. 2000), Ohshiba (1995) failed to show sex categorization of conspecific faces in monkeys. In the present experiment, the monkeys might use face individuality to perform correctly because the partially-presented pictures were the modified versions of the trained pictures. We should examine further whether monkeys practically perform the sex discrimination only by face pictures of unknown individuals.

The partially-presented pictures without conspicuous and sexually characteristic parts, like male breasts and female underbellies, did not give enough cues for monkeys to perceive the sex of the depicted monkeys. For the monkeys, the absence of the scrotum in the picture, for example, might not immediately mean that the depicted individual was a female. These results suggest that the presence of a conspicuous and sexually characteristic part in the pictures made the monkeys' discrimination easier than the absence of such a cue. This tendency is in agreement with the difficulty in categorizing nonadult monkeys who were sexually immature.

General discussion

The results from Experiments 1 and 2 suggested that the monkeys were able to discriminate the sex of individuals from conspecifics' pictures. Although it had not been clear from previous studies, such as Ohshiba (1995) or Mizuno (1997), whether monkeys discriminated between the pictures of conspecific males and females, we demonstrated that monkeys practically had the ability of sex categorization with a great number of controlled whole-body pictures. Experiment 3 examined what cues the monkeys used to discriminate the pictures. The results suggested that the conspicuous and sexually characteristic parts (i.e., the underbelly including male scrotum or the breast including female nipples) played an important role in the sex categorization.

From the present study, we can conclude neither monkeys have similar concept of sex that humans have nor they use the same cues to those of humans in sex categorization. Instead, monkeys were revealed to be able to categorize two sorts of pictures (i.e., males and females), and the performances were controlled by body parts, which show sexual dimorphism. Such ability of visual discrimination provides a basis for social behaviors, and has a fundamental role in monkeys' reproductive success.

Performances of sex categorization might correlate with the reproductive states of both subject and stimulus monkeys. Bielert and van der walt (1982) suggested that the sizes of sexual swellings in female chacma baboons correlate with males' sexual arousals such as masturbatory behavior and the levels of serum testosterone. In further experiments, the red color of female sexual swellings was revealed to elicit sexual arousals in males (Bielert et al. 1989). To examine whether reproductive states of stimulus monkeys affect performances, we will need to use stimulus pictures in the copulation period, which were not presented in the present study. As well, we will need to include female subjects in a future study to examine the effects of reproductive states of subject monkeys.

Rendall et al. (2004) found sex differences in the acoustic structure of baboons' grunt vocalizations, and demonstrated these differences are perceived by conspecifics. It would be interesting to investigate whether Japanese monkeys categorize conspecific sexes by not only visual cues but also vocal cues. Izumi and Kojima (2004) demonstrated a chimpanzee possess crossmodal representations of species-specific vocalizations: the chimpanzee recognized the correspondence between vocalization types and faces. It is plausible that monkeys represent conspecific sex crossmodally, and multiple cues interact with each other for sex categorization.

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