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ARTICLE

Fear responses of Japanese monkeys to scale models

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Abstract This study investigated fear responses of Japanese monkeys (*Macaca fuscata*) to scale models. Fear responses of participants were assessed using rating scores assigned by judges. In Experiment 1, participants were presented with scale models of objects in furniture, vehicle, and mammal categories. Overall, the participants expressed stronger fear responses to mammal objects as compared to the other two kinds. In Experiment 2, participants were presented with scale models of furniture, new mammals, and animals composed of insects, birds, fish, and reptiles. As a whole, the participants showed stronger fear responses to the new mammal and animal objects than to furniture objects. Fear responses to mammal and animal objects were comparable. These results suggest that Japanese monkeys show stronger fear responses to objects possessing perceptual properties of animals, as opposed to objects that do not possess such properties.

Keywords Fear · Emotional behavior · Object recognition · Japanese monkeys · Animal objects

Introduction

Intuitively and empirically, we know that non-human animals as well as humans possess various kinds of emotions. Fear is one of the common basic emotions among species. It seems that exhibition of fear, such as vocalizations and facial expressions, can be recognized objectively, regardless of the individual species to some extent (e.g., Kanazawa 1996). According to Nelson et al. (2003), fear is supposed to be an adaptive emotional response that functions to help organisms avoid potentially harmful stimuli. Fear is one of the mechanisms through which non-human animals and even humans efficiently survive.

Many studies have investigated the non-human primate fear/avoidance responses from diverse perspectives, such as cognitive and medical domains (e.g., Humphrey and Keeble 1974; Haude and Detwiller 1976; Levine et al. 1993; Timmermans et al. 1994; Baross et al. 2000; Rosenblum et al. 2001; Mason et al. 2006). For example, the fear response to snakes, which is prevalent in many primate species including humans, is a famous example (e.g., Murray and King 1973; Mineka et al. 1980; Mineka and Cook 1986; Öhman and Mineka 2001, 2003, for a review). Moreover, an ethological study reported that vervet monkeys (*Cercopithecus aethiops*) emitted different kinds of alarm calls depending on the type of predator, such as a leopard or a snake (Seyfarth et al. 1980). This study suggested that the monkeys developed a classification system for predators, which helped them avoid danger in an effective way.

In a similar vein, we previously examined the kinds of objects that Japanese monkeys (*Macaca fuscata*) recognized as to-be-avoided objects (Murai and Tomonaga 2004). According to the definition of fear by Nelson et al. (2003) mentioned earlier, avoidance stems from fear, and thus avoidance and fear are inseparable. Therefore, "avoidance response" can be defined as "behavior that keeps individuals from contact with, and/or approach to objects because of fear." In this study, the monkeys were presented with three kinds of scale models as stimuli:

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animals (mammals, insects, fish, birds, and reptiles), artifacts (vehicles), and neutral objects (wooden bricks). Avoidance response to the stimuli was assessed by observing the position of the monkey in the cage, and the duration of the monkey's stay at that position during the presentation of the stimulus object. Results showed that the monkeys stayed in a position remote from the stimulus for a long time when presented with animal stimuli, as compared to the other two kinds of stimuli. In addition, the object manipulation time of the monkeys for animal stimuli was significantly shorter than that for furniture and neutral objects, which suggests that the monkeys showed stronger avoidance to animal objects than to the other kinds of objects. Although this study objectively assessed the monkeys' avoidance responses by measuring the distance between the monkey and stimulus object, we cannot eliminate the possibility that the monkeys stood apart from the animal stimuli due to a lack of interest in the object, as opposed to a fear of the object. Therefore, in the present study, we attempted to examine fear responses of Japanese monkeys that were not reflected in a measure of the physical distance.

We assessed fear responses of the monkeys to the stimulus objects using rating scores as a dependent measure. Some judges rated the strength of a monkey's fear using a rating scale from 1 "not feared at all" to 5 "extremely feared," based on the collective impressions of their behaviors to the stimuli, e.g., negative behavior such as grimacing and screaming, and positive behavior such as object manipulation and approaching. In Experiment 1, the monkeys were presented with scale models from the mammal, furniture, and vehicle categories as stimuli. In Experiment 2, they were tested with objects from broader animal categories using insect, fish, bird, and reptile objects that possess various perceptual properties. We examined whether the properties of the objects influence the intensity of the participants' fear response. If the participants exhibited significantly stronger fear responses to a certain kind of object, as compared to the other kinds, it is safe to assume that the fear responses in Japanese monkeys are not random, but dependent on the properties of the objects. This study investigates the objects that elicit fear responses in Japanese monkeys.

Experiment 1

Materials and methods

Participants

Four Japanese monkeys named Ángel, Shingo, Tim, and Romio (all were males) participated in the experiment. They were born in the Primate Research Institute of Kyoto University (PRI) and raised by four human caretakers due to their mother's death or rejection. Ángel, Shingo, and Romio were raised by their caretakers since birth. Tim was raised by his biological mother at first; however, he was given maternal care by human caretakers after the age of 3 months. The monkeys could routinely visit and play at outdoor locations within the institute with peer monkeys and caretakers, in order to have the opportunity for socialization. Thus, they had seen some live animals (e.g., insects: mantis, cicada, centipede, and cockroach; birds: crow and pigeon; mammals: Japanese raccoon, cat, other macaques, gibbon, and chimpanzee). Both Tim and Romio were participants in a previous study (Murai and Tomonaga 2004). In the present study, food and water for the monkeys were unlimited. The care and use of the monkeys adhered to the 2002 version of the Guide for the Care and Use of Laboratory Primates of PRI, and the experimental designs were accepted by the Animal Welfare and Animal Care Committee of the institute.

Stimuli

Novel scale models from three categories were used as stimuli: furniture, vehicles, and four-footed mammals (see Fig. 1). The furniture and vehicle objects were used as stimuli from a contrasting category: artifacts. We selected three kinds of objects as stimuli, because we had determined that Japanese monkeys in early development could visually distinguish among them (Murai et al. 2004). There were eight stimulus objects per category. All the stimuli were realistic three-dimensional scale models, ranging in size 4–6 cm in length and 3–4 cm in height. Various colors and materials were used. No scale model had movable parts. Figure 2 shows the names of all the stimulus objects.

Fig. 1 Examples of the stimulus objects used in this study

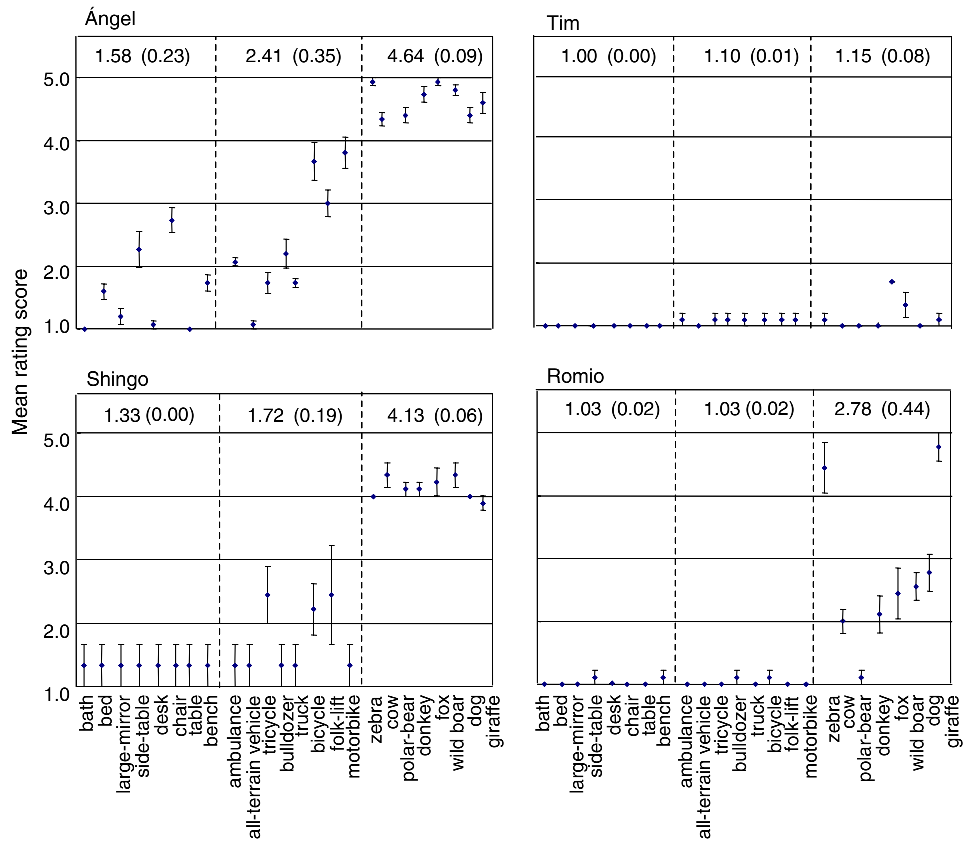

Fig. 2 Mean rating score (±SE) for the stimulus objects from each of the three kinds in Experiment 1: furniture (*left*), vehicle (*middle*), and mammal (*right*). Mean rating score (±SE) for each kind is described at the top of each graph

Procedure

The monkeys underwent tests individually in the home cage that they inhabited daily. Two experimenters (caretakers of the monkeys) conducted the experiments. The experiments were always conducted after feeding, to test the monkeys when they appeared to be relatively relaxed. During the experiment, one experimenter presented the stimulus objects and the other recorded the monkey's responses to the stimuli using a digital video camera (SONY DCR TRV9) for later analysis, and monitored the time schedule. Four stimuli from each of the three categories were randomly chosen, such that in any one session 12 stimuli were used. Stimuli were presented one at a time for 30 s in a random order. The presentation of the stimulus started when the monkey sat in front of the experimenter. During the presentation, the experimenter did not move the stimulus and avoided behavior such as facial expression and vocalization that could influence the monkey's emotional state. Inter-trial interval (ITI) was 90 s, but this could be extended on the occasions when the monkey took longer than 90 s to calm down, after showing vigorous fear responses. The monkeys were allowed to reach, touch, and manipulate the stimuli freely but not to take them away from the experimenter's hand. Twelve 30-s trials constituted a single session and all the monkeys received six sessions overall. All the stimulus objects were used repeatedly, a total of three times. The monkeys underwent one session a day, once or twice a week.

Rating and data analysis

The rating scores given by the judges were applied as a measure of fear response. The persons who frequently encountered the monkeys and the other caretakers who were not involved in the experiments judged the monkeys' responses. Thus, the evaluators were familiar with the monkeys and understood their behavioral tendencies within everyday situations. The ratings were not based on pre-established quantified criteria for fear responses. They depended on collective impressions of participants' behaviors during the presentations of the stimulus objects. As demonstrated by previous fear studies (e.g., Nelson et al. 2003), fear responses of our monkeys varied in quality. We observed that the participants expressed various patterns of negative behaviors, such as jumping away, grimace, and withdrawing (retreating to the back of the cage and being stuck at that position) (see Appendix). In fact, they exhibited not only negative behaviors but also positive behaviors to the stimuli. The rating scores were estimated as a function of such behaviors as a whole. The evaluators had previously viewed these various negative and positive responses of the monkeys in daily encounters with them. According to Nelson et al. (2003), a wide variety of responses to fearsome objects would occur along a continuum; the milder responses reflected orientation and vigilance and extreme responses reflected fear. Although the various negative responses shown by our monkeys might mean not only fear but also orientation or vigilance, we considered these negative responses of participants as "fear" in the present study.

Each judge separately rated the participants' responses in a room, in which a TV monitor and VCR were set up. Prior to the rating, the judges were given the rating form, and were instructed to rate the participants' responses in each trial, using a rating scale from 1 "not feared at all," 2 "slightly feared," 3 "feared," 4 "very feared," to 5 "extremely feared," after watching the videotapes recording the participant's behavior during the entire presentation of stimulus. Thus, a higher score indicated a stronger fear response of the participant. Although we could not particularly define the intensity of participant' responses corresponding to each scoring value, we instructed the evaluators to give the rating value 1 when the monkeys largely showed the expression of neutral or that of other than fear. The stimulus object usually could not been seen by the judge during the rating, since it was held and covered by the experimenter's hand. However, sometimes part of the object was visible for the judge. Even in that case, the judge could not know what the object was, because he/she could not see enough of it. Of course, the judges were not informed of what kinds of objects were presented to the monkeys before the ratings. They were also given no information about the purpose of the experiment.

Possibly, the rating score measure seems to be subjective, unlike a measure of physical distance. However, our measure is probably an adequate, although intuitive, assessment of the participants' fear. In this regard, rating scores based on the collective impressions of participants' responses would be a valid measure, in order to evaluate their emotional behavior. Nevertheless, if the intensity of the participants' fear responses did not vary depending on the object properties, there were no significant differences among the rating scores for the kinds of objects. For Ángel and the other participants, five or three judges rated their responses, respectively. The Pearson correlations among the rating scores given by all the judges were as follows: 0.90–0.95 for Ángel, 0.91–0.92 for Shingo, 0.81–0.91 for Tim, and 0.85–0.92 for Romio.

Results

For each participant, the data was statistically analyzed to examine whether the rating scores among three kinds of objects were significantly different. We conducted one-way analysis of variance (ANOVA) with the object kind (three: furniture, vehicles, and mammals), as within-subject factors on the mean rating scores. We used partial Eta squared (η_p^2) as a measure of effect size. Figure 2 shows the mean rating scores for each kind, as well as those for each stimulus from each kind.

For Ángel, Shingo and Romio, higher rating scores to the mammal objects than to the other kinds of objects were given. For Ángel, mean rating score to mammals ($M = 4.64$) was higher than those to furniture ($M = 1.58$) and vehicles ($M = 2.41$). A one-way ANOVA also revealed the significant effect of the object kind: F (2, 14) = 54.81, MSE = 20.11, $\eta_p^2 = 0.89$, $P < 0.001$. Ryan's procedure confirmed that the rating score to mammals was significantly higher than those to furniture and vehicles. Also, the score to vehicles was significantly higher than that to furniture. For Shingo, tendencies similar to those of Ángel were obtained. Mean rating score to mammals ($M = 4.13$) was higher than those to furniture ($M = 1.33$) and vehicles ($M = 1.72$). The statistical analysis also revealed the significant main effect of the object kind: F (2, 14) = 174.42, MSE = 18.30, $\eta^2{}_p = 0.96$, $P < 0.001$. Ryan's procedure confirmed that the rating score to mammals was significantly higher than those to furniture and vehicles, and the score to vehicles was significantly higher than that to furniture. For Romio, mean rating score to mammals ($M = 2.78$) was higher than those to furniture ($M = 1.03$) and vehicles ($M = 1.03$). Statistically, the significant main effect of the object kind was revealed: F (2, 14) = 15.96, MSE = 8.17, $\eta^2{}_p = 0.70$, $P < 0.001$. Ryan's procedure confirmed the rating score to mammals was significantly higher than those to furniture and vehicles. On the other hand, for Tim, mean rating score to mammals ($M = 1.15$) was not different from those to furniture ($M = 1.00$) and vehicles ($M = 1.10$). Statistically, the main effect of the object kind was not significant: F (2, 14) = 2.59, MSE = 0.05, $\eta^2{}_p = 0.27$, $P > 0.10$. There were no significant differences among the rating scores for the three kinds of objects.

Discussion

For Ángel, Shingo and Romio, we found significantly higher rating scores to mammals as compared to the other kinds, suggesting that they showed stronger fear response to mammals. On the contrary, Tim did not show such higher rating score to the mammal objects. However, we observed that he actually expressed some negative behaviors to mammals but furniture and vehicles (see Appendix). Given this, Tim, like the other individuals, might recognize the mammal stimuli as fearsome objects. He appeared to exhibit the milder fear responses in terms of intensity rather than drastic and overt fear, which resulted in relatively lower rating scores.

The results of multiple comparison tests indicated that Ángel and Shingo showed relatively stronger fear responses to vehicles than to furniture. They also exhibited a number of negative behaviors to the vehicles compared to the furniture (see Appendix). The reason was not clear. However, we thought that the vehicle objects might have some minor properties that are similar to the mammal objects that evoke the participants' fear, e.g., rounded contours of bodies and the headlights might seem similar to the eyes of mammals. However, the important result was that participants' fear responses to the mammal objects were significantly stronger, as compared to either the vehicle or the furniture objects.

Experiment 2

In Experiment 2, we investigated whether the participants exhibited fear responses not only to the objects from the mammal category but also to those from a broader "animal" category.

Materials and methods

Participants

The same monkeys were tested as in Experiment 1. Testing took place for several months after Experiment 1.

Stimuli

Three kinds of scale models were used as stimuli: furniture, new mammals, and animals such as insects, birds, fish, and reptiles (see Fig. 1). Only the furniture objects were identical to those used in Experiment 1. We used these objects as the control stimuli because the participants showed no fear responses to them. To examine whether the mammal objects that we used in Experiment 1 were unique in provoking the participants' fear, new mammal objects were used in this experiment. In addition, to investigate whether the participants exhibited fear responses not only to mammal objects but also to the other kinds of animal objects, we used objects from insect, bird, fish, and reptile categories as stimuli. Although these animal objects possessed various perceptual properties, i.e., shared low perceptual similarities, they maintained some animal-like properties such as eyes, limbs, and rounded contour. There were eight objects in each category. Figure 3 shows the names of all the stimulus objects. For Tim and Romio, several objects different from those for Ángel and Shingo were used.

Procedure, rating, and data analysis

Procedure, rating, and data analysis were identical to those in Experiment 1. For every monkey, three people rated the responses of the monkeys to the stimuli. The Pearson correlations among the rating scores made by all the judges were as follows: 0.94–0.96 for Ángel, 0.84–0.91 for Shingo, 0.80–0.86 for Tim, and 0.81–0.89 for Romio.

Results

As in Experiment 1, for each participant, the rating scores were analyzed with one-way ANOVA with object kind (three: furniture, new mammals, and animals) as within-subject factors. Figure 3 shows the mean rating scores for each kind, as well as those for each stimulus from each kind.

For Ángel, Shingo, and Romio, higher rating scores to the mammal and the animal objects compared to the furniture objects were obtained. For Ángel, mean rating scores to mammals ($M = 4.38$) and to animals ($M = 4.48$) were higher than that to furniture ($M = 1.02$). A one-way ANOVA revealed the significant main effect of the object kind: F (2, 14) = 191.66, MSE = 30.94, $\eta^2_p = 0.96$, $P < 0.001$. Ryan's procedure confirmed that the rating scores to mammals and animals were significantly higher than that to furniture, and there was no significant difference between mammals and other animals. For Shingo and Romio, tendencies similar to those of Ángel were observed. For Shingo, mean rating scores to mammals ($M = 3.56$) and to animals ($M = 3.04$) were higher than that to furniture ($M = 1.40$). Statistically, the significant main effect of the object kind was found: F (2, 14) = 13.99, MSE = 10.23, $\eta^2_p = 0.67$, $P < 0.001$.

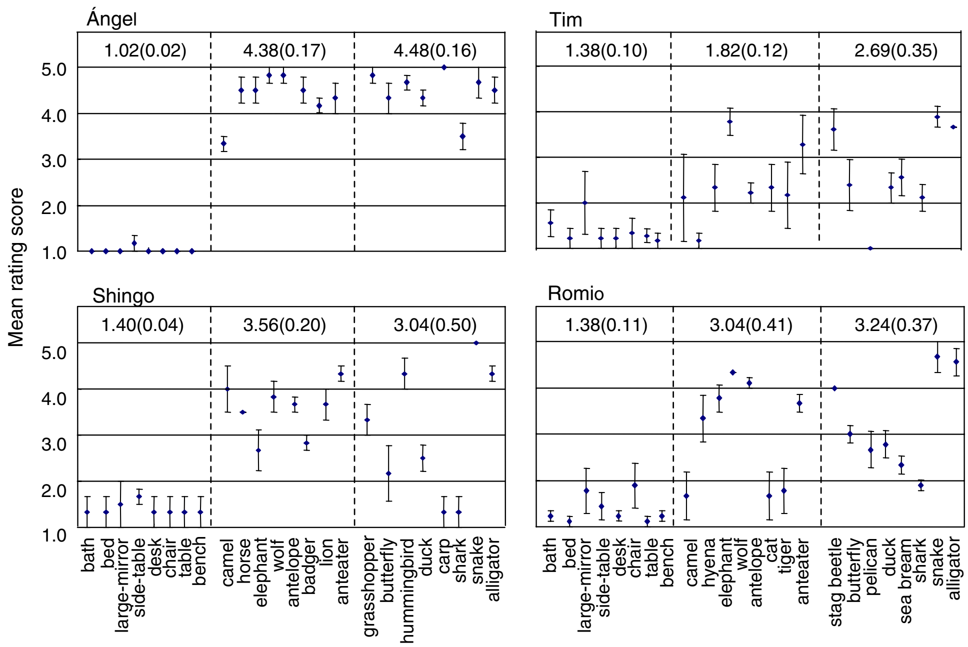

Fig. 3 Mean rating score (±SE) for the stimulus objects from each of the three kinds in Experiment 2: furniture (*left*), mammal (*middle*), and animal (*right*). Mean rating score (±SE) for each kind is described at the top of each graph

Ryan's procedure confirmed that the rating scores to mammals and animals were significantly higher than that to furniture, and the scores to mammals and other animals were not significantly different. For Romio, mean rating scores to mammals ($M = 3.04$) and to animals ($M = 3.24$) were higher than that to furniture ($M = 1.38$). The analysis revealed that the main effect of the object kind was significant: $F\ (2,\ 14) = 8.28$, $\mathrm{MSE} = 8.40$, $\eta^2_p = 0.54$, $P < 0.01$. Ryan's procedure confirmed that the rating scores to mammals and animals were significantly higher as compared to that to furniture, and the scores to mammals and other animals were not significantly different. For Tim, mean rating score to animals ($M = 2.69$) was higher compared to mammals ($M = 1.82$) and furniture ($M = 1.38$). The analysis revealed the significant main effect of the object kind: $F\ (2,\ 14) = 8.06$, $\mathrm{MSE} = 3.60$, $\eta^2_p = 0.54$, $P < 0.01$. Ryan's procedure confirmed that the rating score to animals was significantly higher than those to mammals and furniture, and there was no significant difference between mammals and furniture.

Discussion

For Ángel, Shingo, and Romio, we obtained higher rating scores to the new mammals than the furniture (the control), indicating that they showed stronger fear responses to mammals. Although the results were not surprising per se, this suggested that the mammal objects that we used in Experiment 1 were not unique in provoking participants' fear. However, for Tim, we did not have such consistent findings as seen in Experiment 1. Nevertheless, higher rating scores to the animal objects were given for all participants. Tim expressed some salient and strong fear responses to at least the animal objects.

Unfortunately, we could not statistically examine whether the rating scores for each kind of animal object were significantly different because of the small number of stimulus objects. However, as seen in Fig. 3, the rating scores appeared to differ among the kinds of animal objects. For example, the scores to fish objects appeared to be relatively lower compared to the other kinds of animals. In contrast, interestingly, the rating scores to reptile objects, including snake and alligator, were higher compared to other kinds of animals for every participant. Additionally, the participants showed different patterns of behaviors depending on the object kinds (see Appendix). For example, they expressed no positive response and/or more negative responses for reptiles compared to the other kinds of animal objects. This tendency is consistent with the previous findings of snake fear in non-human primates (e.g., Masataka 1993). It seemed likely that careful processing of the properties within animal categories may underlie the fear responses of the monkeys. To know which properties of animals especially provoke fear in monkeys, we need more detailed studies on the fear responses of monkeys to animal objects, with well-controlled procedures. Nevertheless, we speculate that the monkeys showed stronger fear responses to those objects that share animal-like properties, rather than to objects that have no such characteristics.

General discussion

The present experiments revealed that the participants showed significantly stronger fear responses to mammal and animal objects compared to furniture and vehicle objects as a whole. It is reasonable to assume that the properties possessed by animal objects evoked stronger fear responses by the monkeys, as opposed to properties of other kinds of objects.

Which common property of animal objects evoked stronger fear responses of the participants? The animal objects that we used were scale models and available information from these objects was limited, unlike real animals. The property that these objects share is only an animal-like appearance. At first glance, it appears to be strange that the monkeys exhibited fear to objects that possess animal-like appearances but do not even move. However, the previous studies suggested that object movement is not necessarily the essential cause for an individual's fear response. For example, it was reported that scale models and even photos of snakes provoked fear in primates, including humans (e.g., Murray and King 1973; Masataka 1993; Öhman and Soares 1994). Thus, it is thought that the perceptual property of animal scale models is one of the functional factors to provoke fear responses among the participants.

We could not conclude as to which perceptual properties of animal objects especially elicit the participants' fear responses, only from the present study. However, in relation to this, in Mason et al. (2006) fear responses in rhesus monkeys (*Macaca mulatta*) were tested with toy animals differentiated by the complexity of their facial features. In that study, the monkeys' fear responses were assessed by measuring reluctance to take the food placed with the stimulus objects. Mason et al. (2006) reported that the monkeys took more time to take food when it was close to intact animal-like toys as compared to animal-like toys, without facial features. Thus, the monkeys' fear responses decreased when the facial parts of the animal toys were removed. Although, more examinations are needed, these findings implied that the head, particularly facial parts, of animal objects would be one of the significant properties in evoking participants' fear responses.

Neuropsychological study of brain injury patients and lesion studies with monkeys have revealed the neural mechanism of emotional behaviors. For example, it was mentioned that selective bilateral lesions of the amygdala diminished the ability of monkeys to recognize the meanings of objects, and thus resulted in changes in monkeys' fear behaviors: reduction in expression of anger and fear and an increase in the tendency to approach and examine harmful objects (e.g., Mason et al. 2006). Thus, it was suggested that the amygdala is a key region for fear behaviors in primate species. Additionally, these data demonstrated that the process of object recognition is closely linked to fear behaviors. The neurological studies on emotional behaviors provide us useful information for understanding not only the neural mechanisms of fear responses but also the function of object recognition that underlie fear exhibition.

We should note that it is not determined that fear to the animal objects was prevalent in Japanese monkeys because of the small number of participants. Nevertheless, the present study demonstrated that fear responses by the monkeys were different in terms of intensity and quality, depending on the kinds of objects. This also supports the claim that our previous results from Murai and Tomonaga (2004) were not due to a mere lack of interest in animal stimulus objects, but that the monkeys recognized these objects as to-be-avoided objects. The manifestations of avoidance and fear in Japanese monkeys in our studies are cognitive behaviors based on processing of the perceptual properties of objects.

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Appendix

Table 1

Table 1 List of participants' behaviors observed during the presentations of the stimuli

	Ángel							Shingo						
	Furniture	Vehicle	Mammal	Insect	Bird	Fish	Reptile	Furniture	Vehicle	Mammal	Insect	Bird	Fish	Reptile
Negative														
Jump away		+	+						+	+				+
Turn around and retreat to the back of the cage	+		+			+	+	+	+	+	+	+		+
Run around			+											
Withdraw	+	+	+	+	+	+	+		+	+	+	+		+
Lie low			+		+					+				
Turn his face away		+	+	+	+	+	+		+	+	+	+		+
Turn his back														
Hit										+				
Scratch		+	+					+	+	+				+
Self-grooming														
Grimace		+	+	+	+	+								
Scream		+	+		+									
Intimidating voice														
Positive														
Grasp	+	+						+		+	+	+	+	
Manipulate with hand	+	+						+	+				+	
Manipulate with finger		+	+					+	+	+	+			
Manipulate with mouth	+	+						+	+	+	+	+	+	
Examine closely			+	+	+	+			+	+				
Other														
Take a sniff	+	+	+					+	+	+	+	+		+
Touch a stimulus and take a sniff of his hand														
Touch a stimulus and shake his hand														
Walk round and round										+				
Careful looking from a distance		+	+	+	+	+	+			+		+		+
Jump on the floor									+					

Table 1 continued

	Tim							Romio						
	Furniture	Vehicle	Mammal	Insect	Bird	Fish	Reptile	Furniture	Vehicle	Mammal	Insect	Bird	Fish	Reptile
Negative														
Jump away							+			+				+
Turn around and retreat to the back of the cage			+	+	+	+	+			+				+
Run around														
Withdraw			+	+			+			+	+		+	+
Lie low			+							+	+	+	+	+
Turn his face away			+	+		+	+	+		+	+	+		+
Turn his back			+				+			+				
Hit										+				
Scratch			+				+	+		+	+	+	+	+
Self-grooming														+
Grimace				+										
Scream														
Intimidating voice										+				
Positive														
Grasp	+	+	+	+	+	+	+	+	+	+			+	
Manipulate with hand	+	+	+		+	+		+	+	+				
Manipulate with finger	+	+	+	+	+	+	+	+	+	+	+	+	+	
Manipulate with mouth	+	+	+		+	+		+	+					
Examine closely	+	+	+					+	+	+		+		
Other														
Take a sniff		+	+											
Touch a stimulus and take a sniff of his hand			+	+		+	+			+	+	+	+	
Touch a stimulus and shake his hand										+				
Walk round and round			+							+				
Careful looking from a distance						+	+			+	+		+	+
Jump on the floor														

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