

## Basic Level of Categorization in *Macaca fascicularis*

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Human brain possesses the ability to create a concept to assist the process of grouping individual object or events into different classes or categories. We call this grouping process as categorization. In addition to humans, the ability to categorize has also been proposed for animals. Being able to identify, visually or otherwise, a new object as a member of a category is an advantage for animals. Present experiment aims to test the categorization ability in discriminating species by *Macaca fascicularis*. Using match-to-sample task with photographs of monkeys and human as stimuli, we tested whether monkeys able to categorize monkey individuals as a class against human individuals as another class. We found that monkeys categorized humans differently from monkeys. The monkeys used physical characteristic such as shape and colors from the photographs to create different concepts of human and monkeys.

Key words: concept, categorization ability, species discrimination, *Macaca fascicularis*

### INTRODUCTION

We live in a world full of ever-changing objects. It is impossible for us to memorize each and every new individual we encounter. Our brain should possess the ability to deal with the millions of bits of information that is continuously available in the surrounding environment. One way to overcome the memory storage constraint is to represent factual objects as conceptualized mental images. A concept concludes a lot of information that had been collected at the time we perceive the object and generalizes them to assist the process of grouping individuals or events into different classes or categories. There are several levels of categorization (Rosch *et al.* 1976). We may generalize those levels into two. If the detected physical properties of the individuals within a category are mostly similar, we call it as basic level of categorization (Rosch *et al.* 1976). If the connection between members of one category is not only based on perceptual similarity but more on relations between concepts, we call it as abstract level of categorization (Mervis & Rosch 1981).

In addition to humans, the ability to categorize has also been proposed for animals. Being able to identify, visually or otherwise, a new object as a member of a category is an advantage for animals. It should help them to distinguish between food or non-food, or to discriminate between species of animals. This species discrimination is important to prevent hybridization among species (Yoshikubo 1985; Fujita & Watanabe 1995; Fujita *et al.* 1997).

Present experiment aims to test the ability of species discrimination by primates. In this case, we want to test

whether monkeys are able to categorize monkey individuals as a class against human individuals as another class. Some experiments found that monkeys look to their conspecific longer than to nonconspecific so they used duration of visual fixation to indicate this discriminative capability (Demaria & Thierry 1988; Fujita 1993; Fujita & Watanabe 1995; Fujita *et al.* 1997). However, although counting the fixation time is easy to be described quantitatively, it is uncertain as to what the reaction time measures. For instance, the longer the time could represent two facts; the monkey likes the picture in the stimuli, or it can be the opposite. In fact, in agonistic bouts, monkeys tend to look longer to their opponent (de Waal *et al.* 1976). Thus, the reaction time may better be interpreted as a measure for the attention of monkeys and may not carry information about species discrimination. Moreover, it is not clear whether monkeys are truly able to distinguish between species or their familiarity with their own species due to experience in their life history made them see conspecific longer. Instead of counting fixation time of each stimulus, present experiment test their categorization ability in discriminating dichotomous-stimuli of monkey against human.

### MATERIALS AND METHODS

We assessed categorization ability of *Macaca fascicularis* to discriminate monkey from human using facial features. Both primates possess distinctive physical features, notably different shape of face and the presence of hair in the monkeys face which is absent from human. These distinctions would allow us to safely infer the discriminative ability on the different conceptual class of human and monkey. Fujita and Watanabe (1995)

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demonstrated the ability of species discrimination of Sulawesi macaques using photos as stimuli. Present experiment also use photos as stimuli. For monkey category, we used photos of both sexes of three species of macaques, those were *M. fascicularis*, *M. mulatta*, and *M. fuscata*. For human category, we used female and male photos. Some of the female heads were covered by scarf. Nevertheless, all pictures showed the whole face. Most of former studies of categorization did not control the background of the photos (Demaria & Thierry 1988; Fujita 1993; Fujita & Watanabe 1995; Fujita *et al.* 1997) so it is difficult to delineate which component of the photo provides informations to do categorization. We controlled the background color of all photos by changing the background into green (Figure 1).

Fujita and his coworkers (1993, 1995, 1997) used seeing duration as a measure of species discrimination. Because of limitation of fixation time to infer species discrimination as noted above, present experiment test their categorization ability based on dichotomic discrimination of monkeys against human. To do this, we employed match-to-sample task that were often used in working memory experiments (Miller *et al.* 1996; Rao *et al.* 1997) and later to study categorization experiment (Tanaka 2001; Freedman *et al.* 2002; Hampson *et al.* 2004; Inoue *et al.* 2008). We trained monkeys to associate sample and match stimuli against distractor stimulus. Thus, in every trial, the stimulus set comprised of sample, match and distract stimuli; dichotomically, the sample and matching stimuli were always belong to a same category that differ to the distractor (Figure 2). We assumed that each stimulus is independent from each other so a stimulus could be defined as a matching stimulus in one trial and could be a distractor in other trial depended to the sample stimulus.

In the training phase, we showed monkeys a sample stimulus as reference to be matched (Figure 2). To ensure that the subject paid attention to the sample stimulus, they had to touch the sample stimulus and for this they received reward that was placed beneath the stimulus. Next, we presented two side-by-side stimuli, that was, matching stimulus and distractor which one had to be chosen by subject. For this training phase, sample and matching stimuli were the same and monkey's stimuli were always *M. fascicularis* (Figure 1b,d). When the subject chose the matching stimulus, they received food as a reward; the response was counted as a correct one. When they chose the distractor, they did not get any rewards. Subject's motivation for reward warranted the choice of the matching stimulus. We repeated the trials consecutively with inter-trial intervals for about 30 second. The location of matching and distractor stimuli on the tray was arranged pseudorandomly. We blocked every 20 trials into one session and measured their correct rate. If the subject chose the matching stimuli higher than 90% in a session, it means they were able to associate matching to sample stimuli. When they reached this high performance of discrimination for three successive training sessions, they went to test phase. In this condition, because of matching and distractor stimuli did always

represent monkey and human (or vice versa), the discrimination of sample/matching from distractor stimuli may be inferred as the subject had developed concepts of monkey and human.

To test if a subject could apply the concept of human and monkeys to new individuals, we changed the pictures of matching stimulus with different individuals that belonged to the same category as the sample stimuli (Figure 1c to h); for example, if the sample stimulus is monkey b then the matching stimulus is monkey d. The subject should compare the novel matching stimulus to the available distractor. If the subject could associate the sample and the different-picture of matching stimuli, we may infer that they put those two pictures into one class that dichotomically differs from the class of distractor. This would mean they are able to categorize human and monkey. To get a baseline to these test trials, we included trials where matching stimulus picture was the same as the sample stimulus picture (that is the same as trials in training phase). These baseline trials would also enable us to see the subject's motivation.

The subjects were two adult *M. fascicularis* males, named Ucock and Sukhoi. Both monkeys were maintained at the Department of Biology of Bogor Agricultural University. They were reared in individual cages and tested in the same cage. Experiments were conducted according to the Guide for the Care and Use of Laboratory Animals by the National Institute of Health, U.S.A. (1985), and the Guide for the Care and Use of Laboratory Primates by the Primate Research Institute, Kyoto University (1986, 2002). The training phase was held about two years for Ucock and one year for Sukhoi depend on the ability of learning of the monkeys. The test phase was conducted for few months for both monkeys.

## RESULTS

As mentioned before, this experiment aimed to test the ability of monkeys in categorizing monkeys and humans into two different conceptual classes. In baseline trials, the photos of matching stimuli were the same to sample stimuli. Thus, as expected, all subjects could associate matching to sample stimuli at around 90% of trials (Figure 3). Because the matching stimuli were always of a different category to the distractor stimuli, it might mean they developed different and mutually exclusive concepts of human and monkeys. This result provided a reference to test whether subjects could use the newly developed concepts to identify new individuals. We did this by changing the matching stimulus with pictures of different humans and different kinds of monkeys (Figure 2). We found that all subjects associate sample stimulus to new individuals of matching stimuli. This same result to baseline (glmmPQL,  $P = 0.47$ , Venables & Ripley 2002) would indicate that subjects were able to correctly identify new individuals as members of their own class. This would mean that monkeys categorized humans differently from monkeys.

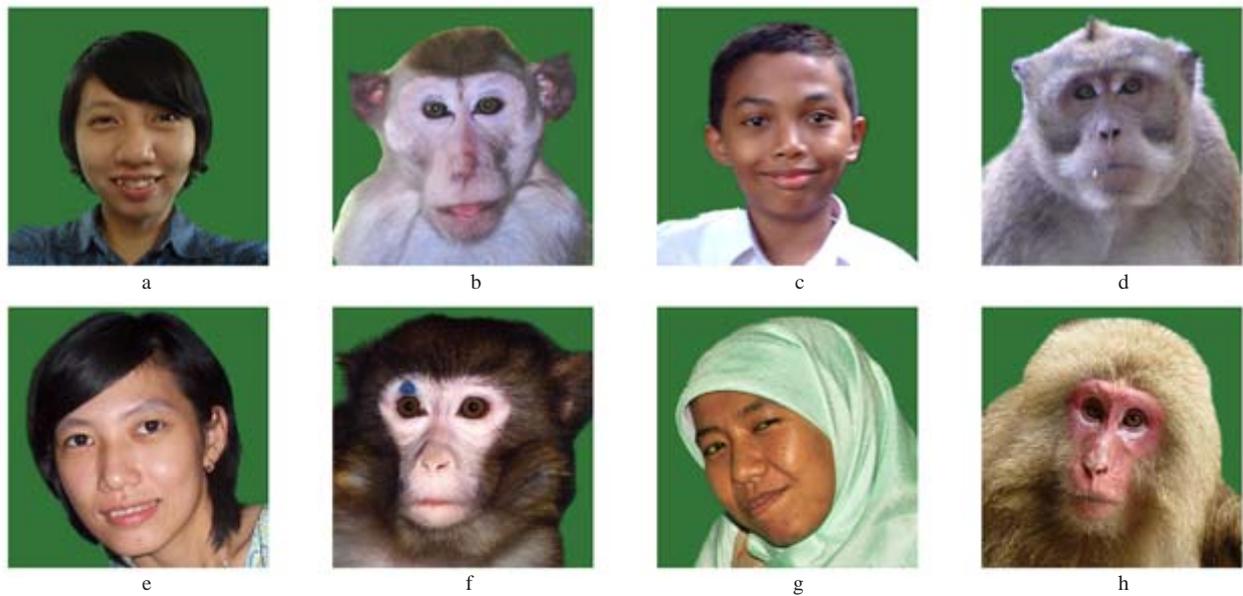


Figure 1. a and b were a pair of stimuli used in baseline trials. Both photos could be sample and matching stimuli, depended on the trials. These stimuli were also used as sample stimuli in test trials. c to h were example of matching stimuli in test trials. c, e, and g were the example of human stimuli. d, f, and h were example of monkey stimuli. d was example of photos of *M. fascicularis*, while f and h were example of *M. mulatta* and *M. fuscata*, respectively.

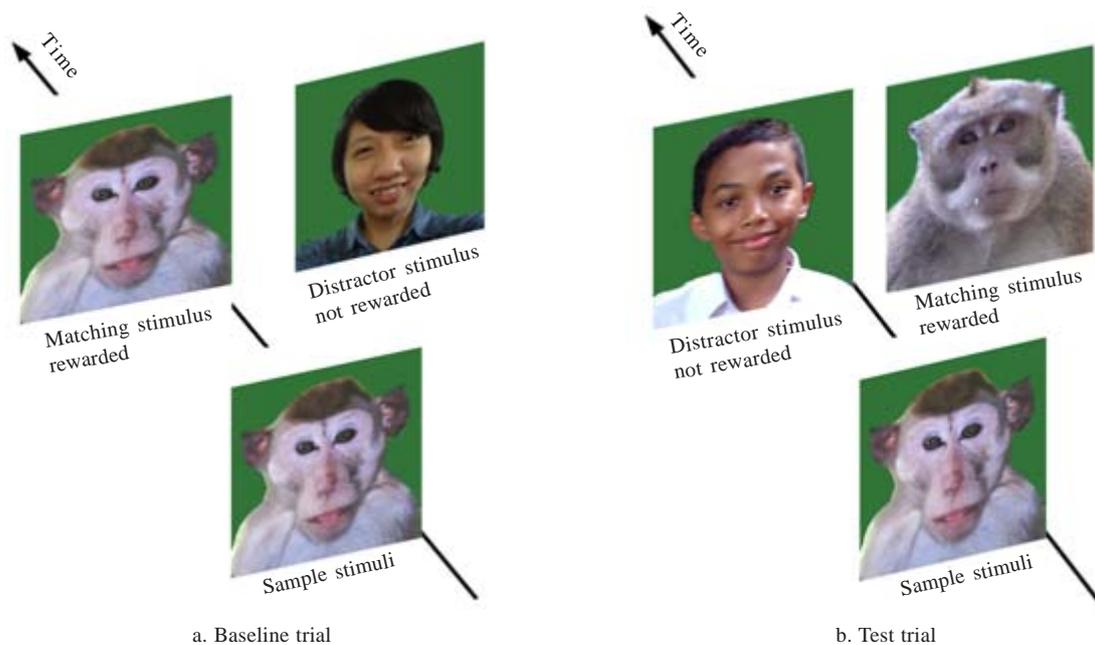


Figure 2. Schematic diagram of operant conditioning match-to-sample task of the experiment in baseline (a) and test trials (b). First, we showed sample stimulus to subject; after that, we showed a pair of stimulus consists of matching and distractor, respectively. Subject need to choose matching stimulus to get a reward. In baseline trials, matching stimuli is the same sample stimulus; in test trials, they were different.

**DISCUSSION**

Fujita and his coworkers (1993, 1995, 1997) found that monkeys see their conspecific longer compared to other species, and this lead to species discrimination. His works using various kinds of pictures of macaques give us an insight into how monkey learn to categorize via species discrimination. However, the methods that he used could be doubted, for example, there were several interpretation for how monkeys see conspecific in longer duration. First,

the longer reaction time might mean that monkey’s attention varied in response to different pictures regardless of their species membership. Second, they were already familiar with their own species since opportunities to learn facial properties of members of its own species exist in the life history of the monkeys. Thus, monkeys may prefer to look longer at a picture that is similar to their group mate and, by doing so, exclude a picture of another species. Although it can be considered as species discrimination, it’s still not clear if monkeys can

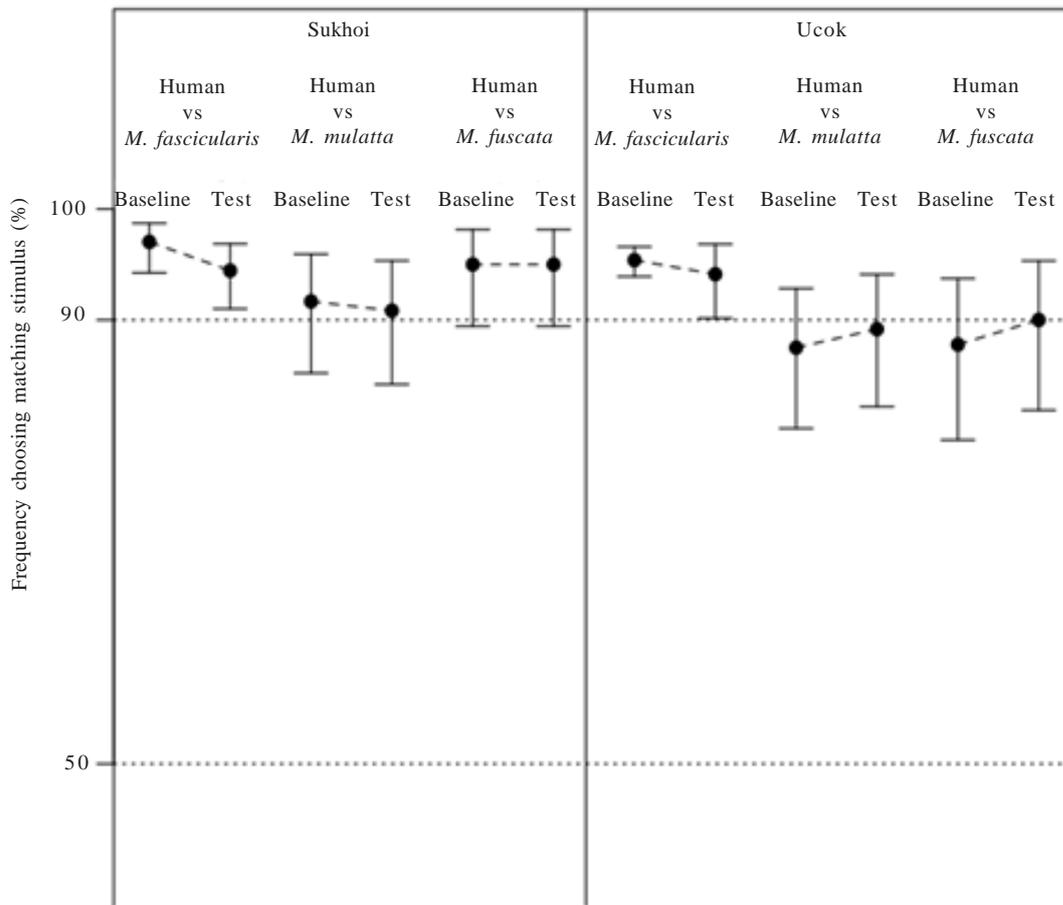


Figure 3. Sukhoi and Ucok performances in categorizing human and monkeys. The vertical lines show the 95% confidence level in the binomial test. The performance levels of both monkeys at test trials were not significantly different from the baseline trials (glmmpQL, P = 0.47, Venables & Ripley 2002).

discriminate various species outside of their own species. Third, since most experiments (Demaria & Thierry 1988; Fujita 1993; Fujita & Watanabe 1995; Fujita *et al.* 1997) did not control backgrounds of the stimuli, it is hard to conclude which part of the stimuli attracts the monkeys attention. The methods of matching to sample task we used might be more reliable than counting perceptual duration for several reasons. First, the training to do match to sample task made sure monkeys would choose the matching stimuli based on sample stimuli, not based on their preference nor by experience they learned from previous life history. This task solved the first and second problems of Fujita. More over, by controlling the background of stimuli, and the use of a specific body part (that is, face), we tried to reduce noise which may distract information deduced from performance of the monkeys. Therefore, our method should make a strong conclusion about the ability of categorization in *M. fascicularis*.

In the training phase, we introduced pictures of humans and monkeys to subjects. There were consistent similarities of physical properties within human and monkey pictures and consistent differences between them. It seemed like our subjects used these similarities and differences to create a concept of human that differs to the concept of monkeys. These concepts were used as basis to categorize pictures in the test phase. In this phase,

we changed the introduced pictures with new pictures so each human or monkey’s picture for sampling and matching stimuli were different in every trial. For monkeys, we used three different species of macaques. It is interesting that although our monkeys (*M. fascicularis*) never saw other species (*M. fuscata* and *M. mulatta*) for their entire life they categorized those species as monkeys instead of human which in captivity they see everyday. Because this categorization was based on perceptual similarity of physical attributes, this might be called as the basic level of categorization (Rosch 1976).

There are some physical properties that may give clues to create concepts in monkeys. First information is the shape. The global shape of human and monkey’s face are very different. While human face are oval, monkey’s faces are rounded with many hair on it. Another possibility is that the subjects detected the presence of the eye. This mechanism, called “eye direction detector”, is important to understand face perception (Baron-Cohen *et al.* 1999; Farroni *et al.* 2002). Given the eyes, its angles with nose and lips of both species are different. Those information may help subjects to recognize and discriminate between categorically human and monkey. The second is color. In this experiment, we used colored photographs. As seen in stimulus photos, compared to uniformly presented background color, the global color of the monkeys was

different to that of human. Our subjects might have used it as information to discriminate between human and monkey. This had been shown by Santos (2001) that colors are used as information to categorize object. Whether color is more dominant information than shape in categorization, is an open question. We should do experiments by taking off color from the photos and by blurring or resizing the stimuli to reduce the detailed information about facial properties of various species of primates. This should lead to further questions of whether monkeys have an ability to create more complex concepts because levels of categorization have positive correlation with the complexity of the concept. The fact that *M. fascicularis* could perform the basic category is interesting. If we manipulate the stimuli in basic category experiments, information needed to carry out the basic ability will be lost and/or changed. Monkey will be forced to generalize the information and associate it with concepts they already have. The association between available concepts in their brain may allow them to create a new concept with higher complexity (higher level of abstraction).

The ability of creating more complex concepts can also be tested by seeing their performance in discriminating between macaque species. All macaque species share many similar properties so they have to device a generalized information and compare it to specific properties of each species. The specific information are new concepts about each species based only on small differences in physical properties. We can test them by using various kinds of macaques excluding human photos as stimuli.

## REFERENCES

- Baron-Cohen S, Ring HA, Wheelwright S, Bullmore ET, Brammer MJ, Simmons A, Williams SCR. 1999. Social intelligence in the normal and autistic brain: an fMRI study. *European J Neurosci* 11:1891-1898. <http://dx.doi.org/10.1046/j.1460-9568.1999.00621.x>
- De Waal FBM, Van Hoof JARAM, Netto WJ. 1976. An ethological analysis of types of agonistic interaction in a captive group of Java-monkeys (*Macaca fascicularis*). *Primates* 17:257-290. <http://dx.doi.org/10.1007/BF02382785>
- Demaria C, Thierry B. 1988. Responses to animal stimulus photographs in stump-tailed macaques (*Macaca arctoides*). *Primates* 29:237-244. <http://dx.doi.org/10.1007/BF02381125>
- Farroni T, Csibra G, Simion F, Johnson MH. 2002. Eye contact detection in humans from birth. *Proc Natl Acad Sci* 99:9602-9605. <http://dx.doi.org/10.1073/pnas.152159999>
- Freedman DJ, Riesenhuber M, Poggio T, Miller EK. 2002. Visual categorization and the primate prefrontal cortex: neurophysiology and behavior. *J Neurophysiol* 88:929-941.
- Fujita K. 1993. Role of some physical characteristics in species recognition by Pigtail Monkeys. *Primates* 32:133-140. <http://dx.doi.org/10.1007/BF02381384>
- Fujita K, Watanabe K. 1995. Visual preference for closely related species by Sulawesi macaques. *Am J Primatol* 37:253-261. <http://dx.doi.org/10.1002/ajp.1350370307>
- Fujita K, Watanabe K, Widarto TH, Suryobroto B. 1997. Discrimination of macaques by macaques: the case of Sulawesi species. *Primates* 38:233-245. <http://dx.doi.org/10.1007/BF02381612>
- Hampson RE, Pons TP, Stanford TR, Deadwyler. 2004. Categorization in the monkey hippocampus: A possible mechanism for encoding information into memory. *Proc Natl Acad Sci B* 101:3184-3189. <http://dx.doi.org/10.1073/pnas.0400162101>
- Inoue T, Hasegawa T, Takara S, Lukats B, Mizuno M, Aou S. 2008. Categorization of biologically significant objects, food and gender, in rhesus monkeys I. Behavioral study. *Neurosci Res* 61:70-78. <http://dx.doi.org/10.1016/j.neures.2008.01.013>
- Mervis CB, Rosch E. 1981. Categorization of natural objects. *Ann Rev Psychol* 32:89-115. <http://dx.doi.org/10.1146/annurev.ps.32.020181.000513>
- Miller EK, Erickson CA, Desimone R. 1996. Neural mechanisms of visual working memory in prefrontal cortex of the macaque. *J Neurosci* 16:5154-5167.
- Rao SC, Rainer, Miller K. 1997. Integration of what and where in the primate prefrontal cortex. *Science* 276:821-824. <http://dx.doi.org/10.1126/science.276.5313.821>
- Rosch E, Mervis CB, Gray WD, Johnson DM, Boyes-Braem P. 1976. Basic objects in natural categories. *Cogn Psychol* 8:382-439. [http://dx.doi.org/10.1016/0010-0285\(76\)90013-X](http://dx.doi.org/10.1016/0010-0285(76)90013-X)
- Santos LR, Hauser MD, Spelke ES. 2001. Recognition and categorization of biologically significant objects by rhesus monkeys (*Macaca mulatta*): the domain of food. *Cognition* 82:127-155. [http://dx.doi.org/10.1016/S0010-0277\(01\)00149-4](http://dx.doi.org/10.1016/S0010-0277(01)00149-4)
- Tanaka. 2001. Discrimination and categorization of photographs of natural objects by chimpanzees (*Pan troglodytes*). *Anim Cogn* 4:201-211.
- Venables WN, Ripley BD. 2002. Modern Applied Statistics with S. Fourth edition. USA: Springer.
- Yoshikubo S. 1985. Species discrimination and concept formation by rhesus monkeys (*Macaca mulatta*). *Primates* 26:285-299. <http://dx.doi.org/10.1007/BF02382403>