Contrafreeloading and the value of control over visual stimuli in Japanese macaques (*Macaca fuscata*)

Tadatoshi Ogura[a,b]

[a] Primate Research Institute, Kyoto University, Inuyama, Aichi 484-8506, Japan

[b] Japan Society for the Promotion of Science, Chiyoda, Tokyo 102-8472, Japan

Correspondence to:

Tadatoshi OGURA

Primate Research Institute, Kyoto University, 41 Kanrin, Inuyama, Aichi 484-8506, Japan

Tel: +81-568-63-0567

Fax: +81-568-62-2428

E-mail: ogura@pri.kyoto-u.ac.jp

Abstract

Contrafreeloading, which means that animals work for food even though identical food is freely available, has been reported in animals' feeding behavior. This phenomenon has been assumed to be explained by the information primacy model, in which the information about a food resource as well as the food itself is valuable for animals. This study confirmed a contrafreeloading-like phenomenon using movies as rewards rather than food in Japanese macaques (*Macaca fuscata*) and investigated the motivational system that exists behind contrafreeloading. In the experiment, movies that were presented dependently on subjects' responses (earned movies) and movies that were presented automatically (free movies) were supplied simultaneously. The subjects continued to make responses to obtain the presentation of the earned movies although identical movies were available as free movies. These results provide the first evidence of contrafreeloading that occurs with movie rewards. The motivation maintaining the contrafreeloading behavior for movies may be control over the environment according to the competence theory.

Keywords: Contrafreeloading; Control over environment; Japanese macaque; Movie; Sensory reinforcement

1. Introduction

Contrafreeloading was first reported by Jensen (1963). This is a phenomenon in animals' feeding behavior according to which animals will work (e.g. press a lever) for "earned" food even though identical "free" food can easily be obtained from a nearby dish (see review in Inglis et al. 1997). For example, rhesus macaques worked for biscuits from a food puzzle, from which skillful manipulation with the fingers was required to retrieve the biscuits, although they were also available from an ordinary food box (Reinhardt 1994). This phenomenon has also been found in laboratory pigeons (Neuringer 1969), crows (Powell 1974), laboratory rats (Jensen 1963), grizzly bears (McGowan et al. 2010), and chimpanzees (Menzel 1991). Thus, contrafreeloading exists commonly in a wide variety of taxa in animals.

Contrafreeloading appears to contradict a basic tenet of most learning, motivation, and optimal foraging theories, namely that animals strive to maximize the ratio of reward, or benefit, to effort, or cost (Inglis et al. 1997). Inglis et al. (1997) discussed the motivational systems that might exist behind contrafreeloading. They suggested that one possible mechanism to develop contrafreeloading might be an information primacy model. According to this model, animals' work for earned food is motivated partly by the food itself, and partly by the information about the food resource. The behavior updating their estimate of the profitability of an uncertain food resource is adaptive because some unpredictable environmental change could turn it into the optimal place to feed. Contrafreeloading might be explained by the information primacy model and the motivation to gather information about the food resource.

The information primacy model was established based on the fact that contrafreeloading should occur under conditions of using food as rewards. Also, some sensory stimuli can work as incentives for behavior in the sensory reinforcement paradigm (Matsuzawa 1981). Primates can recognize movies' contents (Morimura 2006; Morimura and Matsuzawa 2001). So far, contrafreeloading has been investigated using only food as rewards in nonhuman animals. Here, using a sensory stimulus as a reward, I studied a contrafreeloading-like phenomenon under sensory reinforcement, which enabled me to approach the motivational system of contrafreeloading and might suggest another explanation for contrafreeloading. If contrafreeloading for sensory rewards occurs, animals will work for such stimuli even though identical stimuli can be obtained without such work.

2. Methods

2.1. Subjects

The subjects were three male Japanese macaques (*Macaca fuscata*) named Romio, Tim, and Sabu. They were living at the Primate Research Institute of Kyoto University. They were raised by human caretakers because of their mother's death or rejection. Romio (9 years and 3 months old when the experiment was started) was hand-reared from birth. Tim (9 years and 7 months old) was reared by his biological mother at first; however, he was hand-reared by his caretakers after the age of three months. Sabu (approximately 2 years old) was born in the wild. Starting a few months after his birth, he was protected and reared by human caretakers because he was found to be alone and emaciated. The subjects had experienced some psychological studies before this experiment (Murai and Tomonaga 2009; Murai et al. 2004; Ogura and Matsuzawa, unpublished data). At the beginning of this study, all of the subjects had lived in individual cages (175 cm high × 85 cm wide × 80 cm long) for more than 1 year. Therefore, the visual environments of the subjects were restricted. In this study, touch responses of the subjects made on a display to obtain the presentation of movies could be maintained by providing movie rewards (Ogura and Matsuzawa, unpublished data). During this experiment, the monkeys could see other monkeys in the same room. The monkeys were fed monkey pellets and sweet potatoes daily at about 10:00 a.m. and 5:00 p.m. They could drink water ad libitum. Routine care of the monkeys and experiments were performed in accordance with the guidelines of the Primate Research Institute, Kyoto University.

2.2. Apparatus

Two computer-controlled touch-sensitive displays were used in this study. During the experiment, each monkey's home cage was divided into an upper and a lower compartment by inserting a metal board horizontally 50 cm into the cage (Fig. 1). The monkey could move freely between these two compartments. A touch-sensitive display (30.4 cm × 22.8 cm) (model L352T-C-BK, Eizo Nanao, Ishikawa, Japan and model CV516PJ, Totoku electric, Tokyo, Japan) was attached to each compartment. The monkeys were allowed to touch the displays through the bars of their cages. The apparatus was attached only during the experiment and was removed at other times.

Fig. 1 about here

2.3. Stimuli

The stimuli were 21.1 cm × 14.2 cm digitized color movies (720 × 480 pixels, MPEG 1 - Layer 2 files) (Fig. 2). They did not include sound. The duration of each movie was 9.5 s. Each stimulus set was composed of 10 movies showing humans and

10 movies showing animation characters, because the monkeys showed preferences for these movies in our previous experiments (Ogura and Matsuzawa, unpublished data). The humans in the movies were novel persons for the monkeys. The behaviors of the humans in the movies were walking, working, and conversation with another human. Computer-generated humans were used as the animation movies. The backgrounds of the characters were plain vivid colors. I used four sets of stimuli, and therefore, the total number of stimuli was 80.

Fig. 2 about here

2.4. Procedures

In the experiment, both displays showed movies that could be viewed according to different behaviors of the monkeys, namely “free” movies and “earned” movies. As the free movies, one of the displays showed movies in a random order within a stimulus set continuously irrespective of the monkey's response. A session began with a blank screen for 0.5 s with a beep sound, and then, the movie was played for 9.5 s. This routine was continued until the end of the session. As the earned movies, the other display showed movies under a sensory reinforcement paradigm with a conjugate reinforcement condition (Fujita and Matsuzawa 1986; Matsuzawa 1981; Rovee-Collier and Gekoski 1978). In this paradigm, the amount of the reinforcer varies depending on the subject’s response. A session began with the appearance of a starting stimulus (a red, blue, or green square, 3.7 cm × 3.7 cm) at the center of the display. After the subject touched the starting stimulus, a beep sound was played and the starting stimulus disappeared. One second after that, the same movie as the free movie being shown at that same moment was presented in the center of the display as the earned movie. The earned movie was presented as long as the subject touched the movie. If the subject had not touched the movie for 3 s, the beep sound was played and the movie disappeared. One second after that, the start stimulus was presented at the center of the display again. The positions of the two movies (the upper display or the lower display) were randomly changed among the sessions.

In this procedure, subjects' touch responses to the displays were recorded by the computer that controlled the presentation of the movies. Also, the subject’s position in the cage was video recorded.

The sessions started between 2:00 p.m. and 4:30 p.m. and continued for 30 min. Each subject experienced 20 sessions of the experiment, with one session per day.

2.5. Statistical analyses

The duration that the subject stayed in each compartment was measured using instantaneous sampling with a 1-s interval (Altmann 1974) from the video record. The effects of the presentation procedure on the duration that the subject stayed in each compartment were analyzed using a Generalized Linear Mixed Model (GLMM) (lmer, lme4 library, the freeware package R, Version 2.9.2; R Development Core Team 2009); the model was constructed using a Poisson distribution because the number of the sampling points at which the subject stayed in each compartment was non-negative count data (Dobson 2002). The presentation procedure (free/earned) and the position of the display (upper/lower) were the fixed factors. Individual was included as a random factor. Within the selected model, the numbers of the sampling points at which the subject stayed in each compartment were compared in each subject by using the Wilcoxon rank sum test because the normalities of these data were not confirmed by the Kolmogorov-Smirnov one-sample test ($P < 0.10$). This statistical test provided only an informal test of significance because the data points for a single individual were not independent. Each data point represented one session in each presentation procedure.

3. Results

Figure 3 shows the numbers of touch responses to the starting stimulus of the earned movies in each session of each subject. For 20 sessions, the subjects kept touching the starting stimulus, and the presentations of the earned movies were maintained. The proportions of the numbers of touch responses to the starting stimulus, the earned movies, and the black area surrounding the starting stimulus and the movie were 92.4, 6.4, and 1.3 %, respectively. All touch responses were momentary. Sustained touch responses were rarely observed.

Fig. 3 about here

The duration of staying in each compartment was different depending on the presentation procedure. The mean number of sampling points spent staying in each compartment is shown in Table 1. The Akaike Information Criterion (AIC; Akaike 1974, Dobson 2002) can be used to compare models with different numbers of fitted parameters. The model with the lower AIC is preferred. The model including both the presentation procedure and the playing position as the fixed factors showed the smallest AIC, although all models explained the data well (Table 2). The likelihood ratio test showed a significant difference between the model including the presentation procedure and the model without it as the fixed factor ($\chi^2 = 752.54$, $P < 0.001$). The presentation procedure was a factor affecting the duration of staying in each compartment. Within the selected model, however, only Romio showed a significant difference of the staying duration between the compartments of the earned movies and the free movies (Romio: $W = 110$, $P < 0.05$, Tim: $W = 160$, $P = 0.29$, Sabu: $W = 211$, $P = 0.78$).

Table1 and Table 2 about here

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4. Discussion

Here, the contrafreeloading phenomenon was tested using movie stimuli in monkeys. In this experiment, the subject touched the starting stimulus to obtain the presentation of earned movies, although the identical movies were being played as free movies. Any deviation from complete preference for the free reward suggests some level of contrafreeloading (Inglis et al. 1997). Primates spontaneously manipulate some novel objects even without any incentive (Ehrlich 1970). In the present study, however, the subjects kept making responses to obtain the presentation of earned movies continuously throughout the series of sessions even though the manipulandum was a visual stimulus, not a real object. This finding demonstrated a contrafreeloading-like behavior for movie rewards in Japanese macaques.

The presentation procedure might have no significant effect on the value of each compartment. Regarding the duration of staying in each compartment, Romio stayed significantly longer in the compartment with the earned movies than in that with the free movies. Tim and Sabu showed no significant difference in the time stayed between the two compartments. None of the subjects stayed preferentially in the compartment with the free movies. Therefore, only for Romio, the compartment of earned movies had higher value than that of free movie. At least, the free movies did not increase the value of the corresponding compartment.

This study showed that contrafreeloading-like behavior occurs in response to visual stimuli rewards in Japanese macaques. This implies that control over the environment may be the motivation behind the earned reinforcers rather than information useful for locating an alternative food source in the event of a change in the environment. Contrafreeloading is related to the value of control, according to the competence theory (White 1959), which posits that behavior is primarily directed toward controlling and modifying the environment and that such behavior is self-reinforcing (Singh 1970; Singh and Query 1971). Some previous studies revealed the empirical evidences of the value of control over environment for monkeys. In

Washburn et al. (1991), the performance of rhesus monkeys on computer tasks that were selected by themselves significantly exceeded performance on identical tasks when assigned by the experimenter. In Hanson et al. (1976), the plasma cortisol level, the stress state indicator, of rhesus monkeys that had control over high intensity noise was significantly lower than that of the monkeys that received identical amounts of high intensity noise but which had no control over the noise. These studies showed the value of control over environment for monkeys, which seems to work as an incentive to the contrafreeloading behavior. The findings of this study, however, do not necessarily contradict the information primacy model, because contrafreeloading for movies might have a different mechanism from contrafreeloading for food. This study provides the first evidence that contrafreeloading occurs with movie rewards.

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6. References

Akaike H (1974) A new look at the statistical model identification. IEEE Trans Automat Contr 19:716-723

Altmann J (1974) Observational study of behavior: Sampling methods. Behav Brain Res 49:227-267

Dobson AJ (2002) An introduction to generalized linear models - second edition. Chapman & Hall, London

Ehrlich A (1970) Response to novel objects in three lower primates: greater galago, slow loris, and owl monkey. Behaviour 37:55-63

Fujita K, Matsuzawa T (1986) A new procedure to study the perceptual world of animals with sensory reinforcement - recognition of humans by a chimpanzee. Primates 27:283-291

Hanson JD, Larson ME, Snowdon CT (1976) The effects of control over high intensity noise on plasma cortisol levels in rhesus monkeys. Behav Biol 16:333-340

Inglis IR, Forkman B, Lazarus J (1997) Free food or earned food? A review and fuzzy model of contrafreeloading. Anim Behav 53:1171-1191

Jensen GD (1963) Preference for bar pressing over freeloading as a function of number of rewarded presses. J Exp Psychol 65:451-454

Matsuzawa T (1981) Sensory reinforcement: the variety of reinforcers. Jpn Psychol Rev 24:220-251 (in Japanese with English summary)

McGowan RTS, Robbins CT, Alldredge JR, Newberry RC (2010) Contrafreeloading in grizzly bears: implications for captive foraging enrichment. Zoo Biol 29:484-502

Menzel EW (1991) Chimpanzees (*Pan troglodytes*) - problem seeking versus the bird-in-hand, least-effort strategy. Primates 32:497-508

Morimura N (2006) Cognitive enrichment in chimpanzees: an approach of welfare entailing an animal's entire resources. In Matsuzawa T, Tomonaga M, Tanaka M (eds) Cognitive development in chimpanzees, Springer-Verlag, Tokyo, pp 368-391

Morimura N, Matsuzawa T (2001) Memory of movies by chimpanzees (*Pan troglodytes*). J Comp Psychol, 115:152-158

Murai C, Tomonaga M (2009) Fear responses of Japanese monkeys to scale models. J Ethol 27:1-10

Murai C, Tomonaga M, Kamegai K, Terazawa N, Yamaguchi MK (2004) Do infant Japanese macaques (*Macaca fuscata*) categorize objects without specific training? Primates 45:1-6

Neuringer AJ (1969) Animals respond for food in the presence of free food. Science 166:399-401

Powell RW (1974) Comparative studies of preference for free vs response-produced reinforcers. Anim Learn Behav 2:185-188

Reinhardt V (1994) Caged rhesus macaques voluntarily work for ordinary food. Primates 35:95-98

Rovee-Collier CK, Gekoski MJ (1978) The economics in infancy: a review of conjugate reinforcement. In Reese HW, Lipsitt LP (eds) Advances in child development and behavior, Vol. 13. Academic Press, New York, pp 195-255

Singh D (1970) Preference for bar pressing to obtain reward over freeloading in rats and children. J Comp Physiol Psychol 73:320-327

Singh D, Query WT (1971) Preference for work over "freeloading" in children. Psychon Sci 24:77-79

Washburn DA, Hopkins WD, Rumbaugh DM (1991) Perceived Control in Rhesus-Monkeys (*Macaca mulatta*) Enhanced Video-Task Performance. J Exp Psychol Anim Behav Process 17:123-129.

White RW (1959) Motivation reconsidered - the concept of competence. Psychol Rev 66:297-333

7. Figure Captions

Fig. 1 A monkey's home cage was divided into two compartments, and a touch-sensitive display was attached to each compartment. During the experiment, the monkeys were allowed to move between the compartments and to touch the displays

Fig. 2 Examples of the stimulus movies. These photographs show the images at 0, 3, 6, and 9 s from samples of a human movie and an animation movie

Fig. 3 Numbers of subjects' touch responses to the starting stimulus of the earned movies in each session. S1, S2, S3, and S4 mean Stimulus set 1, 2, 3, and 4, respectively

Table 1

Mean (± SE) number of sampling points spent staying in each compartment

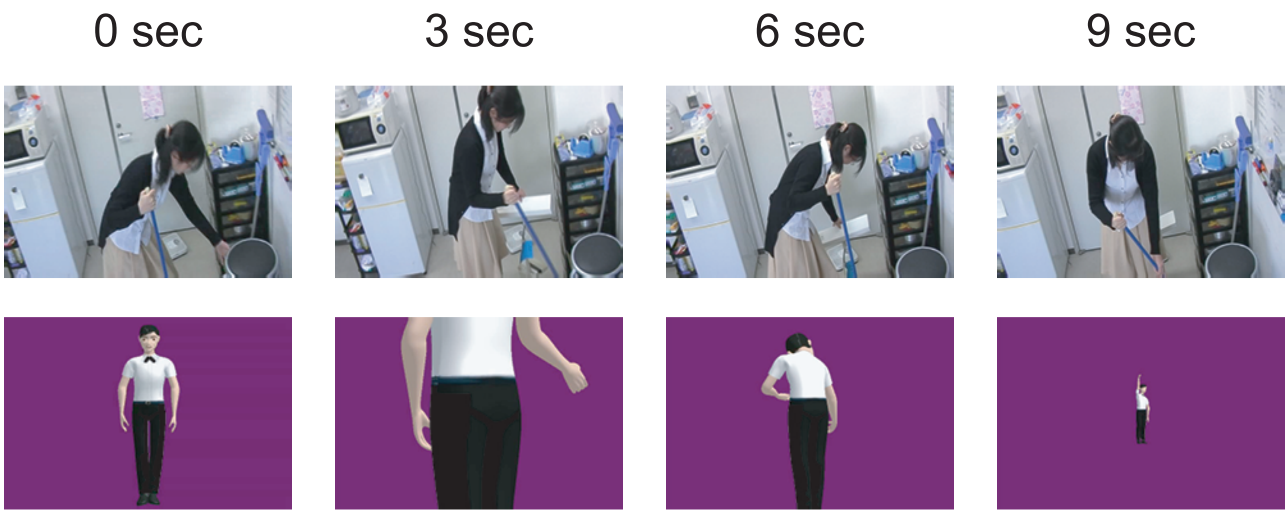
Subject	Free movie	Earned movie
Romio	680.6	1,119.5
	(125.2)	(125.2)
Tim	858.7	941.3
	(168.4)	(168.4)
Sabu	935.5	864.5
	(97.5)	(97.5)

Table 2

Influence of the variables (i) procedure (free/earned), (ii) position (upper/lower), and (iii) procedure and position on the staying duration

Staying duration	*z*	*P*	Model AIC
(i) procedure	27.4	< 0.001	56348
(ii) position	172.4	< 0.001	21119
(iii) procedure	27.4	< 0.001	20369
position	172.4	< 0.001	

The variable “individual” was incorporated as a random effect in all models


0 sec
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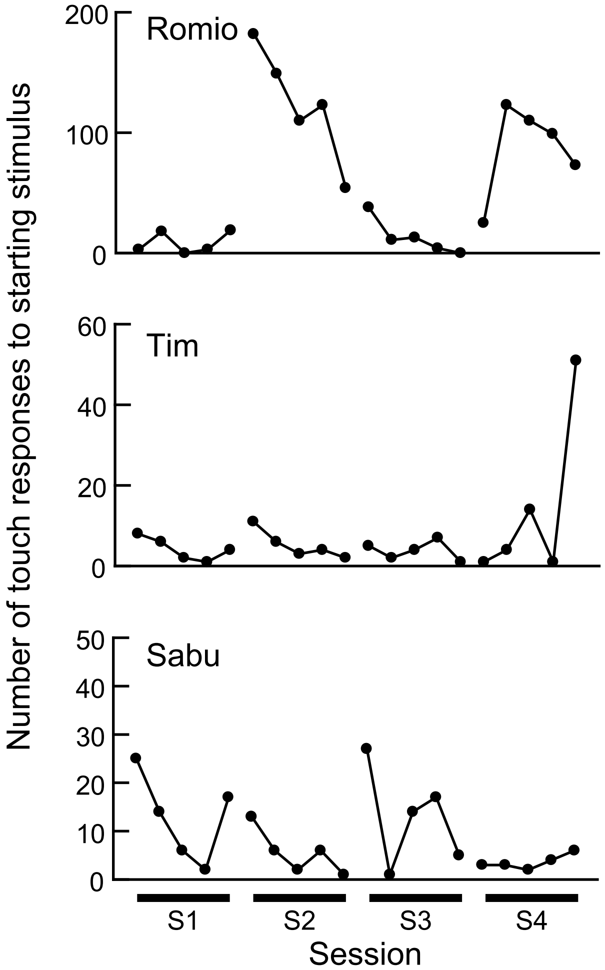
Number of touch responses to starting stimulus
Romio
200
100
0
Tim
60
40
20
0
Sabu
50
40
30
20
10
0
S1
S2
S3
S4
Session