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Kyoto University
Use of video system and its effects on abnormal behaviour in captive Japanese macaques

(Macaca fuscata)

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Abstract

Although nonhuman primates have highly developed visual cognitive abilities, they have few opportunities to exert such abilities in captivity. Video presentation can reproduce multiple features of the complex real visual world. Therefore, video presentation can be expected to act as environmental enrichment for captive primates. The present study evaluated the enriching effects of novelty and content of videos as well as control over videos using newly developed technology including network-shared YouTube videos and an infrared distance sensor.

Baseline data were obtained for 10 days without video display and then 10 days with the display showing no videos in four individually housed monkeys and six pair-housed monkeys. The monkeys were then exposed to videos of conspecifics, people, and animation and observed for 30 days. In some days, the monkeys had control over videos such that videos played only when subjects sat directly in front of the display. Observations were then taken for an additional 10 days with no videos. Behaviors such as time watching videos, abnormal behavior, and time spent in front of display were recorded for 60 min per day using instantaneous sampling with a 30-s interval. Monkeys displayed fewer abnormal behaviors when the video was playing (individually housed: 11.3 sampling points, pair-housed: 7.7 sampling points) than when the video was not playing (individual housed: 22.5 sampling points, pair-housed: 10.8 sampling points) ($P < 0.001$). The abnormal behaviour over the course of the observation days
showed no evidence of habituation to videos. The frequency of watching the videos and abnormal behaviour differed depending on the presented contents of videos ($P < 0.001$). The subjects spent more time in front of the display in the days in which they could control the videos (individually housed: 89.1 sampling points, pair-housed: 17.6 sampling points) than in those in which they had no control (individually housed: 70.1 sampling points, pair-housed: 7.3 sampling points) ($P < 0.001$), suggesting that they were preferentially choosing to watch the videos. These results suggest that video presentation can be a useful technique to decrease abnormal behaviour of captive Japanese macaques. The content and controllability over videos were influential on their behaviour, suggesting that implementation of video enrichment that includes conspecifics videos and controllability over videos can improve animal welfare. Implementation based on an understanding of species-specific characteristics can contribute to effective environmental enrichment.

**Keywords:** Animal welfare; Cognition; Control over environment; Japanese macaques; Video
1. Introduction

1.1. Video presentation as environmental enrichment for captive nonhuman primates

Environmental enrichment can be implemented in various forms (Bloomsmith, Brent, and Schapiro, 1991). The decision about which environmental enrichment is optimal depends on the species-specific characteristics of the animals (Kreger et al., 1998). Since primates have highly developed visual cognitive abilities, video presentation is widely used to provide sensory and cognitive enrichment for primates in research facilities (Reinhardt, 2010) and zoos (Clay et al., 2011). Some previous studies investigated the effect of video presentation on the welfare of captive primates. Platt and Novak (1997) showed that rhesus macaques became more active as a result of video-stimulation. The monkeys engaged in behaviours related to exploration of the environment more frequently during video-stimulation. In chimpanzees, television can attract the animals’ interest even after 2 years of exposure (Brent and Stone, 1996). Individually housed chimpanzees were more likely to attend to video presentations than socially housed chimpanzees (Bloomsmith and Lambeth, 2000). Even in a zoo setting, video presentation can still be useful. Silverback western lowland gorillas spent much time watching a monitor when it displayed videos (Maloney et al., 2011). These studies indicated that video presentation may be a useful enrichment technique for captive primates.

Although video enrichment has been shown to have some effect on the welfare of
primates, its ability to be adjusted to species-specific needs remains to be tested. In the present experiment, key components affecting the enriching effect of videos, such as the novelty and contents of videos and the controllability over videos were examined by using newly developed technology.

1.2. Novelty and contents of videos

Novelty and contents have been studied as key properties of videos that might affect animals’ preference in some previous studies. It is well known that animals become habituated to sensory stimuli which are presented repeatedly and dishabituated to new stimuli (e.g., Koba and Izumi, 2008; Murai et al., 2004; Quinn et al., 2002). Captive primates rapidly become habituated to videos that are presented repeatedly (Bloomsmith and Lambeth, 2000; Lee et al., 2011; Ogura and Matsuzawa, 2012; Platt and Novak, 1997). Novelty affects the attractiveness of videos, and therefore might influence their effect as environmental enrichment for primates. In other words, animals might prefer to watch novel videos than familiar ones.

The content of visual stimuli has also been found to affect the preference of primates. In cognitive studies, bonnet macaques (Andrews and Rosenblum, 2001; Brannon et al., 2004) and rhesus macaques (Washburn et al., 1997) preferred to watch videos with particular contents over other videos. Despite the consistent results from these cognitive studies, other studies examining the effect of contents on behaviour have had mixed results. While some studies
(Bloomsmith and Lambeth, 2000; Maloney et al., 2011; Platt and Novak, 1997) found that videos which were supplied as visual enrichment did not affect the behaviour, another study (Ogura and Matsuzawa, 2012) found that videos with varying content did differentially affect the behaviour in Japanese macaques. Thus, the effects of the contents of visual stimuli have not been entirely consistent in enrichment compared to cognitive studies.

The present study investigated the effects of novelty and content of videos on the welfare of captive Japanese macaques. To supply a large number of novel videos showing various contents, this study tested the use of videos shared on the internet by anonymous people.

1.3. Controllability over videos

How the video is presented may also affect its usefulness as enrichment. Many studies have found that having control over the environment is important for monkeys. In Washburn et al. (1991), rhesus monkeys performed significantly better on computer tasks they selected compared to identical tasks assigned by the experimenter. Hanson et al. (1976) found that rhesus monkeys that had control over a high-intensity noise had significantly lower plasma cortisol concentrations than monkeys exposed to identical amounts of high-intensity noise but without any control. Another phenomenon is contrafreeloading, which experimentally evaluates the value of control as well as reward which can be obtained as a result of control (Inglis et al., 1997; Sambrook and Buchanan-Smith, 1997). This phenomenon was confirmed by using a
visual reward (Ogura, 2011) as well as a food reward (Menzel, 1991; Reinhardt, 1994) in primates. These studies provided empirical evidence of the value of control over the environment for primates.

To make easy for monkeys to understand a contingency between their behaviour and videos, this study utilized a new technique that allowed the monkeys to control videos by altering their location in their cage.

2. Methods

2.1. Subjects

The subjects were 10 adult Japanese macaques living at the Primate Research Institute of Kyoto University. Two of the subjects were individually housed males, each 11 years of age, two were individually housed females, 10 and 13 years of age, and the other six were housed in three, male-female pairs. The ages of the pair-housed subjects were not known because they were born in the wild, but they were fully matured. The individually housed subjects had been maintained in cages (80 cm high × 80 cm wide × 60 cm long) for more than 2 years. Because of limitations of available space, the subjects could not see other monkeys during this study. The pair-housed subjects were maintained in cages (200 cm high × 137 cm wide × 115 cm long) that allowed them to see other monkeys in the same room. All subjects were habituated to the
observer for at least 2 weeks before the start of observations. The monkeys were fed monkey pellets and sweet potatoes daily at about 10:00 h. and 17:00 h and had access to water ad libitum.

Routine care of the monkeys and experiments were performed in accordance with the Guide for the Care and Use of Laboratory Primates produced by Primate Research Institute, Kyoto University.

2.2. Apparatus

The apparatus in this experiment consisted of a laptop computer connected to a colour display (30.4 cm × 22.8 cm) (model LCD-A15GS, I-O DATA, Ishikawa, Japan), and an infrared distance (IRD) sensor. The computer displayed the different content of videos according to the experimental conditions and turn on and off the videos based on signals from the IRD sensor. The IRD sensor consisted of a sensor module (GP2Y0A21YK0F, Sharp, Osaka, Japan) and a microcomputer (Arduino Duemilanove, Smart Projects, Turin, Italy). The IRD sensor emitted infrared laser light to the centre of the bottom of the cage and calculated the distance between the apparatus and the subject who cut off the infrared laser light by sitting in front of it. The whole apparatus was small enough to be carried on a cart. It was set up 50 cm in front of the cage only during the experiment and was removed at other times not to preclude animal access or husbandry activities.

2.3. Videos
The apparatus played videos from the YouTube website (http://www.youtube.com/). At the beginning of each experimental session, the YouTube site was searched using the keyword “Japanese macaques”, “people”, or “animation” and the results were sorted by uploaded date. Thirty of the most recently uploaded video clips were shown in a day. Because the novelty of the videos affects the macaques’ interest in the videos (e.g., Ogura and Matsuzawa, 2012), the search was conducted at the beginning of every session to make a unique video set with newly uploaded video clips. Any video clips that had already been used in past session were replaced with other, older video clips that had not been used.

Each YouTube video was played in full screen mode for no longer 1 min. After one video clip finished, the next one in the video set was played. The first clip in the video set was played again after all other video clips were finished. All video clips were played at least twice in a day. The construction of the video set and the playback of the video clips were automatically controlled by the computer program produced by the author. The sound from the video clips was omitted from the playback.

2.4. Procedures

Each subject experienced 60 observation sessions with one session per day. The sessions started between 12:30 h. and 17:00 h. and continued for 60 min. The observation consisted of four experimental phases conducted in the following order; the no-monitor 1, blank
monitor, monitor with video, and no-monitor 2. In the no-monitor phases, baseline data were collected without the presence of the apparatus for 10 days. After the first no-monitor phase, monkeys were habituated to the physical presence of an apparatus with a blank monitor near their cages (“blank monitor phase”) for 10 days. After that, the “monitor with video” phase was started in which video clips were played on the monitor for 30 days. The “monitor with video” phase consisted of two types: controllable and non-controllable. A different kind of video (“Japanese macaques”, “people”, or “animation”) was used for each of the two types, for a total of six conditions of combinations of video content and controllability. In the controllable condition, the videos were shown on the display only when the subject cut the laser light of the IRD sensor by staying at the centre of the front half of the cage (i.e., the “video zone”). When monkeys want to watch something, it is a very natural response to reach toward it. When the subject left this zone, the videos turned off. Therefore, the duration of the video presentation depended on the subject’s location in the cage. In the non-controllable condition, the videos were shown on the display continuously irrespective of the monkey’s location in the cage. Each condition consisted of five successive days. The order of the conditions was randomized among the subjects. In the final phase, a second no-monitor phase was conducted again for 10 days.

During this testing procedure, the behaviour and cage location of each subject was recorded by the author who directly observed the subjects from behind the apparatus. The data
were collected using an instantaneous sampling method with a 30-s interval (Altmann, 1974). Thus, the number of sampling points per day was 120. There were seven categories of behaviours: abnormal behaviour, feeding, locomotion, self-grooming, social behaviour, watching video, and resting (Table 1). The definitions of abnormal behaviours were based on Mallapur and Choudhury (2003) and Walsh et al. (1982). For the location data, each cage was divided into two zones: the “video zone” defined as the centre of the front half of the cage and the “non-video zone” (the rest of the cage). While the two zones were different in size, video zones were the same for both individual and pair-housing cages. This does not affect the analyses because the duration of time spent in the video zone in the different conditions was compared within the individually housed or pair-housed subjects. The same observation procedure was employed in both individually housed and pair-housed subjects.

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Table I about here

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2.5. Statistical analyses

The number of sampling points (frequency) for which the subjects engaged in each behavioural category and stayed in the video zone were analyzed using a Generalized Linear Mixed Model (GLMM) (lmer, lme4 library, the freeware package R, Version 2.14.2; R
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Development Core Team, 2012). This method is an extension of the ANOVA technique, incorporating and quantifying multiple sources of variation and also allowing for non-normal distributions for the response variable. Therefore, the GLMM technique can analyze repeated measures data that are not normally distributed. The models were constructed using a Poisson distribution because the numbers of sampling points were non-negative count data (Dobson, 2002). One data point indicated the score of each behaviour in each day. The data could have been analyzed as proportions of the total counts of a day under the Binomial distribution, but the residual plots from each analysis indicated the models using the Poisson distribution were a better fit with the observation data than the models using the Binomial distribution. In analyses of the effect of the video presentation on the frequency of each behaviour, the number of each behaviour in each day was the response variable. The model contained the experimental phase as the fixed factor. To test the effect of habituation to the video presentation, as well as the contents and controllability of videos, the models contained the frequency of subjects’ behavior and the frequency at which the subject stayed in the video zone as the response variables. The fixed factors of the models were the observation day, the content, and the controllability of videos. The individual, sex, and pairing (for the pair-housed subjects) were contained in all GLMM analyses as the random factor to control for repeated measures. Therefore, the individually housed subjects and pair-housed subjects were analyzed separately. The models
including the target fixed factor and the models without it were compared based on the Akaike
Information Criterion (AIC; Akaike, 1974; Dobson, 2002). The model with the lower AIC is
preferred. The significance of difference of fitted models was tested using a likelihood ratio test.
For multiple comparisons of the fixed factors, the models which contained every combination of
the fixed factors were also compared.

3. Results

3.1. The effect of video presentation on behaviour

The frequency of abnormal behaviour was the lowest during the “monitor with video”
phase for both individually housed and pair-housed subjects. Fig. 1 shows the frequency of
abnormal behaviour in all four experimental phases. The models that included the experimental
phase as the fixed factor showed significantly lower AICs than the models that did not include it
(Table 2). For both single and pair-housed subjects, the models that included the “monitor with
video” phase at a different level from the other three phases showed the lowest AICs (2773 and
1822) in the multiple comparisons of the experimental phases. This result suggests that the
“monitor with video” phase affected the frequency of abnormal behaviour differently than the
other three phases for both the individually housed and pair-housed monkeys.
Fig. 1 and Table 2 about here

In the analyses of the other behavioural categories, only resting behaviour for the
individually housed subjects was affected by the video presentation. The frequency of resting
behaviour in the “monitor with video” phase (45.1 ± 1.6 sampling points) was lower than in the
other experimental phases (no-monitor 1: 54.6 ± 3.0, blank monitor: 46.3 ± 2.8, no-monitor 2:
47.1 ± 2.9). The model that included the experimental phase as a fixed factor (AIC: 1593)
showed a significantly lower AIC than the model without it (AIC: 1643) ($\chi^2 = 56.01, P < 0.001$).
The models that included the “monitor with video” phase at a different level from the other three
phases showed the lowest AIC (1591) in the multiple comparisons of the experimental phases.
This result indicates that the “monitor with video” phase affected the frequency of resting
behaviour differently than the other three phases for the individually housed monkeys. The other
behaviours were not affected by the video presentation in either the individually housed or
pair-housed monkeys.

3.2. Habituation to the video presentation

Individually housed subjects decreased the amount of time they spent watching the
video over the progression of observation days, whereas pair-housed subjects watched videos
more over time. Fig. 2 shows the frequency of watching behaviour in each day in the “monitor
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The GLMM analysis of watching behaviour revealed that the models that included the observation day as the fixed factor (coefficient: -0.021 in the individually housed subjects and 0.023 in the pair-housed subjects) showed significantly lower AICs than the models without it (Table 2). The negative coefficient value in the selected model indicates that the frequency of time spent watching the video decreased with progression of the observation days. In the first five days and last five days, the mean (± SE) number of sampling points with watching behaviour was 22.1 (± 3.2) and 16.9 (± 2.7) for the individually housed subjects and 5.8 (± 2.4) and 20.8 (± 4.7) for the pair-housed subjects.

Both individually housed and pair-housed subjects decreased abnormal behavior over the progression of observation days. The models that included the observation day as the fixed factor (coefficient: -0.025 in the individually housed subjects and -0.011 in the pair-housed subjects) showed significantly lower AICs than the models without it (Fig. 3 and Table 2). The negative coefficient value in the selected model indicates that the frequency of abnormal behaviour decreased with progression of the observation days. In the first five days and last five days, the mean (± SE) number of sampling points with abnormal behaviour was 16.0 (± 2.7) and
11.0 (± 3.1) in the individually housed subjects and 8.0 (± 2.4) and 5.1 (± 2.2) in the pair-housed subjects.

3.3. The effect of content of videos

Both individually housed and pair-housed subjects spent more time watching “Japanese macaques” videos than other videos (Fig. 4). The models that contained the content as the fixed factor showed significantly lower AICs than the models without the content (Table 2). In the multiple comparisons of the contents, the models including “Japanese macaques” at a different level from the other two contents showed the lowest AIC (497.2 in the individually housed subjects and 857.6 in the pair-housed subjects). These results indicate that the content “Japanese macaques” affected the frequency of watching behaviour differently from the other contents, and that there was no difference between the contents “people” and “animation” in both individually and pair-housed subjects.
Individually housed subjects displayed less abnormal behaviour during videos of conspecifics than the other videos, whereas pair-housed subjects displayed less abnormal behaviour during the videos of people than the other videos (Fig. 5). The models that contained the content as the fixed factor showed significantly lower AICs than the models without the content (Table 2). In the multiple comparisons of the contents, the models including all three contents at different levels showed the lowest AIC (956) in the individually housed subjects and the models including “people” at a different level from the other two contents showed the lowest AIC (786) in the pair-housed subjects. These results indicate that the three different contents affected the frequency of abnormal behaviour differently in the individually housed subjects and that the content “people” affected the frequency of abnormal behaviour differently from the other contents, and there was no difference between the contents “Japanese macaques” and “animation” in the pair-housed subjects.

3.4. The effect of controllability over videos

Controllability did not affect the frequency of abnormal behaviour (Fig. 5). In the individually housed subjects, the model that contained controllability as the fixed factor
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(coefficient: 0.019) showed a higher AIC than the model without it (Table 2). In the pair-housed subjects, the model that included controllability as the fixed factor (coefficient: 0.082) showed a lower AIC than the model without it (Table 2). These differences between the models were not significant.

Subjects spent more time in the video zone (i.e., the part of the cage that allowed videos to be played) during the days in which they could control the videos than during those in which they had no control. In the analysis of remaining in the video zone (Fig. 6). The models that included controllability as the fixed factor (coefficient: 0.231 in the individually housed subjects and 0.257 in the pair-housed subjects) showed significantly lower AICs than the model that did not include it (Table 2). The positive coefficient values in the selected model indicate that the frequency of staying in the video zone in the controllable days was higher than that in the non-controllable days.

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Fig. 6 about here

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4. Discussion

4.1. The effect of video presentation on behaviour
The present study examined the effect of video presentation on the welfare of captive Japanese macaques. Both individually and pair-housed subjects displayed fewer abnormal behaviours during video presentation than when the screen was blank. Further, abnormal behaviour in the blank monitor phase was not significantly lower than the control phases, which suggests that it was not the experimental apparatus but the videos that decreased subjects’ abnormal behaviour. The video presentation decreased abnormal behaviour of captive Japanese macaques, indicating that it improved their welfare (Young, 2003).

The video presentation affected the behaviour of the individually housed and the pair-housed subjects differently. Although abnormal behaviour of pair-housed monkeys was still reduced by video presentation, the effect of decreasing abnormal behaviour was lower in the individually housed subjects. Resting behaviour decreased during the video presentation only for the individually housed monkeys. These results might be due to several differences, including difference in the baseline frequency of abnormal behaviour and/or activity level, the cage size, and ability to see conspecifics. The individually housed subjects could not see other monkeys during their daily housing condition. The effect of video presentation on individually housed monkeys who can see other conspecifics warrants further investigation.

4.2. The effect of novelty of videos

This study tested whether novelty, content, and controllability of videos might make
Video system enrichment more effective. In the individually housed subjects, the frequency of watching videos decreased over the duration of the “monitor with video” phase, even though video clips were replaced everyday and were thus novel. This might suggest that the subjects became habituated to the process of watching video enrichment, not to the content of video clips. Therefore, video enrichment should not be used too frequently. Animals often become habituated to frequent presentation of enrichment material (Kuczaj et al., 2002). Nevertheless, the decline of watching behaviour in the present study was less than habituation found in previous studies (Bloomsmith and Lambeth, 2000; Platt and Novak, 1997) in spite of the longer and more frequent presentation than those studies. The frequency of abnormal behaviour of the individually housed subjects also decreased over the duration of the “monitor with video” phase. In the pair-housed subjects, the frequency of watching videos increased and abnormal behaviour decreased as the observation days progressed, suggesting that the habituation to video enrichment in this study was attenuated by the replacement of all video clips everyday. The enrichment procedure in this experiment might be an effective technique to prevent the habituation of animals to videos.

4.3. The effect of content of videos

The contents of videos differentially affected the amount of time subjects spent watching and the amount of abnormal behaviour they displayed. Individually housed subjects
spent more time watching “Japanese macaques” videos than other videos. They also exhibited fewer abnormal behaviours during this type of video content than other types. As with the individually housed subjects, pair-housed subjects spent more time watching videos of monkeys than other videos. However, they exhibited the fewest abnormal behaviours with videos containing people. These findings indicate that the subjects had a preference for videos of conspecifics, and the contents of videos differentially affect the animals’ abnormal behaviour and, therefore, their welfare (Young, 2003). In previous studies, the contents of video enrichment did not affect the behaviour in rhesus macaques (Platt and Novak, 1997) or chimpanzees (Bloomsmith and Lambeth, 2000). The difference of the conclusions between the present study and those studies might be a consequence of the difference of the videos used in the experiments. Various short video clips uploaded on the YouTube website were used as visual enrichment in this study, whereas the previous studies presented 1-h (Platt and Novak, 1997) or 20-min (Bloomsmith and Lambeth, 2000) videos repeatedly in some sessions, so that habituation to the videos might have masked the preference for contents. Animals will watch a preferred video for long time periods. Habituation therefore can occur within the first few sessions, so that the duration of watching it can fall to the same level as that of watching non-preferred videos in later sessions. As a result, the effect of preferred content might have appeared to be equivalent to that of non-preferred content. In the present experiment, the
relatively small habituation resulting from the replacement of the video clips in every session might have resulted in the observed preference for contents for video enrichment.

The subjects in this experiment watched the “Japanese macaques” videos longer than the other videos, suggesting that they had a visual preference for conspecifics. This might appear to conflict with the result of the experiment in Ogura and Matsuzawa (2012). The subjects in Ogura and Matsuzawa (2012) showed clear preferences for videos showing humans and animation, although they could choose to play videos showing conspecifics. The discrepancy between these results might be explained by a difference between the social experiences during the infancy of the subjects. The subjects in the present experiment were mother-reared for at least 1 year after birth, whereas the subjects in Ogura and Matsuzawa (2012) were reared by human caretakers. Developmental history has been suggested to affect visual preference in Japanese macaques (Fujita, 1990, 1993), gibbons (Tanaka and Uchikoshi, 2010), chimpanzees (Tanaka, 2003, 2007), and gorillas (Maloney et al., 2011). To enhance the effect of video enrichment, the contents of videos could be changed based on animals’ developmental history or individual differences.

**4.4. The effect of controllability over videos**

The subjects stayed in the video zone longer in the controllable days than in the non-controllable days, suggesting that they preferentially chose video presentation. The IRD
system employed in the present study was helpful to satisfy the monkeys’ preference for videos and control over videos. However, even though subjects changed their location in the cages depending on whether or not they had control over the videos, this control did not clearly affect the level of abnormal behaviour in the present experiment.

The procedure which enabled the monkeys to control videos might have a potential for improvement. The pair-housed monkeys watched the videos less when they had control than when they did not. They also stayed at video zone for shorter periods of time than individually housed subjects due to their larger cage size. Therefore, playing duration of videos when the monkeys had control was much shorter than they did not. This explains the shorter watching duration when the pair-housed monkeys had control over video presentation. My system provided control of videos to only one animal. How to provide control to multiple animals living together needs further consideration.

4.5. General discussion

The present study demonstrated that the captive Japanese macaques watched video presentations, which decreased abnormal behaviour. Reduction of abnormal behaviour is considered to be evidence that environmental enrichment improves animal welfare (Young, 2003). The results here showed that video presentation can improve the welfare of captive Japanese macaques.
Environmental enrichment must be implemented within the limitations of time, human, and financial resources, as well as species-specific characteristics of the subjects (Kreger et al., 1998). Two newly developed technologies, namely, a program of automated presentation of network-shared videos and an IRD sensor, were incorporated into the video presentation device used in the present experiment. Both of these technologies helped save financial and human costs of environmental enrichment. The computer program automatically presented novel and preferred videos by accessing a video-sharing website (YouTube), which was less costly and time intensive than having caretakers prepare or purchase videos, something done at many facilities. Utilization of an IRD sensor also reduced the time needed for the training required to provide animals with control over the environment. By employing the IRD sensor, which allowed detection of the distance to an animal, it was possible to make the video presentation contingent on the monkey’s location in the cage. This, in turn, allowed the monkeys to control the videos with natural behaviour, and without any specific training by humans. The presentation device tested in the present experiment can contribute to the welfare of the monkeys with low human cost.

The findings of the present study provide some valuable suggestions for general implementation of environmental enrichment. In the present study, the video enrichment was implemented based on an understanding of the cognitive abilities of Japanese macaques. They
have preferences for the novelty and content of videos (Ogura and Matsuzawa, 2012). Having control over the visual environment is valuable for captive Japanese macaques (Ogura, 2011). These cognitive abilities are classified into the input and output process, respectively, according to the perspective of cognitive enrichment (Morimura, 2006). In the present experiment, the stimulation of such process affected monkeys’ behaviour. This study has provided some empirical evidence that, by taking such properties as input and output processes into consideration, environmental enrichment makes the captive environment more stimulating and supplies captive animals with opportunities to exert their ability to cope with the environment. Implementation of environmental enrichment based on the species-specific characteristics can improve animal welfare. Therefore, understanding the species-specific characteristics of subject animals is essential for appropriate implementation of environmental enrichment.

5. Conclusion

Abnormal behaviour of captive Japanese macaques could be ameliorated by exposure to video presentation. This was achieved at low cost by using developed technologies such as network-shared videos and an IRD sensor, which maintained the novelty of videos, provided preferred video content, and allowed subjects to have control over their visual world. Implementation of video enrichment based on an understanding of species-specific cognitive
characteristics of Japanese macaques increased their welfare. Overall, the present study provides empirical evidence that video enrichment has positive effects on the welfare of captive animals and can be a possible environmental enrichment for them.

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Figure Captions

Fig. 1. Mean (± SE) frequency of abnormal behaviour in each experimental phase. In the first and second no-monitor phases, the enrichment device was not present. In the blank monitor phase, the apparatus was present, but the display showed no videos. In the “monitor with video” phase, the subjects could watch videos on the display. SEs are based on the error across all scores from all subjects.

Fig. 2. The frequency of watching behaviour in each day in the “monitor with video” phase. (a) individually housed subjects, (b) pair-housed subjects.

Fig. 3. The frequency of abnormal behaviour in each day in the “monitor with video” phase. (a) individually housed subjects, (b) pair-housed subjects.

Fig. 4. Mean (± SE) frequency of watching behaviour in each presentation condition in the “monitor with video” phase. The “monkey”, “people”, and “animation” indicate the content of the video clips. In the days of control “+”, the subjects could watch the videos only when they stayed in the video zone in the cage. In the days of control “−”, the videos were shown on the display continuously irrespective of the monkey's position in the cage. The order of the
conditions was randomized among the subjects. (a) individually housed subjects, (b) pair-housed subjects.

Fig. 5. Mean (± SE) frequency of abnormal behaviour in each presentation condition in the “monitor with video” phase. The “monkey”, “people”, and “animation” indicate the content of the video clips. In the days of control “+”, the subjects could watch the videos only when they stayed in the video zone in the cage. In the days of control “-”, the videos were shown on the display continuously irrespective of the monkey’s position in the cage. The order of the conditions was randomized among the subjects. (a) individually housed subjects, (b) pair-housed subjects.

Fig. 6. Mean (± SE) frequency of staying in the video zone in each presentation condition in the “monitor with video” phase. The “monkey”, “people”, and “animation” indicate the content of the video clips. In the days of control “+”, the subjects could watch the videos only when they stayed in the video zone in the cage. In the days of control “-”, the videos were shown on the display continuously irrespective of the monkey’s position in the cage. The order of the conditions was randomized among the subjects. (a) individually housed subjects, (b) pair-housed subjects.
Fig. 1

- Frequency of abnormal behavior
- Individually housed
- Pair-housed

- Comparison of behavior in different conditions:
  - No monitor 1
  - Blank monitor
  - Monitor with video
  - No monitor 2

Bar graph showing the frequency of abnormal behavior across different conditions for individually housed and pair-housed animals.
Fig. 2
Frequency of abnormal behavior over days.

(a) Graph showing frequency of abnormal behavior from day 0 to day 5.

(b) Graph showing frequency of abnormal behavior from day 0 to day 5.

Day
0
1
2
3
4
5

Frequency of abnormal behavior
0
10
20
30
40

Day
Fig. 4
Fig. 5

(a) and (b) show the frequency of abnormal behavior under different conditions: control, monkey, people, and animation. The graphs indicate a trend where the frequency increases with the presence of monkey and decreases with the presence of people and animation.
Fig. 6

(a) Frequency of staying + and - control content
(b) Frequency of staying + and - monkey, people, animation
Table 1

List of behaviours used for behavioural observation in the present study.

<table>
<thead>
<tr>
<th>Abnormal behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autoerotic stimulation</td>
<td>Self-directed sexual activity and masturbation</td>
</tr>
<tr>
<td>Floating limb</td>
<td>Unusual movement pattern of a limb; after visually tracking for a short time, the floating limb is often attacked viciously by oneself</td>
</tr>
<tr>
<td>Self-clasping</td>
<td>Use of hands or feet to hold onto part of body by oneself</td>
</tr>
<tr>
<td>Self-biting</td>
<td>Hands, legs, arms and/or torso bitten in a stereotyped fashion by oneself</td>
</tr>
<tr>
<td>Stereotypic pacing</td>
<td>Repetitive pacing along the same path</td>
</tr>
<tr>
<td>Rocking</td>
<td>Repetitive seated, bipedal, or quadrupedal rocking</td>
</tr>
<tr>
<td>Saluting/eye poking</td>
<td>Poking of one or more fingers into the eye</td>
</tr>
<tr>
<td>Rubbing bars</td>
<td>Repetitive rubbing bars of cages with hands</td>
</tr>
<tr>
<td>Licking bars</td>
<td>Repetitive licking of bars</td>
</tr>
<tr>
<td>Licking hand</td>
<td>Hands or foot licked by oneself</td>
</tr>
<tr>
<td>Hair plucking</td>
<td>Pulling out of own or another animal’s hair</td>
</tr>
<tr>
<td>Feeding</td>
<td>Reaching hand into a food box and putting food into mouth</td>
</tr>
<tr>
<td>Locomotion</td>
<td>Moving bipedally or quadrupedally</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Self-grooming</td>
<td>Pushing own hair aside and picking up something</td>
</tr>
<tr>
<td>Social behaviour</td>
<td>Allogrooming, mounting, and agonistic and submissive behaviour</td>
</tr>
<tr>
<td>Watching video</td>
<td>Directing head and eyes to the display during video presentation</td>
</tr>
<tr>
<td>Resting</td>
<td>Staying still without any other behaviour</td>
</tr>
</tbody>
</table>
### Table 2

Results of Generalized Linear Mixed Model analyses of behavioural observation.

| Response variable | Fixed factor | Individually housed subjects | | | | Pair-housed subjects | | | |
|---|---|---|---|---|---|---|---|---|
| | | Likelihood ratio test | Likelihood ratio test | | | | | |
| Response variable | Fixed factor | AIC<sup>a</sup> | $\chi^2$ | $P$ | AIC<sup>a</sup> | $\chi^2$ | $P$ |
| Abnormal behaviour | experimental phase<sup>b</sup> | 2776 | 702.49 | $< 0.001$ | 1822 | 163.16 | $< 0.001$ |
| | none<sup>c</sup> | 3473 | | | 1979 | | |

**The effect of video presentation on abnormal behaviour**

**Habituation to the video presentation**

Watching the video, content, and controllability

| Abnormal behaviour | observation day, content, and controllability | 498.6 | 71.216 | $< 0.001$ | 859.5 | 66.65 | $< 0.001$ |
| content and controllability | 567.8 | 924.1 |

**The effect of content of videos**

Watching the video, observation day, content, and controllability

| Abnormal behaviour | observation day, content, and controllability | 498.6 | 70.552 | $< 0.001$ | 859.5 | 601.5 | $< 0.001$ |
AIC means the “Akaike Information Criterion”, the index used to compare the fitted models. The model with the lower AIC is preferred.

The experimental phase indicates the four conditions, under which observation was conducted, such as no-monitor 1, blank monitor, monitor with video, and no-monitor 2.

This model contained no fixed factor.