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

4 (*Macaca fuscata*)

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1 Abstract

2 Although nonhuman primates have highly developed visual cognitive abilities, they
3 have few opportunities to exert such abilities in captivity. Video presentation can reproduce
4 multiple features of the complex real visual world. Therefore, video presentation can be
5 expected to act as environmental enrichment for captive primates. The present study evaluated
6 the enriching effects of novelty and content of videos as well as control over videos using newly
7 developed technology including network-shared YouTube videos and an infrared distance sensor.
8 Baseline data were obtained for 10 days without video display and then 10 days with the display
9 showing no videos in four individually housed monkeys and six pair-housed monkeys. The
10 monkeys were then exposed to videos of conspecifics, people, and animation and observed for
11 30 days. In some days, the monkeys had control over videos such that videos played only when
12 subjects sat directly in front of the display. Observations were then taken for an additional 10
13 days with no videos. Behaviors such as time watching videos, abnormal behavior, and time
14 spent in front of display were recorded for 60 min per day using instantaneous sampling with a
15 30-s interval. Monkeys displayed fewer abnormal behaviors when the video was playing
16 (individually housed: 11.3 sampling points, pair-housed: 7.7 sampling points) than when
17 the video was not playing (individual housed: 22.5 sampling points, pair-housed: 10.8
18 sampling points) ($P < 0.001$). The abnormal behaviour over the course of the observation days

1 showed no evidence of habituation to videos. The frequency of watching the videos and
2 abnormal behaviour differed depending on the presented contents of videos ($P < 0.001$). The
3 subjects spent more time in front of the display in the days in which they could control
4 the videos (individually housed: 89.1 sampling points, pair-housed: 17.6 sampling
5 points) than in those in which they had no control (individually housed: 70.1 sampling
6 points, pair-housed: 7.3 sampling points) ($P < 0.001$), suggesting that they were
7 preferentially choosing to watch the videos. These results suggest that video presentation
8 can be a useful technique to decrease abnormal behaviour of captive Japanese macaques. The
9 content and controllability over videos were influential on their behaviour, suggesting that
10 implementation of video enrichment that includes conspecifics videos and controllability over
11 videos can improve animal welfare. Implementation based on an understanding of
12 species-specific characteristics can contribute to effective environmental enrichment.

13 **Keywords:** Animal welfare; Cognition; Control over environment; Japanese macaques; Video

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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

1 primates, its ability to be adjusted to species-specific needs remains to be tested. In the present
2 experiment, key components affecting the enriching effect of videos, such as the novelty and
3 contents of videos and the controllability over videos were examined by using newly developed
4 technology.

5 *1.2. Novelty and contents of videos*

6 Novelty and contents have been studied as key properties of videos that might affect
7 animals' preference in some previous studies. It is well known that animals become habituated
8 to sensory stimuli which are presented repeatedly and dishabituated to new stimuli (e.g., Koba
9 and Izumi, 2008; Murai et al., 2004; Quinn et al., 2002). Captive primates rapidly become
10 habituated to videos that are presented repeatedly (Bloomsmith and Lambeth, 2000; Lee et al.,
11 2011; Ogura and Matsuzawa, 2012; Platt and Novak, 1997). Novelty affects the attractiveness
12 of videos, and therefore might influence their effect as environmental enrichment for primates.
13 In other words, animals might prefer to watch novel videos than familiar ones.

14 The content of visual stimuli has also been found to affect the preference of primates.
15 In cognitive studies, bonnet macaques (Andrews and Rosenblum, 2001; Brannon et al., 2004)
16 and rhesus macaques (Washburn et al., 1997) preferred to watch videos with particular contents
17 over other videos. Despite the consistent results from these cognitive studies, other studies
18 examining the effect of contents on behaviour have had mixed results. While some studies

1 (Bloomsmith and Lambeth, 2000; Maloney et al., 2011; Platt and Novak, 1997) found that
2 videos which were supplied as visual enrichment did not affect the behaviour, another study
3 (Ogura and Matsuzawa, 2012) found that videos with varying content did differentially affect
4 the behaviour in Japanese macaques. Thus, the effects of the contents of visual stimuli have not
5 been entirely consistent in enrichment compared to cognitive studies.

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

9 *1.3. Controllability over videos*

10 How the video is presented may also affect its usefulness as enrichment. Many studies
11 have found that having control over the environment is important for monkeys. In Washburn et
12 al. (1991), rhesus monkeys performed significantly better on computer tasks they selected
13 compared to identical tasks assigned by the experimenter. Hanson et al. (1976) found that rhesus
14 monkeys that had control over a high-intensity noise had significantly lower plasma cortisol
15 concentrations than monkeys exposed to identical amounts of high-intensity noise but without
16 any control. Another phenomenon is contrafreeloading, which experimentally evaluates the
17 value of control as well as reward which can be obtained as a result of control (Inglis et al.,
18 1997; Sambrook and Buchanan-Smith, 1997). This phenomenon was confirmed by using a

1 visual reward (Ogura, 2011) as well as a food reward (Menzel, 1991; Reinhardt, 1994) in
2 primates. These studies provided empirical evidence of the value of control over the
3 environment for primates.

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

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2. Methods

9 *2.1. Subjects*

10 The subjects were 10 adult Japanese macaques living at the Primate Research Institute
11 of Kyoto University. Two of the subjects were individually housed males, each 11 years of age,
12 two were individually housed females, 10 and 13 years of age, and the other six were housed in
13 three, male-female pairs. The ages of the pair-housed subjects were not known because they
14 were born in the wild, but they were fully matured. The individually housed subjects had been
15 maintained in cages (80 cm high × 80 cm wide × 60 cm long) for more than 2 years. Because of
16 limitations of available space, the subjects could not see other monkeys during this study. The
17 pair-housed subjects were maintained in cages (200 cm high × 137cm wide × 115 cm long) that
18 allowed them to see other monkeys in the same room. All subjects were habituated to the

1 observer for at least 2 weeks before the start of observations. The monkeys were fed monkey
2 pellets and sweet potatoes daily at about 10:00 h. and 17:00 h and had access to water ad libitum.
3 Routine care of the monkeys and experiments were performed in accordance with the Guide for
4 the Care and Use of Laboratory Primates produced by Primate Research Institute, Kyoto
5 University.

6 *2.2. Apparatus*

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

18 *2.3. Videos*

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

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

15 *2.4. Procedures*

16 Each subject experienced 60 observation sessions with one session per day. The
17 sessions started between 12:30 h. and 17:00 h. and continued for 60 min. The observation
18 consisted of four experimental phases conducted in the following order; the no-monitor 1, blank

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

17 During this testing procedure, the behaviour and cage location of each subject was
18 recorded by the author who directly observed the subjects from behind the apparatus. The data

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

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13 Table 1 about here

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15 2.5. Statistical analyses

16 The number of sampling points (frequency) for which the subjects engaged in each
17 behavioural category and stayed in the video zone were analyzed using a Generalized Linear
18 Mixed Model (GLMM) (lmer, lme4 library, the freeware package R, Version 2.14.2; R

1 Development Core Team, 2012). This method is an extension of the ANOVA technique,
2 incorporating and quantifying multiple sources of variation and also allowing for non-normal
3 distributions for the response variable. Therefore, the GLMM technique can analyze repeated
4 measures data that are not normally distributed. The models were constructed using a Poisson
5 distribution because the numbers of sampling points were non-negative count data (Dobson,
6 2002). One data point indicated the score of each behaviour in each day. The data could have
7 been analyzed as proportions of the total counts of a day under the Binomial distribution, but the
8 residual plots from each analysis indicated the models using the Poisson distribution were a
9 better fit with the observation data than the models using the Binomial distribution. In analyses
10 of the effect of the video presentation on the frequency of each behaviour, the number of each
11 behaviour in each day was the response variable. The model contained the experimental phase
12 as the fixed factor. To test the effect of habituation to the video presentation, as well as the
13 contents and controllability of videos, the models contained the frequency of subjects' behavior
14 and the frequency at which the subject stayed in the video zone as the response variables. The
15 fixed factors of the models were the observation day, the content, and the controllability of
16 videos. The individual, sex, and pairing (for the pair-housed subjects) were contained in all
17 GLMM analyses as the random factor to control for repeated measures. Therefore, the
18 individually housed subjects and pair-housed subjects were analyzed separately. The models

1 including the target fixed factor and the models without it were compared based on the Akaike
2 Information Criterion (AIC; Akaike, 1974; Dobson, 2002). The model with the lower AIC is
3 preferred. The significance of difference of fitted models was tested using a likelihood ratio test.
4 For multiple comparisons of the fixed factors, the models which contained every combination of
5 the fixed factors were also compared.

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3. Results

8 *3.1. The effect of video presentation on behaviour*

9 The frequency of abnormal behaviour was the lowest during the “monitor with video”
10 phase for both individually housed and pair-housed subjects. Fig. 1 shows the frequency of
11 abnormal behaviour in all four experimental phases. The models that included the experimental
12 phase as the fixed factor showed significantly lower AICs than the models that did not include it
13 (Table 2). For both single and pair-housed subjects, the models that included the “monitor with
14 video” phase at a different level from the other three phases showed the lowest AICs (2773 and
15 1822) in the multiple comparisons of the experimental phases. This result suggests that the
16 “monitor with video” phase affected the frequency of abnormal behaviour differently than the
17 other three phases for both the individually housed and pair-housed monkeys.

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1 Fig. 1 and Table 2 about here

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3 In the analyses of the other behavioural categories, only resting behaviour for the
4 individually housed subjects was affected by the video presentation. The frequency of resting
5 behaviour in the “monitor with video” phase (45.1 ± 1.6 sampling points) was lower than in the
6 other experimental phases (no-monitor 1: 54.6 ± 3.0 , blank monitor: 46.3 ± 2.8 , no-monitor 2:
7 47.1 ± 2.9). The model that included the experimental phase as a fixed factor (AIC: 1593)
8 showed a significantly lower AIC than the model without it (AIC: 1643) ($\chi^2 = 56.01$, $P < 0.001$).
9 The models that included the “monitor with video” phase at a different level from the other three
10 phases showed the lowest AIC (1591) in the multiple comparisons of the experimental phases.
11 This result indicates that the “monitor with video” phase affected the frequency of resting
12 behaviour differently than the other three phases for the individually housed monkeys. The other
13 behaviours were not affected by the video presentation in either the individually housed or
14 pair-housed monkeys.

15 3.2. Habituation to the video presentation

16 Individually housed subjects decreased the amount of time they spent watching the
17 video over the progression of observation days, whereas pair-housed subjects watched videos
18 more over time. Fig. 2 shows the frequency of watching behaviour in each day in the “monitor

1 with video” phase. The GLMM analysis of watching behaviour revealed that the models that
2 included the observation day as the fixed factor (coefficient: -0.021 in the individually housed
3 subjects and 0.023 in the pair-housed subjects) showed significantly lower AICs than the models
4 without it (Table 2). The negative coefficient value in the selected model indicates that the
5 frequency of time spent watching the video decreased with progression of the observation days.
6 In the first five days and last five days, the mean (\pm SE) number of sampling points with
7 watching behaviour was 22.1 (\pm 3.2) and 16.9 (\pm 2.7) for the individually housed subjects and
8 5.8 (\pm 2.4) and 20.8 (\pm 4.7) for the pair-housed subjects.

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10 Fig. 2 about here
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12 Both individually housed and pair-housed subjects decreased abnormal behavior over
13 the progression of observation days. The models that included the observation day as the fixed
14 factor (coefficient: -0.025 in the individually housed subjects and -0.011 in the pair-housed
15 subjects) showed significantly lower AICs than the models without it (Fig. 3 and Table 2). The
16 negative coefficient value in the selected model indicates that the frequency of abnormal
17 behaviour decreased with progression of the observation days. In the first five days and last five
18 days, the mean (\pm SE) number of sampling points with abnormal behaviour was 16.0 (\pm 2.7) and

1 11.0 (\pm 3.1) in the individually housed subjects and 8.0 (\pm 2.4) and 5.1 (\pm 2.2) in the pair-housed
2 subjects.

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4 Fig. 3 about here

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6 *3.3. The effect of content of videos*

7 Both individually housed and pair-housed subjects spent more time watching
8 “Japanese macaques” videos than other videos (Fig. 4). The models that contained the content
9 as the fixed factor showed significantly lower AICs than the models without the content (Table
10 2). In the multiple comparisons of the contents, the models including “Japanese macaques” at a
11 different level from the other two contents showed the lowest AIC (497.2 in the individually
12 housed subjects and 857.6 in the pair-housed subjects). These results indicate that the content
13 “Japanese macaques” affected the frequency of watching behaviour differently from the other
14 contents, and that there was no difference between the contents “people” and “animation” in
15 both individually and pair-housed subjects.

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17 Fig. 4 about here

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

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14 Fig. 5 about here

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16 *3.4. The effect of controllability over videos*

17 Controllability did not affect the frequency of abnormal behaviour (Fig. 5). In the
18 individually housed subjects, the model that contained controllability as the fixed factor

1 (coefficient: 0.019) showed a higher AIC than the model without it (Table 2). In the pair-housed
2 subjects, the model that included controllability as the fixed factor (coefficient: 0.082) showed a
3 lower AIC than the model without it (Table 2). These differences between the models were not
4 significant.

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

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Fig. 6 about here

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4. Discussion

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4.1. The effect of video presentation on behaviour

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

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

17 *4.2. The effect of novelty of videos*

18 This study tested whether novelty, content, and controllability of videos might make

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

16 *4.3. The effect of content of videos*

17 The contents of videos differentially affected the amount of time subjects spent
18 watching and the amount of abnormal behaviour they displayed. Individually housed subjects

1 spent more time watching “Japanese macaques” videos than other videos. They also exhibited
2 fewer abnormal behaviours during this type of video content than other types. As with the
3 individually housed subjects, pair-housed subjects spent more time watching videos of monkeys
4 than other videos. However, they exhibited the fewest abnormal behaviours with videos
5 containing people. These findings indicate that the subjects had a preference for videos of
6 conspecifics, and the contents of videos differentially affect the animals’ abnormal behaviour
7 and, therefore, their welfare (Young, 2003). In previous studies, the contents of video
8 enrichment did not affect the behaviour in rhesus macaques (Platt and Novak, 1997) or
9 chimpanzees (Bloomsmith and Lambeth, 2000). The difference of the conclusions between the
10 present study and those studies might be a consequence of the difference of the videos used in
11 the experiments. Various short video clips uploaded on the YouTube website were used as visual
12 enrichment in this study, whereas the previous studies presented 1-h (Platt and Novak, 1997) or
13 20-min (Bloomsmith and Lambeth, 2000) videos repeatedly in some sessions, so that
14 habituation to the videos might have masked the preference for contents. Animals will watch a
15 preferred video for long time periods. Habituation therefore can occur within the first few
16 sessions, so that the duration of watching it can fall to the same level as that of watching
17 non-preferred videos in later sessions. As a result, the effect of preferred content might have
18 appeared to be equivalent to that of non-preferred content. In the present experiment, the

1 relatively small habituation resulting from the replacement of the video clips in every session
2 might have resulted in the observed preference for contents for video enrichment.

3 The subjects in this experiment watched the “Japanese macaques” videos longer than
4 the other videos, suggesting that they had a visual preference for conspecifics. This might
5 appear to conflict with the result of the experiment in Ogura and Matsuzawa (2012). The
6 subjects in Ogura and Matsuzawa (2012) showed clear preferences for videos showing humans
7 and animation, although they could choose to play videos showing conspecifics. The
8 discrepancy between these results might be explained by a difference between the social
9 experiences during the infancy of the subjects. The subjects in the present experiment were
10 mother-reared for at least 1 year after birth, whereas the subjects in Ogura and Matsuzawa
11 (2012) were reared by human caretakers. Developmental history has been suggested to affect
12 visual preference in Japanese macaques (Fujita, 1990, 1993), gibbons (Tanaka and Uchikoshi,
13 2010), chimpanzees (Tanaka, 2003, 2007), and gorillas (Maloney et al., 2011). To enhance the
14 effect of video enrichment, the contents of videos could be changed based on animals’
15 developmental history or individual differences.

16 *4.4. The effect of controllability over videos*

17 The subjects stayed in the video zone longer in the controllable days than in the
18 non-controllable days, suggesting that they preferentially chose video presentation. The IRD

1 system employed in the present study was helpful to satisfy the monkeys' preference for videos
2 and control over videos. However, even though subjects changed their location in the cages
3 depending on whether or not they had control over the videos, this control did not clearly affect
4 the level of abnormal behaviour in the present experiment.

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

13 *4.5. General discussion*

14 The present study demonstrated that the captive Japanese macaques watched video
15 presentations, which decreased abnormal behaviour. Reduction of abnormal behaviour is
16 considered to be evidence that environmental enrichment improves animal welfare (Young,
17 2003). The results here showed that video presentation can improve the welfare of captive
18 Japanese macaques.

1 Environmental enrichment must be implemented within the limitations of time, human,
2 and financial resources, as well as species-specific characteristics of the subjects (Kreger et al.,
3 1998). Two newly developed technologies, namely, a program of automated presentation of
4 network-shared videos and an IRD sensor, were incorporated into the video presentation device
5 used in the present experiment. Both of these technologies helped save financial and human
6 costs of environmental enrichment. The computer program automatically presented novel and
7 preferred videos by accessing a video-sharing website (YouTube), which was less costly and
8 time intensive than having caretakers prepare or purchase videos, something done at many
9 facilities. Utilization of an IRD sensor also reduced the time needed for the training required to
10 provide animals with control over the environment. By employing the IRD sensor, which
11 allowed detection of the distance to an animal, it was possible to make the video presentation
12 contingent on the monkey's location in the cage. This, in turn, allowed the monkeys to control
13 the videos with natural behaviour, and without any specific training by humans. The
14 presentation device tested in the present experiment can contribute to the welfare of the
15 monkeys with low human cost.

16 The findings of the present study provide some valuable suggestions for general
17 implementation of environmental enrichment. In the present study, the video enrichment was
18 implemented based on an understanding of the cognitive abilities of Japanese macaques. They

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

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5. Conclusion

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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

1 characteristics of Japanese macaques increased their welfare. Overall, the present study provides
2 empirical evidence that video enrichment has positive effects on the welfare of captive animals
3 and can be a possible environmental enrichment for them.

4

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18 and feeding conditions were in accordance with the Guide for the Care and Use of Laboratory

1 Primates produced by the Primate Research Institute, Kyoto University (2nd ed., 2002).

2

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- 18

1

Figure Captions

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

7
8 *Fig. 2.* The frequency of watching behaviour in each day in the “monitor with video” phase. (a)
9 individually housed subjects, (b) pair-housed subjects.

10
11 *Fig. 3.* The frequency of abnormal behaviour in each day in the “monitor with video” phase. (a)
12 individually housed subjects, (b) pair-housed subjects.

13
14 *Fig. 4.* Mean (\pm SE) frequency of watching behaviour in each presentation condition in the
15 “monitor with video” phase. The “monkey”, “people”, and “animation” indicate the content of
16 the video clips. In the days of control “+”, the subjects could watch the videos only when they
17 stayed in the video zone in the cage. In the days of control “-”, the videos were shown on the
18 display continuously irrespective of the monkey’s position in the cage. The order of the

1 conditions was randomized among the subjects. (a) individually housed subjects, (b)
2 pair-housed subjects.

3

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

11

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

Fig. 1

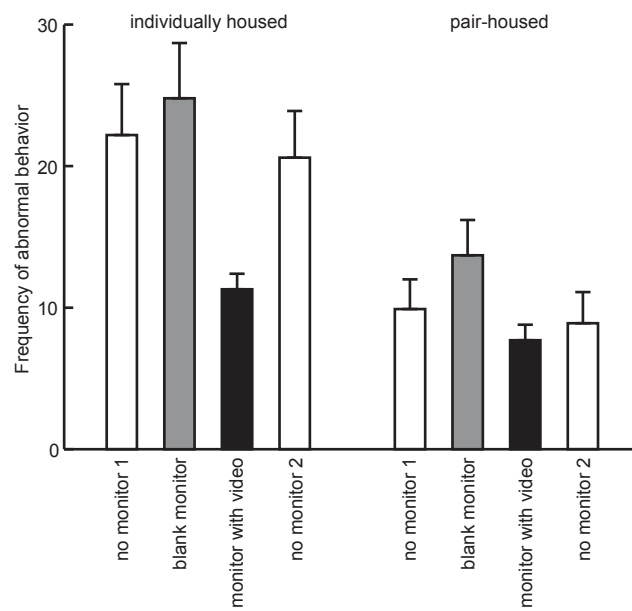


Fig. 2

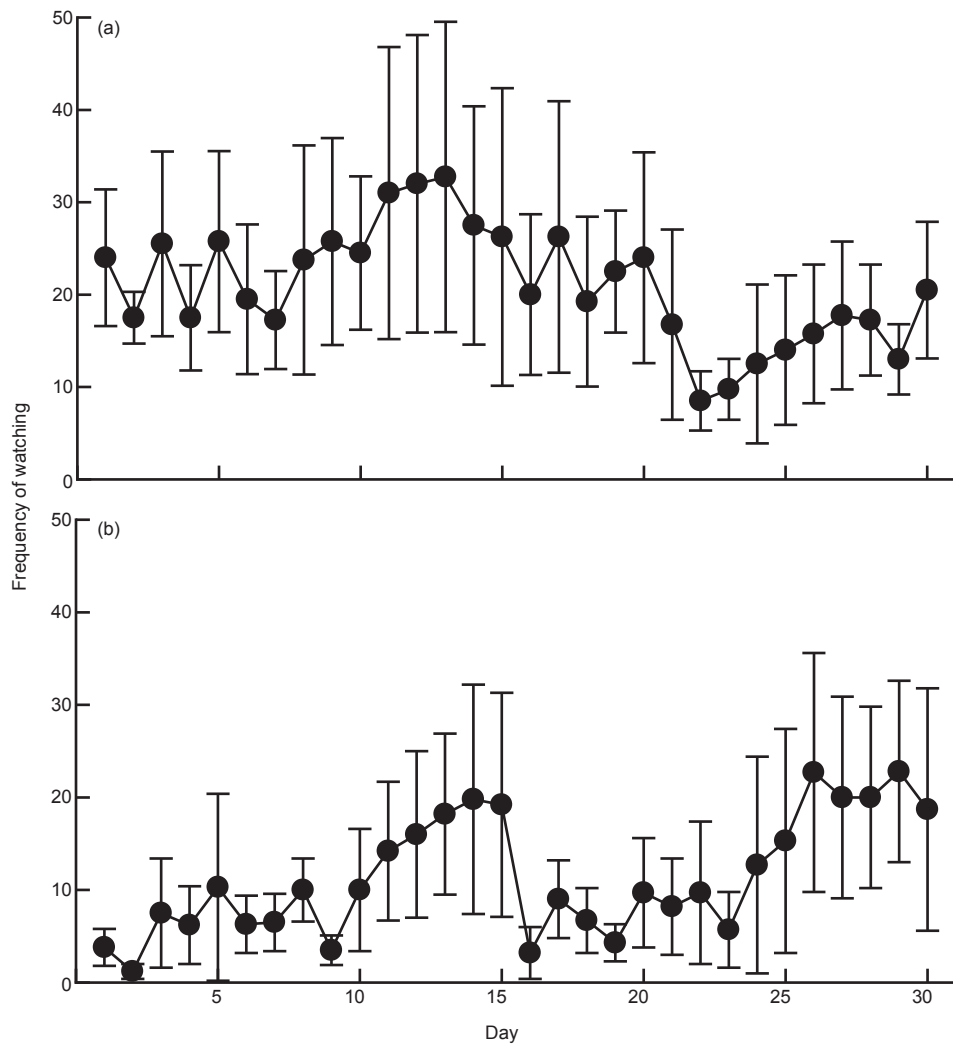


Fig. 3

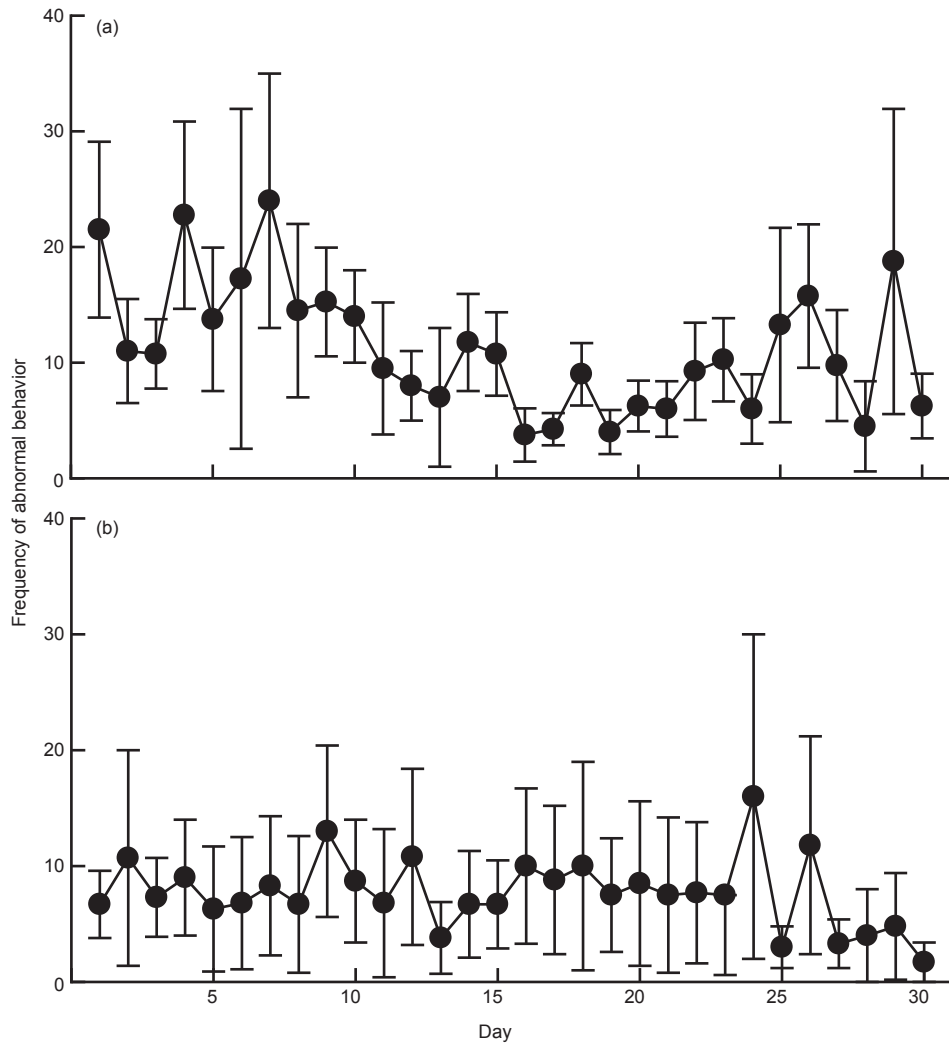


Fig. 4

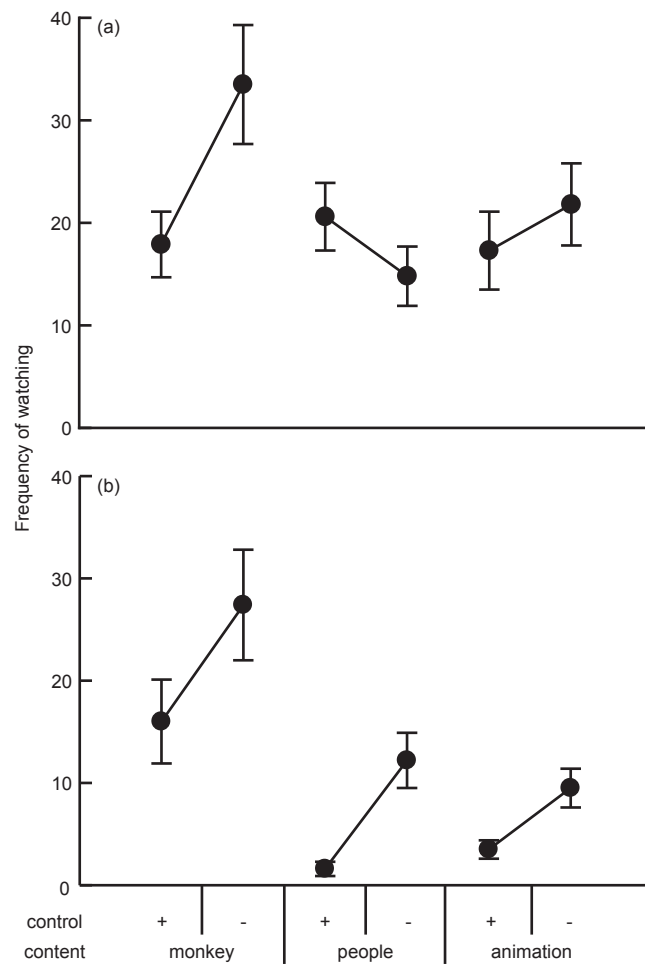


Fig. 5

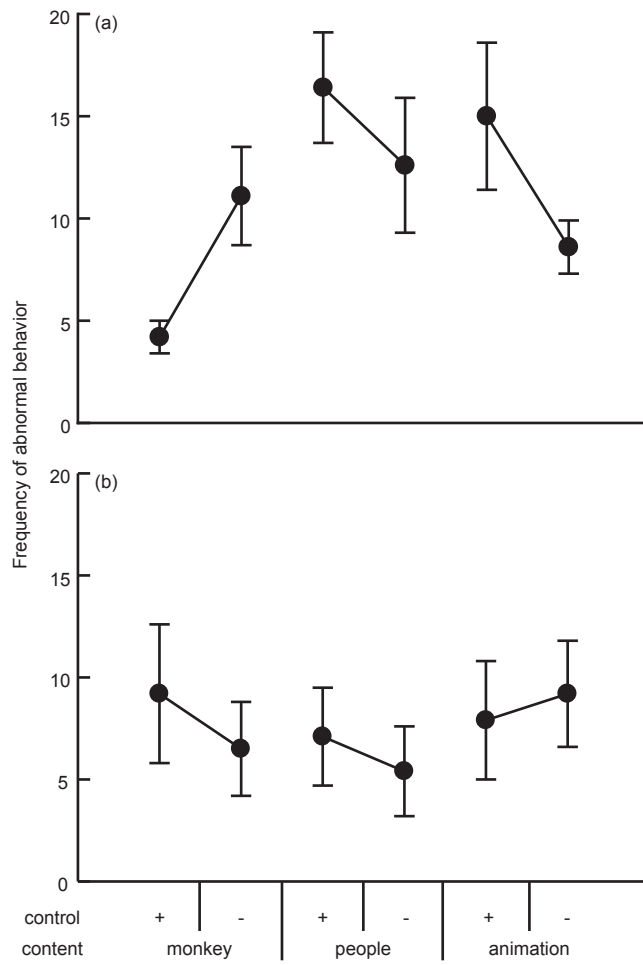


Fig. 6

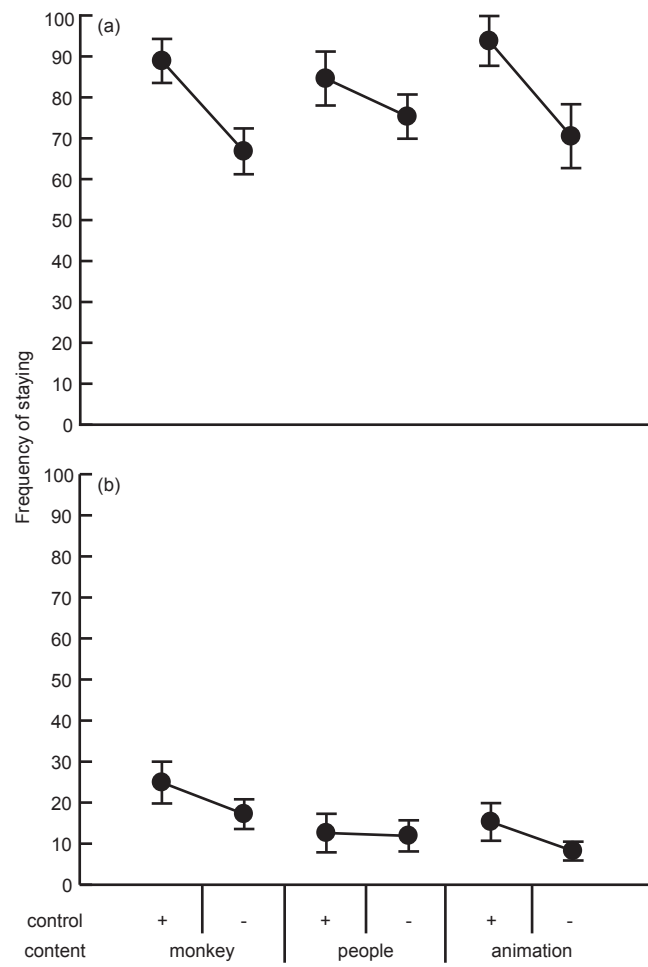


Table 1

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

Abnormal behaviour	
Autoerotic stimulation	Self-directed sexual activity and masturbation
Floating limb	Unusual movement pattern of a limb; after visually tracking for a short time, the floating limb is often attacked viciously by oneself
Self-clasping	Use of hands or feet to hold onto part of body by oneself
Self-biting	Hands, legs, arms and/or torso bitten in a stereotyped fashion by oneself
Stereotypic pacing	Repetitive pacing along the same path
Rocking	Repetitive seated, bipedal, or quadrupedal rocking
Saluting/eye poking	Poking of one or more fingers into the eye
Rubbing bars	Repetitive rubbing bars of cages with hands
Licking bars	Repetitive licking of bars
Licking hand	Hands or foot licked by oneself
Hair plucking	Pulling out of own or another animal's hair
Feeding	Reaching hand into a food box and putting food into mouth

Locomotion	Moving bipedally or quadrupedally
Self-grooming	Pushing own hair aside and picking up something
Social behaviour	Allogrooming, mounting, and agonistic and submissive behaviour
Watching video	Directing head and eyes to the display during video presentation
Resting	Staying still without any other behaviour

Table 2

Results of Generalized Linear Mixed Model analyses of behavioural observation.

		Individually housed subjects			Pair-housed subjects		
		Likelihood ratio test			Likelihood ratio test		
Response variable	Fixed factor	AIC ^a	χ^2	<i>P</i>	AIC ^a	χ^2	<i>P</i>
<i>The effect of video presentation on abnormal behaviour</i>							
Abnormal behaviour	experimental phase ^b	2776	702.49	< 0.001	1822	163.16	< 0.001
	none ^c	3473			1979		
<i>Habituation to the video presentation</i>							
Watching the video	observation day, content, and controllability	498.6	71.216	< 0.001	859.5	66.65	< 0.001
	content and controllability	567.8			924.1		
Abnormal behaviour	observation day, content, and controllability	956.1	62.997	< 0.001	787.5	12.43	< 0.001
	content and controllability	1017			798		
<i>The effect of content of videos</i>							
Watching the video	observation day, content, and	498.6	70.552	< 0.001	859.5	601.5	< 0.001

	controllability						
	observation day and controllability	565.1			1457		
Abnormal behaviour	observation day, content, and controllability	956.1	81.649	< 0.001	787.5	18.79	< 0.001
	observation day and controllability	1034			802.3		

The effect of controllability over videos

Abnormal behaviour	observation day, content, and controllability	956.1	0.111	0.74	787.5	2.29	0.13
	observation day and content	954.2			787.8		
Location in the cage	observation day, content, and controllability	943.9	126.9	< 0.001	3141	40.59	< 0.001
	observation day and content	1069			3180		

^a AIC means the “Akaike Information Criterion”, the index used to compare the fitted models.

The model with the lower AIC is preferred.

^b 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.

^c This model contained no fixed factor.