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BRIEF COMMUNICATION

Receiving Grooming as a Reinforcer for the Monkey

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TAIRA, K. AND E. T. ROLLS. *Receiving grooming as a reinforcer for the monkey.* PHYSIOL BEHAV **59**(6) 1189–1192, 1996.—The present study was intended to evaluate whether receiving grooming, given to a monkey by an experimenter, can be used as a positive reinforcer in operant conditioning. When the monkey touched the surface of the correct pattern in a visual discrimination task after a tone cue, the experimenter groomed the monkey's face, neck, and head with his hand. To test whether the discrimination behavior depended on the shape of the stimuli or on the position of the pattern, these experimental parameters were changed in the different tasks. When the square pattern was assigned as correct and presented on the animal's left side, the average score for correct discrimination was 90% in the last 10 sessions out of 30 sessions, and this was statistically significant at a confidence level of $p < 0.005$ (Grant's table). Correct discrimination was statistically significant when the position of the square was randomly changed to the right and left side of the monkey, and also when the correct pattern was reversed from the square to the cross and its position was again randomly changed. Therefore, it was concluded that the grooming that an experimenter gives to a monkey can be applied as a positive reinforcer in operant conditioning. This experimental paradigm is considered to be useful for neurophysiological analysis of brain mechanisms underlying reward derived from somatosensory input in nonhuman primates.

Positive reinforcer Receiving grooming Operant conditioning Social bond Monkey

IN nonhuman primates, grooming behavior has been considered to be positively reinforcing in ethological studies. A number of different functions of grooming behavior have been proposed concerning social relations, including establishing and maintaining social bonds and group cohesion, reducing tension, and restoring relationships after aggressive encounters (1,2,19,21). Several regions of the central nervous system, such as the amygdala, orbitofrontal cortex, and temporal cortex, have been implicated in the grooming behavior of monkeys in brain lesion studies (7,8). Recently, endogenous opioid systems have been implicated in the grooming behavior of monkeys (10,18).

In the same way that food has been used as a primary (unlearned) reinforcer in a large number of studies on operant conditioning in birds, mammals, and other animals, so receiving grooming has been shown to be a positive reinforcer in operant conditioning in cats (20) and dogs (4). If receiving grooming or tactile stimulation can be demonstrated experimentally to be a positive reinforcer in operant conditioning in nonhuman primates, this would facilitate the neurophysiological investigation of where and how in the brain somatosensory stimulation is represented as rewarding, and where in the brain associations between visual stimuli and the primary reinforcer of being groomed are learned (11,12,17). It is of important to know where tactile stimulation is represented in the brain as positively reinforcing, for tactile stimulation is an important positive reinforcer, and the brain systems involved in processing reinforcement are very closely related to those involved in emotional behavior (13), and damage to these systems can impair normal emotional behavior (16). As a basic experiment for these neurophysiological investigations, the present study was intended to evaluate whether receiving grooming can be shown to be positively reinforcing when it is given to a monkey by an experimenter.

METHOD

The investigation was carried out with a male rhesus monkey (*Macaca mulatta*) aged 2.5 years, which weighed 4.0 kg at the beginning of testing. The discrimination apparatus consisted of square and cross aluminium patterns, the discriminative visual stimuli, which were attached to the center of a rectangular blue

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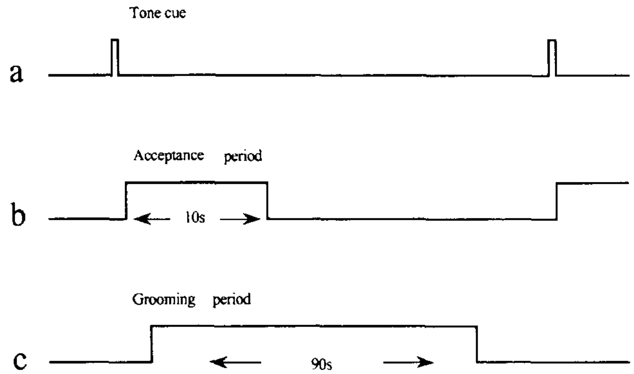

FIG. 1. Time sequences of the experiment. After presentation of the tone cue (0.5 s) (a), the animal received grooming for about 90 s as a reinforcer (c) when the animal touched the correct pattern within 10 s during the acceptance period (b).

plastic plate (20.0 × 7.0 cm). An aluminium handle 18.0 cm long and 1.5 cm in diameter) was attached to the back of the rectangular plastic plate for the experimenter to hold the apparatus. The aluminium patterns were positioned on either side of the handle so as to be symmetrical along their axes.

The discrimination apparatus was held about 20 cm from the face of the animal sitting in a primate chair. When the monkey touched the surface of the correct pattern within 10 s after the tone cue, the experimenter groomed the monkey's face, neck, and head with his hand for about 90 s. If the monkey touched the incorrect pattern, or did not touch either pattern, the experimenter did not groom the monkey, and the next trial was then given after 30 s (Fig. 1). Interaction with the monkey was strictly limited to tactile stimulation so as not to give other cues such as experimenter's gestures or facial expressions during the grooming. One session consisted of 20 trials. Two sessions per day were carried out, lasting 90–120 min. The animal was tested 5 days a week at the same time in the afternoon. Correct patterns were presented to the animal in different tasks as follows: Task A: a square was the correct pattern and was presented on the left side of the animal. Task B: the square was again the correct pattern, but the position of the pattern was randomly changed to the right and left side of the animal. Task C: a cross was the correct pattern and was presented on the right side of the animal. Task D: the cross was the correct pattern. The position of the pattern was randomly changed to the right and left side of the animal.

When the monkey touched the discrimination pattern, this was detected by a touch sensor and the response time was recorded on a laboratory computer. The statistical significance of the experimental data was tested by using Grant's table of runs (6).

RESULTS

Three months were spent prior to systematic testing with the experimental subject. During this period, the animal grew accustomed both to the grooming given by the experimenter and to the discrimination apparatus. The same person engaged in all testing throughout the experiment, because if the experimenter's identity changed, the animal displayed aggressive behavior towards the new experimenter and refused the tasks. Figure 2 shows the task performance obtained after the adaptation period. The ordinate of the graph indicates the percentages of correct responses in each session of 20 trials. The abscissa indicates the sequence of sessions.

In the first task (A), a correct pattern was assigned to the square and its position was always presented on the animal's left side in the test. As shown in block A, correct discrimination was reached at a level of 80% in 2 sessions, and the average score was 85.5% in the last 10 sessions. Correct discrimination was statistically significant at a confidence level of $p < 0.005$ (Grant's table).

In the next task (B), a correct pattern was assigned to the square and its position was randomly changed to the right and left side of the animal to test whether the discrimination behavior depended on the shape of the stimulus, as was appropriate in this task, or on the position of the pattern. As shown in block B, the animal touched the square at a rate of 85% in 8 sessions, and the average was 90.5% in the last 10 sessions. Correct discrimination was statistically significant at a confidence level of $p < 0.005$ (Grant's table).

The next test was carried out to confirm whether the discrimination performance could reverse to the other stimulus. The correct pattern was altered from the square to the cross, and its

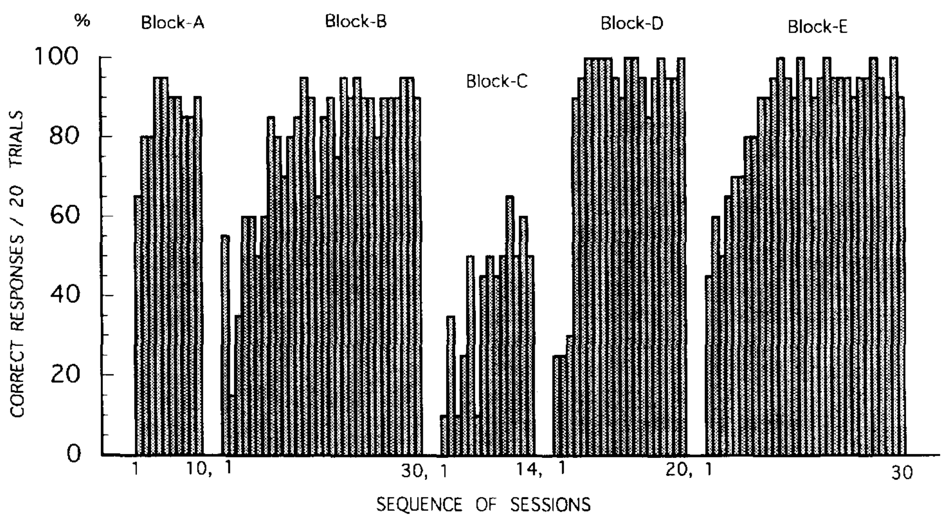

FIG. 2. Scores for the discrimination task. The ordinate gives the percentage of correct responses in each session of 20 trials. The abscissa shows the sequence of sessions. Blocks A, B, C, D, and E show data for task performance corresponding to Task A, Task B, first Task D, Task C, and second Task D, respectively.

position was randomly changed to the right and left side of the animal (Task D). During this discrimination reversal, however, the animal's attitude changed markedly. For successive days, the animal's behavior toward the experimenter became so aggressive that the test could only be performed for 14 sessions out of the planned 30 sessions. Moreover, the animal's performance did not improve: the average performance was 47.5% in the last 10 sessions (Block C). The discrimination was not significant at the confidence level of $p < 0.10$ (Grant's table).

After interrupting the experiment for 1 week, the test was restarted with an easier task, in which the cross pattern was correct and was always presented on the animal's right side in the test (Task C). As shown in block D, correct discrimination was reached at a level of 90% correct in 4 sessions, and the average score was 95.5% in the last 10 sessions. The discrimination was significant at a confidence level of $p < 0.005$ (Grant's Table). No aggressive behavior by the animal was observed during this task.

In the following test, the harder task was reapplied: a correct pattern was assigned to the cross and its position was randomly changed to the animal's right and left sides (Task D). As shown in block E, the performance improved. The correct response rate reached a level of 80% over 7 sessions, and the average was 94.5% for the last 10 sessions. Correct discrimination was significant at a confidence level of $p < 0.005$ (Grant's table). No aggressive behavior by the animal was observed during the task.

DISCUSSION

In the present study, it was possible to demonstrate experimentally that the monkey chose with high scores the visual discrimination pattern that resulted in its receiving grooming, despite random positions of the patterns, and even during reversal of the pattern with which the grooming was associated. The results are consistent with experimental data using petting stimulation as a reinforcer in operant conditioning in the dog (4) and the cat (20). Falk (3) also reported a complementary result that the chimpanzee groomed the experimenter's arm as a reinforcer of operant conditioning. These results indicate that grooming can be used as a reinforcer in operant conditioning in some animal species, and that it establishes a social bond, not only within the same species (1,2,19,21), but also between humans and different animals such as the monkey (present study), the dog (4,5), the cat (20), and the chimpanzee (3). As described in the results, systematic testing was preceded by a 3-month adaptation period, so that the monkey could become accustomed to being handled. When an experimenter not previously encountered by the monkey was introduced, the animal did not perform the tasks. Such an experimental situation has been reported by Fonberg and Kostarczyk in the case of the dog (5). The animal will permit a particular experimenter to touch him because of psychological or social factors arising out of their preliminary interaction. Therefore, the application of the grooming in, for example, electrophysiological studies, would require a special relationship between the individual experimenter and the subject.

The animal's aggressive behavior and lower rate of task performance, as observed in the course of Task D (block C in Fig. 2) could be interpreted in terms of frustration or its lack of a social bond (9). As shown in the results, the animal continued to perform Task D at chance levels. When the easier Task C was used in the following test, the monkey became calm and its performance improved significantly (block D). When the harder Task D was used again, it remained calm and displayed a higher rate of performance (block E). Therefore, the lower rate of task performance may be due to the difficulty of the first Task D, while the monkey's aggressive behavior may be due to the frustration, or to the temporary destruction of the social bond between the animal and the experimenter, when the animal was not receiving enough reinforcing grooming during the early stages of the visual discrimination reversal (9).

In the present study, it was concluded that the grooming that an experimenter gives to a monkey can be demonstrated to be a positive reinforcer in operant conditioning. This experimental paradigm will be useful for neurophysiological (11,12,17) and neuroendocrinological analysis (10,18) of the brain systems involved in reward from somatosensory input in nonhuman primates. For example, somatosensory neurons have been recorded in the primate amygdala (14,17), and the present methods should enable investigation of whether these somatosensory neurons have responses related to the positively reinforcing aspects of the somatosensory stimulation, and whether the amygdala contains neurons that learn associatively to respond to visual stimuli (such as another animal or human) associated with positively reinforcing grooming.

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