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Case Report

Social-Touch Approach for Making Eye Contact and Attenuating the Annoying Behavior in Monkeys

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Abstract

Social gestures convey one's own intentions or the other's mental state in face-to-face interactions. Kumashiro and colleagues have shown that monkeys can communicate with humans through social gestures (Kumashiro et al., 2002, 2003, 2008). Eye contact has a robust role of social gestures. It directs the monkey's attention towards the human, and the monkey will start perceiving the human as a communicator. Direct eye gaze, however, occasionally generates fear or some sort of similar emotions. Some monkeys avoid the human's eyes. Our hypothesis was that social touch would be effective in trying to make eye contact or maintaining social interactions. In case 1, we investigated whether social touch would bring the monkey's eye contact with a human. We gently stroked the face or the arm as the body parts of petting in short or long duration. Monkey's eye contact with the human was induced by arm-petting and was effective in directing the monkey's attention towards the human's face or hand. In case 2, another monkey which already acquired eye contact, pointing, and imitation was subjected. We tested whether social touch would be effective for eating food which the monkey would not otherwise eat. Although social touch did not ameliorate the eating behavior, we found that it was effective for reducing annoying behavior, i.e., throwing food. Gentle stroking by the human's hand is the most convenient treatment for the establishment of communication between the monkey and the human partner. These findings may also have methodological implications for basic or clinical researches of social gestures.

INTRODUCTION

Face-to-face interactions through eye gaze forms the foundation of social communication in humans [1-3] and even in non-human primates [4-7]. In humans, it becomes related to emotion [8] or empathy [9]. Infant's looking at the mother plays an important role [10,11]. Paradoxical eye gaze in social interactions has been presented by people who have autistic disorder [12,13] or psychopathic traits [14]. Given the importance of social gestures, clarifying the monkey's mechanisms would serve an active understanding of social or developmental disorders at single cell level. A recent work found that face-to-face interactions in infant monkeys promoted later social behavior [15]. Reaching deficits after some ventral premotor lesions were ameliorated by face-to-face interactions through eye gaze or pointing in monkeys [16].

Kumashiro et al. (2002) showed that a monkey correctly chose a baited cup between two cups or an experimenter's hand hiding food between both hands by using human's gaze or pointing cues [5]. This monkey screamed out while pointing at a character on the video in social interactions with the human [5], and also imitated the human's action naturally [6]. Another monkey, which failed to make eye contact with the human, could neither choose the correct one nor imitate human's actions. After this monkey was trained for making eye contact, he became to imitate human's actions. Eye contact would be capable of triggering joint attention [5-7], which is looking where someone else is looking [17]. Although the definition of imitation varies among the researchers (such as,[18]), the monkeys imitate the human models or actions through joint attention [6,7]. Mirror neurons, that discharged not only when a monkey did action directed at a target but also when the monkey observed the same action, was discovered in the monkey's ventral premotor area F5 [19-21]. Neurons with mirror properties in monkeys are associated with joint attention [22], requiring extra attention to the target not just the direction of other's gaze. Other's eye gaze modulates mirror neurons in monkeys [23]. The research of eye gaze behavior would lead to find scaffolding function of mirror properties on the other. Mirror neurons system, comprising the inferior frontal gyrus and the inferior parietal gyrus, and which receives a visual input from the superior temporal sulcus [24], appears to be related to language [25], empathy [26-28], and imitation [26,29,30] in humans. Wang et al. (2011) demonstrated that the sensory input to the mirror system was modulated by an interaction between imitation and eye contact in the medial prefrontal cortex [31].

Monkeys could make eye contact with the human partner after two days from the beginning of education in eye contact (see,[7]). A few monkeys, probably for being afraid of humans, would avoid making eye contact with the humans, when we tried to provide Kumashiro's education of eye contact. They might pull the partner's clothes or do nothing. The partner should reduce the monkey's fear or stress to the human. Up to date, there was no report describing the way to reduce monkey's annoying behavior and to make eye contact between the monkey and the human. The monkey's amygdala responds to the scream as a fearful expression of monkeys on the video [32], or responds to monkey's eye contact presented as the direct gaze of the visual stimuli [33]. Monkeys with amygdala lesions increase social interactions and decrease anxiety [34]. Suppression of activations in part of the amygdala in monkeys might be a key to make eye contact socially. Kumashiro monkeys have communicated with experimenters by their gentle stroking of social touch. In humans, a gentle stroking, slow velocity of 1-10 cm/s, elicits pleasantness [35]. C-tactile afferent fibers increase firing when the skin is stroked at a pleasant speed of 3 cm/sec., and it induces the response of the posterior insular cortex [36]. Tactile stimulation reduces infant's physiological responsiveness to stress [37]. The pleasant touch is useful for developing social interactions [38]. Touch is one of the earliest interactions between a caregiver and a child [39]. It is important for the growth and development of human infants [40]. The frequency of the gentle touch for children positively correlates social interest [41]. Human infants emit more eye contact and they spend less time crying during touch condition [42]. Although it has been scarcely examined in monkeys, touch appears to have positive effects on monkeys: monkey's infants received to extra handling in neonatal period demonstrated more social skills than infants without additional handling particularly in new situations [43].

Social touch was presumed to be effective in face-to-face interactions between the human partner and the monkey. We investigated whether the social touch facilitated the establishment of eye contact. Dogs prefer petting to vocal praise [44]. In the effect of social touch on the human, the blood pressure levels of humans were at resting levels during tactile dog interaction with tactile contact comfort [45]. Pretending-to-eat food by the human in front of the monkey also might be useful for directing the monkey's attention towards the human's face. In case 1, we gently stroked the monkey or pretend to eat food in front of the monkey in order to decide which treatments would be effective for monkey's eye contact. In case 2, we investigated whether the social touch could be usable as the social praise for the sake of maintaining the quality of social interactions between the monkey and the human. A subject which participated in case 2, different from the subject in case 1, already had made eye contact with the partner, imitated the partner's hand movements, and pointed to the monkey's desirable food or place. The social praise but not food rewards would be thought to play an important role in maintaining social interactions even monkeys. Taira and Rolls (1996) showed that the social touch of monkeys by the experimenter could be applied as a positive reinforce of operant conditioning [46]. In domestic dogs, petting appears to be an important interaction between dogs and humans that might maintain inter-specific social behavior but vocal praise likely has to be specifically conditioned [44]. In case 2, the monkey was praised by social touch when the monkey ate the food that the monkey did not eat or was reluctant to eat. The clapping was chosen as praise. Clapping was used as applause in humans [47]. This monkey could clap by imitation of human models and share it with the human.

Case 1: two treatments, petting and pretending to eat, in the first face-to-face interactions

Method: We arranged three petting treatments and a pretending-to-eat treatment to make monkey's eye contact with an experimenter. We assigned face and arm for the target parts of petting. We set two durations, five minutes or 30 seconds, as petting durations. We developed a real-time method. By this method, we progressively assessed the monkey's state of the moment in the session. Then, we could change the order of treatments by the response of the monkey.

Subject: A subject was a Japanese monkey, *Macacafuscata* (Yayoi: female, about 7 kg), housed in the single cage. The subject drank water from 600 to 1200 ml per day in the cage. The monkey chow was given 100-300 g daily. The caretakers have been giving food to the subject in the cage by the hand for more than 10 years. Fresh fruits or vegetables were sometimes given in non-experiment days. This study was approved by the Animal and Use Committees at Tamagawa University, and all husbandry and experimental procedures were in accordance with the institutional guidelines.

Procedure: The subject seated comfortably in a primate chair (Muromachi Kikai, Co., Ltd.), facing an experimenter at a distance of 40-70 cm in an isolated experimental room. All sessions were video-recorded through web camera (Logicool, Co., Ltd.) or video camera (Panasonic, Co., Ltd.) set in front of a table.

We designed the three petting treatments, the pretending-to-eat treatment and the eye contact education. The foods used by feeding were sliced apples, sliced sweet potatoes, a piece of bananas, or torn raisins. The monkey had received surgery but did not participate in any eye-contact experiment before the current case. The experimenter washed and put antiseptics on her head' wound for about 20 minutes each time just after the subject entered into the experimental room. The experimenter seated across or diagonally in front of the subject. Although the experimenter started providing a predetermined treatment, the experimenter sometimes presented a slice of apples, sweet potatoes, raisins, or bananas at eye level between the subject and the experimenter in order to check whether the subject was able to look at the experimenter's face through food (see, [7]). Eat was the pretending-to-eat treatment that the experimenter pretended to eat food in front of the subject (Figure 1a). The face-petting treatment named as pFace was that the experimenter gently stroked the subject's face with her palm for 30 seconds on average (Figure 1b). There were two arm-petting treatments

(Figure 1c). One was pArm5m that the experimenter gently stroked the subject's arm or hand with the fingertips of mainly second, third, and forth fingers of the experimenter for about five minutes. The other was pArm30s. It was the same as pArm5m but the petting period was about 30 seconds. The velocity of stroke was mostly 1-5 cm per second in each treatment. The subject occasionally pulled and gave the experimenter a bear hug, and the experimenter gently stroked the subject's trunk including the back in that position in order to loosen the subject's hand. However, the subject showed the desperately unpleasant behavior in the face and trunk petting on the sixth day. This session was pFace Trunk. The education of eye contact was EC. When the experimenter made eye contact with the subject, the experimenter gave the food to the subject (see [7]). When the subject succeeded in making eye contact with the experimenter without annoying behavior in two successive sessions, eye contact education session was temporarily suspended and another experiment was scheduled. The timing of giving food varied depending on sessions. For example, the experimenter did not give the subject food for 30 seconds in pArm30s but for five minutes in pArm5m. The eating behavior of the subject was excluded from the data analysis, because the monkey sometimes pushed the food out after the experimenter gave it. The experimenter determined the order of treatments according to states of subject's attention. When the subject continuously ate the food or the monkey's state was stable, the treatment was not changed. In pFace, one trial was a petting treatment for about 30 seconds. One session in pFace was composed of five trials on average. In Eat, one trial was one pretending-to-eat treatment. On session of Eat and pArm30s consisted of about six trials on average. One session of pArm5m was one trial. The video was recorded every session.

Video analysis: To count the subject's annoying behavior in four treatments and EC, we analyzed the recorded video data with the software, The Observer XT 10.5 (Noldus). An expert observer coded from the video data as follows. Pulling-behavior occurred at significant frequency by monkeys when the monkey faced the experimenter. One-time grab or touch during the monkey' s pulling of the experimenter' s white coat or hand/arm in one treatment session or an eye contact education session was coded as "pulling-behavior" . For example, when the monkey pulled the white coat with one hand and grabbed it with the other hand, the number of "pulling-behavior" was counted as twice. We counted the attention behavior of the subject. The looking behavior to the experimenter's arm/hand, including the monkey's arm/hand, was coded as "attention-hand (aHAND)". The looking behavior to the experimenter's face was coded as "attention-face (aFACE)". We calculated the number of the above events and recorded the duration of one session. We calculated the average number of occurrences of the events per minute in each session.

Results & Discussion: The total sessions in the real-time method were 33 sessions. Figure 2 shows the actual flow, including the session duration and pulling-behavior, in all sessions. The actual flow of all sessions was as follows: pFace, pFace, pFace, Eat, Eat, pFace, pFace, Eat, Eat, pFace, Eat, pArm5m, Ec, Ec, Ec, Ec, Ec, Eat, pFaceTrunk, pArm5m, pArm5m, pArm5m, pArm30s, pArm30s, pArm30s, pArm30s, pArm30s, pArm5m, pArm5m, EC, EC, pArm5m, pArm5m. The experimenter switched

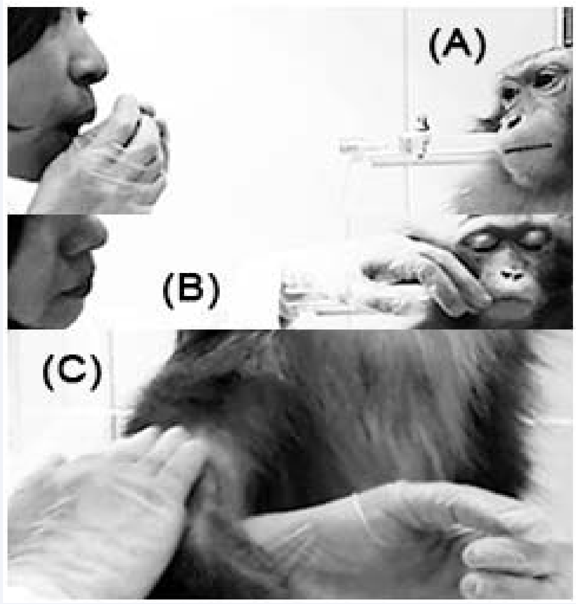

Figure 1 The examples of Eat, pFace and pArm. (A) Eat: the experimenter pretended to eat. (B) pFace: the experimenter gently stroked the monkey's face. (C) pArm: the experimenter gently stroked the monkey's arm.

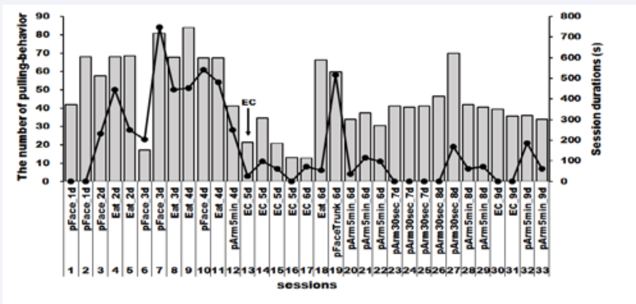

Figure 2 Actual treatment flow of all sessions for nine days. The left vertical axis shows the number that the monkey pulled the human's clothes (a line graph). The right vertical axis shows the required time for one session (a bar graph). The upper part of horizontal axis shows the name of the session and the day. The lower part of horizontal axis shows the sequential order of sessions.

from predetermined Eat to the first EC session because the subject looked at the experimenter when the experimenter implemented the first trial of EC. The average and SD of session duration was about 410 and 174 seconds respectively. The monkey froze and did not show pulling-behavior on the first day, both are common when monkeys encounter the first situation.

Figure 3 shows the number of pulling-behavior per minute in each treatment. This graph excluded the first and second sessions on the first day in pFace. Average number of pulling-behavior per minute was the lowest in pArm30s (pFace: 5.9 pulling-behavior/min., Eat: 3.8, pArm5min: 2.3, EC: 1.1, pArm30s: 0.5). Short term arm-petting was especially effective to prevent face-to-face interactions from the annoying behavior. The number of pulling-behavior in pFace was more than five times per minute even after the fifth session. The grooming on monkey's arm, chest, and mouth by the familiar person reduces the heart rate (HR) [48]. The grooming on monkey' mouth, especially, leads to the lowest HR and the highest heart rate variability (HRV) values among three grooming conditions. The sensation, whether pleasant or unpleasant, might be altered by the degree of social communication.

We recorded the looking behavior of the monkey to the human face or hands. The looking behavior and pulling-behavior were negatively correlated (r=-0.42). We found that the number of the looking behavior was increased after EC (Figure 4,5). EC had a powerful effect on directing the monkey's attention towards not only the face but also hand. The control of the monkey's attention is necessary for imitation of monkeys [6,7]. Our result elicits an idea that eye contact forms the basement of the monkey's imitation since imitation requires the attention towards the model. Activations of mirror neurons might be triggered by the attention towards the human [49]. The looking behavior was observed during Eat before EC. Pretending-to-eat would be candidate to activate the monkey's attention towards the actor. This treatment, however, would not be a suitable intervention for reducing the annoying behavior during unstable interactions between the monkey and the human.

In sum, arm-petting was more effective than other treatments in reducing the annoying behavior. We succeeded in making eye contact with the monkey after the first pArm5min. The monkey gazed steadily at the human partner's eyes in EC (Figure 6). We consider that gentle stroking of arm reduces the monkey's fear to the human. The monkeys could recognize the humans, who were different species from them, as agents with a certain intention of social interactions.

Case 2: Two praises, petting or clapping, in social interactions

Method: We investigated whether the social touch was effective as one of social praises on the monkey that had already interacted with the human. We designed two praises, petting the monkey's face and clapping with the hands. The human partner would give social praises to the monkey when she ate the food which she was reluctant to eat. The monkey had already imitated the human clap-model before the beginning of this study.

Subject: The subject was a Japanese monkey, *Macacafuscata* (Kiki: female, about 6 kg), housed in a single cage. The subject drank water from 600 to 1200 ml per day in the cage. The monkey chow was given 100-300 g daily. Small amount of fresh fruits or vegetables was sometimes given in non-experiment days in the cage. The subject had already been educated eye contact, pointing, and imitation (Figure 7) by the same method as the previous experiments (refer to the section of pre-training in Kumashiro et al., 2002 or the training in Kumashiro et al., 2008). The subject had interacted with the human through gaze behavior, pointing, or imitation before this experiment in the experimental room, seated comfortably in the primate chair (Muromachi Kikai, Co., Ltd) diagonally or oppositely. This study was approved by the Animal Care and Use Committees at Tamagawa University, and all husbandry and experimental procedures were in accordance with the institutional guidelines.

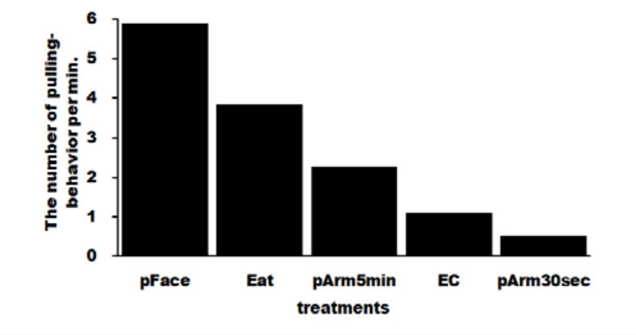

Figure 3 The number of pulling behavior per minute in each treatment; it was the lowest in pArm30sec. The first and second sessions in pFace were excluded.

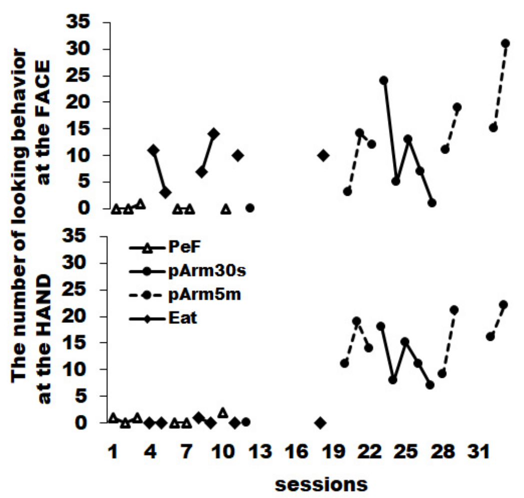

Figure 4 The monkey's attention towards the experimenter's face or hand; the vertical axis of the upper and lower graphs were the number that the monkey was looking at the experimenter's face and at the experimenter's hand, respectively. Looking behavior in EC was not measured.

Figure 5 The monkey's looking behavior toward the experimenter's face in pArm5min.

Figure 6 The monkey's eye contact with the experimenter in EC.

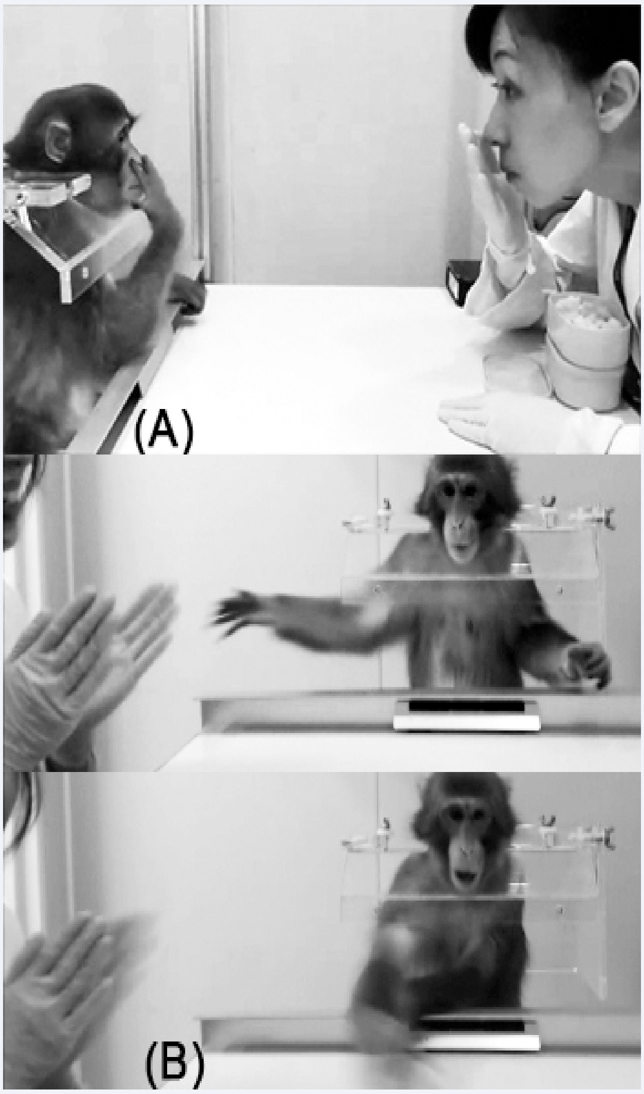

Figure 7 The examples of two imitations. (A) hand-nose: the monkey touched the nose with her hand after the experimenter showed the hand-nose model. (B) clap: the monkey clapped after the experimenter clapped.

Procedure: The subject seated comfortably in the primate chair (Muromachi Kikai, Co., Ltd.), facing the experimenter at a distance of 40-70 cm in the isolated experimental room. All experiments were video-recorded through web camera (Logicool, Co., Ltd.) or video camera (Panasonic, Co., Ltd.) in front of the table.

The experimenter conducted the food-choice task. The sliced three foods, apples, carrots, and sweet potato, were put in each separated container and were aligned in a straight line on the table. The subject pointed at one of the three different foods herself after the food presentation. The experimenter gave the subject the food which she chose. Next, the subject pointed at one out of the two foods. At the end, the subject pointed at the last food. When the subject did not point to the last food or was reluctant to eat the food given by the experimenter, the experimenter gently rubbed around the mouth to encourage the subject to eat it in pFace. The subject was praised by face-petting or clapping when she began to eat the food which the subject seldom pointed to or she was reluctant to eat, mostly carrots. In pFace, the praise was the gentle stroking of the subject's face with the palm when she started eating a slice of the food which she did not try to eat (Figure 8a). The experimenter rubbed around the subject's mouth until the subject started chewing. The experimenter's stroking speed was1-10 cm per second in eating, but sometimes faster than that in reluctant eating. The experimenter occasionally stroked the subject's face or body when the subject did nothing or something unrelated to the task. Clapping was the other praise condition that the experimenter clapped with the hands when she began to eat the least favorite food (Figure 8b). One food feeding was one trial. One block consisted of three trials. The arrangement of three foods was changed every block. After the subject had eaten all foods (sweet potatoes, apples, and carrots), she proceeded to the next block. One session consisted of five to 10 blocks. The session of the day was stopped if the subject did not point at any food, rejected eating, or the session lasted over about 20 minutes, with all things considered, when the experimenter judged not to continue to the next session. It was also implemented by the real-time method. The experiment was preceded at the subject's pace. Pointing or eye contact was not forced by the experimenter. The subject played with the experimenter in a different type of communication in order to check the degree of social communication after the food-choice task (in preparation). All sessions were videotaped. Experimental design was A-B-A design, pFace, Clap, and pFace. The number of sessions was flexible depend on the subject's behavior. We observed the subject's annoying behavior, the subject's pointing or imitative behavior.

Video analysis: In order to observe the subject's behavior in response to two praises, we analyzed the videos with the software, The Observer XT 10.5 (Noldus). The trained expert observer coded behavior from the video data as follows. Throwing of food was shown at significant frequency by this subject in Clap. When the subject threw or dropped the food provided by the experimenter, it was coded as "throwing-food". Pointing at the food around the container was coded as "pointing". Three subject's imitations of human models, hand-nose, grasping, and clapping (see [6,7]) were coded "hand-nose", "grasp", and "clap", respectively. When the subject turned the face towards the experimenter and closed her eyes in Clap, this behavior was coded as "face-turning" and measured the duration of it. When the subject rejected food, this behavior was coded as "food-rejection". We counted the number of the above events. We measured the duration of each session and the eating time of a piece of carrots. The stroking time of before the first clapping session and after the last clapping session was measured because we investigated whether the petting duration was different between those sessions. We calculated the rates of the events as the mean number of occurrences per minute recorded in one session.

Results & Discussion: 24 sessions in food-choice task were recorded for seven days. The first pFace phase was nine sessions for two days. The Clap phases were eight sessions for two days. The second pFace phase was seven sessions for three days. Figure 9 shows the duration of each session. The average duration in the first pFace, Clap, and the second pFace was about 11, 9, and 17 minutes respectively. In the session interval, the experimenter prepared the next sessions. The duration time in the second pFace phase prolonged more than that in other phases. This was partly due to food-rejection (Figure 10), which the monkey rejected the food given by the experimenter. The average number of food-rejection was 22, 6, and 36 times in the first pFace, the Clap, and the second pFace respectively. The average eating-duration was 220, 86, and 216 seconds in the first pFace, the Clap, the second pFace respectively. Eating-duration of the first pFace was similar to that of the second pFace. The food-rejection was, however, the highest in the second pFace among three phases. It appeared that the experience of Clap had negative effects on the second pFace. Although the average number of trials in all sessions of the first pFace or Clap was 30 trials, that in the second pFace was 24 trials but one trial was a human error. Even the human was afflicted by the aftereffect of the Clap interaction. The pointing, especially with gaze alternation, represents a typeof communication with the partner in monkeys [5,50]. There could be weakened intentions of monkey's communication with the partner as the pointing after Clap was decreased in the second pFace (Figure 11).

The monkey showed excessive throwing-food behavior at the 17th session in the Clap (Figure 12). The monkey often clapped in the Clap (Figure 13). It would imply that the clap praise did not function as a social praise for the monkey. When the praise was changed from the Clap to the pFace, the throwing behavior decreased rapidly. The percentage of total petting durationsi n total session durations were about 15% in the last pFace session before clapping and 27% in the fast pFace session after clapping. This result showed that the experimenter used petting in order to facilitate the monkey's communication with the human after Clap. The monkey frequently turned the face towards the experimenter and sometimes closed her eyes as if the monkey was waiting for the experimenter to stroke her face in the beginning of the Clap. The duration of face-turning behavior was about one fifth of the duration of the first and second Clap sessions. The monkey might wait for petting the face by the experimenter. These results suggest that gentle stroking reduces the annoying behavior of the monkey, but petting praise of the face might not be sufficient to encourage the monkey to eat the food which she did not like.

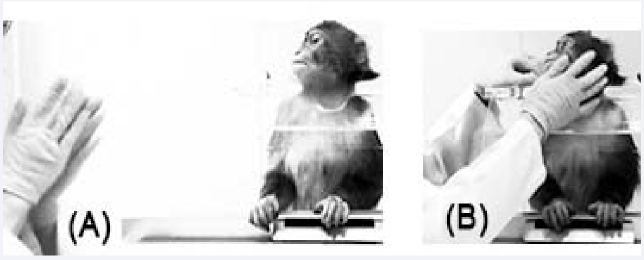

Figure 8 Clapping and petting as a social praise. (A) Clap: the experimenter clapped for the monkey. (B) pFace: the experimenter gently stroked the monkey's face with the palm.

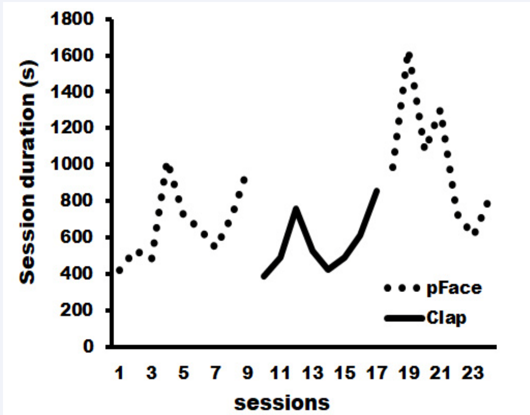

Figure 9 The session duration in all sessions. The Clap sessions led to the remarkable increase in the second pFace.

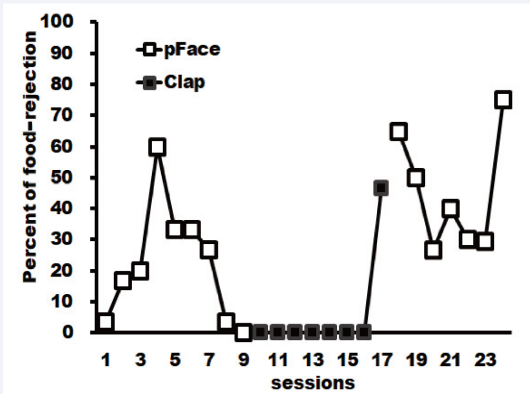

Figure 10 Percentage of food-rejection. Food-rejection rate was higher than 30 percent after the last Clap session.

GENERAL DISCUSSION

Our hypothesis was that the social touch would have a positive effect on social interactions between the monkey and the human. We found that the social touch was a useful approach to reduce the annoying behavior of monkeys in two cases. In the first case, the experimenter had the opportunity to make eye contact with the monkey just after the experimenter stroked the monkey's arm gently for about five minutes. It is well-known that adult monkeys avoid eye contact (for example, [51]). In humans, the gentle touch tends to occur during mutual gaze with their infants [52]. It appears to be the same in the monkey in that there is close relationship between touch and gaze behavior since the education of eye contact was implemented after our touch treatment. Meanwhile, in the pretending-to-eat treatment, the

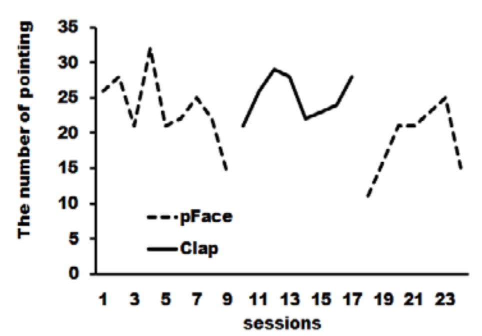

Figure 11 Pointing in all sessions. The number of pointing decreased after the Clap sessions.

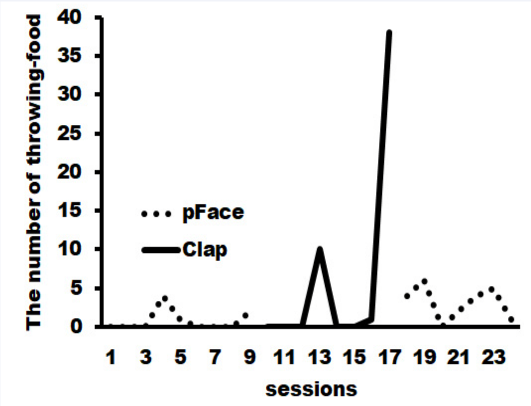

Figure 12 The number of throwing-food behavior. The monkey incessantly threw food at the last Clap session. After switching from Clap to pFace, the number of this behavior decreased dramatically.

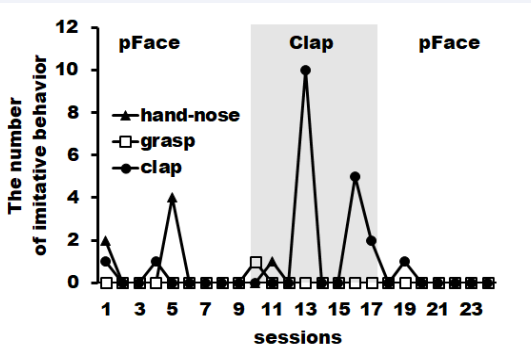

Figure 13 The number of occurrences in monkey's imitative behavior acquired by the education of imitation; the monkey often clapped in the Clap sessions.

monkey directed her attention towards the human face (Figure 4). The gentle stroking, however, could be suitable for reducing the annoying behavior.

The monkey was provided the slow stroking at 1-5 cm per second by the human in case 1. C-tactile afferent fibers, which exist in the hairy skin, respond to slow moving [53-55]. Slow or gentle touch is common in skin-to-skin contact of social interactions. It is considered that C-tactile afferent fibers in humans are important for affective touch and produce the feeling of pleasant [56]. Especially, stroking by the brush on the human hairy skin is pleasant at the velocity of 1-10 cm per second [35]. The slow, affective touch also reduces feelings of social exclusion [57]. The human's touch here should function as affective touch. In case 1, the experimenter rarely stroked the monkey's hand but principally from the elbow to the monkey's wrist (Figure 1c). The arm-petting appears to be more comfortable than hand-petting, since C-tactile afferent fiber is less abundant in the distal part than in the proximal one [53,55]. In our report, 30 seconds stroking on the arm was more effective on the attenuation of the annoying behavior than five minutes stroking (Figure 3). Since low-threshold C fiber shows fatigue to the repeated stimuli [55,58], it could be related to the outcome of the difference between the short-term and the long-term stroking. The methods of using soft brush under the control of the vertical force or the velocity of stroking are excellent and clearly bears categorical results as referred to above. Further research will be necessary for us to clarify the effect of social touch on monkeys by the human's hand in addition to the current cases and some studies [46,48]. The monkeys which had the lesion in part of the ventral premotor area refused to be stroked their bodies by the human [16]. Anatomically, the dorsal premotor cortex is connected with the amygdala in monkeys [59]. There are also multisynaptic projections that arise from the amygdala to the ventral premotor cortex [60]. It would lead to the scientific elucidation of neural mechanisms underlying social gestures via somatosensory by analyzing the role of tactile information in the social communication.

When people succeed in doing something, they mostly receive social rewards, for instance, petting the child's head, applause or verbal reward, before physical rewards. It remains to be clarified how the tactile stimuli affect monkey's behavior. Taira and Rolls (1996) evaluated whether social touch of monkeys had efficacy as a positive reinforce, in order to know where tactile stimulation was represented in the brain as positively reinforcing in the future [46]. In their study, when the monkey touched the correct visual pattern within 10 s after the tone cue, the experimenter groomed the monkey's face, neck and head with his hand about 90 s. The grooming on the monkey's face resulted in the high scores of that task. Before the systematic test, the monkey grew accustomed to the grooming by the experimenter for three months. The monkey in case 1 had never interacted with the human partner through social touch or gestures prior to this experiment. In consequence, face-petting was not good for the monkey in order to make eye contact with the human. Arm-petting should precede face-petting. In case 2, although face-petting did not encourage the monkey to eat the food which she did not like, it was useful to prevent the monkey from throwing food. In humans, there are also C-tactile afferent fibers in the face [54]. In monkeys, the HRV in social touch on the mouth was higher than that in the arm or the chest [48]. There is a possibility that the sensitivity of the mouth includes more features than that of other body parts innervated C-tactile afferent fibers.

The monkey's clapping extremely increased during the 13th session of the clap phase in case 2 (Figure 13). Although the monkey had repeatedly showed clapping behavior toward the human partner, the partner was not able to respond to the monkey's clapping like imitation. As the monkey could not recognize the clap as a prize but imitation, there was possibility that she repeatedly clapped to explore the cause. The monkey's throwing behavior also explosively occurred at the 17th session (Figure 12). Clapping as praise created confusion for the monkey. After the excessive throwing behavior, the monkey's pointing decreased and the session duration prolonged. Weak joint-attention interaction from reducing monkey's pointing caused human negative emotions, resulting in the human error. In humans, parents spontaneously display the smiling when they point, and the positive affective components of joint-attention interaction are encapsulated by parent's pointing-interaction with their infants irrespective of their ages [61]. When the difficult interaction appeared in the communicative situation between the humans and the monkeys, the social touch would be helpful in eliciting the positive affective expression in light of reducing the annoying behavior. The distinct features of clapping are clapping period and synchronization by many people [62], or the time of clapping regardless of the quality of the contents [47]. We, however, could not exclude the possibility that the experience of clapping as the social praise like humans worked in an effective manner even in monkeys.

It is hard for autistic patients to establish eye contact [13]. They have impairments in social skills [63]. Tactile perception in autistic people is different from that in people without autism [64,65]. Psychopathic traits are also involved in poor attention to the eyes of emotional faces or low levels of eye contact [9]. The impairment in amygdala responsiveness to the emotional stimuli could be a marker of callous-unemotional traits in children [66]. However, it is likely to differ in the neural mechanisms of psychopathy and autism depending on the level of amygdala dysfunctions, the luck of brain functions or anatomical structures. Social deficits of children with autism are considered to be an impairment of the mirror mechanism [67]. The psychopath traits also might be linked to the mirror neuron system [68]. Our touch-intervention will enable us to study the neural mechanisms including single cell level analysis of social communication, eye contact, communicative pointing, or imitation, in the near future. It also allows us to examine how the mirror neurons mechanism connects with the other in the external world. Gene expression are changed by the gentle stroking in rats [69]. Taken together, our results suggest that our social-touch approach plays a great role in the control of affective components, and so it opens the gate of initial interaction or smooths a transient heightened emotion.

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