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Intentional Communication and Comprehension of the Partner's Role in Experimental Cooperative Tasks

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A group of five chimpanzees was asked to move from a small enclosure to larger one at Hayashibara Great Ape Research Institute (GARI) as one of their daily procedures. Zamba, Tsubaki, and Mizuki responded to our request and moved smoothly to the large enclosure through a gate. Loi, the alpha male of the group, appeared slightly excited for some reason; his hair bristled and he kicked the nearby wall as he went through the gate. The last chimpanzee, a small female named Misaki, remained in the small enclosure. We asked her to move by calling to her loudly, but she hesitated and simply watched Loi, who is occasionally rough with the females, getting excited outside the doorway. Loi sat in front of the gate, watching her. We continued calling Misaki to move, but she refused. Then Loi came back through the gate into the small enclosure and approached Misaki with his arm extended. Misaki stepped back a little, but Loi continued approaching her with his arm out. Finally he reached and touched her softly, embraced her, and the two chimpanzees went out to the large enclosure together.

We wonder if we are allowed to interpret the above anecdote as Loi's attempt to cooperate with Masaki in moving together. He may instead have been simply attempting to reconstruct a friendly relationship with her. Cooperation is an interesting behavior to look for in the behavior of chimpanzees, but it is difficult to determine its goal and to verify whether an episode fulfills the definition of cooperation during natural interactions. We have several years of experience with captive chimpanzees, but we find it hard to imagine a situation in which the chimpanzees would work together to create something—namely, a clearly distinguishable goal—in their daily lives. It is possible that they do not lack the ability to cooperate, but instead that the situations they are confronted with in captivity provide insufficient motivation for cooperation. It also seems to be difficult to find cooperation in wild chimpanzees, as two individuals rarely need to work together to obtain food. Their main diets are fruits and other vegetation, which they can obtain by themselves. But wild chimpanzees do appear to cooperate in some specific instances, such as in reports of cooperative hunting (but see chapter 18) and cooperative traveling (see chapter 27).

In this chapter, we describe the behavior of a captive female chimpanzee in two types of cooperative tasks in which she was paired with a human and with a conspecific partner. Cooperation in the common sense may refer to a behavior in which an individual actively assists or supports another, with benefits to the receiver and often with costs to the actor (van Schaik and Kappeler 2006). In the tasks reported in this chapter, the chimpanzee actor benefited by obtaining food instead of having to pay the cost of assisting the partner. From this perspective, the chimpanzee's behavior is not cooperative. However, even when a human participates in apparently costly cooperation, he

or she may do so to obtain reputation or social approval in exchange for helping another person (Gächter and Herrmann 2006). Human cooperation has various types of cost/benefit distribution among its participants, along with various types of motivation. We therefore would like to take a more behavioral perspective, rather than emphasizing the outcome in terms of cost and benefit or preceding motivation. This allows cooperation to be defined as two individuals acting together to reach a common goal (Boesch and Boesch 1989). From this perspective, the behavior of chimpanzees described in this chapter can be considered cooperative.

Background

Prior to our work, several studies investigated cooperation in nonhuman primates. Köhler (1925) was a pioneer in studying the behavior and intelligence of chimpanzees in experimental situations, and he described his interest in the cooperation among chimpanzees at his laboratory. Köhler created one of his experiments as a variation of a tool-use test in which the chimpanzees had to pile one box upon another, step on it, and obtain food that was hanging from the ceiling. After the chimpanzees became familiar with piling the boxes, they were allowed to attempt the task while together in the playground. They gathered underneath the hanging food, and each tried to make a box pile to climb in his or her own way. Several of the chimpanzees wanted to climb at the same time and to build their piles unaided. If one was close to finishing a pile, another often came to pilfer the boxes, resulting in the pile being destroyed in the struggle. Thus, there was generally no systematic collaboration or strict division of labor among individuals. However, one of the chimpanzees occasionally helped another. This chimpanzee was better at piling boxes than the others, and when he watched another chimpanzee piling boxes unsuccessfully, he could not keep from lending a hand and supporting a box that threatened to fall. Köhler did not consider this to be helping in a true sense, but rather interpreted it as the skilled chimpanzee being interested in the process of piling the boxes.

Köhler described another example that more strongly resembles cooperation. In this instance, he again provided some food that was tethered from the ceiling and hanging out of reach. The chimpanzees made repeated efforts to reach the food, but without success. A heavy cage was located some distance away; one of the chimpanzees noticed it, shook it back and forth, but could not move it. Another chimpanzee then also went over to hold the cage, and the two chimpanzees acted together to lift and roll it. A third chimpanzee joined them, taking hold of one side of the cage and helping to move it. The three moved the cage to a position under the food and eventually one of them climbed up on it and obtained the food, leaving the remaining two unrewarded. The chimpanzees showed no trace of altruism, but Köhler wrote that all three had the same aim (i.e., to move the heavy cage) and understood one another's intentions. A more experimental approach to cooperation was developed by Crawford (1937), in which he presented chimpanzees a task that required them to pull a pair of ropes to access a box containing food that was too heavy for one chimpanzee to pull alone. In the initial trials, the two chimpanzees did not cooperate. The human experimenter then actively taught them to pull the rope when they heard a verbal cue. Once their cooperation was established in this way, the chimpanzees worked together to pull the box, and they continued to do so even after the human experimenter stopped giving cues. One of the chimpanzees began to solicit the other by touching her, placing an arm over her body, or vocalizing when she was not motivated to pull the string (figure 20.1). When other pairs were tested, the process was somewhat similar. Some years after Köhler's observation, Menzel (1972) observed young chimpanzees cooperating to use ladders. More recently, the method used by Crawford was reintroduced to chimpanzees by Povinelli and O'Neill (2000), who studied the possible use of gestures by an experienced individual to instruct a naïve partner, but found no evidence for such gestures.

Chalmeau (1994; see also Chalmeau and Gallo 1996a, 1996b) also carried out an experimental study of cooperation in chimpanzees. A specially constructed fruit distributor was presented to a group of captive chimpanzees. Two individuals had to simultaneously pull a handle connected to the device to make the fruit fall into the enclosure. A dominant male and an infant produced most of the pull-

Figure 20.1 A chimpanzee solicits the partner to pull the rope. Picture taken from a video clip of Crawford's (1937) study. © Yerkes National Primate Research Center, Emory University.

ing responses, and the male obtained nearly all of the fruit. This male displayed an increasing number of glances toward the infant partner, suggesting that he had learned to cooperate with the infant. In contrast, the infant did not reliably check the partner, and the authors interpreted the infant's behavior as partially linked to play activity.

More recently, Tomasello and colleagues conducted a comparative study of cooperation between chimpanzees and humans in various tasks (Herrmann and Tomasello 2006; Warneken et al. 2006; Warneken and Tomasello 2006). The chimpanzees had difficulty understanding the cooperative communicative motive of a human experimenter, and did not try to maintain joint collaborative activities with the human. However, when the human reached for objects but failed to grasp them, they helped by fetching the object for the human.

Several other studies have probed cooperation in nonhuman primates; some have failed to see cooperation while others have succeeded (see Tomasello and Call 1997, Noë 2006 for review). For example, capuchin monkeys have been studied in various settings. Chalmeau et al. (1997), using the same method as in Chalmeau's (1994) chimpanzee study, found that capuchin monkeys succeeded in accomplishing the task, but had only a limited understanding of the task requirements and did not take the role of the partner into account. The two individuals pulled the handle randomly. However, Mendres and de Waal (2000) used the paradigm pioneered by Crawford (1937) and showed that the capuchin monkeys did understand the role of the partner; they pulled more frequently when the partner was present than when the partner was absent. De Waal and Davis (2003) extended this paradigm and compared cooperation in pairs of monkeys with different dominance or kinship relationships. The results suggested that expectations about the behavior of a partner played a role in the decision to cooperate. Hattori et al. (2005) introduced another type of intuitive cooperative task to capuchin monkeys, and showed that they could successfully cooperate and divide labor.

Questions Addressed

We address three primary issues in this chapter: (1) understanding of the role of others in cooperation, (2) intentional communication between potential cooperative partners, and (3) the role of eye contact in these sorts of interactions. We also use a unique comparative approach in which identical tasks are performed with the opportunity to cooperate with human or conspecific partners.

Earlier, we described studies with chimpanzees in which Crawford (1937) and Chalmeau (1994) both succeeded in creating situations in which two individuals worked together. However, Crawford's initial training phase included human cues—and in Chalmeau's study, one of the two individuals appeared not to comprehend the situation. We attempted to determine how the chimpanzees would begin to coordinate their behavior without external human cues, and to what extent they understood their partner's role in solving the task. More precisely, we were looking for behavioral evidence that the chimpanzees understood their partner's role, such as watching the partner carefully and coordinating their behavior with that of the partner. In addition, we were interested in replicating the result of Crawford's (1937) experiment and Menzel's (1972) observation of chimpanzees, showing soliciting behavior. If the chimpanzees in our studies understood the necessity of the partner and had the ability to communicate to change the partner's behavior, they would show soliciting behavior when the partner was not cooperative.

We combined this question with another line of research about intentional communication. Several studies have investigated this kind of communication in chimpanzees and other apes, with reference to their understanding of the attention of others. They have shown that chimpanzees use communicative signals when a recipient is oriented toward them (Gómez, 1996a, 1996b; Hostetter et al. 2001; Leavens et al. 2004), although there is no clear evidence of their understanding of whether the recipient can actually see (e.g., Povinelli et al. 2000). Orangutans repeated communicative signals when the humans they were signaling did not respond to a request, and in other instances they modified their gestures according to a human response (Cartmill and Byrne 2007). Studying the use of gestures among conspecifics, Tomasello et al. (1994) found that chimpanzees used more visual gestures when recipients were looking at them and more tactile signals when recipients were not looking at them. In the stone-pulling task described below, we modified the orientation of the human partner as well as his responsiveness to the chimpanzee's gesture to further examine the nature of the chimpanzee's soliciting behavior in the cooperative task.

The third focus of our study is the occurrence of eye contact, which is related to the issue of intentional com-

munication and understanding of the attention of others. Gómez (1996a) stated that eye contact in humans is a case of ostensive behavior—a way to express and assess communicative intent—and suggested that in the great apes, it has evolved into a similarly ostensive behavior. For one thing, eye contact is within the repertoire of spontaneous friendly interaction in chimpanzees and other great apes (de Waal 1982, 1989; Goodall 1986), in contrast to the use of eye contact as threats by monkeys. Gómez (1996a) described how the chimpanzees in his experiment established eye contact when they requested food. He reported that the chimpanzees had been waiting for the human partner to direct her gaze at them. Gómez (1990) also described a gorilla making eye contact with a human when requesting the human to open the latch of a door. The great apes thus seem to be capable of some sort of ostensive function by means of eye contact. However, there is conflicting evidence indicating that chimpanzees did not differentiate between a human's eyes being open or closed when they gestured toward the human (Kaminski et al. 2004). To elucidate the possibility of chimpanzees using eye contact to express and assess communicative intent, our study examined whether they made eye contact with cooperative partners. The sample size we report here is small, but we hope that these additional examples contribute to an understanding of the cooperative nature of chimpanzees.

Approach and Results

Participants and Study Site

The subjects were two young female chimpanzees, Tsubaki and Mizuki, housed at the Great Ape Research Institute (GARI) of Hayashibara Biochemical Laboratories, Inc., established in 1999 (Idani and Hirata 2006). These subjects had been moved to GARI together with two young male chimpanzees in January 1999, when Tsubaki was approximately three years old and Mizuki was two. The four chimpanzees lived as a group in a facility consisting of a large outdoor compound of 7400 m^2 that contained natural forest, a pond, and a climbing structure 13 m high. The outdoor compound was attached to a smaller compound and to an indoor shelter. The study took place when Tsubaki and Mizuki were six and five years old respectively. Tsubaki had been mother-reared until a few months before she was moved to GARI, and Mizuki had been hand-reared from a few days after her birth. Both chimpanzees had participated in several types of cognitive tasks, such as tool use and sequential learning using computer-controlled touch screens (see Morimura 2006). The human experimenters had extensive direct contact with the chimpanzees, including feeding, playing, body checks, and training for studies. The chimpanzees typically spent a few hours each day interacting with humans indoors for study or husbandry purposes, and spent their remaining hours with other chimpanzees in the outdoor enclosure or the indoor sleeping areas.

Stone-Pulling Task

TEST WITH A CONSPECIFIC PARTNER. We dug a hole in the ground inside the chimpanzee enclosure, placed a piece of food in it, and covered it with a set of stones wrapped in netting, with attached metal rings that could be used to pull the stones off the hole. The chimpanzees first learned to pull the stones from the hole to obtain the food. Then additional stones were added, gradually increasing the weight of the set until a single chimpanzee could no longer pull it off the hole. When the maximum load, approximately 120 kg, was introduced, we brought in the Tsubaki and Mizuki to see if they would move the set of stones together. A session started when they were released into the enclosure from an adjacent waiting area, and it ended when 3 min passed without either individual manipulating the stones.

When Tsubaki and Mizuki were released to the enclosure, they approached the set of stones and pulled one of the attached rings. In the first session Mizuki approached the stones first, and pulled one of the rings by herself, but the stones did not move. She then sat beside them. Soon after this, Tsubaki approached and also pulled one of the rings by herself while Mizuki watched from nearby, but the stones still did not move. In this way in the first session, Tsubaki made 14 attempts to pull the stones and Mizuki made 13. On three attempts, both chimpanzees pulled the stones at the same time: on two of those attempts they pulled in opposite directions, while on the other they pulled in the same direction but stopped before the stones moved. They never succeeded in moving the stones during this first session. In the second session Tsubaki made three attempts to pull the stones and Mizuki made one attempt; they never both pulled the stones at the same time. In the third session Tsubaki made one attempt

Figure 20.2 Tsubaki pulls the set of stones while Mizuki sits nearby.

to pull the stones and Mizuki made three attempts; they never pulled at the same time. In all three of these sessions, they never succeeded in moving the stones. Because they were beginning to lose interest, we terminated the test after the third session. The frequency of Tsuabki and Mizuki pulling the stones at the same time was significantly lower than would be expected if they had proportioned their pulling efforts randomly throughout the session. Indeed, it seemed that each individual avoided pulling the stones when her partner was pulling them (figure 20.2).

TEST WITH A HUMAN PARTNER. As the next step, we wanted to see whether cooperation in an identical setting would occur between a chimpanzee and a human. SH worked as a cooperative partner with Mizuki. Tsubaki also participated in the test, but since her motivation was inconsistent, her participation was terminated and those results are not reported hereafter.

In the initial test with Mizuki we tested whether she understood the need to adjust the timing of her pulling to match that of her human partner. The human alternately pulled and stopped pulling every 10 s for a total of 3 min during each session. While the human was doing this, Mizuki was released to the enclosure. Across the three sessions conducted, she pulled the stones four times while the human was not pulling. She also pulled four times while the human was simultaneously pulling, but only for a very short time. The stones did not move, and all three sessions ended without success.

We then began training sessions in which less weight was used. Mizuki could pull the weight alone, but the human also intervened and they pulled the stones together. The weight of the stones was gradually increased, and the human adjusted the timing and direction of pulling to match that of the chimpanzee. When the maximum load was again introduced, the chimpanzee successfully coordinated her pulling with that of the human. After she began to move the stones with the human partner, we introduced a test situation in which the stones were pulled in a predetermined direction to see whether Mizuki understood that to move them she had to pull them in the same direction as the partner. The human started pulling in a predetermined direction before the chimpanzee was released into the enclosure. Three trials were conducted in each session. In early trials the chimpanzee did not appear to adjust her pulling direction on her first attempt. She sometimes pulled the stones in a completely opposite direction to that of the human, of course in vain (figure 20.3). In 4 of the first 10 trials, she pulled the stones in the same direction as the human on her first attempt. However, she changed the direction of her pulling when she could not move the stones, and in all of the trails she pulled the stones in the same direction as the human sooner or later, which led to successful displacement of the stones. After approximately 60 trials (20 sessions), the chimpanzee began pulling the stones in the same direction as the human partner on her first attempt in the majority of trials (figure 20.4).

Figure 20.3 Mizuki pulls the set of stones in the direction opposite to that of the human partner.

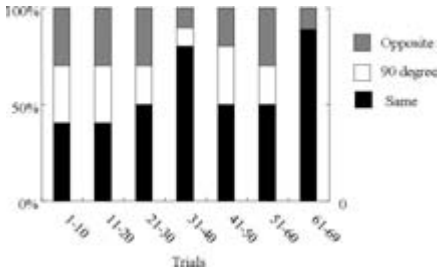

Figure 20.4 Change in the direction in which the chimpanzee initially chose to pull in each trial across blocks of 10 trials. Opposite: the chimpanzee pulled the stone in the opposite direction of the pulling direction of the partner. 90 degree: she pulled at 90 degrees to the direction of the partner. Same: her pulling direction was the same as that of her partner.

(A)

(B)

(C)

Figure 20.5 Mizuki (a) pulls the stones alone, (b) takes the human's hand, and (c) brings him to the stones.

Finally we introduced a test situation to determine whether the chimpanzee would actively solicit assistance in the task. The human experimenter stood at a distance of 1.5 m beyond the stones from the viewpoint of the door through which the chimpanzee was released into the enclosure. There were two variations on this position: the human either faced toward the door or away from it. In the first trial of this test condition, the chimpanzee first tried unsuccessfully to pull the stones alone for a total of 12 s. She then approached the human, took his hand, led him to the stones, and took one of the rings by herself to pull. The human responded and they pulled the stones together. During the six of the first eight trials of this test condition, the chimpanzee first tried to pull the stone by herself and then approached the human to lead him to the stones to pull together (figure 20.5). During the rest of the 40 trials of these test conditions, directly after entering the enclosure without making any effort to pull alone, the chimpanzee approached the human, took his hand, and led him to the stones.

Mizuki never attempted eye contact when she solicited the human and took his hand. The condition in which the human stood with his back turned was used to see whether the chimpanzee would move around the human to make eye contact when she solicited him. No such behavior was observed. When the human's back was turned, the chimpanzee always solicited him by taking his hand from behind his back. She did look up to the area around the human's face most clearly in the first trial, when his back was turned (figure 20.6), although eye contact was not actually established because Mizuki shifted her attention before the human turned around to face her.

To further investigate the chimpanzee's soliciting behavior, we implemented another variation of the test in which the human did not respond to the chimpanzee's soliciting behavior (i.e., the taking of his hand) for 5 s, to see whether this would induce any further communicative behavior by the chimpanzee. We conducted a total of 12 such trials. In half of them the human stood facing the door through which Mizuki was released, and in the other half he stood with his back to the door. The result was that Mizuki repeated the same soliciting behavior—pulling the human's hand—but when the human did not respond, Mizuki pulled his hand again in the same manner. Overt eye contact did not occur in any of these trials.

Because the chimpanzee's soliciting behavior always consisted of taking the human's hand, we made it more difficult for her in the next trials by keeping the human's hands up out of her reach, to see whether that would induce any further communicative behavior on her part. We conducted a total of 24 trials. The human faced the door

Figure 20.6 Mizuki takes the hand of the human, who is facing away from her.

in half of the trials and away from the door in the other half. Mizuki did not use any new behavior patterns, such as going around to stand in front of the human when he had his back turned. She did, however, make eye contact in 3 of 12 trials in which the human was facing her when she took his hand; but this might be explained by her looking for his hand, which he was holding up close to his face.

String-Pulling Task

TEST WITH A CONSPECIFIC PARTNER. We conducted another type of cooperative task with the same chimpanzees using an indoor experimental room (Hirata and Fuwa 2007; Hirata 2007). This experiment began during the same time period as the aforementioned stone-pulling task. The two chimpanzees, Tsubaki and Mizuki, were required to pull both ends of a string simultaneously to drag food within reach. Two blocks, each with a piece of food on top, were placed on the floor outside an experimental room where the two chimpanzees were located. The blocks were connected by a plastic rod and a single string passed through a hole in each block. Both ends of the string extended into the experimental room through openings in the lower wall. The distance between the two ends was greater than a chimpanzee's arm span. Although a chimpanzee could reach a hand through the opening in the wall, the blocks were out of reach. By pulling on both ends of the string, however, the chimpanzee could draw the blocks within reach to obtain the food. If a chimpanzee pulled only one end of the string, she would get only the string while the block remained out of reach. Before the tests, we trained each of the two chimpanzees separately, each with a single block, until they learned to pull both ends of the string by themselves to draw it toward them. Once Tsubaki and Mizuki had each learned to pull both ends of the string by themselves, we began the test situation. First they were brought to a waiting area about 2 m away from the string while the apparatus was prepared. When the setup was complete, they were allowed to behave freely. Ten trials were conducted in each session.

In initial tests, the length of each end of the string extending into the experimental room was short (10 cm), thus requiring two chimpanzees to pull both ends simultaneously. Soon after the start of the first trial, Tsubaki approached one end of the string and pulled it without paying attention to the other end. The string slipped through the blocks and out of the apparatus. She briefly glanced at the other end, which had gone out of the room, and released the end she was holding. Mizuki remained in the waiting area. In the second trial the result was similar. By the third trial Mizuki also began to approach and pull the string; but the two chimpanzees never cooperated, nor did they succeed in pulling the blocks within reach during any of the three sessions conducted. In all 30 trials, only one end of the string was pulled by either of the two chimpanzees.

We then made the situation a little easier by increasing the length of the two ends of string extending into the experimental room to 130 cm (this was called the long-string treatment). In this treatment, both ends of the string would remain inside the room even if one was pulled before the other. Thus, the chimpanzees did not have to pull them simultaneously. Moreover, it was possible for one chimpanzee to pull both ends of the string and succeed by herself in pulling the food within reach. The result was that Mizuki pulled both ends herself, and succeeded in the first trial. Tsubaki did not approach, staying instead at the waiting zone. In the second trial the result was the same; Mizuki succeeded alone. When the third trial began, Tsubaki moved from the waiting zone, approached one end of the string, and started pulling the string, Mizuki then arrived at the other end of the string and pulled. This led to the chimpanzees' first success, in which they drew both blocks within reach and both obtained the food.

During this condition, the chimpanzees' frequency of success gradually increased (figure 20.7). Mizuki began frequently looking at Tsubaki, waiting to see if she was holding the string, and then pulling the string in synchrony with her (figure 20.8). Tsubaki began to behave similarly,

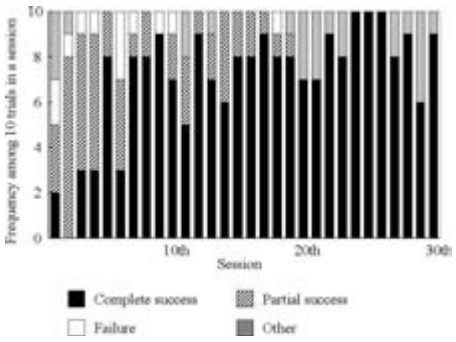

Figure 20.7 Progress across sessions consisting of 10 trials. Complete success: the two chimpanzees pulled the string together and each reached the food after joint pulling behavior. Partial success: the two chimpanzees pulled the string together but only one of them reached the food after joint pulling behavior; when the first chimpanzee reached the food and released the string, the block containing food for the second chimpanzee was still beyond her reach. Failure: the chimpanzees failed to draw the blocks. Other: other result, such as one chimpanzee pulling both ends.

Figure 20.8 Mizuki holds one end of the string and waits for her partner Tsubaki to take the other end. From Hirata and Fuwa 2007. Reprinted with permission of Japan Monkey Center and Springer Japan.

glancing at Mizuki and waiting if necessary. Thus, after some trial and error, the two chimpanzees learned to coordinate their behavior. The string was gradually shortened and they succeeded in pulling both ends simultaneously when the original condition was reintroduced. Of note was that they did not use interactive behavior or eye contact to synchronize their behavior. Both chimpanzees became experienced at this task, and each could coordinate her behavior to that of the other, but this coordination behavior consisted only of glancing and waiting.

We also observed that neither chimpanzee ever waited until her partner drew the block within reach. As illustrated in figure 20.7, there were several cases with partial success, in which both chimpanzees pulled the string together at first, but only one drew the block within reach and then released the string before her partner had finished doing the same. In such cases the remaining individual continued pulling the other end of the string, or succeeded by grabbing the end released by her partner and pulling both ends by herself. We observed no clear evidence of an individual continuing to hold her end of the string and actually waiting until her partner had succeeded in drawing the block within reach. Each individual pulled her end as quickly as possible once she noticed her partner holding the other end, and this resulted in their drawing the blocks within reach together at the same time.

TEST WITH A HUMAN PARTNER. To further investigate the potential for soliciting behavior, we paired Mizuki with a human partner (SH) in the same situation, in which there were two conditions. In the first, the human adjusted his timing to pull the string simultaneously with the chimpanzee. In the second, the human delayed his approach, remaining still for 2 s. This resulted in failure in almost all of the first eight trials, because Mizuki then pulled the string alone. The exception was the seventh trial, in which Mizuki waited for the human; it resulted in success. On the ninth trial, when the human did not approach the string at all, Mizuki looked up at his face, whimpered, and took his hand (figure 20.9). The human was unaware that Mizuki was looking at his face because he always looked forward to avoid cueing her. When Mizuki took his hand he approached the string; this resulted in success (figure 20.10). Mizuki almost always took the human's hand in later trials.

Given that Mizuki had looked up into the human's face during the first trial, we reanalyzed the videotape of later trials and found that she had done so in 6 of 24 of them. The human looked forward to avoid cueing her, and she did not wait for him to look down at her, so eye contact was not established. Taking the human's hand became her routine in this test condition, and she did so regardless of whether he delayed his approach. However, this same behavior was never observed when she was paired with a conspecific partner.

Figure 20.9 Mizuki looks up at the face of the human partner, whimpers, and takes the partner's hand. From Hirata and Fuwa 2007. Reprinted with permission of Japan Monkey Center and Springer Japan.

Figure 20.10 Mizuki and her human partner pull the string together. From Hirata 2007. Reprinted with permission of the Japanese Society for Animal Psychology.

Discussion

Cooperation in Successful Trials

The chimpanzees did not show signs of cooperation in early trials of either the stone-pulling or string-pulling tasks. Furthermore, in the stone-pulling experiment it seemed that the two chimpanzees actually avoided working at the same time. One started to pull the stones after the other had stopped pulling, or stopped when the partner approached the stone. Previous attempts to probe chimpanzee social understanding in cooperative situations have also not been successful (Hare 2001). Hare and Tomasello (2004) showed that chimpanzees behave more skillfully in competitive tasks than in cooperative tasks, and suggested that might be cognitively hardwired to outperform rivals in competitive situations. Our results can be interpreted from a similar perspective, but to make a slightly different point. That is, the tendency to avoid working at the same time may imply that the chimpanzees are trying to avoid conflict in a possibly competitive situation. In addition to the possibility that they are skilled at outperforming rivals in competitive situations, they may also be careful to avoid conflict situations that could be damaging to existing social relationships.

Melis et al. (2006a) conducted experiments of cooperation in chimpanzees using a method fundamentally identical to the string-pulling task (Melis et al. 2006b; see also chapter 21), and they point out the importance of tolerant relationships for the successful performance of a cooperative task. They report that chimpanzees were not more cooperative when they faced a rival; their tendency to avoid working at the same time may have constrained success in the tasks, both in Melis's experiment and in our studies. A similar tendency was noted by Hare et al. (2007), who used the same method to study cooperation in bonobos for comparison with chimpanzees. In that study, the bonobos were more tolerant and also more successful at solving the cooperative task when the food could be monopolized, as they shared food while the chimpanzees did not. Petit et al. (1992) also suggested that tolerance was a critical factor in the different performances of rhesus and Tonkean macaques in a cooperative task; while the Tonkean macaques sometimes engaged in coordinated activity with others, the rhesus macaques did not show such coordination. In summary, a tolerant relationship may have been the basis for the emergence of cooperative behavior in primates.

The fact that Tsubaki and Mizuki did not show an immediate understanding of cooperation is in line with the results of several earlier studies, including the pioneering work by Crawford (1937). It is notable that Mizuki was introduced to the string-pulling task with a conspecific partner after having learned to pull a stone with a human partner (after she had adjusted the direction of pulling, but before having undergone the tests of solicitation), but she did not work with the conspecific partner in the initial stages of the string-pulling task. This is consistent with Crawford's (1941) study in which chimpanzees who mastered one cooperative task failed to show generalization to another kind of cooperative task.

Shared Action and Shared Goal

The chimpanzees in our studies became successful at solving the tasks after some experience. In the string-pulling task, they checked the behavior of the conspecific partner, waited for the partner to hold the string, then pulled the other end themselves. In the stone-pulling task, the chimpanzee adjusted her direction of pulling to match that of the human partner. Thus, the chimpanzees understood the partner's role in these tasks. Such an understanding has been suggested by other studies of several primate species such as chimpanzees (Chalmeau et al. 1994), capuchins (Mendres and de Waal 2000; Hattori et al. 2005), and tamarins (Cronin et al. 2005). In brief, they have shown that an individual performed a necessary behavior more often when the partner was present than when he or she was absent. Therefore, an understanding of the partner's role in cooperative tasks is not a special capability of chimpanzees (see also chapter 21). One may say that adjusting one's own behavior—waiting in the partner's absence and pulling in the partner's presence—may be achieved by mechanical learning, like pulling when a green light is on and not pulling when a red light is on. However, the study by de Waal and Berger (2000), which showed that capuchin monkeys shared more food with the partner with whom they solved a cooperative task, indicates that capuchins regard a partner as more than a red or green light. Note that the string-pulling task described in this chapter is more complex than the simple pulling tasks used in other studies. In our task, the two individuals needed to

pull in a very precisely coordinated way, and when their timing was not coordinated at the beginning of a trial, the trial ended in failure. Such bad timing in other simple pulling tasks does not result in failure; the individuals have a chance to pull again in the same trial, and if they keep pulling, the trial will eventually end in success. In the short-string condition of our string-pulling task, the chimpanzees must coordinate the timing of their pulling precisely; whether other species have the ability to do this is an interesting question for future research.

When the chimpanzee's partner was human, in both the string- and stone-pulling tasks, the chimpanzee solicited the partner to work with her. In other studies with monkeys, such soliciting behavior has never been observed. Together with the examples of Crawford's (1937) study and Menzel's (1972) observation, the emergence of soliciting behavior may reflect chimpanzees' deeper understanding about other individuals as agents, and their greater ability to communicate to alter other individuals' attentional states and behavior.

The chimpanzees' motivation for establishing such behaviors appeared to be the desire to obtain food for themselves. In other words, they may have been using the partner as a tool to achieve their own goal. They never appeared to care about whether the partner achieved his or her goal. This is not surprising in the case of the chimpanzee-human pair, as the human experimenter gives food to the chimpanzee but does not try to obtain food in front of the chimpanzee during their daily interactions. When the two chimpanzees succeeded in the string-pulling task, both chimpanzees attempted to obtain food, but we never observed either chimpanzee waiting until their partner achieved the goal.

Tomasello et al. (2005) argued that chimpanzees lack shared intentionality. We are not certain that the chimpanzees in our tasks had no understanding of each other's individual's intentions. However, it is clear that rather than helping their partner to achieve a goal, they engaged in shared action with the partner to achieve a self-oriented goal. Few studies have explicitly investigated whether an individual would assist a partner to achieve a goal, but Hattori et al. (2005) presented a related situation. They tested pairs of capuchin monkeys in a cooperative task in which two individuals had to perform a sequence of two actions—pulling a tab at one location in the experimental area and then pushing a block in another area—to obtain food. The pairs solved this task by dividing their roles, and they maintained this cooperation even when only one of the two obtained a reward in each trial and their roles were reversed in alternate trials. The authors concluded that the monkeys engaged in attitudinal reciprocity (Brosnan and de Waal 2002), in which a positive attitude is mirrored by the partner. It would be interesting to examine whether these monkeys understood that their behavior assisted the partner in achieving the goal. In addition, one study with chimpanzees tested helping behavior. Warnenken and Tomasello (2006) observed whether chimpanzees would help a human achieve a goal, and found positive evidence in one of the conditions tested. The difference between our result and that of Warnenken and Tomasello may be partly explained by the different goals of the two experiments; the goal in our study was to obtain food while the goal in their study was to obtain objects. As Moll and Tomasello (2007) noted, food is a resource for which apes and monkeys compete with conspecifics; thus a nonfood goal may be better in this context.

In wild chimpanzees, the case of Bossou chimpanzees crossing the road can be considered an example of a shared goal or assisting the goal of another (see chapter 27). The goal in this example is to cross the road, and the role of adult males scanning the road while group members cross it together may be to help others achieve their goal or to facilitate the achievement of a shared goal. A chimpanzee in the Taï forest who appears to be driving a target monkey in the direction of ambusher chimpanzees may also be helping others to achieve a goal (Boesch and Boesch-Achermann 2000). Another possibility that we cannot reject is that the collective efforts of individuals to achieve their own goals could appear like individuals helping each other achieve their goals. More observations in the wild and further experimental study in the laboratory are necessary to understand to what extent the chimpanzees understand the goals of other individuals and whether and how they would assist them in achieving them.

Intentional Communication in Cooperative Tasks

Mizuki's soliciting behavior can be regarded as imperative intentional communication in that she used a communicative signal to get another individual to help her attain a goal (Bates 1976). Several studies have shown that chimpanzees make visual communicative signals to a recipient

who is facing them but not to a person turning away (e.g., Hostetter et al. 2001). The fact that Mizuki did not differentiate her communicative behavior according to whether her human partner was facing toward her or away from her does not conflict with such studies. Her strategy was to pull the partner's hand, and this could be categorized as tactile communication that should work whether or not the partner was looking at her.

We examined not only the occurrence of imperative intentional communication, but also whether it included eye contact. Mizuki did not make eye contact with her conspecific partner. This was, in a sense, a matter of course because she also did not use any other behavior to solicit that partner in the tasks described here. In contrast, she did use soliciting behavior when her partner was a human, but even then eye contact was rare. In the string-pulling task she looked up at the human experimenter, but the experimenter was not attending to her at the moment and Mizuki did not wait for him to look at her. In the stone-pulling task, she never went around in front of the human when he was facing away. Although the chimpanzee repeated her communicative behavior when the human did not respond, eye contact was still rare in these situations. In general, Mizuki solved the situation by establishing a routine (see Hirata and Fuwa 2007 for more description) of repeating a tactic that had worked once and then treating the human as if he were a social tool. However, it should be noted again that the chimpanzee looked up at the human partner in both of the two tasks when she solicited him (figures 20.6 and 20.9). The face, but perhaps not specifically the eyes, might have some ostensive role for chimpanzees, and this role may have emerged as a precursor to eye contact in humans.

Gómez (1996a) noted individual differences in the occurrence of intentional communication among chimpanzees; the chimpanzees that performed better in those experiments had a more extensive hand-rearing history with humans. He wrote that these individual differences could be related to Tomasello et al.'s (1993) concept of enculturation. Call and Tomasello (1996) claimed that intentional communication was one of the domains in which humans seemed to have the greatest effect on apes, and they hypothesized that the experience of being treated intentionally by others in home-raised environments may lead to a fundamental change in their social cognition. Home-raised apes may acquire a deeper understanding of others in terms of their intentions. The results presented here came from a single subject, so making general comments on such a phenomenon is not our aim. However, the results of these studies call careful attention to this issue because the same chimpanzee, Mizuki, showed different communicative behavior with conspecific and human partners. Our tentative interpretation is that experience with others, probably through trial and error in various types of interactions including play, may lead a chimpanzee to an understanding of how specific individuals respond to his or her own behaviors. That is, in the course of daily interactions, Mizuki may have learned that it was fruitless to show soliciting behavior toward Tsubaki, who as a conspecific would mostly be a competitor in the presence of food and not help her to obtain it. On the other hand, she may also have learned that soliciting behavior worked with humans, as her human partners did not compete over food but instead gave it to her or shared it with her in their daily interactions.

We also suspect that younger chimpanzees may tend more than adults to show soliciting behavior toward a conspecific partner in a cooperative task to obtain food. Younger individuals have had less opportunity to learn that such behavior is fruitless, and our observations of the chimpanzees in our facility suggest that competition over food is less severe when they are young. The classic experiments mentioned earlier in this chapter also provide evidence for this idea. When Crawford (1937) found that chimpanzees showed soliciting behavior in a cooperative task, the chimpanzees in his study were juveniles. Another line of support comes from Menzel's (1974) study in a different setting. He created a game for chimpanzees in which a piece of food was hidden in their play yard and one of them knew its location while the others did not. When young individuals who preferred to travel together were tested, the individual who knew the food's location solicited peers by tapping on their shoulders or taking their hand to lead them to it. When older individuals were likewise tested, the situation became more competitive; another individual tried to steal the food from the one who knew its location, who in turn attempted to deceive the competitor by taking a detour to uncover the food in an unguarded moment.

Further interpretation of Mizuki's differentiated behavior will be that she may be able to judge a partner's cooperative intention in advance—that is, she may understand that the human partner is willing to cooperate

while Tsubaki is not (see chapter 19, about chimpanzees' understanding of the intentions of others). Unfortunately, we do not have enough evidence to determine that this is true. We do at least consider, however, that she has an understanding of the effect her behavior has on a particular individual—thus suggesting a sophisticated understanding about others.

Implications and Future Directions

Unlike Crawford, who trained chimpanzees to respond to a human voice saying "pull," we did not use an intensive training phase to teach chimpanzees to respond to a cue given by a third party, but instead allowed them to succeed at the cooperative tasks gradually over time. They spontaneously began to glance frequently at their partners and wait until they were ready. This suggests that they have the ability to adjust their own behavior toward a partner. When wild chimpanzees hunt in groups or cross a road in a systematic progression, they may be using this ability to engage in shared activities.

Intentional communication in a cooperative situation is an important topic to pursue with reference to ostensive behavior (Gómez 1996a) and shared intentionality (Tomasello et al. 2005). The results so far indicate that rearing history affects the production of communicative behavior, and even that the same chimpanzee can behave differently depending on a partner's identity. Comparative cognitive approaches to the chimpanzee generally consider the similarities and differences between species (i.e., chimpanzees and humans), but differences within species (i.e., between chimpanzees with different histories) are another useful source for research on the evolution of intelligence or other features unique to humans.

The chimpanzees in our study did not appear to care whether their partner achieved a goal, which may have been due to our use of food as a reward. Segerdahl et al. (2005) described a process by which a male bonobo acquired language, and explained that using food as a reward sometimes inhibits rather than stimulates the spontaneous behavior of apes. It may also inhibit the cooperative nature of chimpanzees. Hirata (2008) has noted the helping behavior of chimpanzee mothers toward their immature offspring when mother and offspring travel together. As in the case of Bossou chimpanzees crossing the road, they may cooperate and assist each other more readily in achieving a social goal than in a context involving food. Researchers should consider and further investigate the context and situations under which cooperative events occur or fail to occur, as well as the characteristics of the goal for which partners might cooperate.

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