Current Biology *17*, 1345–1348, August 7, 2007  DOI 10.1016/j.cub.2007.06.069

Report

# Orangutans Modify Their Gestural Signaling According to Their Audience's Comprehension

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## Summary

**When people are not fully understood, they persist with attempts to communicate, elaborating their speech in order to better convey their meaning [1]. We investigated whether captive orangutans (*Pongo pygmaeus* and *Pongo abelii*) would use analogous communicative strategies in signaling to a human experimenter, and whether they could distinguish different degrees of misunderstanding. Orangutans' behavior varied according to how well they had apparently been understood. When their aims were not met, they persisted in communicative attempts. However, when the interlocutor appeared partially to understand their meaning, orangutans narrowed down their range of signals, focusing on gestures already used and repeating them frequently. In contrast, when completely misunderstood, orangutans elaborated their range of gestures, avoiding repetition of failed signals. It is therefore possible, from communicative signals alone, to determine how well an orangutan's intended goal has been met. This differentiation might function under natural conditions to allow an orangutan's intended goals to be understood more efficiently. In the absence of conventional labels, communicating the fact that an intention has been somewhat misunderstood is an important way to establish shared meaning.**

## Results and Discussion

Intentional behavior is characterized by how an agent responds to difficulties: persistence indicates that the agent has a definite goal, and elaboration when thwarted shows flexibility in reaching that goal. Everyday speech shows these characteristics routinely, and persistence and elaboration of communicative attempts have also been used as indicators of intentional communication in human infants [1–4] and chimpanzees [5].

In order to determine whether orangutans would alter their communicative strategy when their attempts at communication (apparently) failed, we presented captive orangutans with situations in which out-of-reach food items required human help to access but the experimenter sometimes "misunderstood" the orangutan's requests. Using a partially modified design from Leavens et al. [5], we offered subjects both a highly desirable and a relatively undesirable food, allowing them the opportunity to request one or the other food by gesturing. All food-oriented behavior was directed toward the desirable food, implying that the undesirable food was, in fact, of no interest to the orangutans. The experimenter sat silently facing the orangutan and delayed delivery of the food for 30 s before giving the orangutan either the desirable food (whole goal), half of the desirable food (part goal), or the undesirable food (nongoal) and then returned to their unresponsive state for a further 60 s. In the part-goal condition, the second half of the food was hidden from view in the experimenter's lap during the postdelivery phase. Viewed as the result of communication, the three experimental conditions correspond to the experimenter's fully understanding, partially understanding, or failing to understand the goal of the orangutan.

Six adult female orangutans were tested once in each of the three conditions, giving a total of 18 trials. A pretrial test with the whole-goal condition was performed once prior to experimental testing to familiarize individuals with the design and show them that it was possible to receive the desirable food. Orangutans are sensitive to the presence and visual orientation of a human experimenter, communicating more often when an observer is present and favoring visual signals more when the observer can see them [6–8]. Therefore, to avoid possible effects of human visual orientation in the present study, the experimenter consistently looked toward the subject's face during the trial without staring into its eyes. Each subject was videotaped for 30 s prior to and 60 s after the delivery of food, and all experimenter-directed or food-directed actions were coded. Behavior was classified as predelivery or postdelivery. All apparently communicative actions made by orangutans were recorded and treated as gestures, in the broadest sense, and subcategorized into visual, auditory, projectile, attempted-barter, object-retrieval, or self-directed behavior (see Table 1 for details).

We analyzed the orangutans' behavior to determine whether they would persist in communication when their goal was not fully met, and whether they would vary their attempts following miscommunication in a way that might help a recipient determine their goal. E.C. served as the primary coder for all of the video data, but a second individual coded 16% of the total trials to examine interobserver reliability. Agreement between the two observers was good (Cohen's kappa = 0.85), and all discrepancies consisted of one observer failing to notice a gesture rather than disagreeing on the type of gesture.

Because the predelivery phase of the experiment was the same in all conditions, the orangutans should not have been able to predict which food they would subsequently be given. Predelivery, neither the total number of actions nor the distribution of behavioral categories varied significantly between conditions (Number: Friedman analysis of variance by ranks; n = 6, $\chi_r^2$ = 0.6, df = 2, p = 0.74; distribution of the six behavioral categories: Friedman analysis of variance by ranks; n = 6,

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Table 1. Categorization and Definitions for All Coded Behavior

| Behavior | Definition | Behavioral Category |
|---|---|---|
| Kiss face | Pucker lips as in raspberry sound | Visual |
| Object shake | Hold object out from body and shake | Visual |
| Point | One or two fingers extended during "reach" | Visual |
| Reach | Hand thrust at least halfway through bars or under door | Visual |
| Rock/Swing | Exaggerated pendulum movement of the entire body through at least 45 degrees | Visual |
| Wave | Limb shaken back and forth | Visual |
| Wipe face | Hand is swiped across nose and mouth | Visual |
| Cage bang | Appendage is hit audibly against the wall, floor, or climbing structure | Auditory |
| Object bang | Object is used to perform "cage bang" | Auditory |
| Clap | Hands are clapped together | Auditory |
| Kiss squeak | Sharp squeak made by sucking air through tensed lips | Auditory |
| Raspberry | Air is exhaled through partially tensed lips, creating a buzz | Auditory |
| Spit | Spit through bars | Projectile |
| Throw object | Object is thrown toward experimenter, through bars or under door | Projectile |
| Offer | Object is extended and held through bars or under door | Attempted Barter |
| Fish | Object is used as a tool to reach toward one of the foods (sometimes only a few inches) | Object Retrieval |
| Yawn | Yawn | Self Directed |

df = 2 for all; for "visual," $\chi_r^2 = 4.6$, p = 0.10; "auditory," $\chi_r^2 = 0.9$, p = 0.63; "projectile," $\chi_r^2 = 0.4$, p = 0.82; "self directed," $\chi_r^2 = 1.0$, p = 0.61; "fish," $\chi_r^2 = 3.0$, p = 0.22; and "attempted barter," $\chi_r^2 = 2.0$, p = 0.37). Also, there was no difference in the number of gesture types used predelivery for any of the three conditions (Friedman analysis of variance by ranks; n = 6, df = 2, $\chi_r^2 = 4.1$, p = 0.13). Because predelivery behavior did not differ between conditions, we conclude that conditions did not differ in any way other than the type of food delivered to the orangutan.

## Orangutans Persist in Their Communicative Attempts

If orangutans have a specific goal in mind when attempting to communicate, then they should cease signaling if their goal is reached [9, 10]. We compared the total number of gestures an orangutan made postdelivery in each of the three conditions. The number of gestures varied significantly with the experimental condition (Friedman analysis of variance by ranks; n = 6, $\chi_r^2$ = 11.6, df = 2, p = 0.003). In the whole-goal condition, when the entire desirable food was delivered, all but one of the orangutans ceased signaling entirely, and several individuals retreated into their cages, breaking off contact with the experimenter; only one individual persisted in signaling, making a single barter attempt. In both the part-goal and nongoal conditions, all of the subjects continued to signal to the experimenter after the delivery of food. The orangutans used significantly more gestures after the delivery of half of the desirable food than they did after delivery of the undesirable food (Wilcoxon signed ranks test; z = −2.04, p = 0.04). Because the orangutans signaled more frequently in the part-goal than in the nongoal condition, the cessation of communicative behavior after the delivery of the whole desirable food is unlikely to be an artifact of food processing (e.g., consumption temporarily suppressing other activity).

## Orangutans Use Repeated Gestures if They Are Partially Understood

In natural interactions with conspecifics, orangutans often attempt a second gesture if the recipient fails to respond; of these second attempts, approximately half are repetitions of the first gesture [8]. If orangutans are using repetition communicatively and keeping track of the success rate of their signals, we might expect the frequency of repetition to vary with the degree to which their goal has been met. We compared the frequency of repetitions, i.e., repeating a gesture immediately after it has been used already, for each individual between conditions (Figure 1). After the delivery of food, the numbers of repeated gestures differed between experimental conditions (Friedman analysis of variance by ranks; n = 6, $\chi_r^2 = 11.2$, df = 2, p = 0.004). When an undesirable food was given, orangutans were significantly less likely to repeat gestures than they were after the delivery of half of the desirable food item (Wilcoxon signed ranks test; z = −2.21, p = 0.03). The difference in the tendency to repeat gestures shows that orangutans are able to evaluate their own level of success in communication and modify their subsequent attempts accordingly. If they perceive their prior efforts as having partially succeeded the orangutans in our study repeat signals up to half the time. In contrast, if they have completely failed, they avoid repetition.

It could be argued that repetition might stem simply from increasing frustration with time [11–13]. However, the latency between communicative attempts tended to increase over time, showing that as they continued to receive no response orangutans lost interest rather than becoming increasingly frustrated (Spearman's rank correlation; r = 0.30, p = 0.002; data from predelivery phase used in order to include all three conditions). Gestural repetition therefore cannot simply be attributed to frustration, but reflects an accurate understanding by orangutans of the relationship between their attempts to communicate and their level of success.

## Orangutans Use New Gestures if They Are Completely Misunderstood

If orangutans realize that their signals have been entirely ineffective at achieving their communicative goal, then they should switch to other signals rather than persisting with those that have failed [2]. Consistent with this, we found that in the nongoal condition, when an undesirable food was delivered, the orangutans used more types of gesture than in the part-goal condition, when they received part of the desirable food (Wilcoxon signed ranks test; n = 6, z = −2.04, p = 0.04). We also calculated the frequency of gestures that were used for the first time in the postdelivery phase (novel gestures) by each individual, in both the part-goal and nongoal

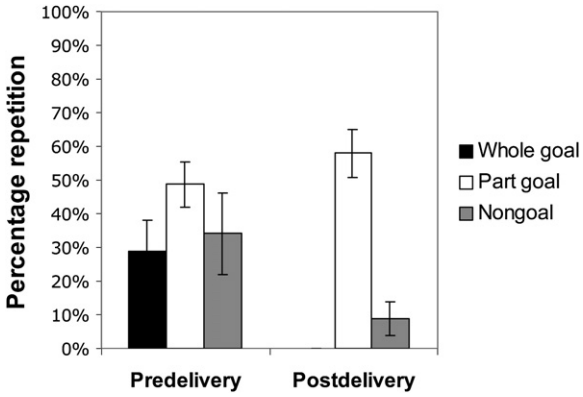


Figure 1. Repeated Communicative Behavior

Mean percentage of all behavior that comprised repetition in the predelivery and postdelivery phases of the experiment. Bars represent standard errors.

conditions. Novel gesture types were more frequent in the nongoal condition (Wilcoxon signed ranks test; n = 6, z = −2.06, p = 0.04; see Figure 2); in the part-goal condition, gestures were likely to recur, i.e., the same gesture was used pre- and postdelivery. Note that, although these data show that gestures found ineffective by orangutans during our experiment tended to be discarded, the same gestures fail to receive a response the majority of the time they are used in daily interaction with human keepers, yet they remain in the orangutans' active repertoire. The changes in gesture use are temporary, forming part and parcel of each communicative exchange.

## Conclusions

The orangutans we tested appeared to have a specific goal in mind, i.e., gaining a desirable food item, that they attempted to achieve indirectly by communicating with the human experimenter. They persisted in their communicative attempts when their goal was not met, as do chimpanzees [5]. Orangutans have previously been found to be sensitive to the visual attention of an interlocutor [6], but the orangutans in our experiment went much further, distinguishing between being partially understood (when given part of the desired food) and being completely misunderstood (when given an unwanted food item). Their subsequent communicative attempts reflected this distinction. When confronted with a response that suggested partial understanding of their desire, the orangutans continued to use those signals they had used before the delivery of any food, often giving a signal repeatedly. When they were given the wrong item altogether, they instead chose to use other signals rather than those used already, and they avoided signal repetition, often attempting each new behavior only once.

The strategy employed by the orangutans resembles that of the parlor game charades, in which players try to get their team to guess the name of a book or movie by acting it out nonverbally. As a player gesticulates on stage, the team calls out their guesses as to what is being portrayed. If your team is close to your answer, the best strategy is to repeat and refine the signals

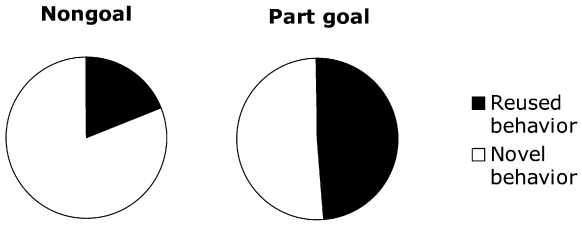


Figure 2. Use of Novel Behavior

Average percentage of novel behavior (i.e., actions used postdelivery but not predelivery) used in the postdelivery phase of the experiment, in nongoal and part-goal conditions.

that have already partially worked. But if your team completely misunderstands your gestures, it is better to switch to new signals until they guess something close to your goal. This strategy not only maximizes a player's efficiency in choosing an effective indicator, but also communicates to the team how close they are to understanding the intended meaning. Although the communication sequences of the orangutans are perhaps not as sophisticated, they nonetheless accomplish the same objectives. By maximizing efficiency at searching for an understood signal and homing in on those that achieve partial success, orangutans are able to overcome misunderstandings. In the absence of a shared lexicon, one way of arriving at a shared meaning is to adopt a charades-like strategy, transmitting not only the content of the intended message but also a signal indicating how well you have been understood. If the recipient can use this information, then the signaler and recipient will be able to arrive at a common understanding much faster. This strategy offers one possible pathway toward constructing a shared lexicon from learned or ritualized signals. Investigations into the structures of intentional communication by apes may therefore provide insight into the prelinguistic devices that helped construct the very earliest forms of hominid language.

## Experimental Procedures

### Study Species

Subjects consisted of three adult female Bornean orangutans (*Pongo pygmaeus*) at Twycross Zoo, England, and three adult female Sumatran orangutans (*Pongo abelii*) at the Durrell Wildlife Conservation Trust, Jersey. Individuals at both zoos were housed with at least one other orangutan. All individuals had received food manually from keepers before, and most had been rewarded for returning foreign objects from their enclosures. Thus all experimental subjects had been rewarded at some point with food items and were familiar with interacting with their keepers through the enclosure bars. The head keeper for the orangutan exhibit at each zoo served as the primary experimenter, and E.C. set up the experiment and recording equipment. The keeper was used as the experimenter for reasons of safety and ethics as determined by both participating zoos.

### Data Collection

Experiments were run at Twycross Zoo in May and October 2006 and at Durrell Wildlife Conservation Trust in July and August 2006. All trials were run prior to the afternoon or evening feed so that the individuals would be food motivated. All individuals were separated from other adults during testing, but mothers were accompanied by their infants or subadult offspring; offspring present during testing ranged from 1 to 7 years of age. Feeding was delayed until the individuals had completed a trial, but no other changes to husbandry were made.

Each individual was first given one familiarization trial (of the whole-goal type). Two individuals did not remain attentive during this trial, moving away from the experimenter or interacting with other orangutans, and these received a second trial to determine whether they would remain attentive, once the first trial had demonstrated the possibility of receiving the food. Individuals that showed no outward attempts to communicate their desires, that appeared uninterested in the food, or that were overly distracted by infants or neighbors were not be used in the study. Two subjects were discarded after the start of experimental testing: an adult male at the Durrell Wildlife Conservation Trust, who consistently failed to show any interest in or preference for the food though he was tested in all three conditions, and one juvenile female at Twycross Zoo, who completed one experimental trial but was deemed by the keeper to be too upset at being separated from her mother.

Each individual was tested once in each of the three experimental conditions, counterbalanced across individuals. Three experimental trials had to be rerun, one because of experimenter error and two because of the orangutan's moving out of the view of the camera during the trial. A Sony Handicam DCR TRV-38 was used to film all trials. The camera was placed on a tripod 2.0–3.5 m from the test subject and positioned so that it filmed the actions of the subject orangutan over the experimenter's shoulder. Prior to testing, a chair was placed 80 cm from the bars of the cage. Two plastic dishes were placed on the floor, approximately 30 cm to the right and left and 20 cm forward of the chair. The subject orangutan was then allowed into the testing area. This involved being separated from the rest of the group in an inside area (often a sleeping area) or being called over by the keeper if the individual was tested in a larger room. Once the orangutan was attending to the chair and the keeper-access area, E.C. entered, placed a desirable food item on one dish and an undesirable food item on the other, and then left the access area. Foods were chosen according to the husbandry practices and preferences of the orangutans at each zoo, such that all foods were familiar to the animals, the desirable food was preferred by all individuals over most other food items, and the undesirable food was typically left untouched or ignored. Foods were, respectively, whole-grain bread and leeks at Twycross Zoo and bananas and celery at the Durrell Wildlife Conservation Trust. After 20 s, the experimenter (keeper) entered the access area and sat on the chair, facing the orangutan in a neutral position with his hands on his knees. He looked at the orangutan, avoiding direct eye contact, and did not speak or respond to any actions of the orangutan. After 30 s, the experimenter delivered either the whole desirable food (whole goal), half of the desirable food (part goal), or the whole undesirable food (nongoal) to the orangutan. In delivering half of the desirable food, the experimenter held up the whole food item and tore it in half; then he gave one half to the orangutan and put the other half in his pocket or in his lap covered by his hands, out of view. After food delivery, the experimenter sat down, remaining in an unresponsive neutral state for 60 s, then left the access area. E.C. then re-entered the access area and removed the camera, chair, dishes, and any remaining food items.

Video data for each trial was downloaded onto a Macintosh Powerbook with a G4 processor with iMovie DV 5.0.2. All food-directed actions, any nonlocomotor and nonfunctional movements of the subject orangutan that took place while the orangutan was oriented or looking toward the experimenter, and any noise-making actions regardless of orientation were coded from the time the experimenter sat down until he stood up (approximately 90–100 s). Both orangutan- and object-produced noises were counted, including blowing raspberries and banging on the cage. Repetitive actions, such as rocking, waving, banging, poking, etc., were counted once for each full bout of movement or noise. We defined repetition as consecutive reuses of a gesture and counted each use after the first in a bout as one repetition. Several bouts could occur in one phase of the experiment. All statistical analyses performed were two-tailed tests.

## Acknowledgments

Research was supported by the University of St Andrews School of Psychology and the Russell Trust. We thank the research departments at Twycross Zoo and the Durrell Wildlife Conservation Trust for permission to conduct the study, and especially J. Woolley at Twycross Zoo and G. Hunt at the Durrell Wildlife Conservation Trust for their help and cooperation in setting up and running the experiment. We are grateful to David Leavens, William Hopkins, Simone Pika, Eric Bowman, Anne Schel, and Lucy Bates for advice on the design and analysis of this study, and to Matt Cartmill, Kaye Brown, and members of the Scottish Primate Research Group for comments and suggestions.

Received: June 1, 2007
Revised: June 26, 2007
Accepted: June 26, 2007
Published online: August 2, 2007

## References

1. Golinkoff, R.M. (1986). "I beg your pardon?": The pre-verbal negotiation of failed messages. J. Child Lang. *20*, 199–208.
2. Bates, E., Benigni, L., Bretherton, I., Camaioni, L., and Volterra, V. (1979). The Emergence of Symbols (New York: Academic Press).
3. Lock, A. (2001). Preverbal communication. In Blackwell Handbook of Infant Development, J.G. Bremner and A. Fogel, eds. (Oxford: Oxford University Press), pp. 379–403.
4. Shwe, H., and Markman, E. (1997). Young children's appreciation of the mental impact of their communicative signals. Dev. Psychol. *33*, 630–636.
5. Leavens, D.A., Russell, J.L., and Hopkins, W.D. (2005). Intentionality as measured in the persistence and elaboration of communication by chimpanzees (Pan troglodytes). Child Dev. *76*, 291–376.
6. Poss, S.R., Kuhar, C., Stoinski, T.S., and Hopkins, W.D. (2006). Differential use of attentional and visual communicative signaling by orangutans (*Pongo pygmaeus*) and gorillas (*Gorilla gorilla*) in response to the attentional status of a human. Am. J. Primatol. *68*, 978–992.
7. Liebal, K., Pika, S., Call, J., and Tomasello, M. (2004). To move or not to move; how apes adjust to the attentional state of others. Interact. Stud. *5*, 199–219.
8. Liebal, K., Pika, S., and Tomasello, M. (2006). Gestural communication of orangutans (*Pongo pygmaeus*). Gesture *6*, 1–38.
9. Shettleworth, S.J. (2001). Animal cognition and animal behaviour. Anim. Behav. *61*, 277–286.
10. McFarland, D., and Bösser, T. (1993). Intelligent Behavior in Animals and Robots (Cambridge, MA: MIT Press).
11. Stout, S.C., Boughner, R.L., and Papini, M.R. (2003). Reexamining the frustration effect in rats: Aftereffects of surprising reinforcement and nonreinforcement. Learn. Motiv. *34*, 437–456.
12. Roberts, S. (1981). Isolation of an internal clock. J Exp Psychol Anim Behav Process. *7*, 242–268.
13. Dickinson, A., and Balleine, B. (1994). Motivational control of goal-directed action. Anim. Learn. Behav. *22*, 1–18.