CHAPTER 2

Addressing the problems of intentionality and granularity in non-human primate gesture

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Any study of communicative gesture must identify which movements are purposeful (*intentionality*) and which examples of movements should be grouped into a single gesture (*granularity*). Where researchers studying human gesture are aided by linguistic context, researchers studying non-human primates must rely on their subjects' movements alone to address these questions. We propose an approach to intentionality and granularity in non-human primate gesture based first on the possibility that only some, but not all individuals that use particular movements do so as intentional gestures, and second on the premise that gestures found to have specific meanings reflect real-world distinctions made by the animals. We apply this approach to the behavior of 28 captive orangutans and identify 64 distinct gestures, 29 of which have specific, predictable meanings.

Introduction

The study of gesture in non-human primates (hereon "primates") presents challenges beyond those encountered in the study of human gesture. Accompanying speech or conversational context can be used to interpret the meanings of human gesture (Iverson & Goldin-Meadow 1998), and it may actually be impossible to understand the meanings of human gestures if they are removed from their spoken context (McNeill 2000). Primate gestures, however, are not produced within a known linguistic framework; it is thus difficult to determine their meanings. Here, we discuss some of the special challenges facing students of primate gesture and propose a systematic approach to studying meanings of gestures. We advocate locating each example of gesture within its communicative and social context, taking into account the behavior of both the gesturer and recipient in communicative exchanges of varying length. We begin by describing two of the most difficult questions facing gesture researchers – (1) how does one know whether a movement is communicative (*intentionality*), and (2) how does one know whether a set of examples constitutes a single gesture (*granularity*). We

explain how these problems are approached in human gesture research and suggest how they might be addressed in primate gesture research. To answer the first of the two questions, we describe an analysis of intentionality based on the behavior of each individual; this allows for the possibility that some but not all individuals that use a particular movement do so as a communicative gesture. To answer the second question, we argue that potential gestures exist as meaningful signals for the individuals who use them if they show predictable meanings across multiple examples.

We use findings from our 3-year study of orangutans to illustrate the effectiveness of an individual, context-based approach to studying primate gesture. Our general methodology centers around a study of meaning, based on both the goal of the gesturer and the outcome of the exchange, and includes gestures produced on their own as well as during extended social interactions. Our focus on identifying specific meanings in primate gestures may come as a surprise to those familiar with other work on ape gesture. Most recent studies of ape gesture have focused on the relative flexibility of gestures compared to vocalizations, and have used this contextual flexibility to support gestural origin theories of language evolution (see Arbib et al. 2008, Call & Tomasello 2007, Pollick & de Waal 2007). The ability to employ gestures flexibly in different ways rather than automatically in response to stimuli demonstrates that apes use gestures *intentionally*. However, if gestures are used so flexibly that there is no predictable relationship between form and meaning, then they are not used intentionally *to communicate something*. Our approach to gesture meaning measures the probability that a particular form is successful at achieving a particular social goal: gestures that very frequently achieve a particular goal are deemed to have that meaning. Redirecting the discussion of ape gesture from flexibility to meaning will open up new comparisons to human language and will allow researchers to test the way in which they define ape gestures.

Identifying intentional gestures

Researchers studying human gesture determine that movements are gestures by requiring that they be part of a communicative act (Iverson & Goldin-Meadow 1998, Kendon 2004). When produced concurrently with speech, the communicative nature of the act is clear. When produced in isolation, clues such as eye contact are used to determine that the gesture itself is communicative (Goldin-Meadow 2004), though discourse-level analysis renders this a fairly straightforward task since solitary gestures are most often contextualized within a larger spoken exchange. Primate researchers, on the other hand, must identify which movements are gestures without the help of an overt communicative context.

Since non-effective movements in primates are typically produced without accompanying vocalizations, researchers must determine whether potential gestures themselves constitute a communicative act, relying on social clues and evidence within

the movements to identify communicative *intentions*. Eye contact, body orientation, response waiting, and persistence are all used as evidence for intentionally communicative gesturing (Call & Tomasello 2007, Genty et al. 2009, Pika et al. 2005).

But complicating the question of intentionality is the possibility that a movement used by one individual as an intentional gesture might also be used by another, but in a non-intentional way. Our approach to intentionality builds on previous work that attempted to identify the intentionality of primate gestures according to strict criteria (see Call & Tomasello 2007); we make the important addition of requiring that intentionality be identified in each individual's use of a particular gesture. Previously, (see Liebal et al. 2004, Liebal et al. 2006, Pika et al. 2003, Pika et al. 2005) it has been assumed that if a gesture were used intentionally by *one* or a *few* individuals, then it was an intentional gesture for *all* individuals. Like Genty et al. (2009), we exclude all examples of a gesture made by individuals who did not show at least one clearly intentional use of that gesture, thereby allowing for the possibility that some individuals in a population might use a movement as an intentional gesture and some might not.

Addressing the granularity of analysis

To identify meaningful gestures, researchers studying both human and primate gesture must address the question of how to categorize individual examples into definable, meaningful gestures. The way in which a movement sequence is segmented into analyzable units and how those units are categorized into definable gestures (i.e. the "granularity" of analysis) will affect what types of analyses are possible and may significantly impact the conclusions of the study. On the one hand, finely dividing complex movements allows for a more detailed analysis of timing and subtlety of meaning. This analysis is effective in revealing the tight association between speech and movement in human discourse (e.g. McNeill 1992), but risks overlooking broad commonalities in form by focusing too closely on the specific gestural elements and is too laborious to apply to large datasets. On the other hand, considering complex movements as whole units (on a level somewhat analogous to noun or verb phrases in speech) is simpler and is successful in identifying commonalities across many examples (e.g. Goldin-Meadow 2003), but risks defining gesture types too generally to reveal much specificity in meaning.

Imagine, for example, if we were to group all oscillating movements of the head into a single gesture type. In this case, nodding and shaking the head would be considered to be the same gesture, and we would conclude that it had a very ambiguous meaning. The possibility of making this type of error affects both human and primate gesture researchers who must therefore keep the problem of granularity in mind when attempting to determine which movements constitute definable gestures and have particular meanings.

Researchers studying primate gesture must tackle the problem of granularity without accompanying speech providing any clues as to how to segment and categorize movements. If researchers apply too fine a granularity to their definitions of gestures, this would lead to an overestimation of the number of gesture types (Figure 1a). This overestimation could lead researchers to conclude that some gesture types were idiosyncratic or limited to highly-specific situations, when a broader analysis would have ignored these small variations and revealed that all individuals use the same gesture type. Underestimation of gesture types by using too coarse a granularity (Figure 1b) could similarly overlook important variations in meaning by erring in the other direction: lumping many different movements into a single type, when the primates themselves perceive differences between them.

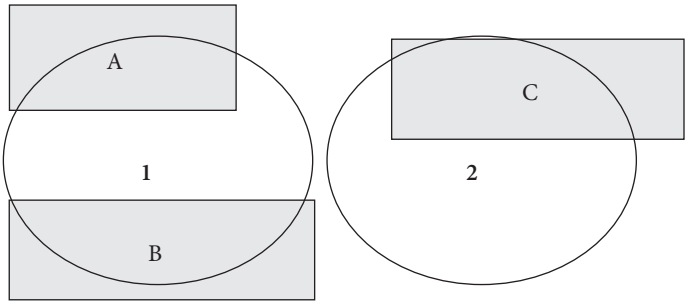

Figure 1a. Gestures defined by too fine a granularity. (The white circles represent gestures 1 and 2 as perceived and used by a group of primates. The grey boxes represent the gestures (A, B, C) as defined by a human observer.)

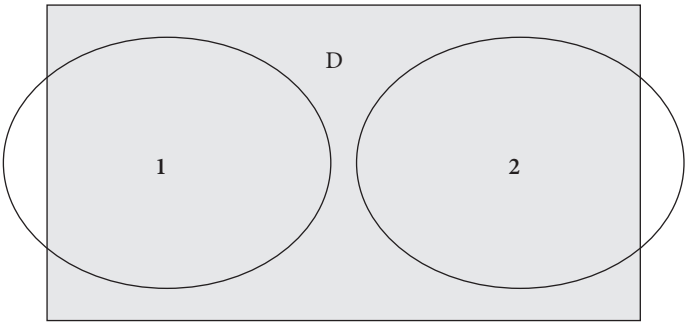

Figure 1b. Gestures defined by too coarse a granularity. (The white circles represent gestures 1 and 2 as perceived and used by a group of primates. The grey box represents the gesture (D) as defined by a human observer.)

The granularity of gesture definitions is of great importance in assessing whether gestures vary between individuals and whether any gestures carry specific meanings. This is a problem common to gesture studies of both humans and primates. Accurately determining the level of analysis is made more complicated by the fact that a structural variable might make a difference to the definitions of some gestures but not to others. For example, whether a movement is performed while holding an object has a large effect in distinguishing *reaching* from *showing* an object, but makes no difference to *pointing* (which could be done with or without an object in hand).

Although intentionality and granularity must both be separately addressed in any study of the meaning of primate gestures, they also interact: movements must be determined to be intentional in order to be defined as gestures, and the granularity of gesture definitions will affect analyses of repertoire size and gesture meanings. Thus, one way to test the adequacy of the gesture definitions at a particular granularity is to determine whether any of the observer-defined gestures have distinct meanings. If they do, it is likely that the granularity of their definitions is not too large. However, attempts to maximize the specificity of gesture meanings by dividing broadly-defined gestures into more narrow ones must be balanced by the desire to avoid defining all gestures as idiosyncratic. If all gestures were defined as idiosyncratic, no further analysis would be possible as each individual's gestures (or even each instance of an individual's gestures) would be considered unique, and thus distinct from all others.

Granularity and gesture meaning

We propose to address granularity through an assessment of gesture meaning: gestures with consistent meanings used by several individuals are deemed to have an appropriate level of granularity, and those without consistent meanings are investigated further to determine whether redefinition of the gesture could increase consistency of meaning. Our attribution of meaning to gestures is systematic and takes into account both the gesture's goal and the recipient's response, a significant departure from analyses of meaning typical in animal communication studies primarily based on the recipient's response (see Hauser 2000). Additionally, we suggest that analysis of meaning should be based on all types of exchanges involving gesture (single gesture events, longer sequences and turn-taking events), whereas some previous studies restricted analyses of meaning to single gesture-reaction events to simplify identification of recipient responses (e.g. Genty et al. 2009). Including all types of gestural exchanges in analyses of meaning is a more naturalistic and more comprehensive approach that should lead to a more representative account of how gesture is used within non-human populations.

Since our approach to evaluating the granularity of the analysis involves identifying consistency in gesture meanings, it is necessary to identify the meanings of the gestures as intended and perceived by the study subjects. We did not expect that each gesture would have a one-to-one correspondence with a particular meaning. However,

if primates are using gesture as a primary means of communication, then it should be expected that at least some of their gestures communicate specific meanings. Our study of orangutan gestures led us to conclude that this is, indeed, the case.

Assessing meaning in orangutan gestures

We began our study of orangutan gesture by opportunistically filming social interactions that occurred amongst 28 orangutans at several European zoos. We first selected all movements performed in the presence of other orangutans that did not appear to have a direct function (e.g. reaching towards an object would be included, but picking it up would not). We then grouped all of these movements into "potential gestures" according to their similarities along certain structural variables: modality, body part, movement, force, speed, and use of an object. We then determined which of these potential gestures were used as intentional communicative signals by applying a strict set of intentionality criteria to all examples and retaining only those gestures performed by individuals who had used those particular gestures at least once in an intentional manner. We deemed an example of a gesture to be intentional if it was (1) directed towards another, with (2) the objective of obtaining a particular goal, and (3) employed flexibly rather than as an automatic response to a stimulus (Bruner 1981, Pika et al. 2005, Tomasello & Call 2007). We used the gaze direction of the signaler prior to gesturing to determine whether visual and auditory gestures had a specific recipient. (Tactile gestures were directed at a recipient, by definition.) In order to establish whether the signaler had an intended goal in gesturing, we looked for evidence that the signaler "expected" a response from the recipient; measures of expected response included response waiting, gaze alternation, persistence, and using modalities appropriate to the attentional state of the recipient (e.g. visual gestures when the recipient is looking).

To address the issue of whether or not our definitions of gestures accurately accorded with the perceptions of the species (i.e. whether the granularity was right) we tested our judgments of gesture granularity by comparing gesture form to meaning. Take the earlier example of grouping nodding and shaking of the head as a single gesture. In this case, one could differentiate nodding from shaking by comparing each example's structure to its contextual meaning. Through that juxtaposition, direction of movement would emerge as a dividing variable, splitting an ambiguous gesture into two meaningful ones. By attributing meanings to a set of apparently successful orangutan gestures and determining whether a particular gesture was consistent in its meaning across examples, we were able to identify ambiguous gestures and reassess our definitions of those gestures in an attempt to better match the way in which orangutans used them.

A systematic approach to assessing meaning

We propose that the process of working out the meaning of a primate gesture should combine a measure of gesturer intent with one of recipient response (for more details on this approach, see Cartmill & Byrne 2010). For each act of gesture, we may be able to identify both an apparent goal of the gesturing individual and a subsequent reaction of the recipient. The reaction of the recipient may either fulfill the gesturer's goal or not – and may be a lack of response altogether. If a reaction does not fulfill the gesturer's goal, he or she might continue to gesture until getting the desired reaction or giving up entirely (see Genty et al. 2009). We define a recipient reaction that causes the gesturer to stop gesturing as an *interaction outcome* (Figure 2a). In interactions consisting of a single gesture and reaction, the reaction immediately following the gesture is the interaction outcome. In longer interactions, the final reaction of the recipient is the interaction outcome for all gestures.

In order to determine whether the interaction outcome satisfied the gesturer's goal, the gesturer must be ascribed a goal every time he or she gestures (Figure 2b). In our study, we ascribed a gesturer goal to each example of gesture based only on (1) the general context of the exchange (e.g. whether either one was feeding), (2) our knowledge of the identity of the individuals involved (e.g. whether an infant was gesturing to her mother), and (3) whether the form of the gesture seemed designed to effect a particular response (e.g. a pushing gesture would be more likely to indicate a goal of moving another than a hitting gesture would). Our attribution of goals to gesturers was thus *not* based on the observed responses in that exchange. This meant that we could ascribe a goal to a signaler and then be surprised when a non-expected reaction caused the gesturer to cease gesturing. We did not assume that every gesture in a sequence shared the same goal, though all shared the same *interaction outcome*. We also assumed that a gesturer always intended to elicit an active behavior from a recipient; thus, the goal could never be "no reaction." The goals we attributed to gesturers were: Affiliate/Play, Stop action, Sexual contact, Look towards, Look at/Take object, Share food/object, Co-locomote, or Move away. Once goals had been attributed to each example of gesture, we defined any examples in which the presumed goal matched the interaction outcome as having *goal-outcome matches* (Figure 2c).

In the example gesture sequence shown in Figure 2c, gestures 1 and 3 have goal outcome matches. This means that the gesturer appeared successful in fulfilling her goal of eliciting a particular reaction from the recipient. If gesture 1 and 3 frequently had the same goal-outcome match when they were produced by other individuals or by the same individual at other points, then we would define them as having *meaning*.

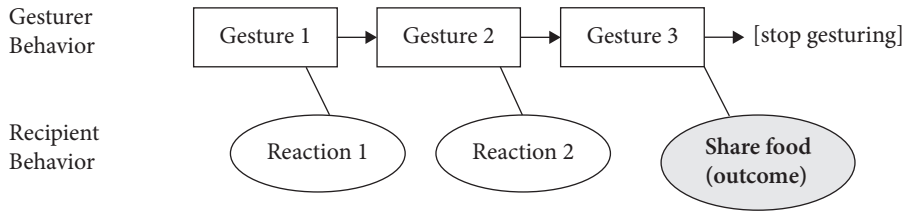

Figure 2a. Directly observable gestures and reactions in a sequence of gestures.

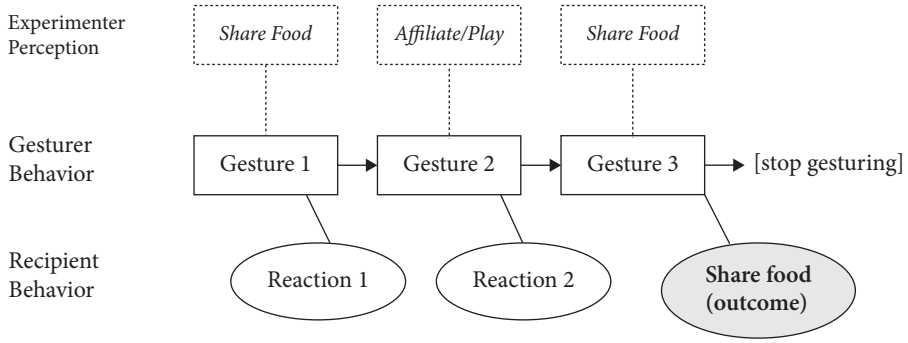

Figure 2b. Gestures, reactions, and experimenter-ascribed goals of the gesturer in a sequence of gestures.

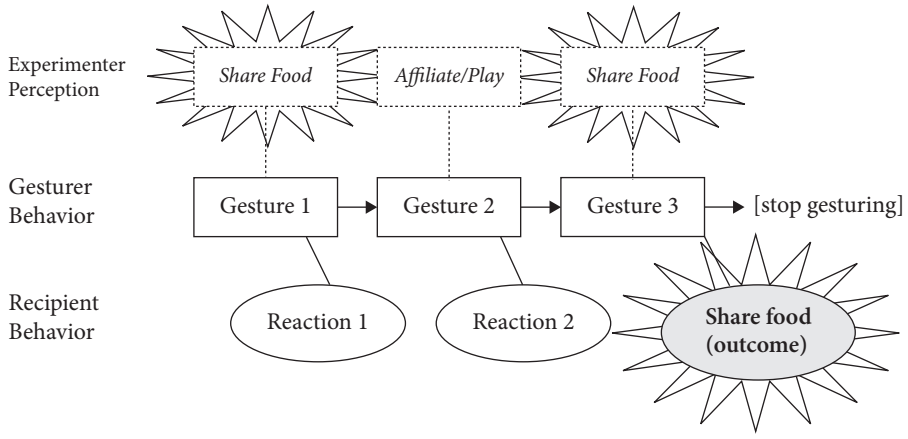

Figure 2c. Goal-outcome matches in a sequence of gestures. Note that both Gesture 1 and Gesture 3 have goal-outcome matches.

Using meaning to evaluate granularity

Determining that a gesture has meaning provides support for the analysis of granularity: if a gesture is found to have the same goal-outcome match in many examples, then it is likely that the gesture exists as a meaningful signal for the primates and is not an artifact of the human observer's interpretation. A lack of meaning for a gesture does not necessarily mean that that gesture doesn't exist. But, if such ambiguous gestures can be combined or subdivided into non-idiosyncratic, meaningful gestures then it is likely that the redefined gestures would provide a more accurate reflection of the real-world gestures. By removing or adding structural variables from the definition of an ambiguous gesture (thereby increasing or decreasing the granularity of the definition), it should be possible to achieve a more accurate definition and determine which variables are important in distinguishing a particular gesture from others.

In our study of orangutan gestures, we used goal-outcome matches as a means of investigating gesture meaning as well as testing the granularity of our definitions. Once we had applied intentionality criteria to all examples of gestures and reduced our dataset to only intentionally-communicative movements, we found that more than half of all observed gestures had goal-outcome matches. Importantly, only 15% had outcomes that conflicted with the presumed goal of the gesturer, the other non-matching cases occurred when the recipient did not respond to the gesturer or looked away.

We defined three degrees of observable meaning for gestures – *tight*, *loose*, and *ambiguous* – based on how frequently they were used with a single goal-outcome match (Cartmill 2008, Cartmill & Byrne 2010). All gestures with tight and loose meanings had one of six meanings: *Affiliate/Play*, *Stop action*, *Look at/Take object*, *Share food/object*, *Co-locomote*, and *Move away*. Where gestures had either loose meanings or were ambiguous, we investigated further in the hope that we could redefine the gestures so as to identify gestures with tight meanings from among the range of ambiguity. We considered including new variables in the definitions, prioritizing different variables, or combining existing gesture types. We found that almost all of the loose or ambiguous meaning gestures in our sample could be redefined by taking into account one of these variables so that a subset of the examples could be defined as a new gesture with a tight meaning. The possibility of new definitions indicated that our original definitions did not always reflect orangutans' perceptual distinctions between gestures. This demonstrates that human observers are liable to make unreliable judgments about what is and is not a gesture in another species and that corrective processes to observers' first attempts can be very valuable.

Though it would have been possible for us to redefine most ambiguous gestures by adding additional structural or social variables, doing so would have resulted in many gestures that were idiosyncratic or were restricted to certain age pairings. We reasoned that social variables in particular – such as the gesturer's identity, age, and relationship to the recipient – should not be used to redefine gestures, since they affected the *use* of gestures (particularly their effectiveness), but not their *forms*. We decided to create

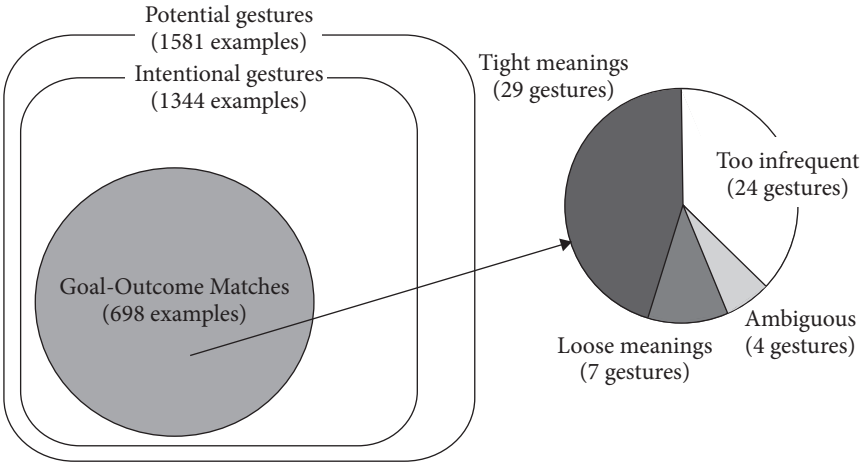

Figure 3. Frequencies of examples of intentional gestures and goal-outcome matches. Examples of goal-outcome matches consist of 64 gestures, categorized into those with tight meanings (29), loose meanings (7), ambiguous meanings (4), and those too infrequent to analyze further (24).

only two new gestures by including the variable "target location" (the place towards which a gesture is directed). When target location was included in the set of defining variables, two new gestures could be defined as having tight meanings. After redefining these gestures, our final set of orangutan gestures consisted of 64 intentional gestures, 29 of which had tight meanings, 7 of which had loose meanings, and 4 of which were ambiguous (for examples of specific gestures and their meanings, see Cartmill & Byrne 2010). The remaining 24 gestures were observed fewer than four times during the study and were deemed to be too infrequent to be included in the analysis of meaning. Figure 3 illustrates our process of narrowing down the observed movements to identify meaningful gestures.

Conclusion

Our approach to studying non-human gesture helps address the problems of intentionality (how do you know whether a movement is communicative?) and granularity (how do you know whether a set of examples constitutes a single gesture?). In our study of orangutans, we deemed movements to be communicative if they met criteria for intentional signals and required that each individual use a potential gesture intentionally before adding that gesture to his or her observed repertoire. We tested the granularity of our definitions of gesture by determining whether any gestures had consistent goal-outcome matches across examples. We concluded that non-idiosyncratic gestures

showing this consistency exist as perceptible, meaningful gestures for the orangutans themselves; the successful assignment of tight meaning to 29 (out of 64) gestures supports the granularity of our gesture definitions. It is essential that researchers studying gestures in animals not shy away from discussing intentionality and granularity as it is precisely these variables that allow us to challenge our assumptions and definitions and to more accurately identify how other species perceive and use gesture.

Acknowledgements

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