

## 5 Conceptual and Methodological Issues in the Investigation of Primate Intersubjectivity

Timothy P. RACINE, David A. LEAVENS, Noah SUSSWEIN,  
Tyler J. WEREHA

**Abstract.** Historically, the ability to point and conversely the absence of pointing in other great ape species has been interpreted as evidence of great discontinuity across the primate lines in the ability to share meaning with an interlocutor. However, this conclusion ignored a variety of observations of nonhuman primates pointing in captivity over the past century and was put to rest by careful experimental work conducted in especially the past decade. Now the debate concerns the human ability to declaratively point and the absence of declarative pointing in other great apes and the same discontinuous conclusions are being drawn. In this chapter, we argue that this is a continuation of the same debate that presupposes certain problematic ideas about the nature of meaning and mind. We attempt to show that the mental state of, for example, a pointer is *not* what makes an act declarative (or imperative) and we examine this mentalistic picture of the mind that guides the work of theorists who claim to be advancing very different explanations of early social cognition. We then turn to a more general methodological critique of existing research in order to show that the lack of valid empirical evidence can speak to these issues.

### Contents

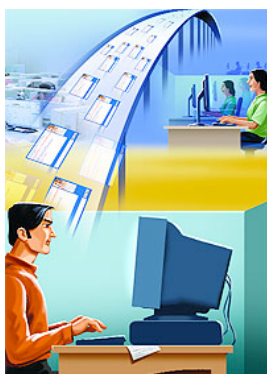
5.1	Introduction.....	65
5.2	Conceptual clarification, theory construction and empirical research .....	67
5.3	Drawing undrawable conclusions .....	71
5.4	Conclusions.....	76
5.5	References.....	77

### 5.1 Introduction

It is generally agreed that we share some capacity for basic forms of intersubjective engagement with other primate species [1, 2]. For example, chimpanzees and humans are both adept at following another's gaze and signalling with communicative gestures. But there is debate concerning how to accurately characterize the cognitive differences across species, particularly concerning the extent to which other apes are able to reach human levels of shared meaning. The general consensus, as a pair of recent target articles in the prestigious journal

Support us – Ask your institution/library/department to order our books or to apply for series membership - ISSN 1566-7677

To order a book contact by fax or by e-mail the offices below:



IOS Press, Inc.  
4502 Rachael Manor  
drive  
Fairfax, VA 22032  
U.S.A.  
Tel.: +1 703 323 5600  
Fax: +1 703 323 3668  
[sales@iospress.com](mailto:sales@iospress.com)

IOS Press  
Nieuwe Hemweg 6B  
1013 BG Amsterdam  
The Netherlands  
Tel: +31 20 688 3355  
Fax: +31 20 620 3419  
[info@iospress.nl](mailto:info@iospress.nl)

IOS Press,  
c/o Ohmsha, Ltd.  
3-1 Kanda Nishiki-cho  
Chiyoda-ku  
Tokyo 101  
Japan  
Fax: +81 3 3233 2426  
(Books only)

IOS Press/  
Gazelle Book Services Ltd  
White Cross Mills  
Hightown  
Lancaster LA1 4XS  
United Kingdom  
Tel.: +44 1524 68765  
Fax: +44 1524 63232  
[sales@gazellebooks.co.uk](mailto:sales@gazellebooks.co.uk)

### Enacting Intersubjectivity

A Cognitive and Social Perspective on the Study of Interactions

**Volume 10** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** F. Morganti, A. Carassa and G. Riva

May 2008, approx. 280 pp., hardcover

**ISBN:** 978-1-58603-850-2 **NEW**

**Price:** US\$161 / €115 / £81

### From Communication to Presence

Cognition, Emotions and Culture towards the Ultimate Communicative Experience

*Festschrift in honor of Luigi Anolli*

**Volume 9** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** G. Riva, M.T. Anguera, B.K. Wiederhold, F. Mantovani

September 2006, 323 pp., hardcover

**ISBN:** 978-1-58603-662-1

**Price:** US\$161 / €115 / £81

### Global Data Management

**Volume 8** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** R. Baldoni, G. Cortese, F. Davide and A. Melpignano

July 2006, 376 pp., hardcover

**ISBN:** 1-58603-629-7

**Price:** US\$161 / €115 / £81

### The Hidden Structure of Interaction

From Neurons to Culture Patterns

**Volume 7** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** L. Anolli, G. Riva, S. Duncan Jr. and M.S. Magnusson

May 2005, 304 pp., hardcover

**ISBN:** 1-58603-509-6

**Price:** US\$161 / €115 / £81

### Ambient Intelligence

The Evolution of Technology, Communication and Cognition Towards the Future of Human-Computer Interaction

**Volume 6** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** G. Riva, F. Vatalaro, F. Davide and M. Alcañiz

January 2005, 316 pp., hardcover

**ISBN:** 1-58603-490-1

**Price:** US\$161 / €115 / £81

### Being There

Concepts, Effects and Measurements of User Presence in Synthetic Environments

**Volume 5** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** G. Riva, F. Davide and W.A. IJsselstein

2003, 344 pp., hardcover

**ISBN:** 1-58603-301-8

**Price:** US\$161 / €115 / £81

### Say not to Say: New Perspectives on Miscommunication

**Volume 3** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** L. Anolli, R. Ciceri and G. Riva

2001, 288 pp., hardcover

**ISBN:** 1-58603-215-1

**Price:** US\$161 / €115 / £81

### Towards CyberPsychology

Mind, Cognition and Society in the Internet Age

**Volume 2** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** G. Riva and C. Galimberti

2001, 326 pp., hardcover

**ISBN:** 1-58603-197-x

**Price:** US\$161 / €115 / £81

### Communications Through Virtual Technologies

Identity, Community and Technology in the Communication Age

**Volume 1** Emerging Communication: Studies on New Technologies and Practices in Communication

**Edited by:** G. Riva and F. Davide

2001, 292 pp., hardcover

**ISBN:** 1-58603-162-7

**Price:** US\$161 / €115 / £81

*Behavioural and Brain Sciences* have argued [3, 4], is that human social cognition is unlike that of any other species in its nature, origins and extent. What is particularly persuasive about this pronouncement is that it comes from two research groups who fail to agree on much else [5, 6]. In this chapter, we conceptually and methodologically analyze the arguments in support of these conclusions.

That human social cognition is unlike that of any other species is beyond dispute in certain respects. For example, concerning meaning shared through language, it is trivially the case that because apes do not develop language in the wild they do not use linguistic symbols to share meaning. Even 'enculturated' and 'language-trained' apes that possess considerable communicative skill [7] are said by many to lack an appreciation of the communicative intention behind the act [e.g., 8]. And conversely understanding communicative intentions is said to enable the sharing of linguistic meaning in human infants [4]. This is a common and commonsensical way of explaining the development of one species and the lack of development of another with a single mechanism.

Using an identical logic, it has been argued that although other apes might gesture or follow another's gaze, they do not appreciate the mental state that is behind and causally related to the act in question. As Tomasello and colleagues recently put it, "To recover the intended meaning of a pointing gesture...requires some fairly serious 'mindreading'" [9]. What is interesting about this claim though is that it follows the statement that, "pointing can convey an almost infinite variety of meanings by saying, in effect, 'If you look over there, you'll know what I mean.'" Therefore, it would be equally valid to claim that understanding the meaning of a pointing gesture requires some fairly serious 'context-reading'. But there is a problem with either of these ways of putting it though because they overemphasize, respectively, the inner and the outer, both of which are intrinsic to the sharing of meaning. However, possibly (a) because researchers have rich access to their own mental lives and (b) reference underdetermines meaning, few researchers would imagine that intersubjectivity involves sharing contexts. Thus, the pendulum swings too far in the other direction, leading to theories of meaning in existing comparative and developmental research that are overly mentalistic and which conceptualize certain forms of shared meaning as the sharing of mental states [1, 2, 10-16].

In this chapter, we argue against this way of thinking on logical and methodological grounds by focussing on the ontogeny and phylogeny of early social cognitive capacities. We first describe and critique widely assumed mentalistic views of meaning and mind and briefly discuss social cognitive capacities in human and nonhuman primates to show the degree to which the extant literature is interpreted within this mentalistic frame of reference. We turn next to a methodological critique that questions the validity of existing empirical evidence with respect to the adjudication of these issues. Our assumption is that the methodological shortcomings that we identify in the existing literature are more likely to occur when one does not have a firm grasp of the relation between the inner and outer. We conclude that the lack of appreciation for conceptual analysis may be helping to fuel debates regarding social cognition in the developmental and comparative literatures.

## 5.2 Conceptual clarification, theory construction and empirical research

In this section we argue that: (a) studying the phylogeny and ontogeny of early social cognition necessarily involves conceptual analysis and (b) problematic preconceptions about the nature of meaning and mind interfere with the interpretation of data and the construction of valid theories. Some might claim that comparative and developmental psychologists should not worry themselves about such issues because theirs is an empirical science and issues of meaning and epistemology are the business of philosophers. However, even if philosophers agreed about these issues, which they do not, psychological theories and empirical research are based on assumptions about these issues and therefore the work raises conceptual, philosophical questions whether we like it or not. Because conceptual analysis is widely viewed as irrelevant to psychological science, however, it is uncontroversial to issue disclaimers such as a recent one by Tomasello and colleagues that “[they] are not attempting to address the large and complex philosophical literature on the nature of mutual knowledge nor the philosophical use of the word ‘know’”[9]. However, in our view this strategy unfortunately obscures researchers’ conceptual commitments, creating ‘invisible philosophy’. Instead, we argue that it is preferable to make assumptions explicit and reflect on the meanings of the concepts that we employ in our investigations [13].

### 5.2.1 Psychology cannot escape its philosophical roots

Although we do not wish to single out Tomasello and his colleagues, their recent article affords us an opportunity to introduce and discuss the issues we raise in this chapter. And it is ironic that although these authors note that they wish to avoid getting into philosophical analyses, when explaining “the basics of pointing” their first substantive references are to the works of two philosophers, Wittgenstein and Grice [9]. This is also an odd juxtaposition in our view because the differences between Wittgenstein and Grice merit serious attention, more attention than we have space for at present. But as Tomasello et al. point out, Wittgenstein noted that reference massively underdetermines meaning and that the meaning of a sign, gesture, and so forth depends critically on the context in which it is embedded [17]. Tomasello and colleagues [18] then argue that:

*“Crucially, as Grice (1957) first observed, cooperative communicative acts also involve in addition an intention about the communication specifically. In this analysis, when I point to a tree for you, I not only want you to notice the tree (for some reason), I also want us to notice together my desire that you notice the tree and this additional tier is necessary to instigate in you the kinds of relevance inference required to identify my reason for communicating in the first place... We call this, following Sperber and Wilson, the communicative intention, and it represents my desire that we both know together that I am referring you to the tree so that you will infer what I want you to know or to do.”*

Strictly speaking of course, these are not Grice’s “observations,” but rather his theory of meaning. To characterize the above propositions as observations obscures the fact that they paint what Wittgenstein called a metaphysical picture

because they do not describe possible objects of observation [17]. To notice, for example, that a person is communicating is not to observe two objects, first a communicative intention and second the behaviour that constitutes the communicative act. However, in making meaning parasitic on intentions, Grice's analysis assumes that communicative content is derivative from mental content<sup>1</sup>. The metaphysical picture underlying this theory is that understanding what a person means by a gesture involves understanding what they have in mind when they perform that gesture. By contrast, Wittgenstein claims, "An intention is embedded in its situation. If the technique of chess did not exist, I could not intend to play a game of chess" [19]. This is not to argue that intentions are somehow non-mental but rather that mental properties are not radically separate from environmental ones, such as social and cultural practices. After all, intending to X presupposes the existence of Xing.

Now, certain cases of sharing meaning may involve determining what another person has in mind. For it seems clear that guessing the referent of an ambiguous point might involve inferences about the pointer's mental state, for example, whether she is attending to X or Y as she points. However, determining the referent of a point is distinct from understanding the intentions of the pointer, for example, whether she is playing a game, making a joke, issuing a warning, and so on. Tomasello and colleagues assume that understanding intentions involves inferences about representations and accordingly is part of what separates humans from other primates [but see 20]. Our point, at least at this juncture, is these researchers could not have constructed the theory they did had they followed Wittgenstein rather than Grice. One might protest that these authors base their theory on Grice because they happen to agree with him, but this is our very point: they can't help but do (invisible) philosophy.

Wittgenstein claimed that conceptual clarity is a precondition for any successful empirical investigation. As Machado and his colleagues [21] have suggested, not only is the need for conceptual analysis poorly understood but:

*"conceptual investigations have also been dismissed as philosophical speculation alien or even inimical to science, as misguided attempts to circumvent empirical research, a sort of shortcut in the path to the truth, or as armchair speculation about the meaning of words."*

We believe that this diagnosis is, unfortunately, correct<sup>2</sup>. And in terms of research concerning primate intersubjectivity, researchers must bear in mind that "Ascribing an understanding of attention to infants specifies what they are capable of doing, not how or why they do it" [22]. Cognitive answers to the causal, empirical, how questions typically involve claims that human-specific joint attention behaviours are causally dependent upon a certain class of mental representations, specifically those that represent the attentional and intentional

---

<sup>1</sup> Although we do not have the space to make our case here, this necessary violates Wittgenstein's private language arguments and leaves Tomasello with an ungrounded level of meaning and a fundamental incoherency in his theory [2, 14]. The basic problem is that it is impossible to extract the meaning of the concept 'intention' or 'attention' simply from private experience.

<sup>2</sup> A recent example is Moore's commentary entitled "Show Me the Theory!" that was written in response to Racine and Carpendale's attempt to clarify the meaning of 'joint attention' as used by contemporary theorists [14, 23].

mental states of others. These theories posit mental representations as causally related to the behaviours that constitute the grounds for ascribing understanding others' attention and intentions. But, given that the only way to determine whether such mental representations are present is to observe the behaviours that are their putative effects, in what sense are joint attention behaviours 'explained' by propositions about representations [13, 16]? This violates a basic scientific tenet that causes and effects be logically distinct.

Fodor has noted that in certain cases, however, the requirement of logical independence for causes and effects has not been met. For example, in Mendel's research, genes were initially defined in terms of their effects; the presence of genes as trait-bearing entities could only be confirmed through observation of those traits that constituted their putative effects. Fodor points out that this did not prevent the development of a successful science of genetics. However, this success entailed the resolution of such ambiguity regarding causes and effects. "Mendel's classic demonstration that recessive characteristics appear unaltered in the offspring of heterozygotes...showed that a distinction is required between traits" (effects) "and their genetic carriers" (causes) [24]. The mental property of a 'communicative intention' is constituted by a family of behavioural properties, namely those behaviours that count as intentionally communicative. It is impossible to identify a 'communicative intention' independent of intentionally communicative behaviours, and thus, the various representational hypotheses that are widely conceived of as competing causal explanations are in fact alternative re-descriptions of the behavioural phenomena they putatively explain [2, 12, 14-16].

### 5.2.2 *What, how and why*

The first order of business in attempting to separate definitional 'what' questions from causal 'how' or 'why' questions is clarifying the grounds upon which mentality is ascribed to others. Simply put, inner states are attributed to others on the basis of behavioural criteria. That is, things that they do, express and so on. However, it is not action alone but action in some specific context that matters, for what is criterial for a given psychological predicate in one situation might not be in another. Because this is perhaps easier to understand in a language using context, consider the following example [25]:

*"Suppose the phone rings—you pick up the receiver, say 'Hello', and enter into conversation with the speaker at the other end of the line. Afterward it could be said that you answered the phone, not that you tried to answer it. If you couldn't get a hold of the receiver, or dropped it breaking the phone, or there was no response from the other end, etc., then it could be said that you tried to answer the phone. There are indefinitely many different situations in which 'answered' can be said; similarly for 'tried to answer'; and indefinitely many situations in which it would not be clear that either thing could be said."*

This is also how researchers often determine the meaning of a pointing gesture. For example, a researcher might activate a toy and when an infant points at the toy, the researcher responds by sharing attention. If the infant stops gesturing she is seen to be satisfied and it is coded as a declarative act, whereas if the infant persists in directing the researcher's attention at an object it is coded as imperative

[e.g., 26]. In other words, overlapping behaviours are criterial for differing 'motivational states' because the sequence of behaviours in which the gesture occurs is manifestly different. This example demonstrates that we say that the motive is declarative (or imperative) *because of the situation in which it is embedded*. Again, this should not be understood as a claim that a motivation, for example, is not a property of an agent and is not in this sense 'inner'.

If children or apes exhibit very similar behaviours in very similar situations it follows that pointing and other aspects of more 'advanced' (secondary) forms of intersubjectivity must apply equally to human and nonhuman primates [27, 28]. This is a logical and not an empirical must. Although the primary application of most of the concepts of mind of interest to comparative and developmental researchers is to human beings, these are sensibly applied to the great apes because of their similarity to humans and their life to the human form of life [17]. The causal issue of how and why apes do such things is a separate question and is in fact the one in which researchers are most interested. The problem in many contemporary theories is that logically indistinguishable causes and effects are posited, which cannot contribute to our understanding of causal issues. Although much creative and informative research has been conducted, in our view the theoretical frameworks within which these data are understood shroud social cognitive capacities in a mentalistic fog that is hard to see one's way through.

In a similar vein, Povinelli claims that chimpanzees satisfy criteria for understanding attention such as careful attention to eyes of human experimenters but yet do not understand the psychological significance of seeing [29]. But to pay careful attention to the eyes and to otherwise monitor the gaze of others are criterial for understanding basic forms of attention. And although they critique one another's work, Povinelli, Tomasello and their colleagues seem to all look for something additional to the activity in question and they assume that what gives the activity the meaning that we attribute to it is the mental state of the agent [2].

The confusions about the relation between causation and definition that inhere in representationalist views are so deeply embedded that they also creep into approaches to mind that try to avoid equating representation with understanding. Proponents of distributed approaches to cognition such as Johnson [e.g., 30] explicitly contrast their theories to ones like Tomasello's or Povinelli's in an attempt to provide a more accurate characterization of the phenomena that constitute understanding attention and other related psychological states. Although we share some of Johnson's motivations and have made similar points ourselves [1, 2, 14], we will use her article as a basis for further clarification.

Johnson claims that, "Rather than using behaviour as the basis for inferences to invisible mental events such as intentions, the distributed approach treats communicative interactions as, themselves, directly observable cognitive events" [31]. Again, Wittgenstein's separation of definitional relations between inner states and behaviour from the causal relations that may obtain highlights the problem here. As Susswein and Racine point out, it is misleading to think of a behaviour as a "directly observable cognitive event" because this conflates the criteria by which cognitive events are ascribed with the cognitive events themselves [16]. As Wittgenstein famously remarked, "An 'inner process' stands in need of outward criteria" [17]. And claiming that criteria are cognitive events obscures causal/definitional and inner/outer in a similar way as the representationalist programme. This is unfortunate because many comparative and developmental

researchers “tend to think of an ‘inner’ mental world of experiences, dispositions, abilities, and preferences, and so on, on the one hand, and an ‘outer’ world of behaviours and environments on the other. But just as heads logically presupposes a tails side of the coin, the relations between the mental and the behavioural are [intrinsically related] and...cannot be identified independently of each other” [32]. Although we sympathize with Johnson’s attempt to avoid logical difficulties inherent in representational approaches, we argue that collapsing, rather than overdrawing, critical distinctions between the inner and outer also obscures these issues of interest.

### **5.3 Drawing undrawable conclusions**

We now move from logical concerns to methodological ones. In recent years, comparative and developmental psychologists have produced a large number of empirical findings purporting to demonstrate that young infants and/or nonhuman primates, especially apes, either have or do not have the capacity to represent the invisible contents of other minds [e.g., 5, 6, 9, 33, 34]. We have argued that the epistemological assumptions upon these studies are based are untenable. We now turn our focus to some of the more common methodological failings of species comparisons designed to assess the cognitive bases of the comprehension or production of manual gestures, the comprehension of gaze, and the comprehension of epistemic states. These shortcomings include (a) failure to control for or otherwise acknowledge rearing history confounds with species [e.g., 1, 10, 35-37], (b) failure to control training regimens across species, thereby confounding training histories with species, and (c) confounding experimental manipulations across levels of independent variables [for an insightful critique of contemporary research into comparative cognition on separate grounds, see 38].

#### *5.3.1 The confound in rearing histories between humans and other apes*

Studies in which the communicative competencies of captive apes are compared with typically developing human children universally suffer from a lack of experimental control over the respective organisms’ rearing histories. Thus, ontogenetically and experimentally relevant factors quite typically experienced by captive apes, such as the early trauma associated with witnessing the murder of one’s mother, rejection by and consequent loss of a primary caregiver, peer-centred attachment relations, impoverished physical environments, and relatively restricted interaction with (and hence, familiarity with) human caregivers are all confounded with the apes’ species classifications. No researcher would: (a) sample human children who have experienced the kinds of extreme trauma, neglect, and impoverishment that is quite typical of captive ape experiences, (b) measure aspects of their sensitivity to human communicative or attentional behaviour, and then (c) generalize from these traumatized and/or impoverished samples to the entire human species. Yet, there are many published examples in which even very eminent researchers have generalized from their captive ape samples to entire species [e.g., 29, 33, 39].

For a typical example, in an oft-cited monograph by Povinelli and Eddy [29], seven orphaned young chimpanzees, who were raised in peer cohorts in the

relatively impoverished circumstances of a nursery in a biomedical research centre, were compared with human 2- to 5-year-old children, raised by their biological parents, in the comparatively enriched circumstances characteristic of Western upbringing contexts in the developed world. The tests were designed to assess the sensitivity of these respective organisms to visual cues of visual attention in human experimenters. In experimental circumstances that were alleged by the authors to be “similar”, the children performed better than did the apes in some procedures. Was this because the apes lacked stable, primary, adult attachment figures over the entireties of their childhoods? Was this because the apes had very much less interactive experience with humans than did the human children? Was this because the apes were representatives of a different species than the human children? Although it is clearly impossible to isolate the factors responsible for the performance differences between the chimpanzees and the children, Povinelli and Eddy concluded that the differences in performance between the two groups were attributable to the chimpanzees’ incapacity to “appreciate the mental connection engendered by visual inspection” and that “despite their striking use of (and interest in) the eyes, 5-6 chimpanzees apparently see very little behind them” [40].

Povinelli and Eddy argued that because they had demonstrated similar baseline performances between the apes and the children in some experimental conditions, and because the differences that they found were evident in only some transfer conditions, that therefore they had demonstrated a deficiency in those transfer conditions by the chimpanzees. However, although it is well established that more experienced animals will more easily transfer their expertise to novel experimental circumstances [e.g., 41], and therefore the poorer transfer performances of the chimpanzees in that study may be due to their species’ inability to discern others’ visual perspectives, their performances might also simply reflect their relative lack of experience engaging with humans, or other incidental effects of their radically different, relatively impoverished rearing histories. And there is no reasonable basis to conclude that the apes had anything like as much pre-experimental experience with human gaze cues of visual attention as did the human children (even the younger human children), and there is every reason to believe that the apes were far less experienced than the human children were (even the younger human children). It is simply impossible to distinguish these possibilities from this research design. The attribution by Povinelli and Eddy of the performance differences between the humans and the apes to their species classifications and not their pre-experimental histories – in the face of obvious rearing history differences that differed immensely between the two groups – is symptomatic of the recent literature on comparative cognition. Although by no means do we suggest that this interpretive bias is characteristic only of one particular group of researchers in one particular laboratory, the fact remains that experimental confounds do not disappear if ignored.

Of course, it is, as a practical and ethical matter, impossible to control these pre-experimental factors in a full factorial experimental design, particularly with organisms as long-lived as humans and other apes. Although developmental research suggests that very impoverished upbringings lead to poor cognitive and social development [e.g., 42-45], we cannot, for example, consign human children to be raised by chimpanzees. Quasi-experimental designs can, however, be achieved by cross-fostering apes with human caregivers. This has been attempted

with great apes of all species, including chimpanzees [46-50], bonobos [7, 51], gorillas [52] and orangutans [53]. Others have raised infants in bi-specific communities consisting of both humans and apes: e.g., Loulis, adopted son of Washoe at the Central Washington University in Bellingham, Washington, U.S.A. [54], several chimpanzees at the Primate Research Centre of Kyoto, Japan, and several animals at the Great Ape Trust of Des Moines, Iowa, U.S.A. However, to our knowledge, only two formal cross-fostering experiments have raised apes in a human culture from near-birth. The first was the study by Hayes and Hayes of a single chimpanzee subject, Viki [49]. The second was by Gardner and Gardner [55]; in this experiment, four chimpanzees were cross-fostered from neonates: Moja, Tatu, Dar, & Pili (Pili died at less than two years of age, so there is a limited behavioural record for him). Thus, to our knowledge, only four chimpanzee subjects in the history of science (excluding Pili) could have served, in principle, as an experimentally valid comparison to human children by virtue of having been raised from birth by humans, with stable, primary attachment relationships to particular human caregivers, in the socio-ecological and physical circumstances typical of human childhood [56, for non-experimental account of cross-fostering a chimpanzee named Lucy, see 57]. These are all astonishingly accomplished animals, whose behavioural competencies refuted a number of recent claims about ape social cognition, decades in advance of those claims. For example, it is widely claimed that apes do not communicate protodeclaratively or imitate despite hundreds of published examples of this in these and other language-trained animals or later-adopted apes [e.g., 49, 58].

There also seems to be a very widespread misconception that any ape raised by humans is therefore cross-fostered by humans to the same degree, regardless of the diversity of circumstances in which these apes have lost their biological mothers, the wide variations in the social, emotional, and physical environments in which they were raised from birth, and the extraordinarily large differences among captive apes in their relative familiarity with humans. We hope that it is now obvious that virtually all direct comparisons of the cognition of apes and humans are invalid from an experimental point of view. This is not to argue that the whole enterprise of comparative cognition is meaningless; we are simply making the rather rudimentary point that if one compares individuals from two separate groups with radically different rearing histories and finds a significant difference in a dependent variable between those two groups, then one cannot rationally conclude that you have uncovered a group, but not a rearing history, difference; it is entirely unclear, in these kinds of research designs, whether differences between apes and humans are attributable to species differences (i.e., different evolutionary histories), rearing history differences, or some interaction between these evolutionary and developmental factors. Whenever a researcher concludes, from research designs like this that they have identified a species difference in social cognition, this conclusion can only illustrate the interpretive bias of the researcher.

If this is still not obvious, then consider the following thought experiment:

*“raise human boys from birth in the same relatively impoverished circumstances in which captive apes are typically raised. Let the comparison group be human girls raised by their biological parents in their homes. Years later, assess the sensitivity of the boys and the girls to subtle cues of visual attention in human adults. Suppose the girls, unsurprisingly, perform better than the boys—would any*

*researcher in their right mind attribute the difference to a gender difference between boys and girls? Of course not, rearing history is clearly confounded with the gender of the subjects. Yet substitute apes for boys and humans for girls in this research design and how often have researchers trumpeted a “species difference” between apes and humans in various aspects of sensitivity to visual attention?”* [59]

Again, in the face of the extraordinary difficulty of adequately controlling for rearing history factors in ape-human comparisons, we believe that these kinds of experiments are worthwhile—what we wish to highlight here is the irrationality of asserting one factor’s influence (e.g., species—they can’t do it because they are chimpanzees), rather than another confounded factor’s influence (e.g., rearing history—they can’t do it because they were exposed to prolonged trauma, neglect, or were relatively less experienced).

### *5.3.2 Methodological misconceptions of behaviour*

Given that this is such a commonplace practice in comparative psychology, it is perhaps not very surprising that rearing histories are ignored in much of contemporary empirical research – albeit with some notable exceptions [e.g., 33]. It is more surprising that it is also common to find researchers claiming to have demonstrated a cognitive deficiency in great apes, relative to humans, in the face of apes’ *superior* performance. A straightforward example of this is a study by Povinelli et al. in which human children and chimpanzees were presented with an experimenter seated behind two containers, one of which was baited with a reward (stickers, in the case of children, and edible treats, in the case of the chimpanzees) [39]. In the critical test trials, the experimenter adopted one of three different postures designed to communicate the location of the hidden treat: (a) head and eyes turned to look at the baited container (At Target), (b) head oriented straight ahead, with eyes peering at the baited container (Eyes Only), and (c) head and eyes oriented considerably above the baited container (Above Container). According to the reasoning of Povinelli and his colleagues, if an organism has a high-level mentalistic concept of visual attention, in which attention is conceived of as a kind of “laser beam,” then that organism ought to find it difficult to locate the hidden treats in the Above Container condition because the gaze is focused decidedly *away* from the baited container. They found that both human children and apes performed poorly (at chance) in the Eyes Only condition, that both humans and apes performed well in the At Target condition, and that apes performed well (above chance) in the Above Target, but the children performed at chance levels. Povinelli et al. attributed the apes’ better performance in the Above Target condition as evidence that apes’ conceptions of visual attention were like “floodlamps,” vaguely and imprecisely indicating a general area, but not a specific locus. They concluded that chimpanzees had only a low-level appreciation of gaze, despite the fact that these same chimpanzees very frequently turned to look at the ceiling behind them, on the same sides at which the experimenters’ eyes were focused [60]. In a study of the performance of human adults, Thomas, Murphy, Pitt, Rivers, and Leavens found that human adults acted just like the chimpanzees in the Above Target condition [61]; taking Povinelli et al.’s hypotheses at face value, this implies that human children have high-level, laser-beam-like

conceptions of visual attention, and then humans lose this conceptual sophistication in adulthood. More likely, the improved performances of the chimpanzees, compared to the human children, simply reflected either their superior grasp of the task requirements or their greater motivation for their rewards, *contra* Povinelli and colleagues.

Another example of this kind of methodological error comes from the same laboratory. Theall and Povinelli attempted to determine whether chimpanzees would exhibit more “attention-getting” behaviour when an experimenter could not see them, compared to when the experimenter could see them [62]. The critical probe trials in which the experimenters adopted their various attentive and inattentive postures were embedded in a series of standard trials, in which the experimenter was attentive. There was one experimental probe trial for every two standard, baseline trials. Crucially, in the standard trials, the chimpanzees were rewarded immediately for placing their hands through a hole in a transparent barrier. In contrast, in the experimental probe trials (in half of which the experimenter was attentive and in half of which the experimenter was inattentive) no reinforcement took place until after 20 seconds had elapsed from the apes’ placements of their hands through the barrier. Thus, the chimpanzees were trained to place their hands in particular holes and to expect immediate reinforcement for doing so, yet, unaccountably, on one-third of all trials—and irrespective of whether the experimenter was “attentive” or “inattentive”—the experimenter simply would not respond with reinforcement until a 20-second interval had elapsed. Thus, when Theall and Povinelli failed to find a difference in the rates of the hapless chimpanzees’ attention-getting behaviour between the so-called “attentive” and “inattentive” conditions, it is entirely unclear whether this is attributable to the apes’ inability to discriminate attentive from inattentive states, as the authors concluded, or whether, as seems much more likely to us, the chimpanzees were displaying attention-getting behaviour to enigmatically unresponsive experimenters, irrespective of their attentional state.

In this study, then, the experimenter’s lack of responsiveness was confounded with the manipulation of the experimenter’s posture, relative to the more numerous baseline trials in which the experimenter responded immediately to the apes’ gestures. Other research protocols have clearly demonstrated that great apes do discriminate different attentional states in human experimenters demonstrating that almost all failures to demonstrate these kinds of discrimination in great apes are attributable to procedural deficiencies, rather than the deficiencies in the animals studied [e.g., 63-66]. There are other serious, yet common shortcomings in direct human-ape comparisons in cognitive performance, but virtually all existing studies purporting to compare humans with apes suffer from one or more of these three major methodological failings: failure to control pre-experimental histories across species, failure to control training protocols across species, or confounding factors across the levels of the intended independent variable. Thus, very strong theoretical positions [e.g., 3, 4, 8, 9, 29, 67] have been taken on the basis of dubious empirical findings.

A more informative and nuanced approach to comparative cognition is to sample apes from varied backgrounds, comparing them to human children. This kind of protocol was pioneered by Tomasello and his colleagues [68, 69]. For example, Carpenter and her colleagues analyzed the joint attentional competencies of: (a) apes who were relatively inexperienced with humans, (b) apes who were relatively

more experienced with humans, and (c) human children. They found that the experienced (“enculturated”) chimpanzees performed much more like human children than did the less experienced (“unenculturated”) chimpanzees, thus clearly implicating rearing history differences as more relevant to performance in joint attention than species differences [70, 71; for a similar apparent rearing history influence on two orangutans see 72; see 10 for relevant discussions of within-species effects of differential exposure of apes to human cultures]. Thus, when within-species variation in rearing history is properly accounted for in ape-human comparisons, the apparent influence of species as a factor in socio-cognitive development is reduced, a conclusion also reached by Tomasello et al. [69].

This truism is underscored by the ease with which chimpanzees and other apes in captivity come to manipulate people in their environments, through pointing and other manual gestures, despite the fact that they virtually never point in the wild [71, 73-76]. Apes in captivity are sensitive to variations in the visual attention of their human caregivers, as evidenced by their requirement that a human is both present [71, 75] and looking at the apes [64, 71] before they display a gesture. Like human children, apes look back-and-forth between the objects of their points and their social partners [73, 74], and they persist in and elaborate their communication in the face of communicative failures [75, 77]. Because these behaviours also define the human developmental transition into intentional communication or secondary intersubjectivity, researchers sometimes balk at attributing the same kinds of mental representations to apes that they attribute to human infants. There is in fact no stronger empirical evidence for intentional communication in preverbal human children than in nonhuman primates.

#### **5.4 Conclusions**

We have argued that developmental and comparative research into early social cognition has failed to adequately address the conceptual aspects of such investigations and has suffered because of it. Because many researchers seem to not have a clear handle on the distinctions between causal and definitional issues and the relation between inner and outer they have imported an overly mentalistic conception of social cognitive activity into their research designs. In our view, the failure to take rearing histories of nonhuman primates into account and the methodological problems that ensue from this error follow from this mentalistic conception of the mind as an inner entity that is logically distinct from activity, cultural surround, rearing history and so forth. That is, ostensible differences between chimpanzee and human minds make a lot more sense when one forgets about the relation between the inner and the outer.

The central message from the comparative literature is that when the behavioural context is used as a basis for the attribution of the cognitive bases for communication, then humans and the great apes manifestly share many aspects of early social cognition. This obviates the need to invoke an evolutionary or ontogenetic *deus ex machina* for what are really rather simple cognitive processes. Despite the recent claims that Darwin was mistaken to argue for continuity in primate cognitive differences [3], in accordance with Darwinian theory, it is crucial that continuity between humans and other animals remains the null

hypothesis, particularly in the face of the numerous methodological failures to convincingly demonstrate discontinuity.

## 5.5 References

- [1] D. A. Leavens, W. D. Hopkins & K.A. Bard, The heterochronic origins of explicit reference. In J. Zlatev, T. P. Racine, C. Sinha & E. Itkonen (Eds.), *The shared mind: Perspectives on intersubjectivity*. Amsterdam: Benjamins, in press.
- [2] T. P. Racine & J. I. M. Carpendale, The embodiment of mental states. In W. F. Overton, U. Müller & J. Newman (Eds.), *Body in mind, mind in body: Developmental perspectives on embodiment and consciousness*, (pp.159-190). Mahwah, NJ: Erlbaum, 2007.
- [3] D. C. Penn, K. J. Holyoak & D. L. Povinelli, Darwin's mistake: Explaining the discontinuity between human and nonhuman minds. *Behavioural and Brain Sciences*, in press.
- [4] M. Tomasello, M. Carpenter, J. Call, T. Behne & H. Moll, Understanding and sharing intentions: The origins of cultural cognition. *Behavioural and Brain Sciences*, 28, 675–735, 2005.
- [5] D. J. Povinelli & J. Vonk, Chimpanzee minds: Suspiciously human? *Trends in Cognitive Sciences*, 7, 157–160, 2003.
- [6] M. Call Tomasello & B. Hare, Chimpanzees understand psychological states—the question is which ones and to what extent. *Trends in Cognitive Sciences*, 7, 153–156, 2003.
- [7] E. S. Savage-Rumbaugh, S. G. Shanker & J. T. Talbot, *Apes, language, and the human mind*. New York: Oxford University Press, 1998.
- [8] M. Tomasello & M. Carpenter, The emergence of social cognition in three young chimpanzees. *Monographs of the Society for Research in Child Development*, 70 (Serial No. 279), 2005.
- [9] M. Tomasello, M. Carpenter & U. Liszkowski, A new look at infant pointing. *Child Development*, 78, 705-722, 706, 2007.
- [10] D. A. Leavens, T. P. Racine & W. D. Hopkins, The ontogeny and phylogeny of non-verbal deixis. In C. Knight & R. Botha (Eds.), *The cradle of language, 1: Multidisciplinary perspectives*. Oxford: Oxford University Press, under review.
- [11] T. P. Racine, Computation, meaning and artificial intelligence: Some old problems, some new models. *Canadian Artificial Intelligence*, 50, 8-19, 2002.
- [12] T. P. Racine, Wittgenstein's internalistic logic and children's theories of mind. In J. I. M. Carpendale & U. Müller (Eds.), *Social interaction and the development of knowledge*, (pp.257-276). Mahwah, NJ: Erlbaum, 2004.
- [13] T. P. Racine & J. I. M. Carpendale, Shared practices, understanding, language and joint attention. *British Journal of Developmental Psychology*, 25, 45-54, 2007.
- [14] T. P. Racine & J. I. M. Carpendale, The role of shared practice in joint attention. *British Journal of Developmental Psychology*, 25, 3-25, 2007.
- [15] N. Susswein & T. P. Racine, Sharing mental states: Causal and definitional issues in intersubjectivity. In J. Zlatev, T. P. Racine, C. Sinha & E. Itkonen (Eds.), *The shared mind: Perspectives on intersubjectivity*. Amsterdam: Benjamins, in press.
- [16] N. Susswein & T. P. Racine, Wittgenstein and not-just-in-the-head cognition. *New Ideas in Psychology*, in press
- [17] L. Wittgenstein, *Philosophical investigations* (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall, 1958.
- [18] M. Tomasello, M. Carpenter & U. Liszkowski, A new look at infant pointing. *Child Development*, 78, 705-722, 707-708, 2007.
- [19] L. Wittgenstein, *Philosophical investigations* (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall, 1958.
- [20] J. Call, B. Hare, M. Carpenter & M. Tomasello, 'Unwilling' versus 'unable': Chimpanzees' understanding of human intentional action. *Developmental Science*, 7, 488-498, 2004.
- [21] A. Machado, O. Lourenço & F. J. Silva, Facts, concepts and theories: The shape of psychology's epistemic triangle. *Behaviour and Philosophy*, 28, 1-40, 25, 2000.
- [22] N. Susswein & T. P. Racine, Sharing mental states: Causal and definitional issues in intersubjectivity. In J. Zlatev, T. P. Racine, C. Sinha & E. Itkonen (Eds.), *The shared mind: Perspectives on intersubjectivity*, 11. Amsterdam: Benjamins, in press.
- [23] C. Moore, Show me the theory! *British Journal of Developmental Psychology*, 25, 39-43, 2007.
- [24] J. Fodor, *Psychological explanation*. New York: Random House, 1968.
- [25] N. Malcolm, In D. M. Armstrong & N. Malcolm, *Consciousness and causality*, 36. Oxford: Blackwell, 1984.

- [26] U. Liszkowski, M. Carpenter, A. Henning, T. Striano & M. Tomasello, Twelve-month-olds point to share attention and interest. *Developmental Science*, 7, 297–307, 2004.
- [27] C. Trevarthen & P. Hubley, Secondary subjectivity: Confidence, confiding, and acts of meaning in the first year. In A. Lock (Ed.), *Action, gesture and symbol: The emergence of language*, (pp. 183-229). London: Academic Press, 1978.
- [28] D. A. Leavens, W. D. Hopkins & K. A. Bard, Understanding the point of chimpanzee pointing: Epigenesis and ecological validity. *Current Directions in Psychological Science*, 14, 185-189, 2005.
- [29] D. J. Povinelli & T. J. Eddy, What young chimpanzees know about seeing. *Monographs of the Society for Research in Child Development*, 61 (Serial No. 247), 1996.
- [30] C. M. Johnson, Distributed primate cognition: A review. *Animal Cognition*, 4, 167-183, 2001.
- [31] *Ibid*, p. 167.
- [32] N. Susswein & T. P. Racine, Wittgenstein and not-just-in-the-head cognition. *New Ideas in Psychology*, 20, n press.
- [33] J. Call & M. A. Tomasello, Nonverbal false belief task: The performance of children and great apes. *Child Development*, 70, 381-395, 1999.
- [34] C. Moore & B. D'Entremont, Developmental changes in pointing as a function of attentional focus. *Journal of Cognition and Development*, 2, 109-129, 2001.
- [35] D. A. Leavens, Having a concept 'see' does not imply attribution of knowledge: Some general considerations in measuring 'theory of mind'. *Behavioural and Brain Sciences*, 21, 123-124, 1998.
- [36] D. A. Leavens, On the public nature of communication. *Behavioural and Brain Sciences*, 25, 630-631, 2002.
- [37] D. A. Leavens, Manual deixis in apes and humans. *Interaction Studies*, 5, 387-408, 2004.
- [38] C. Boesch, What makes us human (*Homo sapiens*)? The challenge of cognitive cross-species comparison. *Journal of Comparative Psychology*, 121, 227-240, 2007.
- [39] D. J. Povinelli, D. T. Bierschwale & C. G. Cech, Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees. *British Journal of Developmental Psychology*, 17, 37-60, 1999.
- [40] D. J. Povinelli & T. J. Eddy, What young chimpanzees know about seeing. *Monographs of the Society for Research in Child Development* 61, (Serial No. 247), 122; 140, 1996.
- [41] H. F. Harlow, The formation of learning sets. *Psychological Review*, 56, 51-65, 1949.
- [42] J. Hodges & B. Tizard, Social and family relationships of ex-institutional adolescents. *Journal of Child Psychology and Psychiatry*, 30, 77-97, 1989.
- [43] T. G. O'Connor, R. S. Marvin, M. Rutter, J. T. Ulrich, P. A. Britner & the English and Romanian Adoptees Study Team. Child-parent attachment following early institutional deprivation. *Development and Psychopathology*, 15, 19-38, 2003.
- [44] M. Rutter, Maternal deprivation. In M. H. Bornstein (Ed.), *Handbook of parenting, 4: Applied and practical parenting*, (pp.3-31). Mahwah, NJ: Erlbaum, 1996.
- [45] R. A. Spitz, Anaclitic depression. *Psychoanalytic study of the child*, 2, 313-342, 1946.
- [46] N. N. Ladygina-Kohts, In F. B. M. de Waal (Ed.), *Infant chimpanzee and human child: A classic 1935 comparative study of ape emotions and intelligence*. New York: Oxford University Press, 2001.
- [47] W. N. Kellogg & L. A. Kellogg, *The ape and the child: A study of early environmental influence upon early behavior*. New York: McGraw-Hill, 1933.
- [48] B. T. Gardner & R. A. Gardner, Two-way communication with an infant chimpanzee. In A. M. Schrier & F. Stollnitz (Eds.), *Behavior of nonhuman primates: Modern research trends*, 4, 117-183. New York: Academic Press, 1971.
- [49] K. J. Hayes & C. Hayes, The cultural capacity of chimpanzees. *Human Biology*, 26, 288-303, 1954.
- [50] E. S. Savage-Rumbaugh, *Ape language: From conditioned response to symbol*. New York: Columbia University Press, 1986.
- [51] E. S. Savage-Rumbaugh & R. Lewin, *Kanzi: The ape at the brink of the human mind*. New York: John Wiley, 1994.
- [52] F. G. Patterson, Linguistic capabilities of a lowland gorilla. In F. C. C. Peng (Ed.), *Sign language and language acquisition in man and ape: New dimensions in comparative pedolinguistics*, (pp.161-201). Boulder, CO: Westview Press, 1978.
- [53] H. L. Miles, The cognitive foundations for reference in a signing orangutan. In S. T. Parker & K. R. Gibson (Eds.), *"Language" and intelligence in monkeys and apes: Comparative developmental perspectives*, (pp. 511-539). Cambridge: Cambridge University Press, 1990.

- [54] R. S. Fouts, A. D. Hirsch & D. H. Fouts, Cultural transmission of a human language in a chimpanzee mother-infant relationship. In H. E. Fitzgerald, J. A. Mullins & P. Gage (Eds.), *Child nurturance: Studies of development in primates*, (pp.159-193). New York: Plenum Press, 1982.
- [55] R. A. Gardner & B. T. Gardner, A cross-fostering laboratory. In R. A. Gardner, B. T. Gardner, & T. E. Van Cantfort (Eds.), *Teaching sign language to chimpanzees*, (pp.1-28). Albany: State University of New York Press, 1989.
- [56] K. A. Bard & D. A. Leavens, Socio-emotional factors in the development of joint attention in human and ape infants. In L. Roska-Hardy & E.M. Neumann-Held (Eds.), *Learning from animals?* London: Psychology Press, in press.
- [57] M. K. Temerlin, *Lucy: Growing up human*. London: Souvenir Press, 1976.
- [58] R. E. Van Cantfort, B. T. Gardner & R. A. Gardner, (1989). Developmental trends in replies to Wh-questions by children and chimpanzees. In R. A. Gardner, B. T. Gardner & T. E. Van Cantfort (Eds.), *Teaching sign language to chimpanzees* (pp. 198-239). Albany: State University of New York Press, 1989.
- [59] D. A. Leavens, W. D. Hopkins & K. A. Bard, The heterochronic origins of explicit reference. In J. Zlatev, T. P. Racine, C. Sinha & E. Itkonen (Eds.), *The shared mind: Perspectives on intersubjectivity*, 17. Amsterdam: Benjamins, in press.
- [60] D. J. Povinelli, D. T. Bierschwale & C. G. Cech, Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees. *British Journal of Developmental Psychology*, 17, 37-60, 1999, see Fig. 7 and pp. 51-52.
- [61] E. Thomas, M. Murphy, R. Pitt, A. Rivers & D. A. Leavens, *Understanding of visual attention by adult humans (Homo sapiens): A partial replication of Povinelli, Bierschwale and Cech (1999)*, under review.
- [62] L. A. Theall & D. J. Povinelli, Do chimpanzees tailor their gestural signals to fit the attentional states of others? *Animal Cognition*, 2, 207-214, 1999.
- [63] J. Brauer, J. Call & M. Tomasello, All primates species follow gaze to distant locations and around barriers. *Journal of Comparative Psychology*, 119, 145-154, 2005.
- [64] A. B. Hostetter, M. Cantero & W. D. Hopkins, Differential use of vocal and gestural communication in response to the attentional status of a human. *Journal of Comparative Psychology*, 115, 337-343, 2001.
- [65] D. A. Leavens, A. B. Hostetter, M. J. Wesley & W. D. Hopkins, Tactical use of unimodal and bimodal communication by chimpanzees, Pan troglodytes. *Animal Behaviour*, 67, 467-476, 2004.
- [66] S. R. Poss, C. Kuhar, T. S. Stoinski & W. D. Hopkins, 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. *American Journal of Primatology*, 68, 978-992, 2006.
- [67] D. J. Povinelli, J. M. Bering & S. Giambrone, Toward a science of other minds: Escaping the argument by analogy. *Cognitive Science*, 24, 509-541, 2000.
- [68] M. Carpenter, M. Tomasello & S. Savage-Rumbaugh, Joint attention and imitative learning in children, chimpanzees, and enculturated chimpanzees. *Social Development*, 4, 217-237, 1995.
- [69] M. Tomasello, E. S. Savage-Rumbaugh & A. C. Kruger, Imitative learning of actions on objects by children, chimpanzees, and enculturated chimpanzees. *Child Development*, 64, 1688-1705, 1993.
- [70] D. A. Leavens & W. D. Hopkins, The whole hand point: The structure and function of pointing from a comparative perspective. *Journal of Comparative Psychology*, 113, 417-425, 1999.
- [71] J. Call & M. Tomasello, The effect of humans on the cognitive development of apes. In A. E. Russon, K. A. Bard & S. T. Parker (Eds.), *Reaching into thought: The minds of the great apes*, (pp.371-403). Cambridge: Cambridge University Press, 1996.
- [72] J. Call & M. Tomasello, Production and comprehension of referential pointing by orangutans (*Pongo pygmaeus*). *Journal of Comparative Psychology*, 108, 307-317, 1994.
- [73] M. A. Krause & R. S. Fouts, Chimpanzee (*Pan troglodytes*) pointing: Hand shapes, accuracy, and the role of eye gaze. *Journal of Comparative Psychology*, 111, 330-336, 1997.
- [74] D. A. Leavens & W. D. Hopkins, Intentional communication by chimpanzees: A cross-sectional study of the use of referential gestures. *Developmental Psychology*, 34, 813-822, 1998.
- [75] D. A. Leavens, W. D. Hopkins & R. K. Thomas, Referential communication by chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology*, 118, 48-57, 2004.
- [76] D. A. Leavens, J. L. Russell & W. D. Hopkins, Intentionality as measured in the persistence and elaboration of communication by chimpanzees (*Pan troglodytes*). *Child Development*, 76, 291-306, 2005.
- [77] E.A. Cartmill & R.W. Byrne, Orangutans modify their gestural signaling according to their audience's comprehension. *Current Biology*, 17, 1345-1348, 2007.