The consequent of (10) carries the presupposition that Marcia regrets selling her bicycle; but (10) as a whole does not presuppose this. Although one can utter (10) in a context in which it's known that Marcia sold the bicycle, it would also be felicitous in a context in which we only know that she was contemplating doing so.

The merits of three principal types of theories of presupposition and of presupposition projection are currently being debated: satisfaction theories (Karttunen 1973; Stalnaker 1974, 1979; Heim 1983, 1992), cancellation theories (Gazdar 1979; Soames 1989), and anaphoric theories (Van der Sandt 1989, 1992). See Beaver 1998 for an excellent technical overview of current theory with extensive comparison. For historical overviews of the linguistic and philosophical literature on presupposition (including the important debate on the purported presuppositions of definite Noun Phrases in Frege 1892; Russell 1905, and Strawson 1950), the reader is referred to Levinson (1983) and Soames (1989). Evans (1977), Heim (1982), Kadmon (1990), and Neale (1990), among others, continue the Russell/Strawson debate. And Roberts (1996a) discusses a phenomenon dubbed *modal subordination*, which poses *prima facie* problems for most theories of presupposition

See also ANAPHORA; GRICE, H. PAUL; IMPLICATURE; PRAGMATICS

—Craige Roberts

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Primate Amygdala

See AMYGDALA, PRIMATE

Primate Cognition

Ludwig Wittgenstein remarked that if lions could speak we would not understand them. David Premack (1986), following this conceptual thread, commented that if chickens had syntax they would have nothing much to say. The first comment raises a methodological challenge, the second a conceptual one. Studies of primate cognition have faced both.

For some, monkeys and apes appear much smarter than nonprimates. If so, why might this be the case? One dominant perspective suggests that social life has exerted extraordinary pressure on brain structure and function, and has led to a mind that is capable of tracking dynamically changing social relationships and political struggles (Byrne and Whiten 1988; Cheney and Seyfarth 1990; Humphrey 1976; Povinelli 1993). In primates—but few other species—individuals form coalitions to outcompete others, and following aggressive attack, subordinates often reconcile their differences with a dominant, engaging in exceptional acts of kindness and trust such as kissing and testicle holding (de Waal 1996; Harcourt and de Waal 1992). Such behavior, along with apparent acts of deception (Hauser 1996), has provided the foundation for experimental investigations of underlying

cognitive mechanisms. Here, I tackle three problems so as to shed light on the architecture of the primate mind: (1) IMITATION, (2) abstract CONCEPTS, and (3) mental state attribution.

Imitation

In some monkey species, all chimpanzee populations, and one orangutan population—but in no gorilla populations—individuals use tools to gain access to food (Matsuzawa and Yamakoshi 1996; McGrew 1992; Visalberghi and Fragaszy 1991). The observation that individuals within a population ultimately acquire the same tool-using technique has been taken as evidence that primates are capable of imitation. There are, however, several paradoxical findings and controversies over the interpretation of these observations (Heyes and Galef 1996; Tomasello and Call 1997; Byrne and Russon forthcoming). First, in some study populations, young require 5–10 years before they master tool technology. Although some of this can be accounted for by maturational issues associated with motor control, one would expect faster acquisition if imitation, or a more effective teaching system, was in place (Caro and Hauser 1992). Second, most experiments conducted in the lab have failed to provide evidence that naturally reared monkeys and apes can imitate (Whiten and Ham 1992), although a recent set of studies on chimpanzees and marmosets suggest that some of the previous failures may be due to methodological problems rather than conceptual ones (Heyes and Galef 1996). Third, and perhaps most paradoxical of all, apes reared by humans can imitate human actions (reviewed in Tomasello and Call 1997). This suggests that the ape mind has been designed for imitation, but requires a special environment for its emancipation—a conceptual puzzle that has yet to be resolved (see SOCIAL COGNITION IN ANIMALS).

Abstract Concept

In several primates, the number of food calls produced is positively correlated with the amount of food discovered (reviewed in Hauser 1996). In chimpanzees, a group from one community will kill a lone individual from another community, but will avoid others if there are two or more individuals. Are such assessments based on an abstract conceptual system, akin to our number system? Recent experiments, using different experimental procedures, reveal that both apes and monkeys have quite exceptional numerical skills (reviewed in Gallistel 1990; Hauser and Carey forthcoming). Thus, chimpanzees who have learned arabic numbers understand the primary principles of a count system (e.g., one-one mapping, item indifference, cardinality) and can count up to and label nine items (Boysen 1996; Matsuzawa 1996). Using the violation of expectancy procedure designed for human infants, studies of rhesus monkeys and cotton-top tamarins have revealed that they can spontaneously carry out simple arithmetical calculations, such as addition and subtraction (Hauser and Carey forthcoming; Hauser, MacNeilage, and Ware 1996). Although nonhuman primates will never join the intellectual ranks of our mathematical elite, they clearly have access to an abstract number concept, in addition to other abstract concepts (e.g., transitivity, color names, sameness, cause-effect, identity, kinship) that contribute to the intricacies of their social life. And primates are probably not even unique within the animal kingdom in terms of such conceptual capacities, as other species have demonstrated comparable cognitive prowess (see review in Thompson 1995).

Mental State Attribution

Are primates intuitive psychologists in that they can reflect upon their own beliefs and desires and understand that others may or may not share such mental states? Consider the following observation: a low-ranking male chimpanzee who is about to mate sees a more dominant male approaching. The low-ranking male covers his erect penis as the dominant walks by. This kind of interaction—and there are thousands of observations like this in the literature—suggests a capacity for intentional deception (see MACHIAVELLIAN INTELLIGENCE HYPOTHESIS). If true, the following capacities must be in place: the ability to represent one's own beliefs and desires, the ability to understand perspective, and the ability to attribute intentions to others. The evidence for each of these capacities is weak, at best, but the experimental research program is only in its infancy. Studies using mirrors suggest that all of the apes, and at least one monkey (cotton-top tamarins), respond to their reflection as if they see themselves, rather than a conspecific (Gallup 1970; Hauser et al. 1995; Povinelli et al. 1993). Self-recognition can be computed by perceptual mechanisms alone, whereas self-awareness implies some access to one's own beliefs and desires, how they can change, and how they might differ from those of another individual. The mirror test is blind to issues of awareness.

Many animals, primates included, follow the direction of eye gaze. However, current evidence suggests that neither monkeys nor apes understand that seeing provides a window into knowledge. A suite of experiments now show that monkeys and apes do not use eye gaze to infer what other individuals know, and thus do not alter their behavior as a function of differences in knowledge (Cheney and Seyfarth 1990; Povinelli and Eddy 1996). Given that this capacity emerges in the developing child well before the capacity to attribute intentional states to others and that perspective taking plays such a critical role in mental state attribution, it seems unlikely that primates have access to a theory of mind. But we should withhold final judgment until additional experiments have been conducted.

The human primate once held hands with a nonhuman primate ancestor. But this phylogenetic coupling happened 5–6 million years ago, ample time for fundamental differences to have emerged in the human branch of the tree. Nonetheless, many features of the primate mind have been left unchanged, including some capacity for imitation and some capacity to represent abstract concepts. The future lies in uncovering the kinds of selective pressures that led to changes in and conservation of the general architecture of the primate mind.

See also LANGUAGE AND THOUGHT; METAREPRESENTATION; PRIMATE LANGUAGE; THEORY OF MIND

—Marc D. Hauser

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Primate Language

Curiosity regarding apes' capacity for language has a long history. From DARWIN's nineteenth century postulations of both biological and psychological continuities between animals and humans, to the more recent discovery (Sibley and Ahlquist 1987) that chimpanzee *(Pan)* DNA is more similar to human than to gorilla *(Gorilla)* DNA, scientific findings have encouraged research into the language potential of apes. A recent report (Gannon et al. 1998) that the chimpanzee planum temporale is enlarged in the left hemisphere, with a humanlike pattern of Wernicke's brain language-area homolog, will provide additional impetus. That area is held basic to human language. Does, in fact, elaboration in the chimpanzee's planum temporale provide for language-relevant processes or potential? Is its elaboration an instance of homoplasy (convergent evolution)? Or is its function not necessarily related to language?

Language research with apes was revitalized in the 1960s as Beatrix and Allen Gardner (Gardner, Gardner, and Cantfort 1989) used a variation of American Sign Language to establish two-way communication with their chimpanzee, Washoe, and as David Premack (Premack and Premack 1983) used an artificial language system of plastic tokens with his chimpanzee, Sarah. In the 1970s, Sue Savage-Rumbaugh's group (1977) developed a computer-monitored keyboard of distinctive geometric patterns, called *lexigrams,* to foster studies of language capacity with Lana, a chimpanzee. Herbert Terrace's (1979) chimpanzee Project Nim, Lynn Miles's (1990) orangutan Project Chantek, and Roger and Deborah Fouts's (1989) project with Washoe and other chimpanzees obtained from the Gardners also started during the '70s.

These projects initially emphasized language production. It was assumed that if an ape appropriately produced a sign then it must also understand its meaning. That assumption proved unwarranted. Apes were proved capable of selecting seemingly appropriate symbols without understanding their meanings, even at a level grasped by 2- and 3-year-old children as they use words. Studies of comprehension ensued.

But how can one assess whether symbol meaningfulness and comprehension are present, given that apes can't speak? There are several ways. First, the meaningfulness of symbols with Sherman and Austin chimpanzees (Savage-Rumbaugh 1986) was documented by their symbol-based, cross-modal matching. Without specific training, they could look at a lexigram and select the appropriate object, by touch, from others in a box into which they could not see. They also could label, by use of word-lexigrams, single objects that they could feel but not see. Second, and more importantly, they learned word-lexigrams for the *categories* of "food" and "tool" to which they appropriately sorted 17 individual lexigrams, each representing a specific food and implement. (Each lexigram represented either a food or a tool, such as a banana, magnet, cheese, lever, etc.) Thus, their lexigrams represented things not necessarily present—the essence of SEMANTICS or *word meaning.*

Comprehension became of special interest with the discovery that Kanzi, a bonobo (a rare species of chimpanzee, *Pan paniscus*), *spontaneously* learned the meanings of word-lexigrams and later came to understand human speech—both single words and novel sentences of request (Savage-Rumbaugh et al. 1993). The discovery was made in the course of research with Matata, his adoptive mother. Matata's essential failure in learning lexigrams was likely a reflection of her feral birth and development.

Though always present during Matata's language training, Kanzi was not taught; but later, when separated from her, it became clear that he had learned a great deal! Spontaneously, he began to request and go get specific foods and drinks, to label objects, and to announce what he was about to do with the appropriate lexigrams.

From that time forward, Kanzi was reared in an even richer language-structured milieu. Caregivers commented on events (present, future, and past) and particularly on things of special interest to him. Where possible, caregivers used word-lexigrams as they spoke specific words. Kanzi was not required to use a keyboard to receive objects or to participate in activities and was given no formal lessons.

Kanzi quickly learned by observation how to ask to travel to specific sites in the forest, to play a number of games, to visit other chimps, to get and even cook specific foods, and to watch television. He also commented on things and events and continued to announce eminent actions. In sharp contrast with our other apes, Kanzi also began to comprehend human speech—not just single words but also sentences.

Consequently, Kanzi's (8 yrs.) speech comprehension was compared with that of a human child, Alia (2½ yrs.). In controlled tests, they were given 415 novel requests—to take a specific object to a stated location or person ("Take the gorilla (doll) to the bedroom"), to do something to an object ("Hammer the snake!"), to do something with a specific object relative to another object ("Put a rubber band on your ball"), to go somewhere and retrieve a specific object ("Get the telephone that's outdoors"), and so on. An ever-changing variety of objects was present on each trial, and the ape and child were asked to fulfil various requests with them. Each request was novel and had not been modeled by others.