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THE PSYCHOLOGY OF LANGUAGE

FROM DATA TO THEORY

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producing sounds, only humans show very strong right-handedness dominance; in other animals gesture production is bilateral across the population. (Although individual nonhuman primates, dogs, cats, and even rats tend to favor one paw, there is no systematic preference for left or right within these species.) As the gesture-based language evolved, vocalizations became incorporated into the gesture system, leading to the specialization and lateralization of the language and gesture systems and the right-handed preference in humans.

Of course, the relation between evolution and language might have been more complex than this. Elman (1999) argued that language arose from a communication system through many interacting "tweaks and twiddles." Deacon (1997) proposed that language and the brain co-evolved in an interactive way, converging towards a common solution for the cognitive and sensorimotor problems facing the organism. Symbolic gestures and vocalization preceded fully blown language. As the frontal cortex of humans grew larger, symbolic processing became more important, and linguistic skills became necessary to manage symbol processing, leading to the development of speech apparatus to implement these skills, which in turn would demand and enable further symbolic processing abilities. Fisher and Marcus (2006) propose that language was not a single wholesale innovation, but a complex reconfiguration of several systems that became adapted to form language. Such a conclusion is similar to that of Christiansen and Chater (2008), who see language itself as an evolving system that has made use of pre-existing brain structures.

DO ANIMALS HAVE LANGUAGE?

Is language an ability that is uniquely human? I examine both naturally occurring animal communication systems, and attempts to teach a human-like language to animals, particularly chimpanzees. There are a number of reasons why this topic is important. First, it provides a focus for the issue of what we mean by the term language. Second, it informs debate about the extent to which aspects of language might be innate in humans and have a genetic basis. Third, it might tell us about which other social and cognitive processes are necessary for a language to develop. Finally, of course, the question is of great intellectual interest. The idea of being able to "talk to the animals" like the fictional Dr. Dolittle fascinates both adults and children alike. It can become an emotive subject, as it touches on the issue of animal rights, and the extent to which humans are distinct from other animals.

Animal communication systems

Many animals possess rich communication systems—even insects communicate. Communication is much easier to define than language: it is the transmission of a signal that conveys information, often such that the sender benefits from the recipient's response (Pearce, 2008). The signal is the means that conveys the information (e.g., a sound or a smell). It is useful to distinguish between communicative and informative signals: communicative signals have an element of design or intentionality in them, whereas signals that are merely informative do not. If I cough, this might inform you that I have a cold, but it is not a communication; but telling you that I have a cold is.

A wide range of methods is used to convey information. Ants rely on chemical messengers called pheromones. Honey bees produce a complex "waggle dance" (see Figure 3.1) in a figure-of-eight shape to other members of the hive (von Frisch, 1950, 1974). The direction of the straight part of the dance (or the axis of the figure-of-eight) represents the direction of the nectar relative to the sun, and the rate at which the bee waggles during the dance represents distance.

Primates use visual, auditory, tactile, and olfactory signals to communicate with each other. They use a wide variety of calls to symbolize a range of features of the environment and their emotional states. For example, a vervet monkey produces one particular "chutter" to warn others that a snake is nearby, a different call when an eagle is overhead, and yet another distinct call

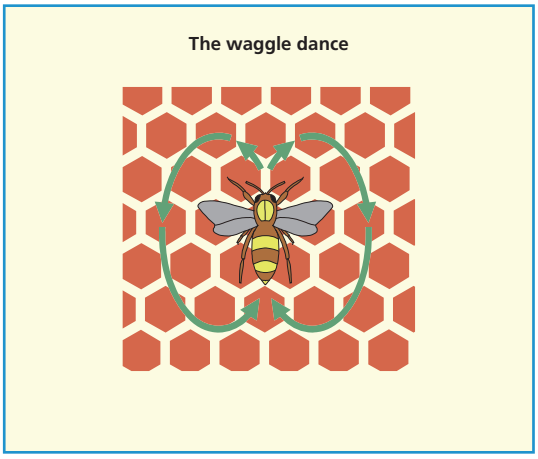

FIGURE 3.1

to warn of approaching leopards. Each type of call elicits different responses from other nearby vervets (Demers, 1988). However, the signals are linked to particular stimuli and are only produced in their presence. Primates communicate about stimuli for which they do not already possess signals, suggesting that their communicative system has an element of creativity.

It is a widespread belief that whales and dolphins possess a language. However, the research does not support this belief. There is currently no evidence to suggest that dolphins employ sequences of sub-units that convey particular messages, in the same way as we combine words to form sentences to convey messages. Early research suggesting that dolphins were communicating with each other to carry out cooperative tasks to obtain fish turned out to be explicable in terms of conditioning; the dolphins carried on making sounds in the obvious absence of other dolphins (Evans & Bastian, 1969). Hump-backed whale song consists of ordered sub-parts, but their function is unknown (Demers, 1988).

How would we decide if an animal communication system had crossed the boundary to be counted as a language?

Defining language

"Language" is a difficult word to define. The dictionary defines language as "human speech

Research shows that dolphins do not possess a language in terms of the intentional structuring of sub-units to deliver intelligible communications. However, this prompts the question; at what juncture do we decide that communication can be classed as a language?

… an artificial system of signs and symbols, with rules for forming intelligible communications for use, e.g., in a computer" (*Chambers Twentieth Century Dictionary*, 1998). Many introductions to the study of language avoid giving a definition, or consider it to be so obvious that it does not need to be defined. To some extent the aim of modern theoretical linguistics is to offer an answer to this question (Lyons, 1977a). Perhaps the difference between an animal communication system and a language is just a matter of degree?

Design features

Hockett (1960) attempted to sidestep the thorny issue of defining language by listing 16 general properties or design features of spoken human language (see Box 3.1). The emphasis of his design features is very much on the physical characteristics of spoken languages. Clearly, these are not all necessary defining characteristics—human written language does not display "rapid fading," yet clearly written language is a form of language. Nevertheless, design features provide a useful framework for thinking about how animal communication systems differ from human language.

Box 3.1 Hockett's (1960) "design features" of human spoken language

1. Vocal-auditory channel (communication occurs by the producer speaking and the receiver hearing)
2. Broadcast transmission and directional reception (a signal travels out in all directions from the speaker but can be localized in space by the hearer)
3. Rapid fading (once spoken, the signal rapidly disappears and is no longer available for inspection)
4. Interchangeability (adults can be both receivers and transmitters)
5. Complete feedback (speakers can access everything about their productions)
6. Specialization (the amount of energy in the signal is unimportant; a word means the same whether it is whispered or shouted)
7. Semanticity (signals mean something: they relate to the features of the world)
8. Arbitrariness (these symbols are abstract; except with a few onomatopoeic exceptions, they do not resemble what they stand for)
9. Discreteness (the vocabulary is made of discrete units)
10. Displacement (the communication system can be used to refer to things remote in time and space)
11. Openness (the ability to invent new messages)
12. Tradition (the language can be taught and learned)
13. Duality of patterning (only combinations of otherwise meaningless units are meaningful—this can be seen as applying both at the level of sounds and words, and words and sentences)
14. Prevarication (language provides us with the ability to lie and deceive)
15. Reflectiveness (we can communicate about the communication system itself, just as this book is doing)
16. Learnability (the speaker of one language can learn another)

Which features do animal communication systems possess? All communication systems possess some of the features. For example, the red belly of a breeding stickleback is an arbitrary sign. Some of the characteristics are more important than others; we might single out semanticity, arbitrariness, displacement, openness, tradition, duality of patterning, prevarication, and reflectiveness. These features all relate to the fact that language is about meaning, and provide us with the ability to communicate about anything. We might add other features to this list that emphasize the creativity and meaning-related aspects of language. Marshall (1970) pointed out the important fact that language is under our voluntary control; we intend to convey a particular message. The creativity of language stems from our ability to use syntactic rules to generate a potentially infinite number of messages from a finite number of words using iteration and recursion (see Chapter 2).

Syntax has five important properties (Kako, 1999a; Pinker, 2002). First, language is a discrete combinatorial system. When words are combined, we create a new meaning: the meanings of the words do not just blend into each other, but retain their identity. Second, well-ordered sentences depend on ordering syntactic categories of words (such as nouns and verbs) in correct sequences. Third, sentences are built round verbs, which specify what goes with what (e.g., you give something to someone). Fourth, we can distinguish words that do the semantic work of the language (content words—see Chapter 2) from words that assist in the syntactic work of the language (function words). Fifth, recursion—phrases containing examples of themselves—enables us to construct an infinite number of sentences from a finite number of rules. No animal communication system has these properties.

We can use language to communicate about anything, however remote in time and space.

Hence, although a parrot uses the vocal-auditory channel and the noises it makes satisfy most of the design characteristics up to number 13, it cannot lie, or reflect about its communication system, or talk about the past. Whereas monkeys are limited to chattering and squeaking about immediate threats such as snakes in the grass and eagles overhead, we can express novel thoughts; we can make up sentences that convey new ideas. This cannot be said of other animal communication systems. Bees will never dance a book about the psychology of the bee dance. We can talk about anything and effortlessly construct sentences that have never been produced before.

In summary, many animals possess rich symbolic communication systems that enable them to convey messages to other members of the species, that affect their behavior, that serve an extremely useful purpose, and that possess many of Hockett's design features. On the other hand, these communication systems lack the richness of human language. This richness is manifested in our limitless ability to talk about anything using a finite number of words and rules to combine those words. However difficult "language" may be to define, the difference between animal communication systems and human language is not just one of degree. All nonhuman communication systems are quite different from language (Deacon, 1997).

Can we teach language to animals?

Perhaps some animals have the biological and cognitive apparatus to acquire language, but have not needed to do so in their evolutionary niche. The alternative view is that only humans possess the necessary capabilities: that other animals are in principle incapable of learning language.

Most people think that dogs and parrots "know" some aspects of language. Dogs respond to instructions. One border collie called Rico knew the labels of over 200 items (Kaminski, Call, & Fischer, 2004), being able to fetch items with different names from around the house, even when he could not see the owner (thereby eliminating the possibility of the "Clever Hans" effect, which is that animals that appear to know language are in fact just picking up cues from their owner). When faced with a new name, he would infer that the name applied to a novel object, rather than being another name for an object with which he was familiar—this "novel name equals nameless category" principle is one that children use to learn some new words. However, unlike children, Rico's knowledge was restricted to the names of physical objects, and he showed no understanding of how the meanings of words might be related (e.g., that doll and ball are both types of toy). Nevertheless, this performance is impressive, and also suggests that general (rather than language-specific) learning mechanisms might go some way to explaining early word learning in children.

Everyone knows that parrots can be taught to mimic human speech. Pepperberg (1981, 1983, 1987, 2009) took this idea further and embarked on an elaborate formal program of training of her African grey parrot (*Psittacus erithacus*) called Alex. After 13 years, Alex had a vocabulary of about 80 words, including object names, adjectives, and some verbs. He could even produce and understand short sequences of words. Alex could classify 40 objects according to their color and what they were made of, understand the concepts of same and different, and count up to six. Alex showed evidence of being able to combine discrete categories and use syntactic categories appropriately. However,

Pepperberg's (1981) African grey parrot, Alex, showed evidence of being able to combine discrete categories and possibly to use syntactic categories appropriately.

he knew few verbs, showed little evidence of being able to relate objects to verbs, and knew very few function words (Kako, 1999a). Hence Alex's linguistic abilities are extremely limited.

Herman, Richards, and Wolz (1984) taught two bottle-nosed dolphins, Phoenix and Akeakamai, artificial languages. One language was visually based, using gestures of the trainer's arms and legs (see Figure 3.2), and the other was acoustically based, using computer-generated sounds transmitted through underwater speakers. However, this research tested only the animals' comprehension of the artificial language, not their ability to produce it. From the point of view of answering our questions on language and animals it is clearly important to examine both comprehension and production. Even so, the dolphins' syntactic ability was limited, and they showed no evidence of being able to use function words (Kako, 1999a).

Most of the work on teaching language to animals involves other primates, particularly chimpanzees, as they are highly intelligent, social animals and are our closest genetic neighbors. In the following discussion it is useful to bear in mind the distinction between teaching word meaning and syntax. Remember that an essential feature of human language is that it involves both associating a finite number of words with particular meanings or concepts, and using a finite number of rules to combine those words into a potentially infinite number of sentences. Before we can conclude that apes have learned a language we need to show that they can do both of these things.

What are the other cognitive abilities of chimpanzees?

We have seen that primates have a rich communication system that they use in the wild. The cognitive abilities of a chimpanzee named Viki aged 3½ years were generally comparable to those of a child of a similar age on a range of perceptual tasks such as discriminating and matching similar items, but broke down on tasks involving counting (Hayes & Nissen, 1971). Experiments on another chimp

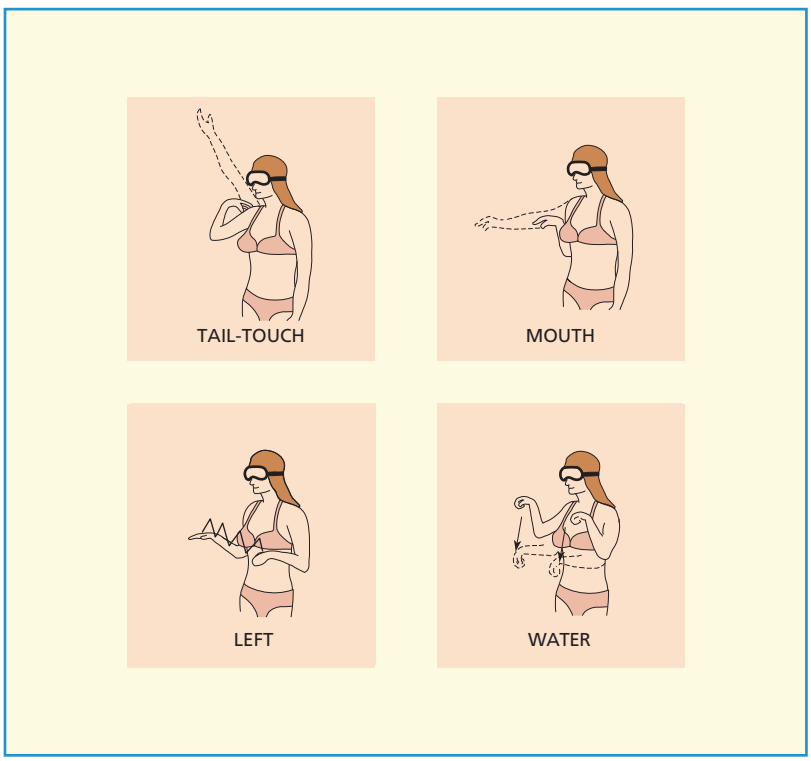

FIGURE 3.2 Some of the gestures used to communicate with Akeakamai the dolphin. Adapted from Herman et al. (1984).

named Sarah also suggested that she performed at levels close to that of a young child on tasks such as conserving quantity, as long she could see the transformation occurring. For example, she understood that pouring water from a tall, thin glass into a short, fat glass did not change the amount of water. Hence the cognitive abilities of apes are broadly similar to those of young children, apart from the latter's linguistic abilities. This decoupling of linguistic and other cognitive abilities in children and apes has important implications. First, it suggests that for many basic cognitive tasks language is not essential. Second, it suggests that there are some non-cognitive prerequisites to linguistic development. Third, it suggests that cognitive limitations in themselves might not be able to account for the failure of apes to acquire language.

Talking chimps

The earliest attempt to teach apes language was that of Kellogg and Kellogg (1933), who raised a female chimpanzee named Gua along with their own son. (This type of rearing is called cross-fostering or cross-nurturing.) Gua only understood a few words, and never produced any that were recognizable. Hayes (1951) reared a chimp named Viki as a human child and attempted to teach her to speak. This attempt was also unsuccessful, as after 6 years the chimpanzee could produce just four poorly articulated words ("mama," "papa," "up," and "cup") using her lips. Even then, Viki could only produce these in a guttural croak, and only the Hayes family could understand them easily. With a great deal of training she understood more words, and some combinations of words.

These early studies have a fundamental limitation. The vocal tracts of chimps are physiologically unsuited to producing speech, and this difference alone could account for their lack of progress (see Figure 3.3). Nothing can be concluded about the general language abilities of primates from these early failures.

Washoe

Although the design of the vocal tracts of chimps is unsuited to speaking, chimps are manually very dexterous. Later attempts at teaching apes language were based on systems using either a type of sign language, or involving manipulating artificially created symbols. Perhaps the most famous example of trying to teach language to an ape is that of Washoe. Washoe is a female chimpanzee who was caught in the wild when she was approximately 1 year old. She was then brought up as a human child, doing things such as eating, toilet training, playing, and other social activities

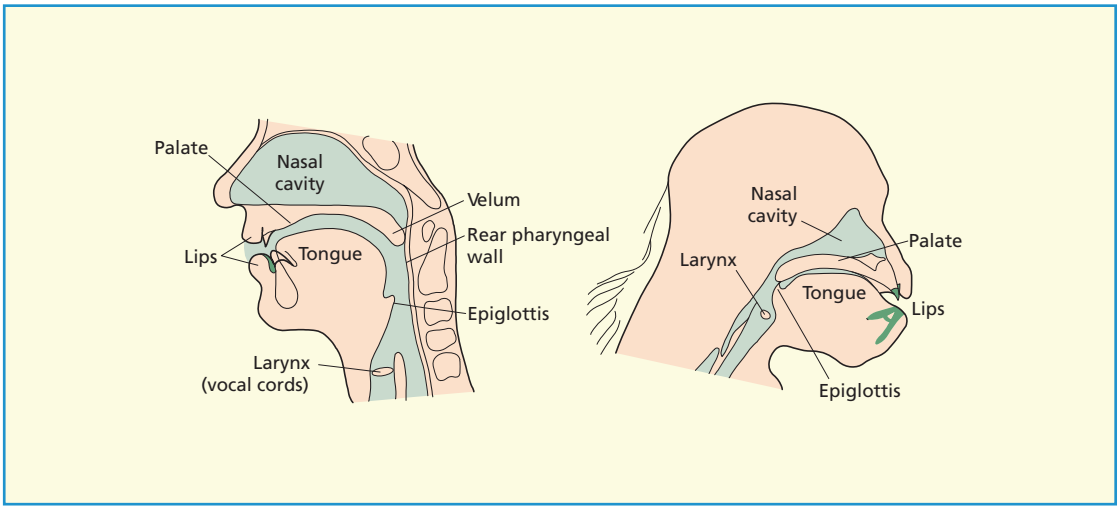

FIGURE 3.3 Compare the adult vocal tract of a human (left) with that of a chimpanzee (right). Adapted from Lieberman (1975).

(Gardner & Gardner, 1969, 1975). In this context, she was taught **American Sign Language** (ASL, sometimes called AMESLAN). ASL is the standard sign language used by people with hearing impairment in North America. Just like spoken language, it has words and syntax.

At the age of 4, Washoe could produce about 85 signs, and comprehend more; a few years later her vocabulary had increased to approximately 150–200 signs (Fouts, Shapiro, & O'Neil, 1978). These signs came from many syntactic categories, including nouns, verbs, adjectives, negatives, and pronouns. Her carers argued that she made over-generalization errors similar to those of young children (for example, in using the sign for "flower" to stand for flower-like smells, or "hurt" to refer to a tattoo). It was further claimed that when she did not know a sign, she could create a new one. When she first saw a duck and had not learned a sign for it, she coined a phrase combining two signs she did have, producing "water bird." Furthermore, she combined signs and used them correctly in strings up to five items long. Examples of Washoe's signing include: "Washoe sorry," "Baby down," "Go in," "Hug hurry," and "Out open please hurry." She could answer some questions that use what are called WH-words (so called because in English most of the words that are used to start questions begin with "wh," such as "what," "where," "when," or "who"). She displayed some sensitivity to word order in that she could distinguish between "You tickle me" and "I tickle you."

Do chimps who have been taught language go on to teach their offspring, or can the offspring learn language by observing their parents? These are important questions, because there is little evidence that human children are explicitly taught language by their parents. Researchers observed that Washoe's adopted son Loulis both spontaneously acquired signs from Washoe and was also seen to be taught by Washoe. Although this is a clear indication of what is known as cultural transmission, it is unclear whether it is a language that has been transmitted, or just a sophisticated communication system (Fouts, Fouts, & van Cantfort, 1989; Fouts, Hirsch, & Fouts, 1982).

At first sight Washoe appears to have acquired the use of words and their meanings, and at least some sensitivity to word order in both production and comprehension.

Sarah

A different approach was taken by Premack (1971, 1976a, 1976b, 1985, 1986a). Sarah was a chimpanzee trained in a laboratory setting to manipulate small plastic symbols that varied in shape, size, and texture. The symbols could be ordered in certain ways according to rules. Together, the symbols and the rules form a language called Premackese. One advantage of this set-up is that less memory load is required, as the array is always in front of the animal. Sarah produced mainly simple lexical concepts (strings of items together describing simple objects or actions), and could produce novel strings of symbols. These, however, were generally only at the level of substituting one word for another. For example (with the Premackese translated into English), "Randy give apple Sarah" was used as the basis of producing "Randy give banana Sarah." She produced sentences that were syntactically quite complex (for example, producing logical connectives such as "if … then"), and showed metalinguistic awareness (reflectiveness) in that she could talk about the language system itself using symbols that meant "… is the name of." However, there was little evidence that Sarah was grouping strings of symbols together to form proper syntactic units. (Also see Figure 3.4.)

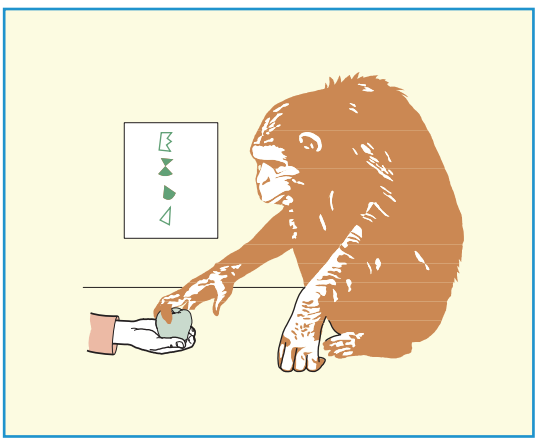

FIGURE 3.4 Here we see another of Premack's chimpanzees, Elizabeth. The message on the board says "Elizabeth give apple Amy." Adapted from Premack (1976a).

Nim and others

Terrace, Petitto, Sanders, and Bever (1979) described the linguistic progress of a chimpanzee named Nim Chimpsky (a pun on Noam Chomsky). They taught Nim Chimpsky a language based on ASL. Nim learned about 125 signs, and the researchers recorded over 20,000 utterances in 2 years, many of them of two or more signs in combination. They found that there was regularity of order in two-word utterances—for example, place was usually the second thing mentioned—but that this broke down with longer utterances. Longer utterances were largely characterized by more repetition ("banana me eat banana eat"), rather than displaying real syntactic structure. Terrace et al. were far more pessimistic about the linguistic abilities of apes than were either the Gardners or Premack. Unlike children, Nim rarely signed spontaneously; about 90% of his utterances were in reply to his trainers and concerned immediate activities such as eating, drinking, and playing, and 40% of his utterances were simply repetitions of signs that had just been made by his trainers. However, O'Sullivan and Yeager (1989) pointed out that the type of training Nim received might have limited his linguistic skills. They found that he performed better in a conversational setting than in a formal training session.

There have been other famous attempts to teach language to primates. Savage-Rumbaugh, Rumbaugh, and Boysen (1978) reported attempts to teach the chimpanzees Lana, Sherman, and Austin language, using a computer-controlled display of symbols structured according to an invented syntax called Yerkish. The symbols that serve as words are called lexigrams (see Figure 3.5). The linguistic abilities of other primates such as gorillas have also been studied (e.g., Koko, reported by Patterson, 1981).

Evaluation of early attempts to teach language to apes

At first sight, these attempts to teach chimps language might look quite convincing. The important design features of Hockett all appear to be present. Specific signs are used to represent particular words (discreteness), and apes can refer to objects that are not in view (displacement). The issue of semanticity, whether or not the signs have meaning for the apes, is a controversial one to which we shall return. At the very least we can say that they have learned associations between objects and events and responses. Sarah could discuss the symbol system itself (reflectiveness). Signs could be combined in novel ways (openness). The reports of apes passing sign language on to their young satisfy the feature of tradition. Most importantly, it is claimed that the signs are combined according to specified syntactic rules of ordering: that is, they have apparently acquired

Student teacher Joyce Butler with Nim Chimpsky the chimpanzee, named after American linguist, philosopher, cognitive scientist, and political activist Noam Chomsky. Joyce is showing Nim the sign configuration for "drink" and Nim is imitating her. Photographed during project Nim, an extended study of animal language acquisition conducted in the 1970s.

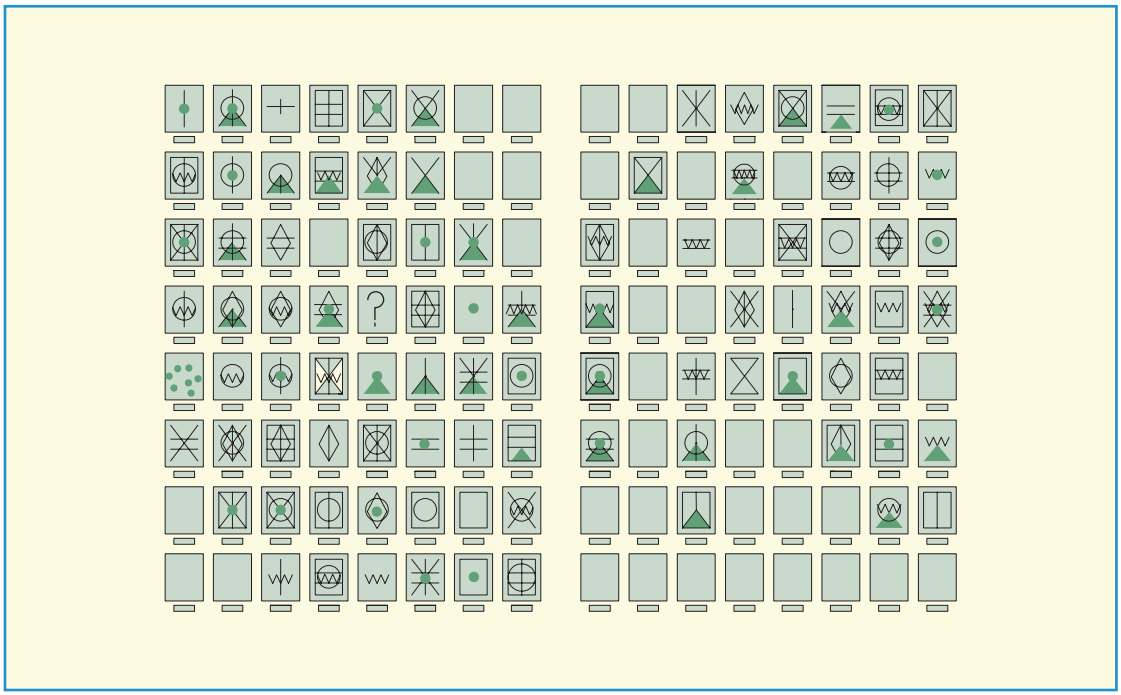

FIGURE 3.5 The arrangement of lexigrams on a keyboard. Blank spaces were non-functioning keys, or displayed photographs of trainers. From Savage-Rumbaugh, Pate, Lawson, Smith, and Rosenbaum (1983).

a grammar. Maybe, then, these animals can learn language, and the difference between apes and humans is only a matter of degree?

Unfortunately, there are many problems with some of this research, particularly the early, pioneering work. The literature is full of argument and counter-argument, making it difficult to arrive at a definite conclusion. There have been two sources of debate: methodological criticisms of the training methods and the testing procedures used, and argument over how the results should be interpreted.

What are the methodological criticisms? First, one criticism was that ASL is not truly symbolic, in that many of the signs are icons standing for what is represented in a non-arbitrary way (Savage-Rumbaugh et al., 1978; Seidenberg & Petitto, 1979). For example, the symbol for "give" looks like a motion of the hand towards the body reminiscent of receiving a gift, and "drive" is a motion rather like turning a steering wheel. If this were true, then this research could be dismissed as irrelevant because the chimps are not learning a symbolic language. Clearly it is not true; not all the attempts mentioned earlier used ASL—Premack's plastic symbols, for example, are very different. In addition, the force of this objection can be largely dismissed on the grounds that although some ASL signs are iconic, many of them are not, and that deaf people clearly use ASL in a symbolic way. No one would say that deaf people using ASL are not using a language (Petitto, 1987). Nevertheless, ASL is different from spoken language in that it is more condensed—articles such as "the" and "a" are omitted—and this clearly might affect the way in which animals use the language. And in Washoe's case at least, a great proportion of her signing seemed to be based on signs that resemble natural gestures. It is also possible that her trainers over-interpreted her gestures, first incorrectly identifying some gestures as signs, or thinking that a particular movement was indeed an appropriate sign. Deaf native signers observed a marked discrepancy between what they thought Washoe had produced (which was very little), and what the trainers claimed (Pinker, 1994). Again, these criticisms are hard to

justify against the lexigram-based studies, although Brown (1973) noted that Sarah's performance deteriorated with a different trainer.

In these early studies, reporting of signing behavior was anecdotal, or limited to cumulative vocabulary counts and lists. No one ever produced a complete corpus of all the signs of a signing ape in a predetermined period of time, with details of the context in which the signs occurred (Seidenberg & Petitto, 1979). The limited reporting has a number of consequences that make interpretation difficult. For example, the "water bird" example would be less interesting if Washoe had spent all day randomly making signs such as "water shoe," "water banana," "water refrigerator," and so on. In addition, the data presented are reduced so as to eliminate the repetition of signs, thus producing summary data. Repetition in signing is quite common, leading to long sequences such as "me banana you banana me give," which is a less impressive syntactic accomplishment than "you banana me give," and not at all like the early sequences produced by human children. The chimps produced many imitations of the signs that had just been produced by the humans, while truly creative signing in the absence of something to imitate is rare. Thompson and Church (1980) produced a computer program to simulate Lana's acquisition of Yerkish. They concluded that all she had done was to learn to associate objects and events with lexigrams, and to use one of a few stock sentences depending on situational cues. There was no evidence of real understanding of word meaning or syntactic structure. (For details of these methodological problems, see Bronowski & Bellugi, 1970; Fromkin et al., 2011; Gardner, 1990; Pinker, 1994; Seidenberg & Petitto, 1979; and Thompson & Church, 1980.)

There are also a number of differences between the behavior of apes using language and of children of about the same age, or with the same vocabulary size (see Table 3.1). The utterances made by chimps are tied to the here-and-now, with those involving temporal displacement (talking about things remote in time) particularly rare. There is a lack of syntactic structure and the word order used is inconsistent, particularly with longer utterances. Fodor et al. (1974) pointed out that there appeared to be little comprehension of the syntactic relations between units, and that it was difficult to produce a syntactic analysis of their utterances. There was little evidence that "acquiring" a sentence structure as in the string of words "Insert apple dish" would help, or transfer to, producing the new sentence "Insert apple red dish." Unlike humans, these chimpanzees could not reject ill-formed sentences. They rarely asked questions—an obvious characteristic of the speech of young children. Children use language to find out more about language; chimpanzees do not. Chimps do not spontaneously use symbols referentially—that is, they need explicit training to go beyond merely associating a particular symbol or word in a particular context; young children behave quite differently. Finally, it

TABLE 3.1 Differences between apes' and children's language behavior.

Apes	Children
Utterances are mainly in the here-and-now	Utterances can involve temporal displacement
Lack of syntactic structure	Clear syntactic structure and consistency
Little comprehension of syntactic relationships between units	Ability to pick up syntactic relationships between units
Need explicit training to use symbols	Do not need explicit training to use symbols
Cannot reject ill-formed sentences	Can reject ill-formed sentences
Rarely ask questions	Frequently ask questions
No spontaneous referential use of symbols	Spontaneous referential use of symbols

is not clear that these chimps used language to help them to reason.

These criticisms have not gone unchallenged (e.g., Premack, 1976a, 1976b). Savage-Rumbaugh (1987) pointed out that it is important not to generalize from the failure of one ape to the behavior of others. Furthermore, many of these early studies were pioneering and later studies learned from their failures and difficulties. Broadly, however, much of the early work is of limited value because it is not clear that it tells us anything about the linguistic abilities of apes; if anything, it suggests that they are rather limited.

Kanzi

The major challenge to the critical point of view comes from more recent studies involving pygmy chimpanzees. Strong claims have been made about the performance of Kanzi (Greenfield & Savage-Rumbaugh, 1990; Savage-Rumbaugh & Lewin, 1994; Savage-Rumbaugh, McDonald, Sevcik, Hopkins, & Rupert, 1986). Whereas earlier studies used the common chimpanzee (*Pan troglodytes*), comparative studies of animals suggest that the bonobo or pygmy chimpanzee (*Pan paniscus*) is more intelligent, has a richer social life, and a more extensive natural communicative repertoire. Kanzi is a pygmy chimpanzee, and many believe he has made a vital step in spontaneously acquiring the understanding that symbols refer to things in the world, behaving like a child. Unlike other apes, Kanzi did not receive formal training by reinforcement with food on production of the correct symbol. He first acquired symbols by observing the training of his mother (called Matata) on the Yerkish system of lexigrams. He then interacted with people in normal daily activities, and was exposed to English. His ability to comprehend English as well as Yerkish was studied and compared with the ability of young children (Savage-Rumbaugh, Murphy, Sevcik, Brakke, Williams, & Rumbaugh, 1993). Kanzi performed as well as or better on a number of measures than a 2-year-old child. By the age of 30 months, Kanzi had learned at least seven symbols (orange, peanut, banana, apple, bedroom, chase, and

Sue Savage-Rumbaugh holds a board displaying some of the lexigrams with which she and Kanzi communicate. From Savage-Rumbaugh and Lewin (1994).

Austin); by the age of 46 months he had learned just under 50 symbols and had produced about 800 combinations of them. He was sensitive to word order, and understood verb meanings—for example, he could distinguish between "get the rock" and "take the rock," and between "put the hat on your ball" and "put the ball on your hat." Spontaneous utterances—rather than those that were prompted or imitations—formed more than 80% of his output.

Both Kanzi's semantic and syntactic abilities have been questioned. Seidenberg and Petitto (1987) argued that Kanzi understands names in a different way from humans. Take Kanzi's use of the word "strawberry." He uses "strawberry" as a name, as a request to travel to where the strawberries grow, as a request to eat strawberries, and so on. Furthermore, Kanzi's acquisition of apparent grammatical skills was much slower than that of humans, and his sentences did not approach the complexity displayed by a 3-year-old child. In reply, Savage-Rumbaugh (1987) and Nelson (1987) argued that the critics underestimated the abilities of the chimpanzees, and overestimated the appropriate linguistic abilities of very young children. Kako (1999a) argued that Kanzi shows no signs of possessing any function words. He does not appear to be able to use morphology: he does not modify his language according to number, as we do when we form plurals. And there is no clear evidence that Kanzi uses recursive grammatical structures.

Kanzi is by far the best case for language-like abilities in apes. Why is Kanzi so successful? Although bonobos might be better linguistic students, another possibility is that he was very young when first exposed to language (Deacon, 1997). Perhaps early exposure to language is as important for apes as it appears to be for humans.

Evaluation of work on teaching apes language

Most people would agree that in these studies researchers have taught some apes something, but what exactly? Clearly apes can learn to associate names with actions and objects, but there is more to language than this. In a recent analysis of a large (3,448) corpus of signs made to humans by five chimpanzees (*Pan troglodytes*) with a long history of sign use, Rivas (2005) found that the chimpanzees used mainly signs for actions and objects. Furthermore, they showed little evidence of either syntactic or semantic structure in their signing, showing instead much repetition and simple concatenation of signs, mostly with the goal of acquiring food or some other object. Rivas concluded that the signing of apes showed many differences from the early language of children.

Let us consider word meaning in more detail. How do we use names—in what way is language different from simple association? Pigeons can be taught to respond differentially to pictures of trees and water (Herrnstein, Loveland, & Cable, 1977), so it is an easy step to imagine that we could condition pigeons to respond in one way (e.g., pecking once) to one printed word, and in another way (e.g., pecking twice) to a different word, and so on. We could go so far as to suggest that these pigeons would be "naming" the words. So in what way is this "naming" behavior different from ours? One obvious difference is that we do more than name words: we also know their meaning. We know that a tree has leaves and roots, that an oak is a tree, that a tree is a plant, and that they need soil to grow in. We know that the word "leaf" goes with the word "tree" more than the word "pyramid." That is, we know how the word "tree" is conceptually related to other words (see Chapter 11 for more detail). We also know what a tree looks like. Consider what might happen if we present the printed word "tree" to a pigeon. By examining its pecking behavior, we might infer that the best a trained pigeon could manage is to indicate that the word "tree" looks more like the word "tee" than the word "horse."

Is the use of signs by chimpanzees more like that of pigeons or of humans? There are two key questions that would clearly have to be answered "yes" before most psycholinguists would agree that these primates are using words like us. First, can apes spontaneously learn that names refer to objects in a way that is constant across contexts? We know that a strawberry is a strawberry whether it's in front of us in a bowl covered in cream and sugar, or in a field attached to a strawberry plant half covered in soil. We do not need different words for each, or restrict our usage to just one context. Second, do these primates have the same understanding of word meaning as we do? Despite the promising work with

Kanzi, there are no unequivocal answers to these questions. For example, Nim could sign "apple" or "banana" correctly if these fruits were presented to him one at a time, but was unable to respond correctly if they were presented together. This suggests that he did not understand the meaning of the signs in the same way that humans do. On the other hand, Sherman and Austin could group lexigrams into the proper superordinate categories even when the objects to which they referred were absent. For example, they could group "apple," "banana," and "strawberry" together as "fruit," although this claim is controversial (Savage-Rumbaugh, 1987; Seidenberg & Petitto, 1987).

In summary, whereas chimpanzees have clearly learned associations between symbols and the world, and between symbols, it is debatable whether they have learned the meaning of the symbols in the way that we know the meanings of words. Nevertheless, they can sometimes learn very effectively, in a manner akin to children (Lyn & Savage-Rumbaugh, 2000). Kanzi and another bonobo chimpanzee (called Panbanisha), also reared in a naturalistic environment, could learn new words naming objects very quickly, with only a few exposures to novel items (at a rate similar to that of language-delayed children). In addition, the chimpanzees could sometimes learn by observation, rather than having to have the object pointed out to them each time its name was presented.

Let us now look at chimps' syntactic abilities. Has it been demonstrated that apes can combine symbols in a rule-governed way to form sentences? In as much as they might appear to do so, it has been proposed that the "sentences" are simply generated by "frames." That is, it is nothing more than a sophisticated version of conditioning, and does not show the creative use of word-ordering rules. It is as though we have now trained our pigeons to respond to whole sentences rather than just individual words. Such pigeons would not be able to recognize that the sentence "The cat chased the dog" is related in meaning to "The dog is chased by the cat," or has the same structure as "A vampire loved a ghost." We have a finite number of grammatical rules and a finite number of words, but combine them to produce an infinite number of sentences (Chomsky, 1957). We have seen that recursion—where phrases can include phrases of the same type—is an essential feature of human language. There is no evidence that apes can use recursion. More recent research reinforces this view. Monkeys can learn very simple grammars, but they cannot learn more sophisticated, human-like grammars that use hierarchical structures where there are long-distance dependencies between words (e.g., the word "if" is usually followed by "then," but any number of words can intervene; we can embed sentences within others, such as in "the cat the rat bit died"). Cotton-top tamarins perform well at a range of language-like tasks. They can, for example, like young children (see Chapter 4), learn which sequences of sounds tend to occur often together (essentially, they can discriminate words from nonwords; see Hauser, Newport, & Aslin, 2001). We can study their abilities to learn grammars by their ability to discriminate instances of strings of sounds that follow a syntactic rule from strings that violate that rule; essentially, we are asking them to make what we call grammaticality judgments. When the monkeys hear a string that violates the rules they tend to look at the loudspeaker; we could say that they "look surprised." The monkeys can be taught simple invented grammars (e.g., that produce a string of sounds corresponding to an ABABAB syllable structure), but are unable to learn more sophisticated artificial grammars that use hierarchical structure (e.g., that produce a string

The cotton-top tamarin performs well on a range of language-like tasks; for example, they can learn which sequences of sounds tend to occur often together.

of sounds corresponding to AAABBB; Fitch & Hauser, 2004). The generation of hierarchical structures such as these depends on the ability to use recursion, and only humans can use recursion.

Hauser et al. (2002) and Fitch et al. (2005) go so far as to claim that recursion is the only uniquely human component of language—yet an immensely powerful one. Pinker and Jackendoff (2005) and Jackendoff and Pinker (2005) take issue with this extreme claim, arguing that there are many more aspects of language, including properties of words and grammar, and the anatomy and control of the vocal tract, that are unique to humans. In addition, the FOXP2 gene (see Chapters 1 and 4) is unique to humans and is involved in the control of speech and language, but does not seem to involve recursion. And furthermore, the Piraha language of the Amazon does not seem to use any recursion, yet is clearly a human language (Everett, 2005).

In summary, some higher animals can learn the names of objects and simple syntactic rules. However, they do not develop sophisticated representations of meaning as do humans, and they cannot learn complex, more human-like grammars.

There is disagreement on how well apes come out of a comparison of chimps and children. One problem is that it is unclear with which age group of children the chimpanzees should be compared. When there is more work on linguistic apes bringing up their own offspring, the picture should be clearer. However, this research is difficult to carry out, expensive, and difficult to obtain funding for, so we might have to wait some time for these answers.

At present we can conclude that chimps can learn some symbols and some ways of combining them, but they cannot acquire a human-like syntax. At best, they have acquired a protolanguage.

Why is the issue so important?

As we saw earlier, there is more to the issue of a possible animal language than simple intellectual interest. First, the debate has led to a deeper insight into the nature of language and what is important about it. We can see what makes human language so very different from vervets "chattering" when they see a snake. Second, it is worth noting that although the cognitive abilities of young children and chimpanzees are not very different, their linguistic abilities are. This suggests that language processes are to some degree independent of other cognitive processes. Third, following on from this, Chomsky claimed that human language is a special faculty, which is independent of other cognitive processes, has a specific biological basis, and has evolved only in humans (e.g., Chomsky, 1968). Language arose because the brain passed a threshold in size, and only human children can learn language because only they have the special innate equipment necessary to do so. This hypothesis is summed up by the phrase "language is species-specific and has an innate basis." (Although as Kako, 1999a, observes, a better statement might be, "some components of language are species-specific.") In particular, Chomsky argued that only humans possess a language acquisition device (LAD) that enables us to acquire language; without this device we would be stuck forever at the level of a protolanguage (see Chapter 1). In particular, the ability to use recursive syntactic rules, which is what gives human language its full power, is unique to humans (Hauser et al., 2002). Even Premack (1985, 1986a, 1990) has become far less committed to the claim that apes can learn language just like human children. Indeed, he also has come to the conclusion that there is a major discontinuity between the linguistic and cognitive abilities of children and chimpanzees, with children possessing innate, "hard-wired" abilities that other animals lack. At the very least we can say that whereas children acquire language, apes have to be taught it.

THE BIOLOGICAL BASIS OF LANGUAGE

What are the biological precursors of language? How is language development related to the development of brain functions? How do biological processes interact with social factors?

Are language functions localized?

The brain is not a homogeneous mass; parts of it are specialized for specific tasks. How do we know this? In the past most of our knowledge