Language Learning in Non-human Primates

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Language learning in non-human primates has been studied with vocal, gestural, and visual symbol systems, in addition to assessments of speech comprehension. Early researchers focused on teaching apes to produce language but noted that comprehension exceeded production. Later research demonstrated the importance of receptive language for productive development. Techniques used to teach apes language vary along a continuum from operant conditioning to enculturation. Apes raised in language-enriched environments (enculturation) learn language more quickly, use it more flexibly and exhibit greater speech comprehension than apes trained with conditioning. While the rate of language learning remains much slower for apes than humans, vocabularies reported across studies of enculturated apes may underestimate competence due to reliance on caregiver diaries and testing. Apes raised in language-enriched environments learn many skills previously believed to be uniquely human: complex associations between symbols and referents, declarative language, pragmatic skills, and aspects of syntax. However, their communication is primarily imperative and they do not recombine units into an unlimited variety of larger structures or use complex mental state terms. Controversy about whether apes can learn language centers around ambiguity concerning what constitutes language.

Although language is often considered uniquely human, many characteristics of language are apparent in animal communication. Non-human primates use and respond to calls referring to specific aspects of the environment and use sequences of calls to convey more information than the calls of which they are composed. However, these calls may lack the referential fluidity of language. Non-human primates also read intentions and segment the speech stream into words. While apes can imitate human sounds, they rarely do so. In general, non-human primates use gestures more flexibly than sounds.

Language learning occurs at the intersection of phylogeny, ontogeny, and culture. By making ontogeny more similar through enculturation, researchers have identified linguistic skills likely to have been present in the common ancestor of humans and other apes, as well as skills that may be unique to humans. Traits observed across related species are likely homologous (present in the last common ancestor). The ancestors of humans likely diverged from *Pan* (chimpanzees and bonobos) 7 to 13 million years ago. Bonobos and chimpanzees diverged 1.5 to 2.6 million years ago. Gorillas diverged from humans and *Pan* 8 to19 million years ago. Orangutans diverged from the other apes 15 to 19 million years ago. Despite the millions of years that apes and humans have been subject to potentially different evolutionary pressures, all great apes exhibit population level brain lateralization in regions important for language learning. While the human brain is proportionally larger than that of the other apes, postnatal brain development is prolonged across apes. This early flexibility allows experience with conspecifics to shape brain development. A sensitive period for language acquisition is present among all apes.

Teaching Apes to Vocalize

In perhaps the first attempt to teach language to apes (1890s), Richard Gardner tried to teach apes in Africa, including a juvenile chimpanzee, Moses, who learned to say “feu” but died. In 1909, Lightner Witmer taught a circus chimpanzee, Peter, to say “mama”. Witmer and his friend Furness attempted to teach two orangutans and two chimpanzees to speak. After 5 years of attempting to form a chimpanzee’s mouth into words with his fingers and a spoon, she learned to say “mama”. A baby orangutan learned “cup” and clung to him when she said “papa” but died. Furness stated that her comprehension far exceeded her production. This distinction between expressive and receptive language would remain consistent throughout ape language research.

Beginning in 1913, Nadezhda Kohts raised a male chimpanzee, Joni, from 1.5 to 4 years of age in her home. When comparing the development of her son and Joni, she emphasized species differences in cognition but attributed Joni's failure to learn language to lack of language instruction.

In 1933, Luella and Winthrop Kellog reared a 7.5-month-old female chimpanzee, Gua, with their 9.5-month-old son, Donald, for 9 months. Attempts to teach speech with lip manipulation were ineffective for both species. Donald's comprehension soon exceeded Gua's, although Gua learned to understand over 100 words.

In 1951, Keith and Catherine Hayes adopted a female chimpanzee, Viki, from 3 days old till death at 7 years. They attempted to mold speech by manipulating her lips. She learned to say: "mama", "papa", "cup" and "up". The Hayes emphasized that Viki understood more than she could produce but that it was impossible to provide a measure of her comprehension because it often appeared dependent on context.

In 1978, Keith Laidler used conditioning to teach a two-year-old orangutan, Cody, to vocalize. After 9 months, the ape could produce four sounds: "kuh", "puh", "fuh" and "tbuh". These sounds were used appropriately in different contexts: "kuh" was used in response to drinks while "puh" was used for comfort.

Teaching Apes to Gesture

In 1967, Allen and Beatrix Gardner adopted a wild captured female chimpanzee, Washoe, who was 8 to 14 months old. They thought that difficulties teaching apes to speak might be attributable to physiological rather than cognitive limitations. Unlike the human larynx, the ape larynx cannot close completely. This prevents apes from making many of the consonant sounds important for speech production.

Washoe's caregivers treated her as if she were intrinsically motivated to communicate and used a simple and repetitive form of American Sign Language (ASL) to sign about daily activities. Spoken speech was limited to focus her attention on ASL. They taught signs using shaping, molding, signing on her body, and (less commonly) modeling. In order for a sign to be considered learned, it had to be observed by 3 observers and then used appropriately on 15 consecutive days. Most subsequent studies modeled measures of productive vocabulary after the Gardners. As Washoe's vocabulary increased (150 signs by 8 years), novel word combinations emerged. Although the combinations had meaning, she typically added a limited number of words, like "more", to nouns. The Gardners stressed that Washoe's comprehension exceeded her production and that conditioning also plays a role in human language development.

The Gardners extended their cross-fostering approach with 4 infant chimpanzees (Moja, Pili, Tatu, and Dar). Their students, Roger and Deborah Fouts, introduced Washoe into a colony of 18 chimpanzees who were encouraged to sign together. Loulis, a male chimpanzee whom Washoe adopted at 10 months, learned 47 signs and combined them, with very limited human sign input. Washoe used techniques used to teach her—molding, modeling, and signing on his body—to teach Loulis. This contrasts with reports from the wild that juvenile apes learn by observing adults who do not directly teach them.

In 1972, Francine Patterson adapted the Gardners' approach (although speech and signs were used simultaneously) to teach a one-year-old female lowland gorilla, Koko. Patterson reported that Koko acquired 250 signs, combined them into meaningful novel statements, showed word order preferences, understood more than she could express, and used language for humor. Another gorilla, Michael, acquired a vocabulary of around 110 words.

In 1973, Herb Terrace began to teach signs to a week-old male chimpanzee, Nim Chimpsky, who lived with a human family until 18 months of age and then with students who trained him in ASL. He was asked to imitate signs and explicitly rewarded for correct sign use. He learned 125 signs. Nim combined sequences of signs but often imitated and interrupted his caregivers. When assessed later in a more naturalistic setting, Nim interrupted and imitated less.

In 1978, Lyn Miles adopted a 9-month-old orangutan, Chantek. Caregivers communicated with him using a pidgin form of ASL. For several years, he was not exposed to speech. Later, signs were delivered with telegraphic speech. Communicative rules were introduced through games while he was taught signs through molding and modeling. He acquired 150 signs and invented signs of his own. As his vocabulary increased, he began to create combinations, to refer to non-present referents, and to deceive. The majority of his signs were for actions and objects rather than edibles.

In a study conducted in a nature reserve (1978), Gary Shapiro trained an adult female orangutan, Rinnie. A referent was presented in conjunction with a prompt, attempts to sign were molded into the

appropriate form, and reinforcement was provided. Most of her vocabulary referred to edibles. She acquired 32 signs. Four juvenile (3-4.5 years old) orangutans (Pola, Princess, Rantai, & Hampas) acquired 4.25 signs on average following 15 months of intensive molding and reinforcing of 10 signs. Princess eventually learned 37 signs although she rarely combined them.

Teaching Apes Visual Symbols with Conditioning

In 1966, Ann and David Premack used conditioning to teach a 5-year-old chimpanzee, Sarah, to "read and write" by attaching plastic symbols representing words that varied in color, shape and size to a metal board. They began training by teaching her to attach a symbol of a fruit to the board in order to receive fruit. Then she had to place the symbols in a specific order in response to questions. She developed a vocabulary of approximately 130 terms. The Premacks claimed that her ability to follow commands and build sequences indicated an understanding of sentence structure. They also trained additional chimpanzees: Elizabeth, Peony, and Walnut. All required hundreds of trials to associate a symbol with its referent. In 1973, Shapiro adapted these methods to teach associations between plastic letters and referents to a juvenile female orangutan at the zoo, Aazk.

In 1971, Duane Rumbaugh used conditioning to teach a 40-year-old female chimpanzee, Lana, a computer-controlled "language" called Yerkish. She was trained to touch a sequence of keyboard lexigrams (arbitrary geometric patterns representing words) to access reinforcers. The keyboard held 50 to 75 lexigrams. The background color of each lexigram indicated its word class. Unlike Washoe, Lana was trained to string symbols together in order to get reinforcers. Thus, the majority of her utterances had a sentence-like structure. She also began to form sequences that were not taught.

In 1977, Rumbaugh's approach was adopted in Japan with a 1-year-old female chimpanzee, Ai. Researchers used matching-to-sample tasks to teach a computer-based keyboard. Their work focused primarily on cognitive and perceptual skills rather than language. Ai was reinforced for successive approximations of key touch behavior alone in a testing booth.

Aping Language

In the 1970s, controversy erupted about whether these apes had been learning language or something simpler. Behaviors that had been described in linguistic terms could be reduced to behavioral principles; Terrace contested Rumbaugh's claim that Lana's "sentences" reflected an understanding of syntax, asserting that they were simply chained associative responses. Given that other species, such as pigeons, can learn associative chains, Terrace argued that Lana's productions were not language. Terrace placed grammar at the center of his definition of language because it is key to generating an indeterminate number of sentences from a finite number of words.

In 1979, Terrace published a paper describing his attempt to replicate the Gardners' work with Nim. Nim produced varied sign combinations that appeared to follow word order rules similar to patterns apparent in human sentences. However, a comparison of training videos of Nim to previous research on human children revealed that many more of Nim's combinations were imitations of his caregivers' input than was the case for human children. Analyzing films of Washoe and Koko, Terrace found similar evidence of imitation. Emphasizing that apes used language imperatively, he concluded that ape language was pragmatically, semantically and syntactically restricted. Terrace highlighted the importance of a record of ape communications and surrounding discourse.

Response to Controversy

This critique cast a shadow over ape language research. Miles responded by comparing Chantek's two-way sign exchanges to those of Nim when both were 26 months old. Chantek exhibited fewer imitations (3% to 38%) than Nim. The Gardners had no record of utterances directed at the apes, and so could not refute Terrace's claims. Fouts (1989) responded to critiques by studying signing between chimps, including signs Loulis acquired from other chimps.

Shortly before these controversies emerged, Sue Savage-Rumbaugh and colleagues began a study examining relationships between language-trained apes. Two co-reared male chimpanzees, Sherman and Austin, were trained to use the same system as Lana but to use single words from 2.5 and 1.5 years old

respectively. Importantly, the keyboard kept a record of their imitations, which were in the range of human children.

Enculturation of a New Species: Bonobo

The next major advance in ape language research involved a new species. Bonobos had not previously been involved in ape language research because they are rare in the wild. Bonobos use multimodal communication more in the wild than chimpanzees. In 1984, Savage-Rumbaugh and colleagues began efforts to teach a wild caught adult female bonobo, Matata, to use lexigrams. Her adopted son, Kanzi, watched attempts to teach his mother. No attempts were made to teach him. Although attempts to teach Matata were largely unsuccessful, when she was removed for 4 months for breeding, at the time Kanzi was 2.5 years old, it became evident that he had learned lexigrams. Researchers decided to use symbols interactively with him rather than training him. Kanzi was not required to use symbols to acquire things but was encouraged to communicate with caregivers indoors and while foraging through 55 acres of forest. Indoors, a lexigram board with approximately 256 symbols was attached to a speech synthesizer. Outdoors, caregivers spoke words associated with lexigrams. By 5 years of age, Kanzi produced combinations that revealed the ability to invent and learn a rudimentary grammar (word ordering preferences) and to use imitation pragmatically.

Savage-Rumbaugh and colleagues compared the language comprehension of a 2.5-year-old human child, Alia, to Kanzi at age 8. Alia was exposed to lexigrams from 3 months of age. Like Kanzi, she was not trained to use them. An examiner behind a one-way mirror asked Alia or Kanzi to respond to novel sentences varying in syntactic complexity. Correct responses were not rewarded. Kanzi was correct following 74% of the sentences while Alia was correct following 65% of them. Many responses were creative. Both Alia and Kanzi demonstrated the ability to respond to words flexibly depending on the sentential context in which the words appeared.

In order to determine if differences between Sherman and Austin and Kanzi reflected species or rearing differences, a bonobo, Panbanisha, and a chimpanzee, Panpanzee, were raised together from soon after birth. Instead of focusing on production, Savage-Rumbaugh and colleagues focused on observational learning and comprehension. Across 4 years, virtually all evidence of symbol production and comprehension was recorded and entered into a database.

By 3 years of age, Panbanisha demonstrated comprehension of 179 words while Panpanzee demonstrated understanding of 79 words. Panpanzee learned symbols later than Panbanisha, relied more on requests, and had more difficulty responding to complex utterances. Their comprehension and use of lexigrams across contexts suggests that they were not simply associative stimuli. Thus, differences between chimpanzees and bonobos in previous research were likely due to environmental factors rather than species differences.

Savage Rumbaugh and colleagues compared the comprehension of apes exposed to language before 2.5 years of age (Kanzi, Mulika, Panbanisha and Panpanzee) with the comprehension of 5 others (Lana, Sherman, Austin, Matata and Tamuli) who were exposed to language after 2.5 years. None of the later apes acquired symbols without extensive training and none demonstrated comprehension of more than a few spoken words by 9 years. All of the apes exposed to language earlier understood at least 40 words by 2.5 years.

Insights for language evolution

Given language-enrichment, speech comprehension emerges across all species of great apes. Thus, the potential for speech comprehension was likely present millions of years before productive speech emerged. Gestures may have provided the means for our ancestors to develop speech. There are a number of lines of evidence for a role of gesture in the evolution of language: gestures used by apes vary more with context than their vocalizations do, the human vocal apparatus emerged relatively late in evolution, and both language and communicative gestures are associated with similar patterns of lateralized brain activity. When the gestures of a human toddler were compared to gestures produced by a language-enculturated bonobo and chimpanzee during the second year of life, striking similarities in the forms and functions of gestures were observed. The majority of the gestures produced by all three species were communicative. While the same types of gestures were observed across species, the child exhibited more evidence of using gestures to share experience with others (by showing objects to caregivers or pointing) than the apes did.

Supporting a role of gesture in the evolution of language, gestures preceded symbol use for all three species.

A key issue at the heart of determining the relationship between ape and human language is how language is defined. Researchers generally agree that it is best defined in terms of overlapping systems such as phonology, syntax, semantics and pragmatics or mechanisms such as sequential learning, reading of social cues, memory and recursion. Marc Hauser, Noam Chomsky and Tecumseh Fitch distinguish between the Faculty of Language Broad (FLB) and the Faculty of Language Narrow (FLN). They hypothesize that FLN, which is specific to humans and to language, could be recursion but emphasize that what FLN is remains an empirical question. They claim that FLB allows humans, but not chimpanzees, to master language without explicit instruction. However, ape language research suggests that apes learn language better when it is embedded in more implicit social routines than when it is taught explicitly using operant conditioning. Additionally, the potential to understand elements of syntax is present in apes. Like human children, apes raised in language-enriched environments exhibit word order preferences, categorize symbols semantically, and use language pragmatically. The role of reinforcement in language learning remains underspecified for both apes and humans. Thus, differences between humans and apes in language potential may be more a matter of degree than of kind.

See Also: Critical period in language development; Evolutionary perspectives on language development; Gestures in communicative development (overview); Imitation (role of) in communicative development; Sign language acquisition; Social foundations of communicative development

Further Readings

Bonvillian, John D., and Francine GP Patterson. "Early sign language acquisition in children and gorillas: vocabulary content and sign iconicity." *First Language,* v.13/39 (1993).

Brakke, Karen E., and E. Sue Savage-Rumbaugh. "The development of language skills in pan: II. Production." *Language & Communication* (1996).

Gardner, R. Allen, and Beatrice T. Gardner. "Teaching sign language to a chimpanzee." *Science*, v.165/3894 (1969).

Gillespie-Lynch, Kristen, et al. "A cross-species study of gesture and its role in symbolic development: Implications for the gestural theory of language evolution." *Frontiers in Psychology*, v. 4 (in press).

Hauser, Marc D., Noam Chomsky, and W. Tecumseh Fitch. "The faculty of language: What is it, who has it, and how did it evolve?" *Science,* v.298/5598 (2002).

Lyn, Heidi. "Apes and the evolution of language: taking stock of 40 years of research." *The Oxford Handbook of Comparative Evolutionary Psychology* (2012).

Parker, Sue Taylor, Robert W. Mitchell, and H. Lyn Miles, eds. *The mentalities of gorillas and orangutans: Comparative perspectives*. Cambridge University Press (1999).

Savage-Rumbaugh, E. Sue, et al. "Language comprehension in ape and child." *Monographs of the society for research in child development* (1993).

Terrace, Herbert S., Laura-Ann Petitto, Richard J. Sanders, and Thomas G. Bever. "Can an ape create a sentence?" *Science*, v.206/4421 (1979).