



Listen up! Both primates and birds have something to say about human language origins.

## EVOLUTION OF LANGUAGE

# Animal Communication Helps Reveal Roots of Language

An interdisciplinary gathering marks a turning point for a field historically richer in talk than data, but which now is increasingly embracing studies of animals

**UTRECHT, NETHERLANDS**—Animals communicate with each other constantly: Birds sing, monkeys chatter, and apes pant-hoot. But what they say is usually pretty simple: They want to mate, send an alert about food or predators, or express their dominance in the group. Only humans appear to have true language, the ability to use abstract symbols—usually words—and combine them in a seemingly infinite variety of meanings about the past, present, and future.

Researchers have pondered the origins of language for at least 200 years, and for much of that time, their conjectures were little more than talk. Unlike many other human behaviors, such as art and toolmaking, language leaves no traces in the archaeological record. And many researchers have been doubtful about how much animal communication could reveal about the unique features of human communication. That began to change in the 1990s, when linguists, evolutionary biologists, psychologists, primatologists, and other scientists teamed up to test new hypotheses about how language arose (*Science*, 27 February 2004, p. 1316). Since 1996, this interdisciplinary crowd has gathered every 2 years at Evolang, a meeting devoted to deciphering the evolutionary origins of language.

Although some say the early Evolang gatherings suffered from too many hypotheses and

too little testing, many think the meeting\* here last month marks a turning point for the field. Participants flocked to hear a barrage of new data from animal and human studies. “The field has matured, and there is a trend towards more empirical work,” says evolutionary biologist W. Tecumseh Fitch of the University of Vienna in Austria.

One reason is that fewer scientists now follow the early views of linguist Noam Chomsky that language emerged *de novo* in humans, with little or no ape precursors. Indeed, Chomsky himself no longer holds strictly to that view, as evidenced by a seminal 2002 paper in *Science* he co-authored with Fitch and Harvard University psychologist Marc Hauser (*Science*, 22 November 2002, p. 1569), urging research into both the aspects of human language unique to humans and the aspects shared with other animals. “The more we study animals, the more we realize that they have abilities similar to ours,” says Natalie Uomini, an archaeologist at the University of Liverpool in the United Kingdom.

The new empiricism may help resolve one of the field’s liveliest debates: whether

the first human language consisted of gestures, similar to today’s sign languages, or articulated speech. And here in Utrecht, a new and unlikely seeming animal model for human language got star billing: songbirds. Their ability to learn and imitate their parents’ melodious tunes has many parallels with the ability of human children to learn spoken language, researchers say.

### Hand, mouth, or both?

Pity poor Viki the chimpanzee. During the 1950s, two psychologists raised Viki in their own home like a human child and tried to teach her to speak. Viki managed a rough approximation of only four words: mama, papa, cup, and (maybe) up. The following decade, researchers had much better luck with a chimp named Washoe when they tried to teach him American Sign Language. But few scientists think Washoe’s impressive efforts represent true language (*Science*, 2 April, p. 38).

Such evidence that apes are poor at vocalizing, but fairly good at gesturing, has bolstered the so-called gestural theory for language origins. According to this model, the first human language

consisted of signing, and articulate speech came later. In recent years, the gestural theory has gained the upper hand in many scientific journals and meetings. “Apes are much better at controlling their hands” than at vocalizing, says Fitch. “Their gestures are more intentional and more under control.”

Many researchers have assumed that most primate vocalizations are innate or instinctual rather than learned, and so are uninformative about the origins of human language. For example, the vervet monkey

## Online

sciencemag.org

Podcast interview with author Michael Balter.

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gives out specific, stereotypical alarm calls corresponding to predators such as leopards, snakes, and eagles. These calls, which are innate, are a stark contrast to the way humans combine words in novel ways.

But psychologist Katie Slocombe of the University of York in the U.K. argues that the data don't support generalizing about all primate calls based on a few examples. In a poster, she and other European colleagues critiqued more than 550 studies of primate communication and found that few studies examined ape vocalization. "Absence of evidence may not reflect absence of [vocal] ability," Slocombe's team concluded.

In other posters and talks, Slocombe and others documented that chimps in the wild do vary their vocalizations in response to circumstances, a step toward language. Slocombe and psychologist Klaus Zuberbühler of the University of St. Andrews in the U.K. showed that chimps modify screams they emit when under attack depending on the severity of the aggression and their social status compared with nearby chimps. Also, wild chimps emit so-called rough grunts—vocalizations associated with the finding of food—more often when chimp allies are present and the food is of high quality.

Such findings got dramatic support from a talk on a more distantly related species, the Campbell's monkeys of the Côte d'Ivoire. Primatologist Alban Lemasson of the University of Rennes 1 in France, Zuberbühler, and their colleagues found that the males of these forest-dwelling monkeys have six different types of calls, which the researchers refer to as Boom, Krak, Hok, Hok-oo, Krak-oo, and Wak-oo. Yet these sounds are rarely used in isolation. Rather, they are combined in vocal sequences averaging 25 successive calls depending on whether the monkeys were encountering predators such as eagles or leopards, falling trees, the presence of neighboring

groups, and so forth. Moreover, the animals carried on complex "conversations" in which the call sequences were constantly being modified or altered (see *ScienceNOW*, <http://news.sciencemag.org/sciencenow/2009/12/04-02.html>).

This complexity is "significantly beyond" what researchers have assumed for nonhuman primates, Lemasson told the meeting, and is "at odds with the gestural origins of language theory." Uomini calls these studies "brilliant



**Do I make myself clear?** Orangutan gestures are intentional and meaningful.

work" and says the call combinations could be considered a form of "proto-language" and "proto-speech." And Erica Cartmill, a psychologist at the University of Chicago in Illinois, agrees that the Campbell's monkeys do seem to have "the ability to combine calls in different ways." But she cautions that the calls fall far short of the kind of syntactical structures typical of human languages, which have specific rules for how words can be put together into sentences.

As the vocalization camp made gains, the gesturalists had advances of their own to put forth. Numerous recent studies have underscored the importance of gestures in both human and ape communication. In most humans, brain regions specialized for language, such as Broca's area, are located in the

left hemisphere, which in right-handers also controls the movements of the right side of the body (see *Science's* Origins blog, <http://tinyurl.com/n8wroy>). Researchers are debating whether nonhuman apes also show asymmetries in homologous brain areas, and if these are the precursors of the lateralized language centers of the human brain.

Recent work by cognitive scientists Jacques Vauclair and Adrien Meguerditchian of the University of Provence in Aix-en-Provence concludes that such brain asymmetries in apes might indeed be linked to gesturing. The researchers found that baboons have a strong right-hand preference during communicative gestures such as begging for food but little hand preference during noncommunicative gestures such as wiping their faces. Captive chimpanzees show similar preferences, according to work reported by the team in *Cortex* this year.

And Vauclair has recently extended such studies to human children. Infants and toddlers tend to use their right hand for pointing—a communicative gesture that appears at about 11 months of age and closely accompanies early spoken language—even if they are ambidextrous or left-handed in other situations, Vauclair's group reported in *Developmental Science* last year. This suggests that human gesture and speech are linked and that both are at least partly localized in the brain's language areas, they concluded.

In Utrecht, Vauclair's Provence colleague Hélène Cochet presented further studies along these lines. She observed the pointing behavior of 48 toddlers in French day care centers. Earlier research has established two types of pointing behavior in young children: imperative pointing, which is used to ask for something the child wants; and declarative pointing, which is used to share interest or information. Researchers consider declarative pointing to reflect more complex cognitive processes, such as understanding that other people are independent agents with their own thoughts. On the other hand, most gesturing by nonhuman apes is only imperative, such as begging for food.

Cochet found that declarative pointing was more often accompanied by spoken utterances than was imperative pointing. And although children used their right hands more often for both imperative and declarative pointing than for noncommunicative gestures such as reaching for an object, the right-handed trend was even stronger when children were declaratively pointing to provide information to an adult. "Our results suggest that such cooperative gestures may have played an important role in the evolution of language,"



**Getting the point.** Both apes and humans may use language-related centers in the left brain when pointing with their right hands.

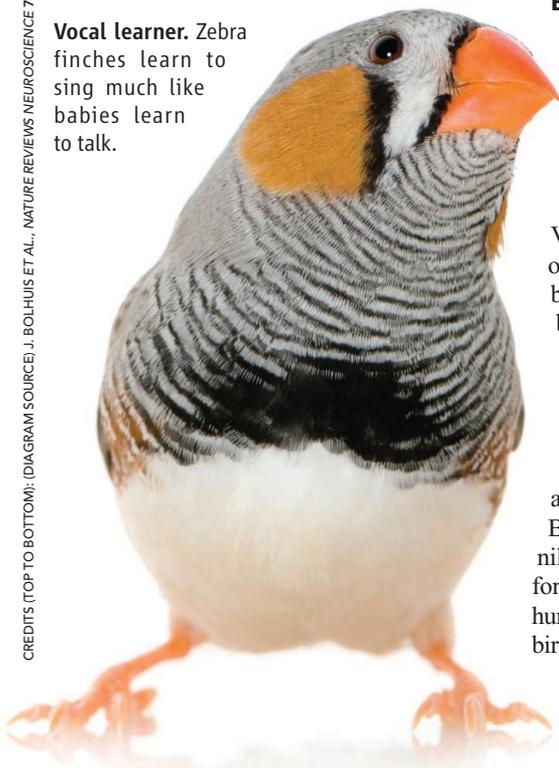


Cochet told the meeting.

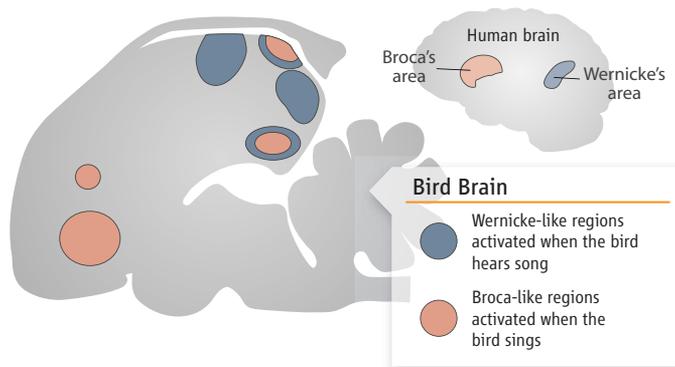
To explore whether ape gestures have specific meanings, Cartmill videotaped 28 orangutans at three European zoos, accumulating more than 100 hours of recordings. She identified 37 gesture types that could be reliably assigned to one of six different meanings, such as “play with me,” “share your food,” and “go away.” Thus the apes are conveying meaning to each other with their gestures, Cartmill concluded. “Intentional, meaningful, and socially sensitive communication emerged long before” the kind of symbolic communication typical of human language, she says.

But was that early human communication primarily gestural or vocal? Each camp continues to make its case, but some researchers at the meeting urged that the field acknowledge the importance of both. “Both modalities provide potential [primate] precursors for different elements of language,” says Slocombe, “but neither of them alone can provide the complete picture.” Thus primate vocalizations are discrete signals that can be combined in sequences—as in the Campbell’s monkey—although primate gestures have the advantage of being flexible and highly intentional, Slocombe says. In his talk, Meguerditchian proposed that as early human language evolved, gestures

**Vocal learner.** Zebra finches learn to sing much like babies learn to talk.



## CONVERGENT EVOLUTION OF VOCAL LEARNING



**Singing centers.** Birds may help reveal how humans learn to speak, because both species have areas of the brain specialized for vocal learning.

might initially have been more effective for “talking,” although vocalizations might have been better suited for listening. Primate gestures appear more localized to brain areas homologous to Broca’s area—implicated in speech production—whereas primate vocalizations have been more closely linked to brain areas homologous to Wernicke’s area, which is involved in the understanding and perception of speech, he pointed out.

“Gesture ... might have helped get speech off the ground over evolutionary time,” suggests psychologist Susan Goldin-Meadow of the University of Chicago. “The gesture-speech relationship we see today, where [they] work synergistically to form an integrated system, might have been there from the start.”

### Birds move to center perch

Language evolution researchers have concentrated on apes and other primates because they are our closest relatives. But those animals can’t match a key feature of human language: vocal learning, the amazing ability of young children to imitate the sounds of adults. Vocal learning does turn up in a handful of other species, including whales and possibly bats, but the masters of this talent are songbirds, parrots, and hummingbirds (*Science*, 31 January 2003, p. 646).

In his talk leading off a songbird workshop, biologist Johan Bolhuis of Utrecht University listed the numerous parallels between the way songbirds learn to sing and the way human infants learn to speak. Both must be exposed to adult “tutors”; juveniles of both species have a sensitive period for vocal learning; and both young birds and human infants “babble” (called “subsinging” in birds) while learning to vocalize.

Over the past few years, Bolhuis and other researchers have traced vocal learning and song production to bird

brain areas that appear analogous to human language areas such as Wernicke’s and Broca’s areas (see diagram). These similarities are not likely to be the result of shared evolutionary history, because the lineages leading to birds and humans diverged roughly 300 million years ago. But they may prove instructive all the same, Fitch says. “To do vocal learning, you need to ... hear something and then pipe it over from the [brain’s] auditory cortex to the motor cortex,” which controls speech production, Fitch argues. “There are probably not that many

different ways of getting those connections.”

Thus, Fitch says, the bird model might be able to tell us “how to build a brain that can do vocal learning.” Researchers are beginning to find some of the molecular details of how that happens. At the Evolang meeting, Kazuo Okanoya, a biolinguist at the RIKEN Brain Science Institute in Wako City, Japan, reported that genes coding for molecules called cadherins—involved in nerve cell connections in humans and other mammals—are expressed at high levels when Bengalese finches listen to adult songs and down-regulated when they start to sing themselves.

Evidence for parallels between bird song and human language continues to accumulate. Some researchers have argued that only humans are able to distinguish words that closely resemble each other. But Verena Ohms of the Institute of Biology Leiden in the Netherlands taught zebra finches to distinguish two very similar-sounding Dutch words, pecking a button after hearing the correct word of either *wit* (white) or *wet* (law), even when the words were spoken by a variety of human voices, both male and female.

Fitch says that these parallels suggest that language evolution researchers can learn a lot about human speech by studying our distantly related feathered friends. He points to recent work by animal behaviorist Constance Scharff of the Free University of Berlin and her co-workers, showing that *FOXP2*, a gene implicated in human speech, also plays an important role in bird-song learning. Fitch says that such molecules might have been recruited by natural selection to perform similar functions even in species that went their evolutionary ways long ago. Thus, despite their distance from humans, birds are now perched firmly on the Evolang agenda. Indeed, the next meeting, in Kyoto, Japan, in 2012, will be organized by bird-brain expert Okanoya and his colleagues.

—MICHAEL BALTER