The Gift *of* Gab

Grooves and holes in fossil skulls may reveal when our ancestors began to speak. The big question, though, is what drove them to it?

Matt Cartmill

People can talk. Other animals can't. They can all communicate in one way or another—to lure mates, at the very least—but their whinnies and wiggles don't do the jobs that language does. The birds and beasts can use their signals to attract, threaten, or alert each other, but they can't ask questions, strike bargains, tell stories, or lay out a plan of action.

Those skills make *Homo sapiens* a uniquely successful, powerful, and dangerous mammal. Other creatures' signals carry only a few limited kinds of information about what's happening at the moment, but language lets us tell each other in limitless detail about what used to be or will be or might be. Language lets us get vast numbers of big, smart fellow primates all working together on a single task—building the Great Wall of China or fighting World War II or flying to the moon. It lets us construct and communicate the gorgeous fantasies of literature and the profound fables of myth. It lets us cheat death by pouring out our knowledge, dreams, and memories into younger people's minds. And it does powerful things for us inside our own minds because we do a lot of our thinking by talking silently to ourselves. Without language, we would be only a sort of upright chimpanzee with funny feet and clever hands. With it, we are the self-possessed masters of the planet.

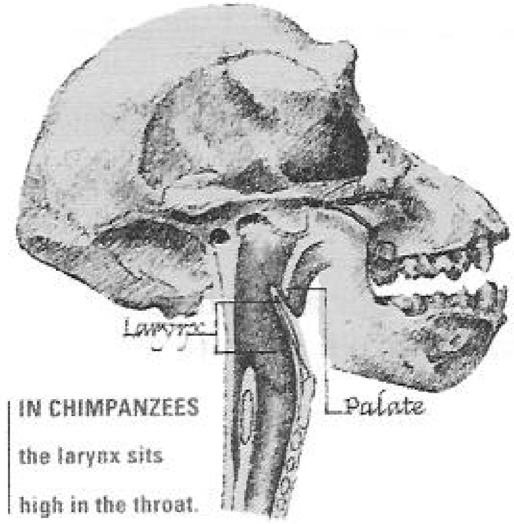
How did such a marvelous adaptation get started? And if it's so marvelous, why hasn't any other species come up with anything similar? These may be the most important questions we face in studying human evolution. They are also the least understood. But in the past few years, linguists and anthropologists have been making some breakthroughs, and we are now beginning to have a glimmering of some answers.

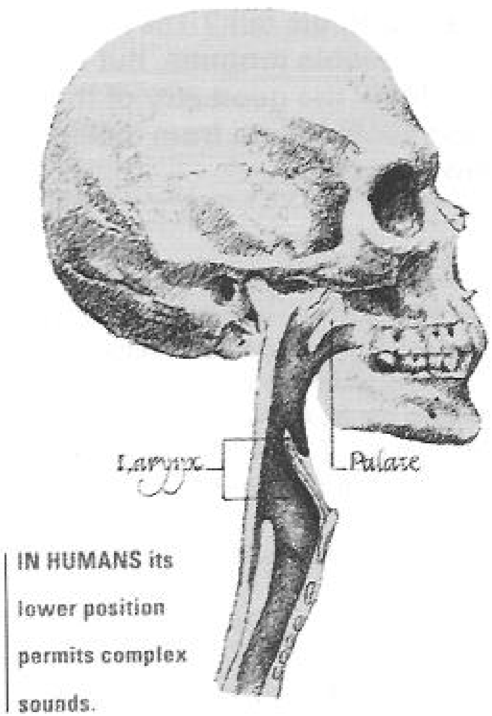
Could Neanderthals talk? They seem to have had nimble tongues, but some scientists think the geometry of their throats prevented them from making many clear vowel sounds.

We can reasonably assume that by at least 30,000 years ago people were talking—at any rate, they were producing carvings, rock paintings, and jewelry, as well as ceremonial graves containing various goods. These tokens of art and religion are high-level forms of symbolic behavior, and they imply that the everyday symbol-handling machinery of human language must have been in place then as well.

Language surely goes back further than that, but archeologists don't agree on just how far. Some think that earlier, more basic human behaviors—hunting in groups, tending fires, making tools—also demanded language. Others think these activities are possible without speech. Chimpanzees, after all, hunt communally, and with human guidance they can learn to tend fires and chip flint.

Paleontologists have pored over the fossil bones of our ancient relatives in search of evidence for speech abilities. Because the most crucial organ for language is the brain, they have looked for signs in the impressions left by the brain on the inner surfaces of fossil skulls, particularly impressions made by parts of the brain called speech areas because damage to them can impair a person's ability to talk or understand language. Unfortunately, it turns out that you can't tell whether a fossil hominid was able to talk simply by looking at brain impressions on the inside of its skull. For one thing, the fit between the brain and the





Illustrations by Dugald Stermer

bony braincase is loose in people and other large mammals, and so the impressions we derive from fossil skulls are disappointingly fuzzy. Moreover, we now know that language functions are not tightly localized but spread across many parts of the brain.

Faced with these obstacles, researchers have turned from the brain to other organs used in speech, such as the throat and tongue. Some have measured the fossil skulls and jaws of early hominids, tried to reconstruct the shape of their vocal tracts, and then applied the laws of acoustics to them to see whether they might have been capable of producing human speech.

All mammals produce their vocal noises by contracting muscles that compress the rib cage. The air in the lungs is driven out through the windpipe to the larynx, where it flows between the vocal cords. More like flaps than cords, these structures vibrate in the breeze, producing a buzzing sound that becomes the voice. The human difference lies in what happens to the air after it gets past the vocal cords.

In people, the larynx lies well below the back of the tongue, and most of the air goes out through the mouth when we talk. We make only a few sounds by exhaling through the nose—for instance, nasal consonants like *m* or *n*, or the so-called nasal vowels in words like the French *bon* and *vin*. But in most mammals, including apes, the larynx sticks farther up behind the tongue, into the back of the nose, and most of the exhaled air passes out through the nostrils. Nonhuman mammals make mostly nasal sounds as a result.

At some point in human evolution the larynx must have descended from its previous heights, and this change had some serious drawbacks. It put the opening of the windpipe squarely in the path of descending food, making it dangerously easy for us to choke to death if a chunk of meat goes down the wrong way—something that rarely happens to a dog or a cat. Why has evolution exposed us to this danger?

Some scientists think that the benefits outweighed the risks, because lowering the larynx improved the quality of our vowels and made speech easier to understand. The differences between vowels are produced mainly by changing the size and shape of the airway between the tongue and the roof of the mouth. When the front of the tongue almost touches the palate, you get the *ee* sound in *beet;* when the tongue is humped up high in the back (and the lips are rounded), you get the *oo* sound in *boot,* and so on. We are actually born with a somewhat apelike throat, including a flat tongue and a larynx lying high up in the neck, and this arrangement makes a child's vowels sound less clearly separated from each other than an adult's.

Philip Lieberman of Brown University thinks that an ape-like throat persisted for some time in our hominid ancestors. His studies of fossil jaws and skulls persuade him that a more modern throat didn't evolve until some 500,000 years ago, and that some evolutionary lines in the genus *Homo* never did acquire modern vocal organs. Lieberman concludes that the Neanderthals, who lived in Europe until perhaps 25,000 years ago, belonged to a dead-end lineage that never developed our range of vowels, and that their speech—if they had any at all—would have been harder to understand than ours. Apparently, being easily understood wasn't terribly important to them—not important enough, at any rate, to outweigh the risk of inhaling a chunk of steak into a lowered larynx. This suggests that vocal communication wasn't as central to their lives as it is to ours.

Many paleoanthropologists, especially those who like to see Neanderthals as a separate species, accept this story. Others have their doubts. But the study of other parts of the skeleton in fossil hominids supports some of Lieberman's conclusions. During the 1980s a nearly complete skeleton of a young *Homo* male was recovered from 1.5-million-year-old deposits in northern Kenya. Examining the vertebrae attached to the boy's rib cage, the English anatomist Ann MacLarnon discovered that his spinal cord was proportionately thinner in this region than it is in people today. Since that part of the cord controls most of the muscles that drive air in and out of the lungs, MacLarnon concluded that the youth may not have had the kind of precise neural control over breathing movements that is needed for speech.

This year my colleague Richard Kay, his student Michelle Balow, and I were able to offer some insights from yet another part of the hominid body. The tongue's movements are controlled almost solely by a nerve called the hypoglossal. In its course from the brain to the tongue, this nerve passes through a hole in the skull, and Kay, Balow, and I found that this bony canal is relatively big in modern humans—about twice as big in cross section as that of a like-size chimpanzee. Our larger canal presumably reflects a bigger hypoglossal nerve, giving us the precise control over tongue movements that we need for speech.

We also measured this hole in the skulls of a number of fossil hominids. Australopithecines have small canals like those of apes, suggesting that they couldn't talk. But later *Homo* skulls, beginning with a 400,000-year-old skull from Zambia, all have big, humanlike hypoglossal canals. These are also the skulls that were the first to house brains as big as our own. On these counts our work supports Lieberman's ideas. We disagree only on the matter of Neanderthals. While he claims their throats couldn't have produced human speech, we find that their skulls also had human-size canals for the hypoglossal nerve, suggesting that they could indeed talk.

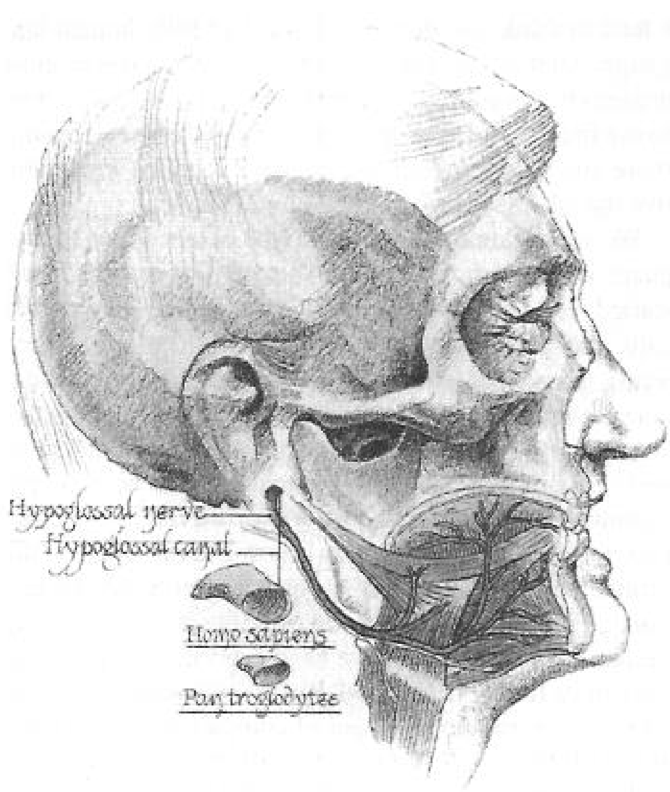
The verdict is still out on the language abilities of Neanderthals. I tend to think they must have had fully human language. After all, they had brains larger than those of most humans.

In short, several lines of evidence suggest that neither the australopithecines nor the early, small-brained species of *Homo* could talk. Only around half a million years ago did the first big-brained *Homo* evolve language. The verdict is still out on the language abilities of Neanderthals. I tend to think that they must have had fully human language. After all, they had brains larger than those of most modern humans, made elegant stone tools, and knew how to use fire. But if Lieberman and his friends are right about those vowels, Neanderthals may have sounded something like the Swedish chef on *The Muppet Show.*

We are beginning to get some idea of when human language originated, but the fossils can't tell us how it got started, or what the intermediate stages between animal calls and human language might have been like. When trying to understand the origin of a trait that doesn't fossilize, it's sometimes useful to look for similar but simpler versions of it in other creatures living today. With luck, you can find a series of forms that suggest how simple primitive makeshifts could have evolved into more complex and elegant versions. This is how Darwin attacked the problem of the evolution of the eye. Earlier biologists had pointed to the human eye as an example of a marvelously perfect organ that must have been specially created all at once in its final form by God. But Darwin pointed out that animal eyes exist in all stages of complexity, from simple skin cells that can detect only the difference between light and darkness, to pits lined with such cells, and so on all the way to the eyes of people and other vertebrates. This series, he argued, shows how the human eye could have evolved from simpler precursors by gradual stages.

Can we look to other animals to find simpler precursors of language? It seems unlikely. Scientists have sought experimental evidence of language in dolphins and chimpanzees, thus far without success. But even if we had no experimental studies, common sense would tell us that the other animals can't have languages like ours. If they had, we would be in big trouble because they would organize against us. They don't. Outside of Gary Larson's *Far Side* cartoons and George Orwell's *Animal Farm,* farmers don't have to watch their backs when they visit the cowshed. There are no conspiracies among cows, or even among dolphins and chimpanzees. Unlike human slaves or prisoners, they never plot rebellions against their oppressors.

Even if language as a whole has no parallels in animal communication, might some of its peculiar properties be foreshadowed among the beasts around us? If so, that might tell us something about how and in what order these properties were acquired. One such property is reference. Most of the units of human languages refer to things—to individuals (like *Fido*), or to types of objects (*dog*), actions (*sit*), or properties (*furry*). Animal signals don't have this kind of referential meaning. Instead, they have what is called instrumental meaning: this is, they act as stimuli that trigger desired responses from others. A frog's mating croak doesn't *refer* to sex. Its purpose is to get some, not to talk about it. People, too, have signals of



The Tongue-Controlling hypoglossal nerve is larger in humans than in chimps.

this purely animal sort—for example, weeping, laughing, and screaming—but these stand outside language. They have powerful meanings for us but not the kind of meaning that words have.

Some animal signals have a focused meaning that looks a bit like reference. For example, vervet monkeys give different warning calls for different predators. When they hear the "leopard" call, vervets climb trees and anxiously look down; when they hear the "eagle" call, they hide in low bushes or look up. But although the vervets' leopard call is in some sense about leopards, it isn't a word for leopard. Like a frog's croak or human weeping, its meaning is strictly instrumental; it's a stimulus that elicits an automatic response. All a vervet can "say" with it is " *Eeek!* A leopard!"—not "I really hate leopard!" or "No leopards here, thank goodness" or "A leopard ate Alice yesterday."

Australopithecus Africanus and other early hominids couldn't speak.

In these English sentences, such referential words as *leopard* work their magic through an accompanying framework of nonreferential, grammatical words, which set up an empty web of meaning that the referential symbols fill in. When Lewis Carroll tells us in "Jabberwocky" that "the slithy toves did gyre and gimble in the wabe," we have no idea what he is talking about, but we do know certain things—for instance, that all this happened in the past and that there was more than one tove but only one wabe. We know these things because of the grammatical structure of the sentence, a structure that linguists call syntax. Again, there's nothing much like it in any animal signals.

But if there aren't any intermediate stages between animal calls and human speech, then how could language evolve? What was there for it to evolve from? Until recently, linguists have shrugged off these questions—or else concluded that language didn't evolve at all, but just sprang into existence by accident, through some glorious random mutation. This theory drives Darwinians crazy, but the linguists have been content with it because it fits neatly into some key ideas in modern linguistics.

Forty years ago most linguists thought that people learn to talk through the same sort of behavior reinforcement used in training an animal to do tricks: when children use a word correctly or produce a grammatical sentence, they are rewarded. This picture was swept away in the late 1950s by the revolutionary ideas of Noam Chomsky. Chomsky argued that the structures of syntax lie in unconscious linguistic patterns—so-called deep structures—that are very different from the surface strings of words that come out of our mouths. Two sentences that look different on the surface (for instance, "A leopard ate Alice" and "Alice was eaten by a leopard") can mean the same thing because they derive from a single deep structure. Conversely, two sentences with different deep structures and different meanings can look exactly the same on the surface (for example, "Fleeing leopards can be dangerous"). Any models of language learning based strictly on the observable behaviors of language, Chomsky insisted, can't account for these deep-lying patterns of meaning.

Chomsky concluded that the deepest structures of language are innate, not learned. We are all born with the same fundamental grammar hard-wired into our brains, and we are preprogrammed to pick up the additional rules of the local language, just as baby ducks are hard-wired to follow the first big animal they see when they hatch. Chomsky could see no evidence of other animals' possessing this innate syntax machinery. He concluded that we can't learn anything about the origins of language by studying other animals and they can't learn language from us. If language learning were just a matter of proper training, Chomsky reasoned, we ought to be able to teach English to lab rats, or at least to apes.

As we have seen, apes aren't built to talk. But they can be trained to use sign language or to point to word-symbols on a keyboard. Starting in the 1960s, several experimenters trained chimpanzees and other great apes to use such signs to ask for things and answer questions to get rewards. Linguists, however, were unimpressed. They said that the apes' signs had a purely instrumental meaning: the animals were just doing tricks to get a treat. And there was no trace of syntax in the random-looking jumble of signs the apes produced; an ape that signed "You give me cookie please" one minute might sign "Me cookie please you cookie eat give" the next.

Duane Rumbaugh and Sue Savage-Rumbaugh set to work with chimpanzees at the Yerkes Regional Primate Research Center in Atlanta to try to answer the linguists' criticisms. After many years of mixed results, Sue made a surprising break-through with a young bonobo (or pygmy chimp) named Kanzi. Kanzi had watched his mother, Matata, try to learn signs with little success. When Sue gave up on her and started with Kanzi, she was astonished to discover that he already knew the meaning of 12 of the keyboard symbols. Apparently, he had learned them without any training or rewards. In the years that followed, he learned new symbols quickly and used them referentially, both to answer questions and to "talk" about things that he intended to do or had already done. Still more amazingly, he had a considerable understanding of spoken English—including its syntax. He grasped such grammatical niceties as case structures ("Can you throw a potato to the turtle?") and if-then implication ("You can have some cereal if you give Austin your monster mash to play with"). Upon hearing such sentences, Kanzi behaved appropriately 72 percent of the time—more than a 30-month-old human child given the same tests.

Kanzi is a primatologist's dream and a linguist's nightmare. His language-learning abilities seem inexplicable. He didn't need any rewards to learn language, as the old behaviorists would have predicted; but he also defies the Chomskyan model, which can't explain why a speechless ape would have an innate tendency to learn English. It looks as though some animals can develop linguistic abilities for reasons unrelated to language itself.

Brain enlargement in hominids may have been the result of evolutionary pressures that favored intelligence. As a side effect, human evolution crossed a threshold at which language became possible.

Neuroscientist William Calvin of the University of Washington and linguist Derek Bickerton of the University of Hawaii have a suggestion as to what those reasons might be. In their forthcoming book, *Lingua ex Machina,* they argue that the ability to create symbols—signs that refer to things—is potentially present in any animal that can learn to interpret natural signs, such as a trail of footprints. Syntax, meanwhile, emerges from the abstract thought required for a social life. In apes and some other mammals with complex and subtle social relationships, individuals make alliances and act altruistically towards others, with the implicit understanding that their favors will be returned. To succeed in such societies, animals need to choose trustworthy allies and to detect and punish cheaters who take but never give anything in return. This demands fitting a shifting constellation of individuals into an abstract mental model of social roles (debtors, creditors, allies, and so on) connected by social expectations ("If you scratch my back, I'll scratch yours"). Calvin and Bickerton believe that such abstract models of social obligation furnished the basic pattern for the deep structures of syntax.

These foreshadowings of symbols and syntax, they propose, laid the groundwork for language in a lot of social animals but didn't create language itself. That had to wait until our ancestors evolved brains big enough to handle the large-scale operations needed to generate and process complex strings of signs. Calvin and Bickerton suggest that brain enlargement in our ancestry was the result of evolutionary pressures that favored intelligence and motor coordination for making tools and throwing weapons. As a side effect of these selection pressures, which had nothing to do with communication, human evolution crossed a threshold at which language became possible. Big-brained, nonhuman animals like Kanzi remain just on the verge of language.

Fossils hint that language dawned 500,000 years ago.

This story reconciles natural selection with the linguists' insistence that you can't evolve language out of an animal communication system. It is also consistent with what we know about language from the fossil record. The earliest hominids with modern-size brains also seem to be the first ones with modern-size hypoglossal canals. Lieberman thinks that these are also the first hominids with modern vocal tracts. It may be no coincidence that all three of these changes seem to show up together around half a million years ago. If Calvin and Bickerton are right, the enlargement of the brain may have abruptly brought language into being at this time, which would have placed new selection pressures on the evolving throat and tongue.

This account may be wrong in some of its details, but the story in its broad outlines solves so many puzzles and ties up so many loose ends that something like it must surely be correct. It also promises to resolve our conflicting views of the boundary between people and animals. To some people, it seems obvious that human beings are utterly different from any beasts. To others, it's just as obvious that many other animals are essentially like us, only with fewer smarts and more fur. Each party finds the other's view of humanity alien and threatening. The story of language origins sketched above suggests that both parties are right: the human difference is real and profound, but it is rooted in aspects of psychology and biology that we share with our close animal relatives. If the growing consensus on the origins of language can join these disparate truths together, it will be a big step forward in the study of human evolution.

Matt Cartmill is a professor at Duke, where he teaches anatomy and anthropology and studies animal locomotion. Cartmill is also the author of numerous articles and books on the evolution of people and other animals, including an award-winning book on hunting, *A View to a Death in the Morning*. He is the president of the American Association of Physical Anthropologists.