ORIGIN OF LANGUAGE

Language represents a fundamental character of modern humans, Homo sapiens. All animals engage in some form of communication. For example, single-cell organisms may relate to individuals around them via chemicals, whereas birds prefer more vocal communication. Researchers who study communication in nonhuman animals, such as Sue Savage-Rumbaugh (in bonobos) and Irene Pepperberg (in parrots), may argue that human communication skills are not very different from those of some animals. However, researchers continue to debate the question of whether any species other than humans are capable of language, although there does appear to be a significant difference between animal communication and human language.

Human language evolved over the course of several million years through the modification of the hands, larynx, and brain, arising as an elaborate form of gestural communication in the ancestor of apes and humans to become the vocal communication observed throughout cultures today.

What Is Language?

Communication, which all forms of life engage in at some level, can be thought of as a process in which information is exchanged between individuals through a system of symbols, signs, and/or behaviors. This could include the use of odors that can determine rank, sexual status, location, and a host of other information forms of which humans have little understanding. Nonhuman primates make use of odors to express and convey some information, and humans do this as well to a certain degree. Where primates differ dramatically from other animal groups is in the use of gestures for communication. Gestural communication includes everything from the obvious, such as a sweeping hand or body motion, to the subtle, such as a slightly raised eyebrow.

Excellent examples of communication abound in nonhuman primates. For example, gelada baboons (Theropithecus gelada) live in the mountainous region of Ethiopia. The uneven terrain of their habitat makes it impossible for individuals in separate groups to communicate with each other using the vocal calls familiar to other primates and especially birds. Geladas use primarily gestures to communicate to distant groups often positioned at varying elevations. When the male of a group wants to send a warning to a male in an adjacent group, the first signal that he may give is a wide yawn that exposes his large canines. This somewhat benign gesture indicates to the other male that he is a little too close for comfort. If the adversary does not respond appropriately, he may receive a brief look from the male in which the eyebrows are briefly raised to reveal a patch of white skin around the otherwise dark skin eyelids. This gesture makes the eyes appear larger than normal and makes the other male understand that he is being watched closely. The gelada may engage in a variety of long-distance gestures that culminate in an eyebrow raise with a lip-flip accompanied by a sharp thrust of the body and face in the direction of the antagonist. This lets his adversary know that the next gesture may be actual physical contact, the ultimate gesture that most organisms avoid if possible.

Geladas, however, do not focus all of their gestures on aggression. They also use them to communicate sexual status. Geladas spend more time sitting than do other baboons and, as such, do not communicate sexual status to each other in the same way as is seen in other nonhuman primates. In most species of primates, females develop obvious swellings of the external genitalia around the time of ovulation. These swellings are an indicator or form of communication to males that a mating at the time of maximal swelling has a better chance of being successful. Geladas, however, do not produce swellings that are as obvious as those of other baboons. Instead, geladas possess a hairless patch of skin on the chest that changes color and develops nodules as the female enters into estrous. Moreover, like other primates, the female will solicit the male around the time of estrous to indicate that she is willing to mate with him.

Geladas do not engage in the most elaborate forms of communication known in nonhuman primates, but they do provide an excellent example of how communication works in nonhuman primates. Most forms of nonhuman communication are restrictive and stereotypical. All male geladas use eyebrow raises, yawns, and lip-flips to communicate threats to other males, and the order in which the gestures appear is predictable. Vocal communication is no different. Primates and birds are capable of producing a vast number of sounds, yet they only use a limited range of vocal calls to communicate.

Based on the results of studies on nonhuman primate as well as those on other animals, it is obvious that communication and language are not the same. Language involves a systematic method of communicating that incorporates gestures, sounds, and signs that have understood meanings. In addition, language takes the elements of communication and places them into a system that allows the speaker to alter the way in which the elements are presented to convey a different thought by adhering to the rules of the language. Known as syntax, the rules of a language determine the order of words in a sentence, enabling the speaker to convey an infinite number of ideas so long as they are presented in the correct sequence. For example, the sentence “This is the house that Jack built” makes it known to the reader that Jack built the house the observer sees. However, the sentence “Jack is house this built that the” may have the same words as the preceding sentence but does not covey the same thought and is perceived to be nonsensical because the presentation of the words does not adhere to the syntax of the language.

Language also differs from gestural communication in that it allows the speaker to express ideas that concern the past or future. In general, communication is literal and is concerned primarily with the present. Although a male baboon may be able to present a gesture that tells the receiver that he should move away from the group or else he may be attacked, the gesture does not indicate that the receiver should move away or else he will be attacked tomorrow. Indeed, even human gestures indicate nothing of future or past events unless they are presented in the context of a formalized language such as sign language (for example, American Sign Language) or gesturing while talking.

Although primates, especially chimpanzees and bonobos, are capable of incredible feats of communication, such as learning sign language or a set of symbols that carry meaning, they do not engage in language as defined in humans. Moreover, they do not develop languages on their own, a trait seen in humans. However, this does not imply that the apes are not unique among nonhuman primates for the elaborate nature of their communication. For example, Kanzi, a bonobo, understands more than 200 symbols and has developed the ability to string symbols together into phrases that enable him to convey a thought or understand a command. This does not indicate that chimpanzees possess a language or are capable of language given that Kanzi's ability for language is little better than that of a 2½-year-old human. Nevertheless, Kanzi's capacity to learn elements of language indicates that the seeds of language extend back beyond the evolution of modern humans.

The Requirements for Language and Speech Production

Language has evolved through the adaptation of three structures to accommodate the requirements of verbal and written language: the brain, larynx, and hand. Without changes in all three from the ape condition, it would not be possible to place words into a structured syntax. Moreover, it would not be possible to understand what the words on this page mean without changes in the brain other than those required to produce language.

The Hand

The hand is an often-overlooked aspect of language. The hands (as well as the whole body) are used for gesturing, which at its most basic level conveys a simple thought much as gestures in nonhuman primates work. However, hands also play an important part in language. During conversation, the hands as well as the body can be used to emphasize the point of a sentence or the action contained within it. The dexterity of the humanhand allows people to produce an infinite variety of gestures that can be used to make language more efficient. For example, a person can efficiently explain how much smaller one object is than another object by using his or her hands while speaking rather than spending time using words to explain the difference.

The hand is also important to written language. Without the manual dexterity exhibited in the human hand, it would be impossible to manipulate the fine movements of a writing instrument on a page. This ability is the product of significant changes that occurred in the muscles of the thumb.

In chimpanzees and other primates, the muscle that flexes the tip of the thumb is the same as the muscle that flexes the tips of the other four digits, the flexor digitorum profundus. Although chimpanzees share the other muscles of the hand with humans, the lack of independent control of the tip of the thumb prevents nonhuman primates from manipulating objects in the same manner that is seen in humans. In humans, the thumb or pollex has a tendon with an independent muscle belly running to the tip of the thumb, the flexor pollicis longus. This muscle enables the thumb to strongly oppose the other digits. It gives humans the ability to hold a hammer firmly through what is called a power grip. It also lets humans hold a piece of paper firmly between two digits in what is referred to as a precision grip.

The origin of the flexor pollicis longus, and thus the power precision grip, occurred approximately 2.5 million years ago when tool use appeared, according to the human fossil record, with the first members of the genusHomo. Humans from before this period, like chimpanzees today, used tools, but these were relatively simple tools that required little modification such as digging sticks. Stone tools represent an essential shift away from the lifestyle of the first hominids and apes to one that resembles that of modern traditional cultures.

To manufacture a stone tool, one must have the ability to form a mental picture of the finished product, which has no resemblance to the original stone. A stone tool is derived from a core stone. To form a tool, the core stone is hit with a hammer stone to remove flakes, which can then be modified to create the tool or be discarded if the core stone is to be modified into a tool. To remove flakes from the core stone, it is necessary to hit the core stone in the correct location. These precision blows arise from the power precision grip and eye–hand coordination.

Although tool use is not language, many researchers, such as Ralph Holloway and William Calvin, believe that the expansion and reorganization of the brain, and thus the rudiments of language and its evolution, may have begun with tool use. This is in part because once tool use develops, humans begin to move away from the social nuances of their ancestors and more toward groups involved with cooperative gathering and scavenging and later hunting. Such cooperative living would have encouraged the development of more complex forms of communication. Also, once languages developed, the dexterity of the hand allowed for the development of a written language. Although the first formal written languages are only a little more than 5,000 years old, it is possible that informal written languages date back beyond 30,000 years through the use of drawings and other ornamentation.

The Larynx

Speech is the most recognizable aspect of modern human language. Humans have an ability to produce an infinite variety of sounds that can be strung together to form words. Although the possibility of human-like communication skills in other species is debated, the uniqueness of human speech is not. Only birds have the ability to approximate human speech, yet no single species of bird is capable of producing the entire range of sounds in the human repertoire.

Human speech is the product of modification of airflow from the lungs by the larynx and the supralaryngeal airways (for example, pharynx, nasal cavity, oral cavity, mouth). Although none of the features is unique tohumans, the arrangement of the structures permits a speaker to produce the subtle sounds associated with any language. Of these features, however, the larynx appears to have undergone the greatest change.

Study by researchers such as Edmund Crelin, Jeffrey Laitman, and Philip Lieberman on the hominid larynx has revealed that the position of the human larynx is most responsible for the range of sounds associated withhuman speech. All nonhuman primates have a larynx that is positioned high in the throat, a condition found in most mammals. The normal mammalian condition allows the larynx to overlap the soft palate. This gives mammals the ability to drink and breathe at the same time because the high position of the larynx lets liquids flow around it and into the esophagus without crossing the path that airflow follows. This condition likely evolved to let prey animals flee predators more effectively when drinking at exposed watering holes. The drawback to the normal mammalian condition is that nonhuman mammals lack the ability to produce the range of sounds of which humans are capable.

In modern humans, the larynx sits low in the throat. The low position of the larynx creates an additional space in the supralaryngeal airway called the oropharynx. This added space, in addition to the extra distance air travels before it reaches the lips, allows humans to produce additional sounds that other mammals cannot produce. Indeed, even birds lack the ability to produce the range of sounds that adult humans can produce. Much of the ability of birds such as parrots to form sounds that mimic those of human speech patterns are perceived rather than the result of true mimicry.

Not all modern humans, however, produce the same range of sounds. For example, an infant is incapable of producing little more than a few sounds that may carry meaning but are indecipherable to an adult. This is because the larynx at birth is in the normal mammalian position. It is not until the child is around a year old that the larynx begins to make its descent into the throat. This descent can be observed in any child as he or she progresses from making baby talk to producing sounds more consistent with human speech. By the time an individual reaches the final stages of puberty, the final changes in the larynx and related structures are complete.

The position of the larynx in the throat in primates appears to be related to the degree of basicranial flexion observed. In chimpanzees as with other mammals, the base of the skull is flat in profile, whereas that in adult modern humans is flexed toward the anterior side of the midline. The degree of flexion in the skull base relates to the degree of laryngeal descent. With a flat skull base, a chimpanzee has a larynx that sits high in the throat. Because of this position, chimpanzees are unable to produce a variety of vowels and consonants that adult humans use. When one looks at the hominid fossil record, it is apparent that the descent of the larynx is a relatively recent phenomenon.

In early hominid fossils such as Australopithecus afarensis at 3.5 million years ago, and likely back to Australopithecus anamensis (4.2–3.9 million years ago) and even Sahelanthropus tchadensis (7.0–6.0 million years ago), the skull base resembles that of a modern chimpanzee. In fact, nearly the entire morphology of the face is more reminiscent of an African ape than of a modern human. This morphology indicates that the larynx would have resided high in the throat, meaning that early hominids would have been incapable of modern human speech. Instead, they would have been limited to the range of sounds seen in chimpanzees.

Later in hominid evolution, the cranium began to shift away from the ape condition of a prognathic or jutting face, small brain, and flat cranial base to a more vertical face, large brain, and flexed cranial base. Although the appearances of these features do not coincide with each other, the gradual shift toward the condition seen in modern humans implies that speech capabilities evolved gradually over time. The first indication of a possible change in the position of the larynx occurs in Homo erectus (also called Homo ergaster for early members of the species from Africa). The skull base of H. erectus (1.8–0.4 million years ago) is only slightly flexed over the condition seen in earlier hominids, but the slight flexion of the cranial base may indicate that H. erectus was capable of producing a greater range of sounds than A. afarensis would have been able to produce.

With the appearance of Homo heidelbergensis (400,000–150,000 years ago), the skull base becomes more flexed. Again as with H. erectus, H. heidelbergensis was likely incapable of producing the range of sounds seen in modern humans. Neandertals, once considered a subspecies of modern humans, have a skull base similar to that of H. heidelbergensis. Although they possessed cultural characters more similar to modern humans than did previous groups of hominids, it is likely that even Neandertals were limited in their speech capabilities.

It was not until the appearance of H. sapiens some 200,000 years ago that modern human speech capabilities arose. Modern humans are the only hominid group that possesses marked skull base flexion. Cranial base flexion allows the larynx to reside lower in the throat, adding to the distance a sound travels before it passes out of the mouth. With this morphology, humans have the ability to manipulate a puff of air coming from the lungs to form difficult sounds such as “b” and “p” in addition to the various forms of each consonant and vowel found in different languages.

The Brain

No other structure in human evolution receives more attention than the brain. The human brain is capable of things well beyond the abilities of any other creature. Arguably the most unique ability of the human brain is its capacity for language. With language, humans are able to communicate ideas beyond the simple emotions conveyed through the gestural–visual communication of the great apes. However, although the mental capabilities of modern humans are apparent and easy to assess, those of the fossil ancestors of humans are very difficult to define. Despite this shortcoming of the fossil record, it is possible to understand what is required for language in the brain and when those features may have developed in human evolution.

In 1861, the eminent French physician and anthropologist Paul Broca described what he called the “seat” of language in the brain. By studying a patient who had suffered damage to the left frontal region, Broca found that although the patient developed the ability to understand speech during the course of therapy, the patient lacked the ability to produce language except in limited capacity. Over time, the region associated with language production, which would come to be known as Broca's area, would be isolated to the inferior third convolution (gyrus) of the frontal lobe.

Broca's area represents the motor speech area of the brain. Located in the left inferior frontal lobe in most right-handed and some left-handed people, this region allows the intricate muscle movements of the lungs, larynx, and supralaryngeal airway needed for modern human speech production. Moreover, this area allows the fine movements of the hand required for writing. As Broca discovered, damage to this region of the brain may leave a person incapable of communicating with others.

In 1874, the German neurologist Carl Wernicke completed the language picture by identifying the area of the brain for language comprehension. Located posterior to Broca's area in a region called the parieto–temporal junction, Wernicke's area enables an individual to understand the words spoken by another individual or those that appear on this page. Together, Wernicke's and Broca's areas, along with other regions of the brain involved in aspects of language, have allowed humans to create the approximately 6,000 languages that are spoken today.

Although there is a general understanding of the brain regions involved in modern human language, what is less clear is the evolution of these areas. When one looks at the fossil record, it is evident that the knowledge contained within it is limited. In general, only the most durable parts of an organism fossilize. These include calcified materials such as bones and teeth. Only under rare circumstances will soft tissue be preserved, and so far no brain of any extinct species has ever been discovered. As such, the ability to interpret brain evolution is limited. Those that study brain evolution using the fossil record, paleoneurologists, use the various clues available on fossils. An important piece of evidence is the endocast.

An endocast is a cast derived from the endocranium or inside the skull where the brain resides. Although the external surface of the brain is distanced from the endocranial table of bone by cerebrospinal fluid, the endocranial surface does approximate the overall shape of the brain and in certain regions picks up the specific shape of a structure (for example, the course of a sulcus, the protrusion of a gyrus). Because of this intimate relationship, a cast of the endocranium may contain a large amount of information about the brain.
In some cases, sediment seeps into the skull during decomposition and hardens during fossilization to form a natural endocast. If the sediment seeps in before other forces act on the skull to possibly change its shape, the endocast preserves a reliable replica of the endocranial surface. Alternatively, a cast of the endocranium can be made after the fossil has been excavated. In both cases, the endocast can be used to determine overall brain size as well as general, and occasionally specific, features of the brain.

During human evolution, the brain has increased significantly in size from the 400-ml capacity of a chimpanzee brain to the 1400-ml capacity of the human brain. During the early part of the 20th century, it was assumed that increased brain size was the first adaptation to appear in human evolution. This would have indicated that early hominids would have been capable of some form of speech. However, after the discovery ofAustralopithecus africanus by Raymond Dart in 1924 and the subsequent exposure of the Piltdown hoax, it was apparent that human brain evolution proceeded in a very different manner. Instead of the brain exploding in size early in hominid evolution, brain evolution proceeded in a much more gradual fashion, with brain size increasing only later.
Early hominids possessed brains that were little different in size from those of chimpanzees. A
lthough this would indicate that early human brains functioned like those of their ape ancestors, this might not be the case. Endocasts from early hominids indicate that the brain underwent some form of reorganization once hominids were adapted to a bipedal posture. Although there is no indication that early reorganization included adaptations for language areas in the brain, it is possible that the changes that did occur laid the groundwork for later changes leading to the development of Broca's and Wernicke's areas.
Broca, and later the linguist Noam Chomsky, proposed that the human language areas represent an “organ” unique to humans. This philosophy of the uniqueness of human language and the structures responsible for it dominated much of linguistic and neurological study until the late 1980s, when it was discovered that there is no isolated language organ. Instead, it

was found that there are language-related areas in many different parts of the brain that are connected to each other by vast neurological pathways. This alternate view of language and the brain meant that language might not have evolved de novo and at a single time in human evolution but that, instead, its history is much more complicated.

The German neurologist Korbinian Brodmann produced cytoarchitectural maps of the human brain during the early part of the 20th century. The area described as Broca's area was assigned to Brodmann's areas 44, 45, and 47. From his studies, it was possible to measure precisely the boundaries of this region and other regions for study in anthropology, medicine, and other fields. A few years later, Brodmann produced the same type of maps for the brains of great apes, identifying a region as area 44, implying that it possessed the same cytoarchitecture as that of modern humans. Brodmann did not think that chimpanzees having an area 44 in their brain meant that they possessed the same speech motor skills as did humans. Moreover, neither did his successors who found similar results. However, the presence of an area 44 in chimpanzees, an area clearly related to Broca's area inhumans, indicates that the precursors of brain language areas were present in the ape–human ancestor.

A second line of evidence indicates that some of the regions in the brain for language, and
thus the rudiments of language, are ancient comes from a 1998 study by Patrick Gannon and colleagues that demonstrated the presence and asymmetry of a structure, the planum temporale, in the parieto–temporal region of the brain in chimpanzees. The planum temporale is within Wernicke's receptive language area in humans. Its presence in chimpanzees, as well as in gorillas and orangutans, indicates that some of the components for higher levels of communication are ancient. Moreover, the finding that the feature is asymmetric is also significant.
Because some features thought to be entirely unique to modern humans have been discovered in chimpanzees and other primates, it had been thought that one unassailable feature of the human brain is the asymmetry displayed between the left and right cerebral hemispheres. In general, chimpanzee brains, as well as those of other nonhuman primates, are symmetrical in appearance. In this case, the left and right sides of the cerebrum appear to be equal in size. In humans, however, the brain is asymmetrical, such that one portion of the brain is measurably larger than the other side of the brain. This asymmetry in humans is related to the division of cerebral functions between the left and right sides of the cerebrum. Thus, whereas speech production may occur in Broca's area on

the left side of the brain, the right side may assume some other aspect of language. In this fashion, it is thought that the brain can process information efficiently by not first needing to integrate that information traveling to redundant areas. This is what makes speech fluid and abundant.

With the knowledge that chimpanzees possess brain areas resembling those found in humans for language and that these areas are often asymmetrical, it is possible to assume that language did not arise only within modernhumans. Instead, as with other aspects of human evolution, language likely evolved over time, becoming more elaborate as structures in the brain and throat changed.

The first indication of modern-like human language areas in the fossil record may have been some 2.5 million years ago with Homo habilis. However, data from this time period are very incomplete, making any judgment of the neurological state of early Homo all but impossible. It appears likely, however, that there were few changes in the brain of H. habilis, indicating that the development of language areas did not appear until H. erectus. This is due in part to the relatively small increase in hominid brain size from 6.0 to 2.0 million years ago. In addition, the features that are discernible on endocasts for language lack the asymmetry seen in modern humans. For example, according to research performed by Ralph Holloway, Broca's cap, an endocast feature that corresponds to a portion of Broca's area in the brain, is symmetrical in chimpanzees and early hominids, whereas it is asymmetrical in modern humans. This does not appear to be a consistent asymmetrical feature in the fossil record until H. erectus.

The appearance of Broca's cap in the fossil record suggests that the neurological components necessary for modern human speech are very old, dating to some 500,000 years ago or possibly earlier. At this point, the brain is approximately 1,000 ml on average, indicating that an increase in brain size may also have been related to the advent of language. Later reorganization of the brain, along with further increases in the size of the brain, likely led to changes important to fully modern human language.

The early development of modern-like language areas, such as the planum temporale in the brain and Broca's cap in endocasts, indicates that the neurological aspect of language is ancient in origin. However, as stated earlier, modern human language is a product of neurological and anatomical components. For example, although some researchers support the view that H. erectus and Neandertals were capable of language, others argue that the speech capabilities of premodern hominids were severely limited even though the neurological components for language may have been present early on. Thus, although species such as H. erectus likely had language, they were incapable of producing the range of sounds found in modern human speech. This limitation may have hindered the development of complex speech and further adaptation of brain structures for speech until the larynx evolved into the form seen today.

By the close of the 20th century, anthropologists had made significant advances in understanding the origin of language not known of during the first 100 years of human evolutionary study. Some of these advances were due to the discovery of new fossils. Many, however, were made through improved techniques of observation such as computed tomography (CT) and magnetic resonance imaging (MRI).

Today, much of the focus on the origin of language is in the study of great apes. Studies of chimpanzee communication skills by researchers such as Savage-Rumbaugh continue to provide important data on the mental abilities of the closest living relative of humans. Moreover, understanding the full capabilities of the chimpanzee mind provides the most important line of evidence as to the abilities of the ancestors of modern humans.

Additional lines of study include elucidation of the ape brain. As continuing research has shown, the brains of chimpanzees appear to share more with humans than they do with other primates. This indicates that much of what is thought to be unique about the human brain has instead been exapted from the ape brain. Much research is still needed in this area, however, before there is a full understanding of what any possible similarities might mean.

—Douglas C. Broadfield

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