The Marvel of Language: Knowns, Unknowns, and Maybes

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Amid our delight in the beauties of literature, our satisfaction in our writing (scholarly, technical, or creative), and the gratification and challenge inherent in our teaching, we often end up giving little attention to *language*, the faculty which makes all of those endeavors possible and which is the very foundation of our work as language professionals. I would like to use the opportunity of this keynote address to share with you what I see as some of the marvels of language, as I have observed them over the decades of my study and teaching of languages and linguistics.

What Kinds of Things Are Linguistically Knowable?

For centuries and even millennia, many minds–great and ordinary–have observed that man alone speaks, that language is a panhuman feature that both identifies and unites us. Linguists, and before them philologists, grammarians, philosophers, scribes, and translators, have worked both independently and collaboratively to devise rigorous methodologies for the analysis and description of language. Under objective study and analysis, many of language's elements have been amenable to discovery. A few of the key things that are linguistically knowable are:

- Language is an abstract and complex system of rules.
- These rules, or operating principles, are organized internally into subsystems, which are themselves made up of smaller and smaller subsystems.
- A vast and intricate web of connections links the rules both within and across systems and subsystems.
- These rules reside and operate in the minds of the language's speakers.
- The functioning of these rules is in many ways effortless and unconscious.

These properties, and many others, are things we know as linguists.

They have emerged from decades of inquiry and constitute what we think of as some of the fundamental properties of language; they are among what I call *the design features of human language*.

Yet the marvel that is language remains a mystery to us in significant ways, due in no small measure to the limits of what is knowable linguistically. For many crucial properties of language, linguists depend on the research of scholars from other disciplines whose conceptions of and about language often do not correlate with what linguists think of as "knowns."

Let us consider three of those complex and deeply important questions that surpass the field of linguistics itself, and let us try to integrate a linguistic perspective into the views and findings of other disciplines. I will mention a few key aspects of each topic, and then conclude each of the three sections with a summary of "knowns," "unknowns," and "maybes."

I. Language and the Brain: Where is language and how does it operate in the brain?

Our knowledge of language as seated in the brain began with the study of *focal brain damage*, that is, injuries to specific areas in the brain, and any concomitant changes in language ability. Wars in the last half of the 19th century–the American Civil War in the 1860s and the Franco-Prussian War in the 1870s–resulted in many head wounds from sabers, cannon shot, and musket balls, accompanied by many forms of language impairment, collectively known as *aphasia*. In 1861, French surgeon Paul Pierre Broca found that damage in part of the left frontal lobe (specifically, the left inferior frontal gyrus) was accompanied by impaired speech production. That region of the brain came to be called "Broca's area." Building on Broca's published findings, Carl Wernicke, a German neuropathologist and surgeon during the Franco-Prussian War, traced impairment in language comprehension to some of the wounds he treated in another part of the brain—located further back than Broca's area—a small part of the left temporal lobe (specifically, the left posterior superior temporal gyrus), which became known as "Wernicke's area."

In the 20th century, the importance of Broca's and Wernicke's areas for language was confirmed by many studies of strokes and other brain injuries. For instance, detailed aphasia studies conducted in France in the 1930s greatly expanded our understanding of which aspects of language were involved with the two physiological areas. Electro-encephalograms and other improved imaging technology in the 1970s and 1980s confirmed the dominant role of the left hemisphere for language. Very clever and innovative studies extended to sign language as well, revealing, somewhat unexpectedly, that it is the left hemisphere, which mediates sign language too, rather than the right hemisphere, which is more associated with movement and its perception. Such conclusions correlated well with the perspective of linguists that language is a unique mental attribute, separate from general intelligence or other human cognitive abilities.

In the search for the locus of language in the brain, bilinguals were an early and frequent subject of neurological study and still are today. In the 1960s and 1970s, for instance, neurologists (often working with linguists) searched for the "two tanks" that would house each of a bilingual speaker's two languages. Indeed, it is common for bilinguals to express an intuition of moving from place to place, so to speak, in their minds when navigating between their two languages. I expect that many of you here tonight have had that same experience, such as failing to understand something said in your dominant or native language because you were "listening" in your other language. However, no such dedicated or separate areas could be found. Instead, the movement of an electrode by only a few millimeters in an exposed brain would result in the patient switching from language to language in simple word tasks, such as identifying a picture. Studies since 2000 have found that lesions in the frontal lobe caused a bilingual patient to exhibit "pathological code-switching," changing from language to language in unexpected and random ways. Still newer studies have identified Broca's area as responsible for choosing the right word in the right language. Such research continues to show that along with the left hemisphere generally and smaller, specific areas in the brain which are especially dedicated to various aspects of language, there is a wide network of brain activity involved in both language production and comprehension.

Nevertheless, despite great strides in understanding the neurology of language, a key question remains unresolved, namely, where exactly are the rules linguists believe to be residing and operating, largely unconsciously, in the brain? Put even more simply, what must happen at the level of the individual neuron and the individual synapse in order for us to, for instance, know a word? One recent line of inquiry involves Purkinje cells, named after Czech scientist Dr. Johannes Purkinje, who first identified them in 1837. Purkinje cells are found in the cerebellum (at the back of the brain), and are different from any other neurons. The stem of a single Purkinje cell divides into a vast mat of hundreds of branches and thousands of sub-branches. The human brain has between 15 and 25 million Purkinje cells, and each one makes synaptic connections to over 200,000 other neurons. From the linguist's perspective, here is a neurological structure that seems capable of being the seat of the complex rules of syntax. Purkinje cells have received a lot of scientific attention in the last decade or two, among other things, as the site of muscle memory – the way we remember how to write our name, type on a keyboard, or even drive a car. The semi-autonomic character of language shares some properties with muscle memory, so this hypothesis seems to me to be especially promising.

Language and the Brain – Summary:

Knowns

- Many loci for language activity in the brain have been identified and categorized over the past 150 years.
- More and more is being revealed about how bilingual individuals mediate their two language systems, choose words, and keep the domains of each straight.

Unknowns

- Much more remains to be done on the specific language functions of various brain areas and how they connect to each other.

Maybes

- The intriguing Purkinje cells seem an especially fruitful area of inquiry in this regard, by both their number and their structural complexity.

II. Origin of Language: How did this complex system become part of the human mind?

For centuries, the idea of language as the unique gift of humans has been a commonplace in philosophy, theology, and myth. But, across those same centuries, no progress could be made to account for how humanity attained this faculty. A dormant or even discredited topic for decades, the concept of the origin of language is now the center of the burgeoning new field of *evolutionary linguistics*, and this new interdisciplinary field has many stakeholders across the biological and social sciences, as well as linguistics proper.

Such progress was slow in coming. There seemed to be no way to get a scientific rope around the topic, no way to go about developing a serious model for language origins. An article by prominent structuralist linguist Charles F. Hockett, published in *Scientific American* in September 1960, was a significant step toward just such a methodology. Titled "The Origin of Speech," it proposed looking at language as a system of communication alongside other communication systems in the animal world and identifying similarities and differences for what he proposed as 13 essential traits, such as broadcast transmission, vocal-auditory channel, rapid-fading signal, and most importantly for human language, semanticity and duality of patterning. The differences would provide a starting point for investigating how human language could have developed those traits which other systems lack. It was a very influential article designed to reach a wide academic audience, and it did, sparking research into animal intelligence, animal social systems, and animal communication, in addition to the origin of human language.

As early as the 1940s and 1950s, primate language experiments presented another way to delve into language origins. The idea was to see what our closest primate cousins, the chimpanzees, could and could not do by way of a human-like symbolic system, or might be able to do with explicit and repeated training. Keith and Catherine Hayes, of the Yerkes Laboratories of Primate Biology in Florida, undertook the first study. They took a chimp, Viki, into their own home as an infant and tried to teach her English as if she were a human baby. But, after much training and reward, Viki could only say *papa, up*, and *cup* on her own and *mama*, with someone guiding her lips. Unfortunately, chimps don't have the anatomy to produce human consonants and vowels, and the experiment failed. Later efforts, in the 1960s and 1970s, focused instead on using gestures or physical tokens to stand for words and combine into "sentences." For instance, Sarah, at University of Santa Barbara (and other institutions), used colored plastic tokens on a magnet board and could form sequences such as "Sarah wash apple" and "Sarah eat grape." Washoe, at University of Nevada Reno, used American Sign Language gestures and even taught her infant son Loulis to sign. Nim Chimpsky, a male chimp, at Columbia University, was taught ASL also in an attempt to replicate the successful Washoe's accomplishment. However, he was judged to be only imitating his trainers, not actually using the signs to communicate, and his experiment failed. (You may be familiar with *Project Nim,* the very sad 2007 documentary film on the aftermath of that study.)

In all of these efforts, the intent was to identify what the young chimp lacked and the human child possessed that accounted for language in the one and not in the other, and also to determine if that missing piece could perhaps be supplied by environment and/or training. That notion has always seemed to me to be fundamentally flawed. It presumes that human language is an incremental structure, one that can begin with something like chimp Viki's "up," "cup," and "papa" and develop into full-blown sentence structures by going through small additions and changes. Such a model is conceivable only up to a very rudimentary point. That is, we can think of a beginning of vocal communication starting with a few words, perhaps arising, as old textbooks used to say, in imitation of the wind, other natural phenomena, or even animal calls, or from spontaneous cries of joy or pain. Call that, if you will, a one-word stage, where each of these few words represents its own utterance. Then more such words might be created or borrowed so that there are now 20 words, or 50, or even 100. We can conceive of a stage where those words can be put in pairs, or even in groups of three, similar to Sarah's token sequences of "Sarah want apple" or Viki's "Up cup."

However, as linguists, we can't identify anything in the nature of language that allows this incremental model to expand beyond the very limited level of communication offered by the two-word or three-word sentence. How is the gap between those simple arrangements of words and normal human sentences to be bridged? Paleontologists and others writing about pre-human hominins sometimes use terms like "rudimentary language" for these species, but human language is not ever rudimentary; it is all or nothing. We observe this in the acquisition of language by children. Like the examples above, children too begin with individual words, each of which can be its own sentence. Think of the one-year-old's all-purpose "No!" or "Daddy!" which can mean

"I see Daddy," "Where is Daddy?" or "I want Daddy" – the so-called one-word stage. Then children progress to the two- and three-word stages, with "Me Daddy go" (meaning "I want to go with Daddy" or "Can I go with Daddy?" or "Daddy and I are leaving.") But, very quickly afterward or even concurrently with that stage, children will produce completely normal and surprisingly complex sentences, such as "Those are my daddy's boots," as uttered by a three-year-old niece of mine right after she had said "We go park?"

It is well established in linguistic inquiry that the acquisition of syntax by human children does not come in bits and pieces; it comes in a gigantic wave of linguistic competence. Consequently, it has always been impossible for me (and linguists in general) to conceive of any developmental linguistic process by which a 50-word vocabulary and the imagined two- or three-word sentence pattern of a primitive hominin species could have become human language as we know it to work. The gap between the two is equivalent to the notorious human "missing link," so sought after in the 19th and early 20th centuries to complete the evolutionary trail from primates to humans. As in the case of that missing link, the linguistic missing link likewise cannot be supplied or accounted for within what I like to call the Darwinian incremental model, officially termed in evolutionary studies, *gradualism*. Consequently, in this area, linguists and other scholars of human evolution have differed in ways that seemed irreconcilable.

Fortunately, another theory of evolution presents a workable model for the knowable properties of language: the *punctuated equilibrium theory* proposed by Stephen Jay Gould and Niles Eldredge, both paleontologists and evolutionary biologists, in their 1972 article, "Punctuated Equilibria: An Alternative to Phyletic Gradualism." Essentially, this model accounts for situations where there are not eons-long, gradual changes in a species across each generation, but instead, major or significant changes over only a few generations. With evidence from Pleistocene land snails and Paleozoic invertebrates, Gould and Eldredge proposed that species may persist over long periods of time in equilibrium, exhibiting few morphological changes. Then if something happens to break, or punctuate, that equilibrium, such as climate change, loss of habitat, or new predators, rapid changes can take place in a very short span of evolutionary time. In this way, a punctuated equilibrium can result in big changes within a single species or the rapid development of new species.

For linguistics, Robert M. W. Dixon, noted historical linguist and specialist in Australian languages, proposed the concept of punctuated equilibrium to account for language change in his 1997 book *The Rise and Fall of Languages*. I happened to encounter it a year after its publication as part of my summer reading on extinct languages, and it was like a revelation! It was also a great relief that I could finally see my way to a means of filling that notorious gap: "the linguistic missing link." It then made perfect sense to me that human language had developed in our species during a puncture of the equilibrium, just as happens with other biological properties in other species.

The consensus today, among both linguists and many scholars in other fields, is that hominin species became endowed with human language only when one of them became *Homo sapiens,* that is, fully modern humans. That happened in Africa about 100,000 years ago. (There is good evidence for that time depth; some evidence is claimed for a 200,000-year time depth.) Those tall, long-limbed, warm-adapted ancestors of ours moved north out of East Africa through the Middle East, leaving considerable evidence in caves in Israel and other sites. They entered Europe about 50,000 years ago as the Cro-Magnon people, named after a fossil site in France. The Cro-Magnons were fully modern, with fully developed human languages as well as culture, art, and tool-making prowess. In short, they were us. Linguistically, I always like to fantasize about time-travelling back to the caves of Lascaux, France, or Altamira, Spain, and doing linguistic fieldwork among the painters of those artistic treasures. As I tell my students, I have no doubt that the design features of human language, the language universals, as we know them, and the universal tendencies we see in languages past and present would all be apparent, along with some unique surprises.

But what of all the other hominin species represented in the fossil record? Did the effects of punctuated equilibrium apply in the same way to them, giving them language too? The consensus is no. Language as we are speaking of it here is specifically human, belonging to *Homo sapiens,* our species only. What evidence might we seek that language originated in this very restricted way? For one thing, there are physical necessities for human language: the round human tongue, the arched (instead of flat) palate, and a lowered larynx are required evolutionary modifications that accommodate speech in *Homo sapiens*. The fossil record has evidence for one of these: the lowering of the larynx. Modern human skulls have a *flexed basicranium*. Among other characteristics of the bones of the face and skull, basicranial flexion also involves a curved notch (like a half-circle) in the middle of the back bottom edge of the skull (at the nape of the neck), where the lower jaw fits against the cranium. A bigger notch gives room for a lower larynx, and consequently room for the round human tongue to move around and make the sounds of human language. A smaller notch means a larynx higher in the throat, along with a flatter tongue and palate, and consequently, narrower possibilities for speech sounds. A comparison of skulls from various species of hominins shows flat basicrania, with no notch in the more ape-like *Pithecanthropus* species, the beginnings of a notch in *Homo habilis*, and a little bigger notch in later *Homo erectus*. These two species likely had a somewhat lowered larynx, but still not the mouth structure needed for the sounds of human language.

Even with skeletal evidence that supports the emergence of language in humans alone, it is still difficult to conceive of how it all happened. That might be partially because we are still used to thinking of evolutionary change as long and accomplished in tiny steps. The best explanation comes from paleontologist Richard Leakey in *Origins Reconsidered*. He describes language as "part of an evolutionary package" that included the amazing human hand and the big human brain. Various scholars try to make one of those the driving force: the big brain had to develop to run the wonderful hand, which incidentally provided room for language to develop. Or the big brain developed on its own when nutrition improved, giving room for the hand to develop and language as well. Or language was developing, necessitating a bigger brain, which also allowed for a more developed hand. Leakey, however, sees them as a concomitant package – a set of evolutionary innovations in response to a particular set of circumstances. I find that intellectually satisfying. When archaic sapiens, as they are called, explored north out of Africa, they came with their bags packed, so to speak, having already acquired, in a single evolutionary leap, the wonderful trifecta (brain, hand, and language) of which we are the beneficiaries

Before we leave the matter of language origins, there are two more issues to consider briefly: the so-called "language gene" and the status of Neanderthal in the human language question. Many of you have probably heard of the discovery of a single gene that is responsible for the faculty of language. Technically, it is called the "forkhead box P2 protein" or Fox P2 for short. In humans, it is located on chromosome 7. In the 1990s, geneticists discovered that a genetic mutation (in the form of an amino acid substitution) in this gene caused drastic language impairment in 15 members across three generations of a family identified as the KE family in the United Kingdom. This caught the attention of social media and the popular press and was hailed as evidence of the great genetic breakthrough that gave our species language.

It is far more complicated than that, however. The FoxP2 gene is not a human innovation. It is found in non-human primates, mice, bats, carnivorous mammals, zebra finches, dolphins, whales, fish, reptiles, and alligators, with only varying numbers of different amino acids in different places in the protein line-up. In these species, and in our own, the Fox P2 gene is found in various locations in the brain, including the Purkinje cells, as well as in the lungs, spinal column, and other tissues. It is a *transcription factor*, meaning that it controls the activity of other genes, perhaps hundreds of them. Clearly, this gene cannot by itself be responsible for the origin of human language, since it occurs almost identically among so many varied species. In addition, a recent study of so-called "knock-out mice," where one copy of the Fox P2 gene was removed, revealed how much this gene is responsible for: Newborn mice with only one copy of the gene were runted, had brain abnormalities, including in the Purkinje layer, had inadequate lung development, and died after three weeks. For the weeks that they lived, the mouse pups didn't squeak or respond to squeaks. The reduced vocalization by the baby mice, along with similar studies of songbirds, indicates that FoxP2 is not the magic missing link for human language, but is instead an important gene regulating communication in general as well as many other functions in many different species.

Finally, consideration of human language and human identity would not be complete without including Neanderthals. These pre-Cro-Magnon European inhabitants have received a lot of attention, both scholarly and popular, over the last decade. My linguistics students always ask if Neanderthals had human language. The question became more complicated by the announcement a few years ago that the FoxP2 gene was part of Neanderthal DNA too, not just ours. However, as we have seen, that likely means merely that Neanderthals communicated with each other, which was probably never in doubt. The extent of the Neanderthals' communicative abilities hinges on whether they were in possession of the same evolutionary package that endowed the Cro-Magnons with language. Based on the bone evidence and the archaeological record of culture and artifacts, the consensus of experts has been no. Reconstructions of the Neanderthal face and mouth have involved a flat palate, flat tongue, and high larynx, meaning that the array of consonants and vowels that could be articulated would be very limited. Consequently, whatever vocal communication Neanderthals had (and they almost unquestionably did have such a system), it would not have sounded like human language. Recently, however, those reconstructions have been disputed, and evidence has been offered for more cultural artifacts, more evidence of artistic pursuits, and indications of more intelligence.

Also unresolved is the question of species. Are Neanderthals a subspecies of *Homo sapiens* (that is, *Homo sapiens neanderthalensis* versus our *Homo sapiens sapiens*) or are they a separate species (that is, just *Homo neanderthalensis*)? Their status as a separate species was argued in articles going back to the 1980s, and the distinct species names appear in scholarly literature of the 1990s. This is not a question that linguists can resolve. Yet it needs resolving if we are to continue to consider language as the defining characteristic of our species and only our species. Many (possibly most) of the prominent scholars in the field consider Neanderthals to be a separate species, although there has been no official pronouncement from scholarly bodies or organizations. If it does turn out that the two groups are recognized as distinct, it would be useful to have more evidence on their language capabilities because the answer to that question would bear significantly on both the time horizon of language and its relation to our identity as humans.

Origin of Language – Summary:

Knowns

- A firm minimum time horizon for the emergence of language at 100,000 years ago.
- Overwhelming consensus (among linguists, at least) that

language is a particular evolutionary development specific to humans, *Homo sapiens*.

UNKNOWNS

- Even though Punctuated Equilibrium seems to account most plausibly for the emergence of language, still, how exactly did this emergence occur? What mechanism filled that notorious gap between words and syntax?

MAYBES

- The FoxP2 gene: more research is needed to understand how its lack disrupts grammar and comprehensible speech.
- What about Neanderthals? Their taxonomic status has an important bearing on the time and manner of language origins.

III. LANGUAGE VS. ANIMAL COMMUNICATION: Are humans alone in possessing language?

A significant attendant benefit of the renewed interest in the origin of language was increased study of animal intelligence and animal communication. What Hockett's article "The Origin of Speech" did to revitalize and legitimize inquiry into the origin of language, it did for animal studies as well. In the 1940s and 1950s, animal studies were in the harsh grip of the Behaviorist model. My generation went from grade school through high school haunted by images of Pavlov's sad, drooling dogs, cats up to their necks in iron funnel-like structures (to make them pay attention), and a tiny baby monkey clinging to a "mother" monkey figure made of bare crisscrossed wire (to see if an unresponsive mother would hinder its emotional development). Everything was stimulus and response, environment over heredity, operant conditioning, and instinct, not intelligence.

We have seen how primate experiments began in the 1940s and 1950s, not to find out what the capabilities of the chimps were, but to use their behavior and responses as a starting point for understanding human evolution and the development of language. Many of the investigators were psychologists–human psychologists, not zoologists–and were not trained or equipped to study animal individuals or populations. Gradually, however, beginning with the decade of the 1960s and into the 1970s and 1980s, research interests began to shift from forced primate "language acquisition" to the animals themselves, their social organization, and their authentic communication among themselves. Hockett's article included examples from various animal species, such as stickleback fish, honeybees, gibbons, and Western meadowlarks, which at least gave a glimpse of different modes of communication in the animal world, and many studies encompassed a wide range of species in terms of their social organization, intelligence, and reasoning. Most famous, perhaps, was the brave and groundbreaking work done by Jane Goodall with wild chimpanzees and by Dian Fossey with mountain gorillas.

Investigation into animals' own communication systems expanded to include the calls of gibbons and wild chimpanzees, the danger signals of vervet monkeys, the "dialects" of European bird songs, and the meaning of bee dancing, for which Karl von Frisch won the Nobel Prize in 1973. Of special interest to us here are studies of animal communication and intelligence that might seem to open the question of the exclusivity of human language. In that regard, we can examine four examples of animals that are remarkable for their intelligence, communication, and teachability. Our animal superstars are Koko, a gorilla; Kanzi, a bonobo (pygmy chimpanzee); Rio, a California sea lion; and dolphins, in captivity and in the wild.

Koko, the gorilla, is a California celebrity, having appeared on many television shows and played host to many other celebrities over the years, including Mr. Rogers, William Shatner, Robin Williams, and Leonardo di Caprio. She is known for her knowledge and use of sign language, for her painting, for her pet cats, and for her "conversations," portrayed in numerous media appearances and in commercial videos dating from 1978, 1999, and 2016. Koko's story is familiar to millions of fans through the website of The Gorilla Foundation and several picture books about her. She was born in the San Francisco Zoo on July 4, 1971. When she was six months old, she became seriously ill. Stanford graduate student, Francine (Penny) Patterson, was hired to care for her, presumably as a short term endeavor. It became a life-long relationship and career when Patterson became Koko's legal guardian and created her gorilla compound in Woodside, California.

A student in psychology and communication, Patterson was interested in the other primate experiments going on at the time and decided to try sign language with Koko. She would form the baby animal's hand into the shape of a sign for "milk" or "blanket" and would repeat the guided gesture until Koko learned what it meant – or at least how it functioned. Koko is reported to now use over 1000 signs and to have made up some novel ones herself, such as "lip" to mean "girl" and "finger bracelet" for "ring." As part of the expansion of her vocabulary, the signs of American Sign Language have been modified to fit the size and different dexterity of her hands. Her handlers call her system GSL, or Gorilla Sign Language.

Koko has had two male companions: Michael, a wild-born gorilla from Cameroon, whose mother was killed by poachers, and more recently, Ndume, a younger male born at the Cincinnati Zoo. Michael learned a considerable number of signs, around 600, before he died in 2000. Ndume reportedly has learned a few signs, which he regularly exchanges with Koko. Ron Cohn, Patterson's partner, has scrupulously documented on film the gorillas' behavior and interactions with each other and with humans. In addition, all of the gorillas' signs are transcribed from the video tapes and catalogued by staffers, resulting in reams and reams of records for future study and analysis. Koko and Michael have painted many pictures and even named their paintings, which have been sold locally to support The Gorilla Foundation. There was the beginning of a plan for a larger operation on the island of Maui, Hawai'i, with more gorillas in a more natural habitat, but to date, it has not progressed beyond the acquisition of the site. Koko and Ndume remain in their compound in the northern California woods.

In assessing Koko's significance regarding a connection between animals and human language, observers differ. Some accept that Koko has mastered the language of another species and uses it regularly to communicate with that species (humans), as well as with her own (Michael and Ndume). Other commentators study the videos and feel that the signs are too imprecise to be interpreted as what her handlers say they mean. Koko's signs do often appear to be vague, coached, or trial-and-error imitations. My opinion falls somewhere between the two positions. Without question, Koko is very intelligent and willing to connect with humans. For me, therein lies the greatness of her contribution to animal science – to let humans see and understand the mind and soul of another creature.

Kanzi is a bonobo, also known as a pygmy chimpanzee. Bonobos are much gentler than chimpanzees, which has made lifelong research with Kanzi possible. (Male chimps become very aggressive at puberty, which is why they are seldom used in long-term studies.) Kanzi was born in captivity in 1980. His researcher is Sue Savage-Rumbaugh, a very well-known figure in the field of primatology. Kanzi lived for many years with other bonobos at Georgia State University. In 2012, he and Savage-Rumbaugh moved to The Great Ape Trust in Des Moines, Iowa. Kanzi does not use sign language to communicate, but rather uses what his handlers call *lexigrams*. These are complex calligraphy-like designs that stand for whole words. He accesses the symbols from a computer screen or on a laminated board for portable purposes.

A significant thing about Kanzi is that he was not specifically drilled and rewarded for remembering the symbols and performing correctly, as all of our previous primate examples were. Instead, he learned in what might be called a natural way, while observing over his adoptive mother's shoulder as she was supposed to be learning lexigrams. The female, Matata, was not a successful learner, but Kanzi excelled. He is also known for his intelligence and sophisticated behavior, comparable to that of a two- or three-year old child, in terms of following complex, multi-step instructions whether conveyed in spoken English or via lexigrams. He is adept at making and using tools (such as lighting a campfire or making flaked stone tools) and at solving problems, and like Koko, he makes up novel and meaningful word combinations.

Another special thing about Kanzi is that he is now the father of a son, Teco. In videos, he can be seen teaching Teco the symbols on the lexigram board and seemingly trying to communicate with him through that medium. That was one of the great hopes for Koko and Michael, and then for Koko and Ndume: that they would reproduce and thereby create a natural environment for the transmission of their learned human system to a new animal generation, for whom it would be a native or natural "first language." Kanzi's family dynamics and his relationship with Teco (and possibly other children to come) bear watching. If the bonobos in Kanzi's group come to use lexigrams across the generations, as they seem to do with each other, this would provide a significant point in the argument that animals like Kanzi truly have acquired a human-like communication system and use it in an authentic way.

Our third extraordinary animal is Rio, a sea lion. She was born in 1985 and was hand-reared in Long Marine Lab in Santa Cruz.

For decades, she has been part of the research team at the Pinniped Laboratory at the University of California Santa Cruz. Research with Rio began with trying to teach her a symbol-like language similar to those used in some of the chimp studies. That soon gave way to intelligence studies involving classification and memory. As documented in many news articles and videos as early as 1993, Rio could recognize very complex symbols as the same or different and do so extremely rapidly. She also learned to associate one symbol with another, in the absence of any logical connection, such as the outline of a snowman with the shape of a banana. She would be presented with the target symbol and match it with one of two others. Then Rio surprised her researchers by taking the further step of identifying the third relationship implicit in the other two pairs. For example if the snowman equals the banana, and the banana equals the pickup truck, then, logically, the pickup truck also equals the snowman, and vice versa. So if A = B, and B = C, then A = C and C = A. Rio was never trained or rewarded on this task. She was simply given the option for the third pair as part of her regular matching game. She matched the novel A = C pair 11 out of 12 times and the C = A pair 17 out of 18, on her first try!

Research with Rio is not a language or communication study per se, but is connected to language in an important way. Rio has demonstrated *equivalence classification*, which was thought to exist only in humans, and she was the first non-human creature to do so. Her ability to do this makes us rethink the relationship between language and logic. Possession of language was thought to be a prerequisite for logical reasoning, since having names for things allows us to classify objects and find equivalence between them. What Rio did so naturally and effortlessly suggests instead that logic may be the prerequisite for and indeed may serve as "an evolutionary precursor" of language. This seems to me to be a very promising direction for thinking about both the origin of human language and the relationship between human language and thought.

Our last example of amazing animal intelligence and communication comes from dolphins, both in captivity and in the wild. Captive dolphins for decades have been tested for complex discrimination tasks and the ability to execute commands involving multiple steps. They have been asked to perform complex synchronized swimming and leaping movements that require communication cues between them for correct timing, or to communicate with each other through a cement pool wall, without seeing each other. Not only can they recognize themselves in a mirror or on television, but they also can recognize that a human whose image they see on an underwater television and who tells them to find an object and "bring it to me" is the same person they see in the pool, and thus are able to deliver the requested object. We have heard stories of wild dolphins performing complex group herding maneuvers to round up fish for easy catching and even rescuing swimmers in distress off the Mediterranean and Australian coasts. Even more remarkable is that this array of amazing feats is not attributable to one or two very gifted dolphins, who might just be the geniuses of their species–as perhaps are Koko, Kanzi, and Rio. No, these are multiple dolphins–sometimes of different species, across the years, in different locations, and with different researchers, trainers, and tasks.

In the realm of language investigations, an August 2013 article published in Proceedings of the National Academy of Sciences of the United States describes work with dolphins in the wild by marine researchers from St. Andrews University in Scotland. Their observations of natural dolphin interaction led them to conclude that each dolphin has a short, recognizable (even by human listeners) sound sequence which they termed its "signature whistle." An individual dolphin consistently gives out its signature whistle when it first joins a group of its fellows. The scientists also found that when a recording of these calls is played, each dolphin recognizes its own call and responds by answering back. A dolphin will answer only to its own signature, not to the signatures of other members of the pod or to random sounds recorded from other dolphin groups. This seems significant; the existence of self-given names and their recognition and use by both the individual dolphin and its fellows indicate self-awareness, semanticity (that is, the connection of a communication element with a meaning unrelated to itself), and a crucial sequenceability within the dolphins' complex sound arrays–all important to human-like communication.

Further, a September 2016, study by Russian researcher Vyacheslav Ryabov of a pair of captive Black Sea bottlenose dolphins has even greater implications. Ryabov believes that the pulses, clicks, and whistles of dolphins' ordinary interactions correlate to human language's phonemes, words, and sentences—in short, it is the dolphins' equivalent of a spoken language. Moreover, he and his team have observed what they consider conversational behavior. The two dolphins, longtime companions, spontaneously exchange sequences of pulses, appear to listen to each other, and then take their turn without interrupting the other. His article in the journal *Mathematics and Physics* has stirred a lot of controversy, much of it among marine biologists. However, if Ryabov's complex data can be authenticated and his conclusions substantiated, it could erode the exceptionality claim for human language. We might then no longer be unique in having a complex, rule-based system of communication.

The consensus among linguists has long been that animal communication, in all of its forms, is essentially different from human language. It is not a matter of being simpler, or more rooted in the now, or mediated through different channels, such as smell, sight, or movement; it is different by its very nature. Human language, with its infinite productive capacity and its rule-based grammar, is of a fundamentally different design from any animal system known. Yet when dolphins introduce themselves to the pod and call each other by name, when gorillas Koko and Michael use little private signed words with each other, when chimp Washoe signs to her baby son, it is tempting to see these behaviors as a knock on the door to a more language-like system. Only time will tell.

Language vs. Animal Communication – Summary:

Knowns

- Animals have far greater cognitive capabilities than has been acknowledged.
- Animal systems of communication are amazingly rich and varied from species to species.
- Yet they are all fundamentally different from human language, and so far as we know now, language is species-specific to humans (*Homo sapiens*).

Unknowns

- What do long-term primate experiments (such as those with Koko and Kanzi) really mean?
- Even if individual animals do use the learned human or human-like symbolic systems with their offspring, does this necessarily alter our view of language as a uniquely human faculty?

Maybes

- The FoxP2 gene, again: what will more studies of how it works in other species reveal about its function, both for human language and for animal communication?
- Dolphins and whales: if any species turns out to have a human-like system of communication (rule-based,innovative rather than imitative, and with syntax), it is likely to be one of them.

IV. The Value of a Linguistic Perspective in Interdisciplinary Matters

Much of what linguists need to expand our own understanding of our subject matter–language–must come from other sources. Unfortunately, the inclusion of linguists in conceiving, planning, and executing such research projects, or even linguists' participation in analyzing the results, is not as regular as it ideally should be. Therefore, the conclusions reached by investigators in other fields are often a mismatch for what we consider our "known knowns" in linguistics, that is, our solid principles concerning what language is and how it works—truths, if you will, which have been refined and tested by centuries of painstaking linguistic analysis. Consequently, if an anthropologist, psychologist, biologist, paleontologist, or neurologist were to speak on the three big questions I have chosen, the knowns, unknowns, and maybes would almost inevitably be very different.

Yet that would not necessarily be an adverse outcome. In these complex matters, linguists need the perspectives, expertise, and data from all relevant fields, just as scholars in those fields likewise need the perspective, expertise and data from linguistics. This sort of interdependence is by no means foreign to linguists; in fact, linguistics, with its many sub-branches—applied linguistics, psycholinguistics, neurolinguistics, sociolinguistics, anthropological linguistics, and the like—is inherently collaborative. Even our less appreciated endeavors of detailed language analysis and description have wider relevance and application. Such research expands our collective knowledge of the range of possible language structures, which in turn informs our understanding of the nature of language in general. In both of those pursuits—the specific and the general--we perform an even more important task: the study of language goes right to the heart of what it means to be human.

Therefore, linguists bring essential knowledge and valuable expertise to a broad range of undertakings—in universities, on review boards, in public education, on cultural preservation committees, among literacy strategists—in fact, wherever there is inquiry into weighty questions like the three we have touched on here or, indeed, any issue involving one of the many facets of language. Thus, in whatever manner science--including linguists—collectively might solve these kinds of deep and abiding questions, or even if the questions must remain forever as tantalizing maybes, by working together from our own places of knowledge, we can come to understand not only the marvel of human language, but also ourselves, our history, our nature, and our place in the world, more completely and from a multitude of perspectives.

Afterword

For the article version of this address, I have kept to my original conference presentation as much as possible. Yet in the intervening months, some things have changed; others have not. Most notably, gorilla Koko has died. She died in her sleep on June 19, 2018, a little more than two weeks before her 47th birthday. A year later, on June 14, 2019, her male companion Ndume, at age 37, returned to the Cincinnati Zoo, per the contract with The Gorilla Foundation. The nearly 50-year-long grand experiment centering on Koko has ended. We will probably never see its like again.

In terms of language origins, the Neanderthal question is no closer to being resolved. As recently as January 29, 2020, an overview of the matter in *Sapiens* digital magazine reported that stakeholders, caught up in DNA and matters of interbreeding, cannot decide what determines a species, let alone decide where Neanderthal falls in that regard. Similarly, the FoxP2 gene has been the subject of numerous articles rejecting more strongly the earlier claims of it being the human language gene and instead focusing on its other roles in communicative behavior and organ functions.

For language and the brain, several recent neurological studies have focused on undocumented roles played by the right hemisphere (rather than the traditional left hemisphere) in processing sounds and in learning the phonology of a new language. Other research has considered the possible involvement of lateralization (separation of functions between the two hemispheres) in language issues manifested in autism and schizophrenia.

Finally, popular media have embraced the idea of dolphin names and dolphin phonemes, those ideas receiving mention in a children's nature show on public television and in science news and popular documentary clips. Newspapers reported in August 2018 that a trained show dolphin released into the wild has taught her wild pod members how to walk on their tails--another example of dolphin ingenuity and adaptability and, some say, the only known example of a mammal passing on human-taught tricks to a wild population. This is interesting linguistically in terms of what type of communication the dolphin might have used to convey the details and specific steps of how to accomplish this feat.

Research reports about our three big questions flow out steadily, and the new information is intriguing and easily accessible. Yet nothing I have read in the interim has debunked any of my knowns, moved any of my unknowns into the maybes, or any of my maybes into the knowns. I hope this written version of my speech will prompt those who shared it with me that evening, as well as other readers, to join me in tracking the progress of our knowledge on these and other marvels of language.