Animal Linguistics

HOW HUMAN LANGUAGE DEVELOPED FROM ANIMAL COMMUNICATION

By **Fritz Josephsen**

Living in the middle of a consciousness revolution, new insight comes from the strangest of places. In the past few decades, geneticists, neuroscientists, psychologists, sociologists, economists and others have made huge progress towards understanding the inner workings of the human mind. The pieces of information presented now give us a better grasp of human character, emotion, social bonding, and human communication. In many ways, the gap left void by theology and widened by philosophy is being filled by brain science.

To give us a sense of this consciousness revolution let's consider human language. The leading authority on language development, MIT scientist Noam Chomsky, hypothesized that a specific aptitude for language is encoded in the human brain at birth. According to Chomsky, this so called 'language organ' is responsible for the human brain's capacity to understand complex communication. Possessing the language organ is to be equipped with a type of universal grammar, a set of rules that is shared by all languages.

A distinction between communication and language must be established. Communication encompasses all exchange of information that is verbal and non-verbal. Facial expressions, body gestures, visual art, mimicry, and even odor signals are methods of communication. Language, however, is a tool invented by humans in order to communicate more effectively. Chomsky and other psycholinguists have studied the properties of human languages to gain an understanding of specific characteristics of human intelligence. This effort by linguists is an attempt to learn something about human nature. Now, looking towards animal communication, the very foundations of human language can be assessed. Aside from humans, many animals have relied upon communication systems to form complex social bonds, and thereby create intricate societies. Studying communication by animals reveals the workings of simpler brains, which has the potential to teach us about our own brains.

For ages, language has been described as a talent unique to human beings. This ability to transmit encoded thoughts from one individual mind to another is perhaps the basis for all human advancement. Human beings sharing ideas has led to a larger, species-wide awakening. Sharing ideas caused an enlightenment that gives us an advantage over other creatures and has given birth to the modern day. But how are we so adept at sharing thought? Where did this "language organ" come from? Can archaeological research elucidate an understanding of language's birth, or is it lost to time? Attempts to teach other great apes language has generated more controversy than it has illumination; how then, can we go about discovering this foundation of language?

The first hint of an early human tongue may not lie in an ancient African tomb, but in another living animal. Perhaps that animal is swimming in the oceans. Maybe it's flying in the air. Clearly, forms of animal communication fall short of language, but their feats of socialization warrant attention by the larger scientific community. These beasts of the wild have communication systems advanced enough to both utter and perceive specific sounds. Some species can even learn new units of sound then combine these sounds to create new meaning!

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Vocal learning is a remarkable ability that is rare amongst the animal kingdom. Most communicative animals have a sound's meaning pre-recorded from birth; very rarely are sounds learned after birth. The vervet monkey is famous for its use of distinctive alarm calls.

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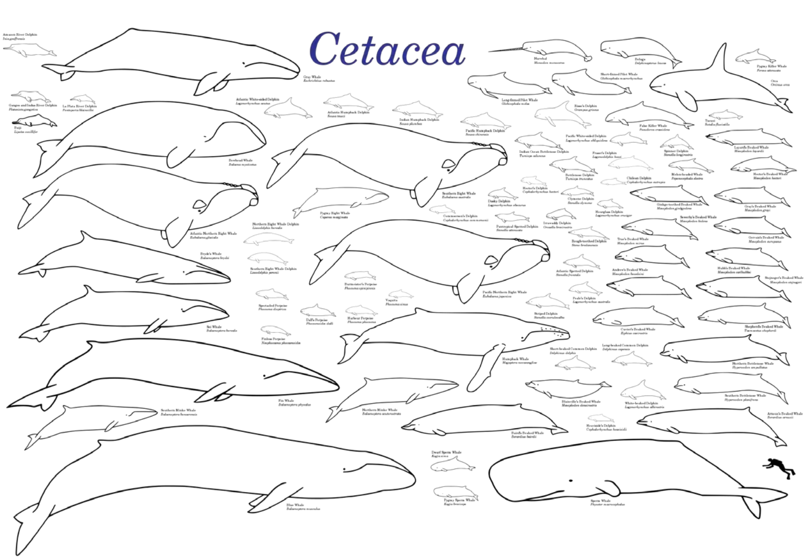
These alarm calls indicate specific predators, such as leopards, eagles, or snakes, to be in the area. These alarm calls are learned just after birth and are never relearned or replaced throughout life.[1]

While vervet monkeys represent vocal learning animals that acquire knowledge of vocal calls during a single period of life, other animals learn and relearn vocal signals throughout their lifespan. Cetaceans are a clade of 89 extant species of aquatic mammals that are experts at learning signals.[2] This clade includes: porpoises, dolphins, and whales. Baleen whales have been found to learn songs after birth and learn new songs seasonally. Toothed whales use learned auditory signals to maintain their social relationships which change daily for hunting purposes. Likewise, bottlenose dolphins' use learned sounds referentially to determine individuals within a pod.

One incredible aspect to bottlenose dolphin communication is their signature whistle. In a pod of dolphins, each dolphin will call out a distinctive whistle representing an individual dolphin's name.[2,3] In the deep murky waters of the ocean, wild free-ranging bottlenose dolphins will call their



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signature whistle to alert others in the pod of their location. Dolphins familiar with the caller will repeat that signature whistle, as if echoing another’s name. If a dolphin hears it’s own signature whistle it is very likely to respond. Whereas, if a dolphin hears the whistle of a familiar dolphin it is slightly less likely to respond. Dolphins will never respond to unheard whistles.[2,3] This name-calling behavior is the foundation for every dolphin pod’s unique hierarchical structure.

Still, dolphin communication is not limited to name-calling. Dolphins frequently emit their whistles and clicks to communicate with one another, but they also are able to use echolocation to communicate. Echolocation enables all cetaceans to send out sound waves, which allow them to identify location, shape, and size of distant objects in the water. This biological sonar allows cetaceans to orient themselves, detect their prey, and coordinate hunting tactics. In fact, echolocation allows dolphins to hear and produce some of the highest frequency sounds of all mammals. In perspective, humans have a hearing range from about 20 Hz to 20kHz, whereas dolphins have a hearing range that exceeds 150kHz.[4] This intense range of sound detection has led many scientists to speculate that dolphin communication is more advanced than previously thought. Some have even argued the possibility of dolphins having a language system of their own, a language system which humans would be unable to detect.

A recent study popularized by the Ted Talk, “Could we speak the language of dolphins?”, looked into the question of dolphin’s having the capacity for language. Performed in collaboration between leading researcher of cetacean intelligence Denise Herzing, and computer scientists at Georgia Tech, a device was created to bridge the gap between human language and dolphin communication. The device called CHAT (Cetacean Hearing and Telemetry) contains a microphone able to detect the entire acoustic range of dolphins. Furthermore, with the touch of a button, this device can repeat any signature whistle recorded in the wild.[4] Using this device, free-diving researchers were able to communicate with dolphins to form temporary alliances with the pods of dolphins in the wild.[4] Using this communication the divers were able to play games with the dolphins, such as passing a scarf from one individual to another. Shockingly, the animals began to reference the researchers with signature whistles! In this way, the human researchers were integrated into the pod, and even assigned names by the dolphins.

“Dolphins familiar with the caller will repeat that signature whistle as if echoing another’s name.”

There are many theories regarding how cetaceans developed complex communication systems. Morphological studies have compared dolphin brain cryoarchitecture to that of other highly social aquatic and terrestrial species. These studies have shown that cetaceans posses the largest brain in absolute size related to body mass.[5] There have been several confounding theories presented to explain their brain development as being distinct from other mammals. Many of these theories assert that readapting to an aquatic environment has influenced their brain development; however, the scientific community now largely refutes these theories. After whole and sectional morphological analyses the structural complexity of their brains has been linked with sociality and cognition. In particular, the high density of Von Economo neurons, characterized as having extended axons for fast neural information transfer, has been credited as being highly involved with aquatic mammalian learning, memory, and spatial navigation pathways.[6] This finding is notable, as a quality of human brain communication areas are a particularly high density of Von Economo neurons.[6] The high density of these neurons is a quality of human brain language centers that is shared by the cetacean brain.

However, dolphins are not the only animal to display complex social behavior, nor are they the only animal to have the ability to communicate using ultrasonic frequencies. Indeed, bats are equipped with this same biosonar and can produce and detect up to 250kHz soundwaves. Evolutionary scientists believe these two animals convergently evolved,[7] or independently developed these traits. That means these two animal groups having the ability to produce, detect, and interpret ultrasonic waves does not give evidence of a similar lineage between these two animal groups.

Bat vocalizations have been shown to be even more complex than dolphin whistles,[8] and for good reason. While bottlenose dolphin pods may merge to form superpods with over 1,000 individuals, a bat colony can contain up to a million bats! Remarkably, bats make up a quarter of all mammalian species on Earth. These highly social animals need to communicate amongst their colonies to cooperate on migration patterns.

To compare bat vocalizations with human language, first, human sentences must be broken down into discrete parts. In a single sentence, a human can: distinguish another person's voice, understand meaning from words spoken, and understand a speaker's intention by tone of voice. Human speech parallels bat vocalizations on a number of levels. A single Egyptian fruit bat vocalization has been shown to include

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information about: the identity of the emitter, context of the call, behavioral response to the call, and even the addressee of the call.[8]

In morphological studies comparing the brain sections of bats, shrews, mice, rats, and humans, the organization of calbindin-cholinergic cells shows a marked difference in bat and human brain than that of the rodent brain.[9] In bat and human brains, cholinergic innervation avoided calbindin patches, this showed intermittent entorhinal theta activity, whereas rodent brains entorhinal theta activity features cholinergic innervation within calbindin patches.[9] A common factor between bats and humans caused selective pressure for this conservation of cholinergic stellate and pyramidal cells avoidance of calbindin patches. This means that bat brains have developed more complex brain structures than their more related cousin species in order to allow for more advanced social behavior. Still, in comparing cell distribution patterns, bat brains are not as advanced as human brains. Between human and bat medial as well as caudal entorhinal cortices, relative neuron numbers of these calbindin patches was not constant.[10]

How have bat brains become more advanced than closely related rodent species? A species' brain morphology is almost entirely dependent upon that species' genetics. Even the amount of a gene expressed during an individual animal's development can alter that animal's brain structure. New research is ending the idea that the origins of language are lost in time. Linguists can no longer ignore the archaeological clues emerging from genetics.

Almost two full decades ago the gene related to a developing brain's communication center was identified. The FoxP2 gene has been recognized as the gene involved with development of speech and language areas of the brain.[3,11,12] This gene displays extreme conservation in sequence across all bird species having very low rates of substitution. In fact, all animals show high conservancy of this gene. Between zebrafish and humans, the FoxP2 gene has been shown to be 98% similar.[11,12] This gives evidence suggesting its huge involvement in animal development. Avian species have shown location dependent and seasonal dependent expression of this gene. Meaning, whether the songbird is in its mating season, FoxP2 will be more or less expressed. Differential expression of FoxP2 in avian vocal learners is associated with vocal plasticity.[3]

While, as one might expect, dolphins and bats do not have special versions of this gene, they do however, express higher levels of FoxP2 genes during fetal development than comparative animals. During brain development, dolphins and bats have similar FoxP2 relative expression patterns as humans.[11]

Dolphins and Bats are two examples of animals that have developed complex communicative behaviors. These behaviors have become essential parts of these animals' lifestyles. We now understand the behavioral, morphological, and genetic conditions that animals must meet in order to possess a capability for complex communication.

These two animals live in social groups and depend upon these groups for their longevity. Dolphin and bat brains feature large centers that are used for communication. Perhaps given another few thousand years for these animals to develop, a definitive language will be created. Indeed, the only key element of language these animals seem to be without is what linguists call "recursion," or the mind's ability to create a phrase based off another into the syntax of an elaborate sentence. It is believed that early humans attained this ability from the use of another brain system, such as the system animals use for navigation.

For a long time biologists and linguists have purposefully inhabited different worlds, because linguists take little interest in evolution, which is the fundamental theory of biology. Any hypotheses put forward regarding the evolution of language, therefore, is promptly contested. However, since the FoxP2 gene breakthrough shook science nearly two decades ago, a solid hypothesis regarding the origin of language has been put forward.

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The evolutionary theory of the origin of complex human language follows the gradualism model of evolution, meaning that language developed gradually over time, without rapid bursts on the evolutionary time scale. The "sexual selection information-sharing hypothesis" states that vocal learning causes more selective mating preferences.[13] These selective mating preferences, in turn, cause the next generation of offspring to produce equally or more complex vocalizations. This hypothesis hinges upon information-sharing from one generation to the next occurring during the language acquisition period.[13,14] The human language acquisition period peaks at around six years of age with the window of opportunity to naturally pick up on a language declining after this age. This hypothesis was imagined after better understanding the foundations of language, that is, after understanding other forms of animal communication.

The age-old mystery, "Where did human language originate?" is being solved. With new insight from genetics, and an understanding supported by observing animal forms of communication, human language can be traced back to the time before our globalized world's effective communication. Back to a time before the consciousness revolution, before written, or even, spoken history was recorded.

Only after making sense of animal communication can we imagine the pre-neolithic world:

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early hominids communicating abstract thoughts vocally, but not yet speaking a set language. Entire generations of early hominids lived within a community and underwent vocal learning during their language acquisition periods. With each generation, an expansion arose in the community's vocal repertoire. Within-group communication became easier while between-group communication became more difficult. Hence, sexual selection favored information sharing.

This pre-neolithic world is analogous to the pre-globalized world, which had many distinct languages, limiting genetic information transfer. This theory states that for much of human history, kin selection has been determined by an individual's ability to communicate with one another, which was determined from birth. Finally, amongst these early hominid groups, different vocal repertoires further increased and diverged. Communication better represented complete thoughts until, tremendously, it happened. Language was born.

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