'Uniquely human' component of language found in gregarious birds

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Photo by Daniel D. Baleckaitis

Although linguists have argued that certain patterns of language organization are the exclusive province of humans — perhaps the only uniquely human component of language — researchers from the University of Chicago and the University of California San Diego have discovered the same capacity to recognize such patterns and distinguish between them in Sturnus vulgaris, the common European starling.

In the April 27, 2006, issue of *Nature*, the researchers show that these

starlings — long known as virtuoso songbirds and expert mimics — can be trained to reliably discriminate between two different patterns of organizing the sounds they use to communicate.

"Our research is a refutation of the canonical position that what makes human language unique is a singular ability to comprehend these kinds of patterns," said Timothy Gentner, assistant professor of psychology at UCSD and lead author of the study. "If birds can learn these patterning rules, then their use does not explain the uniqueness of human language."

The researchers focused on recursion, or center-embedding, a characteristic, found in all human languages. Recursion is one way of creating of new and grammatically correct meanings by inserting words and clauses within sentences — theoretically, without limit. So, for example, "The bird sang," can become "The bird the cat chased sang."

Following the lead of language theorist Noam Chomsky, linguists have held that this recursive center-embedding is a universal feature of human language and, moreover, that the ability to process it forms a unique computational ability important for human language.

"Linguists have developed a mathematically rigorous set of definitions, a hierarchy of syntactical complexity, that governs the process of how humans create and understand utterances," said Daniel Margoliash, professor of anatomy and organismal biology at the University of Chicago and co-author of the study. "These rules govern how to properly express yourself — how to structure your phrases and sentences.

Language experts have used properties of these rules, whose complexity is described by the Chomsky hierarchy, "to define the boundaries between humans and other creatures," said Margoliash. "Now we find that we have been joined on this side of that boundary by the starling. It should no longer be considered an insult to be called a bird brain."

Although they are not known for the lilting beauty of their songs, starlings produce an amazing array of complex sounds, combining chirps, warbles, trills and whistles with rattling sounds.

They also have a talent for mimicry. One starling famously copied an unpublished tune that Mozart whistled in a pet store; the composer purchased the bird and kept it as a pet. The starling is mentioned only once in all of Shakespeare, but in that passage an angry warrior, forbidden by the King to speak of a rival, Mortimer, decides he will "have a starling shall be taught to speak nothing but 'Mortimer,' and give it him to keep his anger still in motion." (Because of this passage, 100 European starlings were first introduced to New York City's Central Park in the 1890s. They flourished. North America now has an estimated 200 million starlings.)

One previous study, however, suggested that even non-human primates are incapable of recognizing anything beyond the simplest syntax. A paper published in Science in 2004 by scientists at Harvard and MIT found that cotton-top tamarin monkeys were not able to master higher-level grammar patterns. "The acquisition of hierarchical processing ability," the authors of that paper conclude, "may have represented a critical juncture in the evolution of the human language faculty." They also noted that vocal learners, such as songbirds, might have produced different results.

"When I saw that study I was not convinced of the significance of the failure of the monkeys," said Howard Nusbaum, chairman and professor of psychology at the University of Chicago and senior author of the Nature study. "There are many ways for an experiment to fail and most failures are not scientifically interesting. I immediately thought: we could do that in starlings."

Nusbaum, Margoliash and psychologist Kimberly Fenn had previously

collaborated on studies of the role of sleep in speech perceptual learning. Gentner, a neuropsychologist, expert on starlings and, at the time, a postdoctoral fellow at the University of Chicago, was an essential addition.

To assess the birds' syntactical skills, the research team exploited the diverse sounds in starling songs. They recorded eight different 'rattles' and eight 'warbles' from a single male starling and combined them to construct a total of 16 artificial songs. These songs followed two different grammars, or patterning rules.

Eight songs followed the "finite-state" rule, the simplest sort, thought to account for all non-human communication. A finite-state grammar allows for sounds to be appended only at the beginning or end of a string. These songs were built up from a rattle-warble base by adding rattle-warble pairs at the end. The simplest song (ab) was one rattle followed by one warble. The next simplest a rattle, then a warble, followed by a different Rattle and Warble (abAB).

The other eight songs followed the "context-free" rule, which allows for sounds to be inserted in the middle of an acoustic string, the simplest form of recursive center-embedding. So a context-free sequence also began with rattle-warble base (ab) but built up by inserting new sounds in the middle, such as rattle-Rattle-Warble-warble (aABb).

Eleven adult birds were given lessons on distinguishing between these two sets of songs using classic reinforcement techniques. The birds were rewarded with food when they heard a song from the context-free set and for refraining when they heard one from the finite-state set.

After 10,000 to 50,000 trials over several months, 9 of 11 tested starlings learned to distinguish the patterns. The birds were not simply memorizing particular sequences of rattles and warbles they could

distinguish between different patterns even when presented with entirely new sequences of rattles and warbles. They were applying rules to solve the task.

The researchers also checked to see how the birds responded to "ungrammatical" strings, songs that violated the established rules. The starlings treated these differently, as expected if they had learned the patterns.

The experimenters then asked if the birds were capable of a key feature of human grammars. Could the starlings extrapolate these patterning rules to distinguish among longer strings? Remarkably, after learning the patterns with shorter songs made up of two pairs of rattles and warbles, the birds were able to recognize strings containing 6-to-8 song elements (abababab — vs — aaaabbbb).

The finding that starlings can grasp these grammatical rules shows that other animals share basic levels of pattern recognition with humans. "There might be no single property or processing capacity," the authors write, "that marks the many ways in which the complexity and detail of human language differs from non-human communication systems."

"It may be more useful," they add, "to consider species differences as quantitative rather than qualitative distinctions in cognitive mechanisms."

"The more closely we understand what non-human animals are capable of," Gentner said, "the richer our world becomes. Fifty years ago, it was taboo to even talk about animal cognition. Now, no one doubts that animals have complex and vibrant mental lives."

"When I describe our results to linguists and psycholinguists, they are amazed," Nusbaum said. "When I mention them to people who study

animal behavior," Margoliash countered, "they are not surprised. They are well aware of the cognitive abilities of many animals."

"These birds are a lot smarter than you might think," Margoliash said. "They have innate abilities. They solve interesting problems and learn difficult tasks. Any number of times during the experiments I said 'they can't possibly do that,' and they did."

"There has long been a temptation," writes cognitive neuroscientist Gary Marcus of New York University in a commentary, "to sum up the differences between human and other species in a neat turn of phrase — but most posited differences turn out to have been overstated."

But these iridescent six-inch, three-ounce singing black birds have known this all their lives. They were only waiting for this moment to arise.

Source: University of Chicago