MAX PLANCK SOCIETY

Press Release

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Chatty Finches

Max Planck Scientists and their American co-workers identified "Speech-Gene" in songbirds

Mutations in the so-called FOXP2 gene are associated with a specific speech deficit, affecting articulation and comprehension of language. Apparently FOXP2 plays a central role in the development of speech. Neurobiologists now report that FOXP2 could also play a key role for the ability of birds to learn song. Scientists from the Max Planck Institute for Molecular Genetics in Berlin and from Duke University, USA, discovered an almost identical version of FoxP2 in songbirds and could then show that the corresponding protein was expressed in brain regions critical for song learning. These results were reported in the March 31st issue of the Journal of Neuroscience.

In 2002 Svante Pääboo's group at the Max Planck Institute for Evolutionary Anthropology in Leipzig compared the DNA sequence of the intact FOPX2 gene in humans and chimpanzees. They found that the human gene carried a unique sequence variation that was estimated to have evolved roughly at the same time as language is thought to have emerged in the hominid lineage. Because FOXP2 is a transcription factor, i.e. a protein that regulates the activity of many other genes, the sequence changes of FOXP2 in the hominid lineage could, in the course of evolution, have triggered a chain of events. The Leipzig team found evidence that indicate that the human version of FOXP2 was advantageous for the individuals that carried it and suspect that it could have been pivotal for the origin of human language.

Young birds of many species need to learn the sounds they communicate with in a manner akin to the way infants learn to speak, which is in contrast to mice and non-human primates who don't learn their vocalizations. Constance Scharff, head of the Neurobiology group at the Max Planck Institute for Molecular Genetics, therefore asked whether the songbird FoxP2 carried sequence variations similar to those found in humans. Together with Sebastian Haesler in her group and her colleagues Erich Jarvis and Kazuhiro Wada at Duke University they compared the expression of FoxP2 in a variety of bird brains. Among those were song-learners, such as zebra finches, canaries, chickadees, sparrows, hummingbirds, parakeets, and non-learners, e.g. pigeon and chicken. In addition, the scientists studied the gene in the closest relative of birds, the crocodile.

The first part of the study determined when and where the gene was expressed. Was FoxP2 expressed in brain regions that control singing? Was it expressed during learning of song, or during singing itself, and what happens when the learning is finished? In addition, the team analyzed the sequence of the zebra finch gene and compared it to the human sequence. They found that the FoxP2

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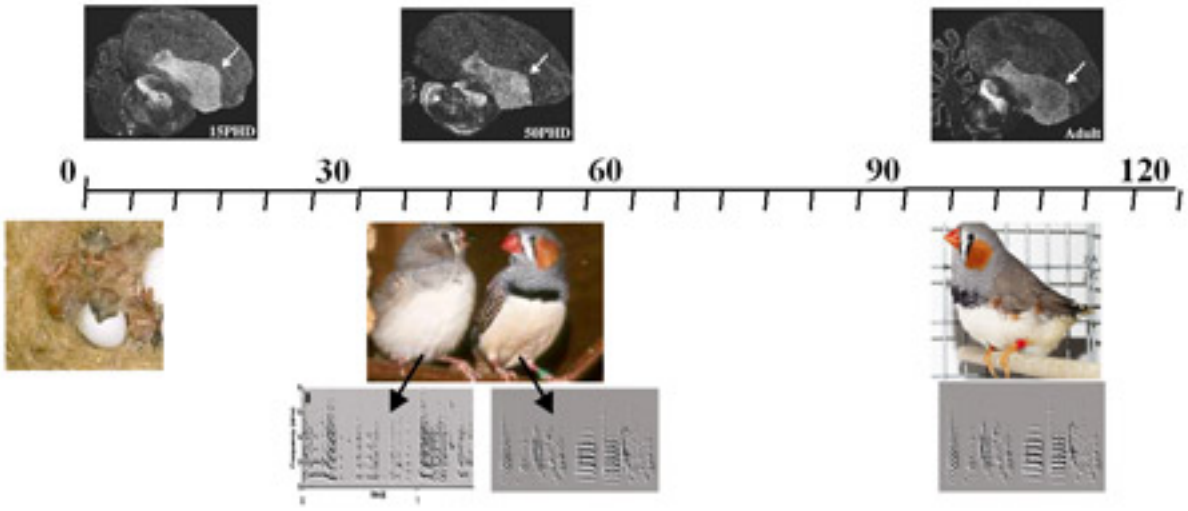
gene from finches was extremely similar to the human version, but did not carry the human-specific sequence variation.



Developmental plasticity of FoxP2 expression in zebra finches: The time line indicates the age of the bird. At left, a hatchling emerges from the nest (day 1), to the right a young male is shown sitting next to his adult male tutor (sonograms of their respective songs shown underneath). Far right the young bird has reached adulthood and has learned to imitate his tutors song (compare sonograms). The images above the time line show FoxP2 expression in brain sections of birds at the different ages (regions of high FoxP2 expression are white). A brain region essential for song learning, Area X, expresses more FoxP2 only at the time (50 days) when song learning occurs.

Image: MPI for Molecular Genetics

"Apparently, the human-specific version is not essential for songlearning in birds", says Constance Scharff, "or other variations that exist in the songbird version of the gene helped develop this ability". In collaboration with the Leipzig team of Max Planck scientists they are comparing FoxP2 sequences of song-learning birds with those of non-learners to see whether differences exist similar to those found between humans and chimps.

Certainly, the FoxP2 brain expression pattern the scientists now report is striking. The gene is expressed in bird brains in a manner astonishingly similar to the distribution in mammalian brains, including humans. What's more, expression in the Basal Ganglia, which help coordinate sequenced movements, peaks around the time of song learning, which in zebra finches occurs just once during development, but recurs seasonally in canaries. "We could show that FoxP2 levels increased in a basal ganglia region that is specialized for song learning, just at the time when song changes in both finches and canaries" Scharff explains.

Based on these findings the scientist now hope to extend their studies to elucidate the role this gene plays in shaping the architecture and function of brain circuits that control song learning and song production. "The discovery of FoxP2 in birds is only the beginning, there is no direct evidence yet that the gene is necessary for song learning or singing," cautions Scharff. Experiments to interfere with the expression of the gene using molecular tools to see whether it is really necessary for song learning are therefore top priority for the lab.

[CB]

Original work:

S. Haesler, K. Wada, A. Nshdejan, E. Morrisey, E.K.T. Lints, E.D. Jarvis, and C. Scharff
FOXP2 Expression in Avian Vocal Learners and Non-Learners
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