

Changes in the path of brain development make human brains unique

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How the human brain and human cognitive abilities evolved in less than six million years has long puzzled scientists. A new study conducted by scientists in China and Germany, and published December 6 in the online, open-access journal *PLoS Biology*, now provides a possible explanation by showing that activity levels of genes in the human brain during development changed substantially compared to chimpanzees and macaques. What's more, these changes might be caused by a handful of key regulatory molecules called microRNAs.

The authors studied [gene activity](#) in human, chimpanzee and macaque brains across their lifetimes. Starting from newborns, they investigated two [brain regions](#); the cerebellum, which is responsible for motor activity, and the prefrontal cortex, which has roles in more complex behavior such as social interactions or abstract thinking. They first studied the simple gene activity differences between species that are seen at all ages. Although many genes show such simple differences, there was no disparity in numbers of these differences between the human and the chimpanzee [evolutionary lineages](#). Moreover, most of these differences were observed in both of the brain regions studied, and the genes involved are not thought to be specifically involved in [brain function](#). In the opinion of Mehmet Somel, the lead author of the study, these differences represent evolutionary "white noise" and have little importance for human brain evolution.

The authors then looked for changes in gene activity during development, comparing the activity of genes in newborns and adults. In

general, brain developmental patterns tend to be quite similar in humans, other [primate species](#), and even mice. Nevertheless, the authors found that for hundreds of genes, humans display unique developmental patterns, with profiles that were different in shape and/or timing from those found in chimpanzees and macaques. Such human-specific developmental gene [activity patterns](#) were particularly widespread in the prefrontal cortex, where genes showing human-specific changes outnumbered genes showing chimpanzee-specific changes by four-fold. Developmental patterns in the cerebellum, by contrast, were much less human-specific. Furthermore, many genes displaying these human-specific patterns in the prefrontal cortex were known to have specific neural functions, implying roles in human cognitive development.

Looking for possible causes of this widespread developmental remodeling in the human prefrontal cortex, the authors stumbled upon an unexpected signal. Developmental patterns of genes that encode microRNAs (tiny but powerful regulators that target many other genes and processes) showed even greater excess of human-specific changes in the [prefrontal cortex](#) than did comparable developmental patterns in ordinary genes. Several of these changes in microRNA activity could be directly linked to human-specific changes in activity of their target genes. Since each microRNA may regulate the activity of hundreds of other genes, this finding provides a possible explanation to how hundreds of genes changed their activity patterns (in a coordinated way) during human brain development.

This result further implies that the evolution of human cognitive abilities might be traced back to a small number of mutations in key developmental regulators. Philipp Khaitovich, the senior author of the study, suggests that "identifying the exact genetic changes that made us think and act like humans might be easier than we previously imagined". This said, it is likely to require much more work with a focus on the dynamics of brain development and wider use of transgenic mice, and

even primate models.

Further to this, the authors point out that identification of the key human-specific DNA mutations could help us to determine how close the Neanderthals' cognitive abilities were to ours. "If Neanderthals' brain development was similar to that of [chimpanzees](#) and [macaques](#), it would be no wonder that they became extinct when confronted by Modern Humans," says Mehmet Somel.

More information: Somel M, Liu X, Tang L, Yan Z, Hu H, et al. (2011) MicroRNA-Driven Developmental Remodeling in the Brain Distinguishes Humans from Other Primates. *PLoS Biol* 9(12): e1001214. [doi:10.1371/journal.pbio.1001214](https://doi.org/10.1371/journal.pbio.1001214)

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