Differences in human and Neanderthal brains set in just after birth

November 8 2010

The brains of Neanderthals and modern humans are very similar at the time of birth. A reconstruction of a Neanderthal baby is compared to a modern human newborn. While the face of the Neanderthal is already larger than in a modern human at the time of birth, their brain shapes and volumes are very similar. Internal casts of brain cavities of skulls (Neanderthal: red; modern humans: blue) provide information about the relative size and form of the brain. Image: Max Planck Institute for Evolutionary Anthropology

(PhysOrg.com) -- The brains of newborn humans and Neanderthals are about the same size and appear rather similar overall. It's mainly after birth, and specifically in the first year of life, that the differences between our brains and those of our extinct relatives really take shape, according to a report published in the Nov. 9 issue of *Current Biology*.

Whether cognitive differences exist between modern humans and Neanderthals is the subject of contentious disputes in anthropology and archaeology. Because the brain size range of modern humans and Neanderthals overlap, many researchers previously assumed that the cognitive capabilities of these two species were similar. Among humans, however, the internal organization of the brain is more important for cognitive abilities than its absolute size is. The brain's internal organization depends on the tempo and mode of brain development.

Based on detailed measurements of internal shape changes of the braincase during individual growth, a team of scientists from the MPI has shown that these are differences in the patterns of brain development between humans and Neanderthals during a critical phase for cognitive development.

Discussions about the cognitive abilities of fossil humans usually focus on material culture (e.g. the complexity of the stone tool production process) and endocranial volumes. "The interpretation of the archaeological evidence remains controversial, and the brain-size ranges of Neanderthals and modern humans overlap," says Jean-Jacques Hublin, director of the Department of Human Evolution at the MPI-EVA in Leipzig where the research was conducted. Hublin adds, "our findings show how biological differences between modern humans and Neanderthals may be linked to behavioural differences inferred from the archaeological record."

Nature of the evidence: As the brain does not fossilize, for fossil skulls, only the imprints of the brain and its surrounding structures in the bone (so called "endocasts") can be studied. The researchers used state-of-the-art statistical methods to compare shape changes of virtual endocasts extracted from computed-tomographic scans. The distinct globular shape of the braincase of adult Homo sapiens is largely the result of a brain development phase that is not present in Neanderthals.

One of the key pieces of evidence was the skull reconstruction of a Neanderthal newborn. In 1914, a team of French archaeologists had excavated the skeleton of a Neanderthal baby at the rock shelter of Le

Moustier in the Dordogne. The original bones of the skeleton had been lost to science for more than 90 years, until they were rediscovered among museum collections by Bruno Maureille and the museum staff. The restored original baby bones are now on permanent display at the Musée National de Préhistoire in Les Eyzies-de-Tayac-Sireuil. The museum's director Jean-Jacques Cleyet-Merle made it possible to scan the delicate fragments using a high-resolution computed-tomographic scanner (µCT). Using computers at the Max Planck Institute's virtual reality lab in Leipzig, Philipp Gunz and Simon Neubauer then reconstructed the Neanderthal baby from the digital pieces, like in a three-dimensional jigsaw puzzle. "When we compare the skulls of a Neanderthal and a modern human newborn, the Neanderthal's face is already larger at the time of birth. However, most shape differences of the internal braincase develop after birth," explains Gunz. Both Neanderthals and modern human neonates have elongated braincases at the time of birth, but only modern human endocasts change to a more globular shape in the first year of life. Modern humans and Neanderthals therefore reach large adult brain sizes via different developmental pathways.

In a related study the same team of MPI researchers had previously shown that the developmental patterns of the brain were remarkably similar between chimpanzees and humans *after* the first year of life, but differed markedly directly after birth. "We interpret those aspects of development that are shared between modern humans, Neanderthals, and chimpanzees as conserved," explains Simon Neubauer. "This developmental pattern has probably not changed since the last common ancestor of chimpanzees and humans several million years ago." In the first year of life, modern humans, but not Neanderthals, depart from this ancestral pattern of brain development.

Establishing when the species differences between Neanderthal and modern human adults emerge during development was critical for understanding whether differences in the pattern of brain development might underlie potential cognitive differences. As the differences between modern humans and Neanderthals are most prominent in the period directly after birth, they likely have implications for the neuronal and synaptic organization of the developing brain.

The development of cognitive abilities during individual growth is linked to the maturation of the underlying wiring pattern of the brain; around the time of birth, the neural circuitry is sparse in humans, and clinical studies have linked even subtle alterations in early brain development to changes in the neural wiring patterns that affect behaviour and cognition. The connections between diverse brain regions that are established during this period in modern humans are important for higher-order social, emotional, and communication functions. It is therefore unlikely that Neanderthals saw the world as we do.

The new study shows that modern humans have a unique pattern of brain development after birth, which separates us from our closest relatives, the Neanderthals. This uniquely modern human pattern of early brain development is particularly interesting in light of the recent breakthroughs in the Neanderthal genome project. A comparison of Neanderthal and modern human genomes revealed several regions with strong evidence for positive selection within Homo sapiens, i.e. the selection occurred after the split between modern humans and Neanderthals. Three among these are likely to be critical for brain development, as they affect mental and cognitive development.

"Our findings have two important implications," says Philipp Gunz. "We have discovered differences in the patterns of brain development that might contribute to cognitive differences between modern humans and Neanderthals. Maybe more importantly, however, this discovery will tell us more about our own species than about Neanderthals; we hope that our findings will help to identify the function of some genes that show evidence for recent selection in modern humans."

More information:

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Provided by Cell Press

Citation: Differences in human and Neanderthal brains set in just after birth (2010, November 8) retrieved 26 April 2024 from https://phys.org/news/2010-11-differences-human-neanderthal-brains-birth.html

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