Human Brain Evolution Laboratory

Director: Assistant Professor P. Thomas Schoeneman, Department of Anthropology

At the Human Brain Evolution Laboratory, medical technologies such as computed tomography (CT), magnetic resonance imaging (MRI), and computer modeling are used to study the evolution of the brain, with special reference to the skull and fossil endocasts. The following are a few of the ongoing research projects.

<u>Genetics and Human Brain Growth Study</u>

This study explores whether there is an association between normal variation in human brain anatomy and specific genes which we believe have played a role in the expansion of the cerebral cortex in humans. With the collaboration of Dr. Thomas F. Budinger from the Department of Nuclear Medicine and Functional Imaging, Lawrence Berkeley National Laboratory and Dr. Bruce Lahn from the Department of Human Genetics, University of Chicago, brain scans of normal subjects will be analyzed along with DNA obtained from these subjects.

<u>Functional Brain Imaging of Stone Tool Manufacturing</u>

The focus of this study is to explore what cognitive resources are required in stone tool making, a significant early hominid activity. In collaboration with Dr. Britton Chance and Dr. Shoko Nioka from the Department of Biochemistry and Biophysics, University of Pennsylvania, who developed a non-invasive light technique to record active brain responses, the brain activity of subjects with a variable range of stone making expertise are recorded.

<u>Chimp-Human Brain Morphology Differences</u>

In collaboration with Dr. James Gee and Brian Avants from the Department of Radiology, University of Pennsylvania, we are quantifying human-chimp brain differences by morphing chimp brains into human brains (and vice-versa). The distortion fields describing this process results in a 3D map of differences between the species.

<u>Left-Right Asymmetries in Chimpanzee Brains and Possible Associations with Handedness</u>

In collaboration with Dr William Hopkins at Yerkes National Primate Research Center and Dr. James Gee and Brian Avants from the Department of Radiology, University of Pennsylvania, we are quantifying left-right asymmetries using advanced imaging techniques on their MR images. This will allow us to determine whether there are any associations with the known handedness of each chimp.

<u>Brain/Behavior Associations in Humans</u>

In order to properly interpret anatomical changes in human brains that occurred during human evolution, we are continuing investigations into the associations between brain anatomy as assessed by MRI, and behavioral abilities on a range of cognitive tasks. With Dr. James Gee and Brian Avants from the Department of Radiology, University of Pennsylvania, we are quantifying anatomical variation on a 3D, voxel-by-voxel basis.

We have just completed a 2D study of the corpus callosum, showing that women with more male-like splenia (posterior portion) do better on mental rotation spatial tasks.

Penn Cranial CT Project

The Penn Cranial CT Database contains high resolution (sub-millimeter) CT scans of human and non-human crania from Penn's Museum specimens, as well as those gathered through contributions from other institutions, such as American Museum of Natural History, Smithsonian Institution, and Columbia University Department of Anthropology. The database is stored on computers in the Human Brain Evolution Laboratory (http://www.sas.upenn.edu/~ptschoen/lab.html), and is continually growing as new scans are obtained. It is hoped the database will become a clearing-house for CT data useful to researchers in anthropology, biology, and medicine. We are presently working to make these data available online, so that they may be easily accessible to researchers worldwide.

Precise Descriptions of Fossil and Modern Cranial Morphological Variations

To further illuminate the question of how modern humans evolved, researchers in the Human Brain Evolution Laboratory, in collaboration with Dr. Janet Monge at the Museum of Anthropology, University of Pennsylvania and Dr. James Gee from the Department of Radiology, University of Pennsylvania, are using methods adapted from medical imaging research to more accurately describe variations in the morphology of fossil crania, as compared to the variations in modern human and primate crania. The use of MR imaging and computer modeling allow researchers to gather precise morphological measurements, and provides a more precise means of testing hypotheses that have relied on more typical, but more subjective/less precise, measurements using instruments such as calipers. Basically, we are able to ask questions such as: how -- and by how much -- one has to distort a fossil endocast to match a chimp or human? Does the left hemisphere have a greater bulge over Broca's area than the right in modern humans and apes? If so, by how much?

Endocast Analysis

In order to determine the viability of using endocasts of fossil crania to study hominid brain evolution, state-of-the-art deformation-based morphometric techniques <http://grape.anthro.upenn.edu/~lab/pennct/endocast-comparisons.html> were used to analyze CT scans of endocasts and the corresponding crania. This project was possible through the collaboration of Dr. Ralph Holloway from Columbia University, who generously provided plaster endocasts and their corresponding crania, Dr. James Gee from the Department of Radiology, University of Pennsylvania, and Dr. Janet Monge Department of Anthropology, University of Pennsylvania.

Cranial Atlases Project

In the field of evolutionary comparative studies, 3-D renderings of cranial specimen provide a powerful tool for conducting morphological and statistical analyses of fossil and modern specimen. By morphing representative samples of crania from a particular species into a common atlas, and using the transformation mappings to construct a description of the range of variability on a point-by-point basis, complete atlases of modern species cranial (and endocranial) forms may be constructed. This will allow researchers to map exactly where and how a fragment is different from existing morphological variability in modern apes and humans in 3D, and calculate statistical tests of the degree of fit. Currently, the project has done CT scans of 20 chimpanzee skulls (18 obtained from the American Museum of Natural History), 130 modern human crania from the Department of Anthropology's Morton Collection, University of Pennsylvania, as well as several research-quality casts of 3.2 million year old *Australopithecus afarensis* specimens, from the Institute for Human Origins' collection at Arizona State University.