

**Presentation Titles, Authors, and Abstracts
for
“THE HUMAN BRAIN EVOLVING:
PAPERS IN HONOR OF RALPH L. HOLLOWAY”**

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“Music and the Brain: Implications for the Evolution of Functional Localization in Human Evolution”

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Abstract

Debates about the place of music in human evolution have recently intensified. Is it a pre-linguistic adaptation, important in sexual selection, or behavioral “cheesecake”? Critical to this debate will be determining the neurocognitive underpinnings of musical ability. Paradigms addressing these underpinnings include comparing the neuroanatomy of musical experts and non-experts, examining the functional relationships between music and other cognitive domains, and characterizing the unique neurocognitive attributes of musical prodigies or people with absolute pitch. We will discuss the functional localization of musical ability and expertise in the context of music as an evolved behavior and as a potential model for the evolution of complex behaviors in general.

“Neuroanatomical Reorganization in Early Hominins: Evidence from our Closest Living Relatives”

Douglas Broadfield, Departments of Anthropology and Biomedical Science, Florida Atlantic University

Abstract

Human brain evolution is characterized by an overall increase in brain size, cerebral reorganization, and cerebral lateralization. The question of when brain enlargement occurred during human evolution is generally understood, but the issues of cerebral reorganization and hemispheric lateralization are more difficult to determine from brain endocasts, and have been topics of considerable debate. Evidence from *Australopithecus* endocasts indicate that brain reorganization may coincide with the development of bipedalism, or potentially earlier. One cerebral cortex region that may represent the earliest evidence for brain reorganization is the primary visual cortex (PVC), or area 17 of Brodmann. In early hominid fossil (*Australopithecus*) endocasts it appears that this region occupies a smaller area than is known in nonhuman primates. In nonhuman primates, this region is larger in volume, demarcated anteriorly by the lunate sulcus, and is positioned significantly more anterior than is seen in modern humans. Some regard it necessary that the brain first underwent size expansion prior to reorganization, while others maintain reorganization predated brain

expansion. Based on data from the brains of our closet living relatives, chimpanzees, it appears that reorganization of the posterior aspect of the cerebral cortex preceded general expansion. While the brain experienced numerous expansion and reorganization events throughout human evolution, evidence from chimpanzee brains offers significant support for the hypothesis that the neurogenetic basis for brain reorganization was present in our early fossil ancestors prior to brain enlargement.

“The Evolution of the Parietal Cortical Areas in the Human Genus: Between Structure and Cognition”

Emiliano Bruner, Istituto Universitario di Scienze Motorie, Laboratorio di Anatomia Funzionale, Roma

Abstract

The parietal lobes have been hypothesised to have a major role within the early hominid evolution. On the contrary, the role of these areas within the evolution of the human genus is rather neglected, because of their supposed lack of association with “higher” cognitive functions. The parietal areas are hypothesised to be influenced by allometric constraints, modern humans displaying a non-allometric enlargement of their surfaces. This suggests a possible relationship between structural and cognitive rearrangements. Considering the visuo-spatial functions localised in the parietal cortex, and the association with hand movements or even imagination, such morphological differences should be carefully investigated.

“Micro-Vertical Organization in the Cortex: A Template for Change”

Daniel P. Buxhoeveden, Department of Anthropology, University of South Carolina

Abstract

Adult micro-vertical organization is based on the ontogenetic radial column which is a ubiquitous feature of the mammalian cortex. This developmental structure is known to play a key role in the encephalization of the cortex. It is also argued that changes initiated at this level present an opportunity for reorganization. Therefore, genetic and epigenetic influences acting on these units are thought to have contributed to both the expansion and the re-wiring of the cortex in primate evolution. Re-organization in the absence of encephalization is also considered.

“The Study of Human Brain Evolution: From Comparative Morphology to Evodevo”

Terrence W. Deacon, Department of Anthropology, UC Berkeley

Abstract

It should be obvious that evolution does not proceed from mature form to mature form, but is rather a constant tweaking of developmental mechanisms. Yet despite a century of critical reflection on this relationship, including the repudiation of overly simple attempts at a synthesis, the implications of this simple fact have yet to take hold in the study of human brain evolution. Consequently, much thinking about human mental evolution is held captive by century old assumptions about brain size, brain structure, and brain function; including the ghosts of progressivism, recapitulation, phrenology, hopeful monsters, and atomistic adaptationism. Intense research into the molecular-cellular-embryonic mechanisms involved in brain development are, however, quietly poised to revolutionize how we think about brain evolution. And computational simulation approaches to the study evolutionary mechanisms are beginning to reveal unexpected complexities in the logic of natural selection and its entanglement with developmental, social, and niche construction processes. These advances in understanding the mechanisms underlying brain and behavioral evolution can't help but radically reshape the field in the coming century. Drawing examples from comparative and developmental neuroscience, molecular embryology, animal behavior studies, and computer simulation research I will critically re-examine some tacitly accepted assumptions and outline a vision of a multilevel evodevo approach to human brain evolution.

“The Brain of Dmanissi’s Hominids, Georgia”

Dominique Grimaud-Hervé, Département de Préhistoire du Museum national d'Histoire naturelle

David Lordkipanidze, Musée national géorgien, Département de Géologie et de Paléontologie, Académie des Sciences de Géorgie

Abstract

The Dmanissi hominid site in Georgia has yielded numerous fossil remains dated at about 1.8 million years ago, and is probably the oldest out-of-Africa site, most likely representing an important migration route into Europe and Asia from Africa. The endocranial remains are of great interest with regard to their size, asymmetry, encephalic morphology and vasculature pattern, and are here compared with the fossil hominids from East and West Turkana, and Asiatic remains from Sangiran, Trinil, and the Zhoukoudian Lower cave.

“Changing Hominid Foraging Strategies in the Plio-Pleistocene: Implications for Understanding Human Brain Evolution from a Case Study in the Lake Turkana Basin”

J.W.K. Harris, Rutgers University
D. Braun, University of Cape Town

Abstract

One of the first of many seminal papers by Ralph Holloway on human brain evolution was “Culture as a human domain.” This paper integrated aspects of the archaeological record with other factors contributing to our understanding of brain evolution. In our paper we revisit his original hypothesis. We discuss stone tools as markers for the movements and foraging of Plio-Pleistocene hominids taking a regional perspective in examining the archaeological traces in the Lake Turkana basin, as the spatial unit for analysis. Increasing complexity observed in the archaeological record when linked to ecological and other behavioral correlates provides a contribution to understanding the earlier stages of human brain evolution.

“Evaluating White Matter Pathways in Fixed Ape Brains with High-Field Diffusion MRI”

Jason A. Kaufman, Division of Biology, California Institute of Technology
J. Michael Tyszka, Brain Imaging Center, California Institute of Technology
John M. Allman, Division of Biology, California Institute of Technology

Abstract:

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a new, non-invasive means of obtaining data on brain connectivity. Here we demonstrate the use of high-field DW-MRI and fiber tractography to trace long-distance connections in fixed ape brains. Using probabilistic fiber tractography, we are able to parcellate cerebral white matter into major fiber tracts such as the optic radiation, cingulum bundle, corticospinal tract, and longitudinal fasciculi, as well as interhemispheric commissural pathways. We believe that quantitative comparisons of the strength and distribution of cortical connections may reveal distinct specializations related to the evolution of the human brain.

“Probing the Genetic Basis of Human Brain Evolution”

Bruce T. Lahn, Department of Human Genetics, University of Chicago

Abstract

Human evolution is characterized by a dramatic increase in brain size and complexity. Traditionally, efforts to study human brain evolution have focused on the anatomical and physiological differences between the human brain and that of the other taxa, as well as the behavioral manifestations of these differences. We sought to study human brain evolution from a genetics point of view. To this end, we examined the evolution of genes involved in diverse aspects of nervous system biology. We found that these genes display significantly higher rates of protein evolution in primates than rodents. Importantly, this trend is most pronounced for the subset of genes implicated in nervous system development. Moreover, within primates, the acceleration of protein evolution is most prominent in the lineage leading from ancestral primates to humans. Thus, the remarkable phenotypic evolution of the human nervous system has a salient molecular correlate, *i.e.*, accelerated evolution of the underlying genes, particularly those linked to nervous system development. In addition to uncovering broad evolutionary trends, our study also identified many candidate genes — most of which are implicated in regulating brain size and behavior — that might have played important roles in the evolution of the human brain. More detailed analysis of these candidate genes found in several of them strong signatures of positive selection in the lineage leading to humans. Remarkably, some showed evidence of ongoing positive selection within anatomically modern humans.

"The Maternal Energy Hypothesis of Brain Evolution: An Update"

Robert D. Martin, Department of Anthropology, The Field Museum, Chicago

Abstract

Mammalian brain tissue has high energy demands, so energy supply is a key issue in evolution of the primate brain, notably for particularly large-brained hominids. The author's Maternal Energy Hypothesis (MEH) focuses on energy supplied by the mother during brain development up to weaning. New comparative analyses of brain size in mammals with improved datasets have confirmed links to both basal metabolic rate and gestation period, meeting predictions of MEH. The evidence now available in support of MEH will be reviewed and implications for primate evolution (especially regarding hominids) will be explored.

“Of Brains and Teeth: Can Dental Development Provide Insights into the Evolution of the Brain?”

Dr. Janet Monge, Department of Anthropology, University of Pennsylvania
Dr. Alan Mann, Department of Anthropology, Princeton University

Abstract

Calcification and eruption of the dentition has often been employed to reconstruct patterns of maturation in earlier hominins. Recent evaluations of modern children indicate dental development has significantly accelerated in comparison to the standards established half a century ago. In addition, new data on chimpanzee dental maturation signal the need for a re-evaluation of current views of growth and maturation in early hominins. Holloway’s suggestion that neurological re-organization was one of the major changes in early hominin evolution, permitting incorporation of more complex data about environmental resources, may be directly linked to longer maturational periods for incorporation of this information.

"Searching for Human Brain Specializations with Structural and Functional Neuroimaging"

James K. Rilling, Departments of Anthropology and Psychiatry and Behavioral Sciences, Emory University
Todd M. Preuss, Departments of Anthropology and Psychiatry and Behavioral Sciences, Emory University

Abstract

Ralph Holloway is a pioneer in using the comparative method to inform human brain evolution. The recent advent of multiple brain imaging technologies has made it possible to non-invasively probe brain structure and function of living primates for the first time ever. By comparing human and non-human primate brains using these techniques, it is possible to identify anatomical and functional specializations of the human brain. In this paper, we present results from comparative studies of structural and functional magnetic resonance imaging (MRI), diffusion tensor imaging (DTI), and Positron Emission Tomography (PET) imaging and discuss their implications for human brain evolution.

“Emergents and Culture: Comparisons of Prosimians, Monkeys, Apes, and Humans”

Duane M. Rumbaugh, Great Ape Trust of Iowa, Des Moines, Iowa
E. Sue Savage-Rumbaugh, Great Ape Trust of Iowa, Des Moines, Iowa

Abstract

With elaboration of the primate brain in both size and complexity came altered patterns of learning, enhanced capacity to transfer even small amounts of learning to an advantage in new situations, increased ability to learn observationally even during infancy, and the capacity to learn and use even arbitrary symbols referentially. All of these processes and skills enhanced adaptation in changing environs. All of these trends enhanced communication and the eventual emergence of language and culture. Data are clear that great apes have substantial advantages over monkeys in learning, intelligence, and language. Comparative studies have served to help us understand the remarkable adaptive competence of *Homo sapiens*.

“The Meaning of Brain Size: The Evolution of Conceptual Complexity”

Tom Schoenemann, Department of Behavioral Sciences, University of Michigan
Dearborn

Abstract

A complete understanding of exactly how to interpret changes in brain size during human evolution remains a major unresolved question. A common misconception is that absolute brain size is not behaviorally relevant, and that only relative brain size (controlling for body size through, e.g., encephalization quotients) has any evolutionary importance. The problems with this position are reviewed. It is argued that - whatever else brain size increases brought - they likely resulted in fundamental increases in the complexity of conceptual understanding. This, in turn, likely played a central role in spurring language evolution.

“Brain Reorganization in Humans and Apes”

Katerina Semendeferi, Department of Anthropology and Graduate Program in
Neurosciences, University of California at San Diego

Nicole Barger, Department of Anthropology, University of California at San Diego

Natalie Schenker, Department of Anthropology, University of California at San
Diego

Abstract

Selected gross anatomical regions, individual cortical areas and subcortical nuclei as well as their characteristic quantifiable parameters, point toward selective reorganization of human and great ape brains. Accumulating evidence is based specifically on the distribution of space for connectivity within the cortex including aspects of vertical organization in Broca's area and the frontal pole, the orbitofrontal cortex, the gyral white matter in the frontal and temporal lobes, the differential distribution of some neuronal phenotypes, and the different patterns of organization of subcortical structures, like the amygdala. Subject to further investigation is the extent of the observed anatomical reorganization and its possible functional significance.

“Brain Reorganization Writ Small: Tales from Histology”

Chet C. Sherwood, Department of Anthropology, The George Washington
University

Abstract

Ralph Holloway's work has consistently emphasized the importance of reorganization in understanding the evolution of species-specific behavioral adaptations. At present, most of the comparative research on primate brains concerns phylogenetic variation in volumes of large-scale neuroanatomical regions. New findings, however, indicate that the histological architecture of brains differ substantially among species. These differences may take the form of novel neuronal cell types, modified distributions of cellular components, or changes in the chemical and molecular composition of tissues. In the future, it will be interesting to examine how microstructural reorganization relates to neuroanatomical changes at larger scales and overall brain size.

“New Evidence of Brain Size and Growth in *Homo erectus* from Afar Regional State, Ethiopia”

Scott W. Simpson, Department of Anatomy, CWRU-School of Medicine & Laboratory of Physical Anthropology, Cleveland Museum of Natural History
Sileshi Semaw, Stone Age Institute & Indiana University (CRAFT Research Center)
Jay Quade, Department of Geosciences, University of Arizona
Ralph L. Holloway, Department of Anthropology, Columbia University

Abstract

Fossils recovered between 1999 and 2003 from the Early Pleistocene deposits within the Gona Paleoanthropology Research Project area in the Afar Regional State of Ethiopia have allowed us to explore further brain size, anatomy and growth in *Homo erectus*. The two best-preserved crania are dated to ~1.6Ma. These near contemporary crania provide an interesting anatomical contrast in craniofacial details as well as broaden our knowledge of Early Pleistocene brain size variation. New estimates of adult and neonatal brain size in *H. erectus* allow for greater fidelity in reconstructing growth patterns in this species.

“The Neural Correlates of Early Stone Age Tool Making: Evolutionary Implications”

Dietrich Stout, Institute of Archaeology, University College London & Stone Age Institute
Nicholas Toth, Stone Age Institute & Indiana University (Department of Anthropology and Cognitive Science Program)
Kathy Schick, Stone Age Institute & Indiana University (Department of Anthropology and Cognitive Science Program)

Abstract

Stone artifacts provide some of the most detailed remaining evidence of pre-modern hominin behaviour and cognition. However, definitive interpretations of this record have remained elusive. Functional brain imaging offers a new empirical dimension to this debate by revealing the neural correlates of specific stone tool making behaviours. Results from studies of Oldowan and Acheulean stone knapping indicate shared reliance on parieto-frontal circuits involved in sensorimotor regulation, as well as increasing prefrontal and temporal activity with technological complexity. These results correspond with palaeoneurological and comparative evidence of hominin brain evolution, and provide support for hypotheses linking tool making and language in human evolution.

“Mosaic Cognitive Evolution”

Francys Subiaul, Department of Speech & Hearing Science, The George Washington University

Abstract

What makes the human mind, ‘human?’ One possibility is that the evolution of the human mind is like the evolution of the human body: a mosaic of differential evolution in various cognitive domains. A mosaic cognitive profile is exemplified by children with autism who suffer from abstract socialization deficits but not abstract causal-physical deficits. In contrast, most primates are better suited to reason abstractly about social problems. The modern human mind was likely the result of selection pressures in the physical and social domains, independently favoring physical-causal skills for tool-making and social-causal skills to better understand the intentions of rivals.

“Hominid Brain Reorganization, Technological Change, and Cognitive Complexity”

Nicholas Toth, Stone Age Institute & Indiana University (Anthropology Department & Cognitive Science Program)

Kathy Schick, Stone Age Institute & Indiana University (Anthropology Department & Cognitive Science Program)

Mohamed Sahnouni, Stone Age Institute & Indiana University (CRAFT Research Center)

Abstract

Patterns in the evolution of the hominid brain over the past two-and-a-half million years are mirrored by changes in the archaeological record, notably in lithic technology for most of this period. Here we examine the relationships between Holloway *et al.*'s major stages of hominid brain evolution and the evolution of hominid technologies. We propose a graded scale of technological complexity to correspond with major thresholds observed in prehistoric hominid brain evolution and critically examine the nature of key technological innovations observed in the archaeological record.

“Post-Pleistocene Brain Evolution: A Chronological Framework Integrating Genetic, Morphological and Behavioral Evidence”

Anne H. Weaver

Abstract

The cerebral hemispheres are relatively smaller and the cerebellum relatively larger in recent humans than terminal Pleistocene humans. The cerebellum did not reach modern proportions until the very late Pleistocene (apparently, some time after 28,000 years BP) – several thousand years after modern humans arrived in territories occupied by archaic humans. Cerebellar evolution occurred in the context of genetic and behavioral evolution in post-Pleistocene humans. Temporal correlations among morphological, behavioral, and genetic evolutionary changes can provide the basis for hypothesis testing and enhance our understanding of how the modern human cognitive pattern emerged.

“Holloway’s Hypotheses and Syntheses of Human Brain Evolution”

Michael S. Yuan, College of Dental Medicine, Columbia University

Douglas C. Broadfield, Departments of Anthropology and Biomedical Science,
Florida Atlantic University

Ralph L. Holloway, Department of Anthropology, Columbia University

Abstract

Holloway’s theoretical view of human brain evolution has been one of the foundations in integrating comparative neuroanatomy, biobehavioral neurosciences, paleoneurology, and the hominid fossil record. He has suggested that the human brain evolved under strong natural selection for enhanced social behavior with emphasis on communication and other forms of interpersonal behavior. His syntheses of human brain evolution combines the changes in both absolute and relative brain size, with different reorganizations of the brain, hierarchy or maturation, hemispheric asymmetry, and neuroreceptor distribution, along with allometric and/or non-allometric growth of the human brain. His hypothesis of “culture as the human domain”, providing the basis of neural integration of tool making, symbol using, and throwing as the driving force of human brain evolution, remains an important paradigm in studying brain evolution.