Impact of Tool Use and Technology on the Evolution of the Human Mind

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ABSTRACTS

Culture, Demography and Patterns of Human Genetic Diversity
Marcus Feldman, Stanford University

Advances in DNA genotyping and sequencing technology have led to an upsurge in studies of "polygenic" influences on many human behavioral traits. In this talk, I will discuss how human cultural norms and preferences have affected, and continue to affect, patterns of genomic variation in different populations. Examples include studies of ancient and modern populations, with genetic variation obtained from the Y-chromosome and the other 22 pairs of human chromosomes.

Tool Use by Non-Human Primates
Dorothy Fragaszy, University of Georgia

Humans have used tools since the dawn of our species. Evidence is accumulating that extinct hominins also used stones as tools, apparently in ways similar to how a few species of primates in South America, Africa, and Asia use them: as hammers to open encased foods. Nonhuman primates, compared to humans, use simpler objects as tools and use tools in simpler ways. Unlike humans, no nonhuman primate is an obligate tool user. Individuals neither teach others nor learn via imitation to use tools. Nevertheless, we consider that the populations of primates that use tools possess technical traditions, because young individuals learn to use tools in social settings. Certain features of ecology, behavior, sociality, and life history characterize all the species of primates, including humans, that use tools. I will use the example of bearded capuchin monkeys, small monkeys from South America that routinely use stone hammers to crack nuts, to illustrate the natural history of a technical tradition in a nonhuman primate, and the individual attributes and social and ecological contexts that support this tradition. Bearded capuchins give us a suggestion of the features that led hominins, that last shared a common ancestor with capuchin monkeys 35 million years ago, into routine tool use. Comparing tool use in nonhuman primates and humans leads to ideas about the attributes of humans that have led us to differ so dramatically from other primates in technical prowess and technical traditions.

Early Hominin Stone Tools
Dietrich Stout, Emory University

The simple fact of tool-making no longer provides a sharp dividing line between "Man the Tool-Maker" and the rest of the animal world. It is now clear that many other species make and use tools, and that distinctly human technology emerged through a long and meandering evolutionary process rather than the crossing of some critical threshold. However, it would be a mistake to underestimate the transformative effects of tools on everything from our hands and brains to our reproductive strategies and social organization. Humans may not be uniquely defined as "a tool-using animal" but we do inhabit a uniquely elaborated technological niche. The earliest known stone tools predate evidence of brain expansion by many hundreds of thousands of years during which their occurrence was extremely patchy and discontinuous. Far from a breakthrough, stone tool-making appears to have been a fragile behavior of marginal value. This is expected for a technology located near the limits of contemporary hominin capacities, with high learning costs, limited flexibility, and high rates of failure offsetting its benefits. Natural selection acting on hominin brains and bodies during this lengthy period of experimentation may eventually have eased these costs, leading to a dramatic proliferation of "Oldowan" tool-sites after about 2.0 million years ago (mya). This is closely co-incident with the first appearance of larger-brained and –bodied *Homo erectus* by ~1.9 mya and was rapidly followed by the invention of more sophisticated Acheulean "handaxe" technology by 1.76 mya, marking an important inflection point in the biocultural feedback processes that eventually produced the modern human technological niche.

The Combinatorial Creature: Cortical Phenotypes Within and Across Lifetimes

Leah Krubitzer, UC Davis

The neocortex is one of the most distinctive structures of the mammalian brain, yet also one of the most varied in terms of both size and organization. Multiple processes have contributed to this variability including evolutionary mechanisms (i.e., alterations in gene sequence) that alter the size, organization and connections of neocortex, and activity dependent mechanisms that can also modify these same features. Thus, changes to the neocortex can occur over different time-scales, including within a single generation. This combination of genetic and activity dependent mechanisms that create a given cortical phenotype allows the mammalian neocortex to rapidly and flexibly adjust to different body and environmental contexts, and in humans permits culture to impact brain construction.

Behavioral Modernity vs. Complexity: What Stone Tools Teach Us

John Shea, Stony Brook University

European paleoanthropologists developed the behavioral modernity metaphor in the 1970s when it became clear that the archaeological record for human origins in Europe 45,000 years ago differed from that found with older "archaic" humans in Africa and Asia. Since then, archaeologists have defined behavioral modernity strategically, varying diagnostic criteria to draw attention to one or another kind of evidence. Many have cited the use of projectile weaponry as evidence for modern human behavior and cognition, but changes in projectile weaponry do not correlate with any major inflection point in human evolution. This should surprise no one, because the projectile technology-behavioral modernity link rests on little or no prior theory. Archaeologists developed it after-the-fact to explain early evidence for projectile technology. Rather than focusing on behavioral modernity, paleoanthropologists should focus on behavioral complexity. Complexity is a metaphor, too, but it is also a statistically-measurable property of any quantitative evidence. The stone tool record begins to exhibit increasingly complex variability after 0.2-0.3 million years ago, during a period correlated with *Homo sapiens* origin and dispersal. This complex variability most likely reflects an evolving relationship between technology and spoken language – an uniquely derived human behavior, that intensified as humans became Earth's only obligatory tool-using primate.

Writing and Reading: The Evolution of Social Media

Paula Tallal, Salk Institute

Language co-evolved with the human brain throughout the evolution of Homo sapiens. Writing, on the other hand, is a relatively new technology that was invented by humans to translate spoken language into a visual form for transmitting verbal communication broadly to many people over large distances and time. As such, writing and reading can be considered the first 'social media' technology. Written language co-opted the brain substrates that evolved for spoken language. While language develops naturally in most humans based on exposure rather than explicit instruction, reading and writing require painstaking instruction and years of practice to reach proficiency. This talk will trace the history of the invention of writing, explain how English ended up with such a cockeyed spelling system, which leads in many cases to Dyslexia, and speculate as to how newer technologies may impact reading and writing and the many brain functions that have been enhanced by it.

Quantity, Number, and Mathematics

Rafael Núñez, UC San Diego

Mathematics is one of the most sophisticated, precise, and abstract conceptual edifices humankind has ever created, supporting science, technology, economics, and deep philosophical investigations. Yet, mathematics is a remarkably recent invention in the history of *Homo sapiens*. What made it possible? One fundamental building block is "number," whose simplest forms, conventional wisdom holds, are said to be biologically endowed and shared by many species. What is shared, however, are general mechanisms for perception of quantities, not number. Number —i.e., exact symbolic quantification, as in our familiar "seven" or "8"— is complex and abstract, and although ubiquitous in the industrialized world, is far from being present in all human cultures. While there are biologically evolved preconditions for quantity discrimination shared by many species, the presence of number (and arithmetic) proper is a cultural, not a biological trait. Exact quantification was brought to being via relatively recent (only thousands of years) cultural preoccupations and practices that were crucially supported by language-mediated cognitive tools (e.g., symbolic reference, analogical/metaphorical reasoning) and material technology (e.g., writing, abacus)— essential dimensions that lie largely outside natural selection. Language thus is a necessary—but not a sufficient— condition for number. I'll briefly review some relevant empirical data and illustrate the power of cognitive tools with the passage from "number" to the "number line." This 17th century move (which required conceiving numbers metaphorically as locations in space) quickly led to analytic geometry, infinitesimal calculus, differential equations, and more. The path from quantity perception—shared by many species— to number, to mathematics is a story of human "biological enculturation."

Digital Technologies and the Development of the Human Mind

Candice Odgers, UC Irvine

Adolescents spend an average of 6 to 8 hours online and in front of screens each day for non-school related tasks. Globally, one in three internet users worldwide are under the age of 18. Yet the online world and complex machine learning algorithms that drive and direct young people's experiences have not been constructed with their needs in mind. Using streaming information from mobile phones and wearable devices, Odgers shares new data describing how digital technology use relates to adolescents' same-day emotions, behaviors, and health. Key findings regarding the effects of digital technologies on children and youth are highlighted, challenging many of the common fears regarding the influence of the digital age on developing minds.

The Collective Brain

Joe Henrich, Harvard University

Long before the origins of agriculture or the rise of the first cities, our species spread out across the globe into an immense diversity of environments, from the frozen tundra of Siberia to the arid deserts of Australia. Our species' immense ecological success in these environments depended not on our vaulted intelligence or rationality, or on any array of local genetic adaptations as in other species. Instead, human survival and success depends on the inheritance of large bodies of culturally-transmitted information that accumulates and aggregates over generations to produce cultural adaptations. Our species' degree of reliance on cultural learning means that a population's ability to generate and maintain complex cultural repertoires, tools and technologies, such as those commonly found among hunter-gatherers, depends on its sociality, and specifically on its social norms and institutions. Thus, our apparent intelligence derives more from our collective brains than our individual intelligence. Overall, the emergence of this second system of inheritance sparked a culture-gene coevolutionary duet that has driven genetic change in our species for over a million years. Many aspects of our anatomy, physiology and psychology, from our big brains to our short colons, only make sense in the light of culture-gene coevolution.