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Genes, Language, Cognition, and Culture: Towards Productive Inquiry

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Abstract

The Queen Mary conference on "Integrating Genetic and Cultural Evolutionary Approaches to Language," and the papers in this special issue, clearly illustrate the excitement and potential of trans-disciplinary approaches to language as an evolved biological capacity (phylogeny) and an evolving cultural entity (glossogeny). Excepting the present author, the presenters/authors are mostly young rising stars in their respective fields, and include scientists with backgrounds in linguistics, animal communication, neuroscience, evolutionary biology, anthropology, and computer science. On display was a clear willingness to engage with different approaches and terminology and a commitment to shared standards of scientific rigor, empirically driven theory, and logical argument. Because the papers assembled here, together with the introduction, speak for themselves, I will focus in this "extro-duction" on some of the terminological and conceptual difficulties which threaten to block this exciting wave of scientific progress in understanding language evolution, in both senses of that term. In particular I will first argue against the regrettably widespread practice of opposing cultural and genetic explanations of human cognition as if they were dichotomous. Second, I will unpack the debate concerning "generalpurpose" and "domain-specific" mechanisms, which masquerades as a debate about nativism but is nothing of the sort. I believe that framing discussions of language in these terms has generated more heat than light, and that a modern molecular understanding of genes, development, behavior, and evolution renders many of the assumptions underlying this debate invalid.

Keywords

EVOLUTION OF LANGUAGE, MODULARITY, NATIVISM, PHYLOGENY, GLOSSOGENY

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Cultural and Biological Explanations of Human Cognition

Humans are cultural organisms: a human raised in isolation or by non-cultural animals will be as deficient as a bird prevented from flying or a mole prevented from digging. A human child comes into the world with a capacity (and a hunger) to absorb its caregivers' language, music, ethical norms, clothing styles, and myriad other systems, and will do so nearly effortlessly and without

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conscious thought or explicit tuition. This is simply not true of chimpanzees, cats, or cows, none of whom will absorb the language or music of their environment if raised in a human home. Nor do these species need to "learn" their species-typical vocalizations in their natural environments: such calls are reliably developing, genetically canalized ("innate") aspects of the biology of these species. More importantly, humans use language to communicate (and refine) thoughts and explanations of the physical world, social and ethical systems, and ritual behavior, and this very transmission is the primary engine of cultural development over generations. Language and culture (at least in this advanced human sense) are inextricably intertwined, and both rest on a firm biological basis, not present in any other known species.

Because of the human reliance on socially shared information and norms, with language playing a central role, we are able to a large degree shape our own selective environment. This is a prime example of "niche construction" (Odling-Smee et al. 2003), the process whereby organisms' effects on their environments (e.g., beavers building dams, or worms aerating the soil) feed back upon the selection experienced by future generations. Although humans are not unique in this, our reliance upon culture means that "cultural niche construction" (Laland et al. 2001) plays a central role in human evolution. Probably because of a long disciplinary distinction between the "social" and the "natural" sciences, and a long resistance among anthropologists and psychologists to any sort of biological determinism, it has taken a surprising amount of time for these simple facts to be recognized. But facts they are, and there is now a healthy body of theory concerning gene-culture interaction and co-evolution (Richerson and Boyd 2005) and abundant empirical data exploring specific examples of how and why this happens (Durham 1991; Laland et al. 2010). The keyword here is "co-evolution," and this literature emphasizes that neither genes nor culture are the primary causal forces in this ongoing evolutionary dance; rather they are causally intertwined.

Although this literature does not, to my taste, adequately emphasize the prime role of language in cultural evolution, scientists interested in language evolution have provided insightful investigations of gene-culture coevolutionary dynamics in the domain of language evolution. Although Darwin had recognized the parallels between phylogeny and glossogeny, linguist Rudi Keller and evolutionary neuroscientist Terrence Deacon were some of the first to explore the interaction of language change and language evolution (biologically) in detail, and Deacon has insightfully unpacked the possible role of Baldwinian-like processes in human evolution (Keller 1995; Deacon 1997, 2003). Computer modeler Ted Briscoe has convincingly shown that, given realistic assumptions, genetic assimilation of cultural/behavioral variants can occur (Briscoe 2002, 2003). Other computer models of language change also demonstrate the need for a nuanced, multidimensional perspective on how glossogeny might influence phylogeny (Kirby 1999). Of course, the value of computer models depends very much on the assumptions built in to them, and no single approach to simulation can prove any general result. But these models argue strongly against any strong opposition between cultural and genetic explanations of human language acquisition, and the few simulation studies that reach different conclusions need to be interpreted, and skeptically examined, in this context (e.g., Kirby et al. 2007; Chater et al. 2009).

There can be little doubt that both human culture and human language have a biological basis, that it is critical to our species at present, and that language shaped the evolutionary process that led to our current state. Nor should we think that biological evolution ground to a halt once cultural evolution began. Once language was in place, the chance of a human without language surviving and producing offspring was clearly limited. Thus, there must be powerful selection, in every generation since language arose, for a child to acquire language. This, at the very least, would act to eliminate alleles that disrupted language learning, generating stabilizing selection. Such elimination of deleterious mutations is one of the most important and powerful evolutionary forces and may be one reason that human children so reliably and effortlessly master language. Language, culture, and human biology are inextricably intertwined.

The "General Purpose" versus "Domain-Specific" Debate: Beyond an Unhelpful Dichotomy

Today, there is a near-complete consensus that the human capacity to acquire language has a strong genetic basis, aspects of which evolved uniquely in our species. From this viewpoint, everyone is a nativist (cf Fitch, in press). Current debates concern not whether there is a human instinct to learn language, but rather its nature and specificity. Among linguists, Pinker and Jackendoff have championed a form of "special nativism" which posits a rich suite of language- and human-specific adaptations. In contrast, Chomsky's "minimalist" research program of the last decades seeks to sharply limit the innate syntax-specific aspects of language, as a research strategy. While rejecting any form of "universal grammar," psychologist Michael Tomasello and colleagues posit an innate, human-specific propensity for "shared intentionality", lacking in our great ape cousins (Tomasello et al. 2005). They see this capacity as primarily a cultural, rather than linguistic, component of human cognition. Similarly, while psycholinguist Stephen Levinson rejects syntax-specific linguistic universals as a "myth" (Evans and Levinson 2009), he and his colleagues affirm the existence of pragmatic universals of turn-taking and conversation structure in all human cultures (Stivers et al. 2009). Psychologists Csibra and Gergely assert that humans are unique in a capacity to engage in, and respond to, "natural pedagogy," and that this ability is crucial to both word-learning and understanding many other aspects of human behavior (Csibra and Gergely 2009). Finally, Lee, Schumann, and colleagues posit an "interactional instinct" as the key innovation leading to language innovation, again prioritizing cultural factors over strictly linguistic ones (Lee et al. 2009).

Clearly, the real debate here concerns the specific nature of the innate biases and proclivities that underlie the acquisition of language and culture, and how specific to language (or even syntax) they are. Implicit in this debate is the notion that we can meaningfully categorize innate human cognitive capacities, such that distinctions like "general purpose" versus "special to syntax" are both biologically meaningful and psychologically and evolutionarily important. I suggest that this implicit assumption is often incorrect, and indeed based on a combination of conflations and misconceptions about genetic and neural specificity that have become suspect, if not entirely outmoded, given recent progress understanding genes, brains, and their evolution.

A central fact of modern biology is that the mapping from genes to cognitive phenotypes is extremely indirect. Genes do not provide a blueprint for neural circuits. Rather they anchor and channel the developmental process, which involves constant interactions within and between cells, tissues, local neuronal circuits, and whole-brain networks. Every stage of this epigenetic process is influenced by, or dependent upon, interactions between individuals and their environment (Fitch 2009). This indirection means that genes with simple, easy-to-understand mappings to specific phentoypic traits are extremely rare (Fisher and Francks 2006; Ramus 2006). There is nothing atypical about human cognition here: consider human bipedalism. Admitting that there is a strong, reliably developing propensity for bipedalism in humans neither denies the role of environmental interaction, motor learning, and cultural mores on walking nor implies that one or a few genes determine this innate human capacity. No one expects to find "bipedalism genes"; rather, we expect that novel alleles, recently evolved in the human lineage after its split from chimpanzees, channel and constrain the acquisition of the species-typical human locomotion style. Neither the lack of such genes, nor the existence of environmental and cultural effects on walking, leads anyone to mount a challenge to the idea that human bipedalism has a powerful innate basis. Why should language be any different?

Imagine that two decades from now we fully understand the genetics of human bipedalism, and that some alleles are discovered which have an effect on walking but not other aspects of motor control (say, tool use or swimming abilities). These novel alleles, in the current terminology, would be "domain-specific" to walking. But this does not imply that the genes themselves, or the underlying neural circuitry, are "uniquely human." Far more likely most aspects of bipedalism are based on pre-existing locomotory and motor control circuits, perhaps shared with a wide variety of other species. Even if bipedalism, as a behavior, has evolved in the last six million years, it is highly unlikely that it involved wholly new neural circuits, or wholly new genes. Rather, we expect that it "hijacked" pre-existing systems and put them to new use: the "tinkering" process typical of evolution (Jacob 1982). Again, why should language be any different? The discovery that changes in some ancient brain systems like the basal ganglia are involved in language (cf Lieberman 2007) tells us nothing about how and why these changes occurred: perhaps for tool use or bipedalism or perhaps for language (or other, broader aspects of cultural acquisition). But neither the neural circuitry, nor the genetic variants alone, suffice to resolve this question.

Finally, one might hope that the real resolution of the psycologists' "special" versus "general" debate, for any particular trait, will be in evolutionary terms. Then, a trait would be special to language insofar as its adaptive function, the grounds for its selection, was "for" language (Pinker and Jackendoff 2005). This approach is likely to be unsatisfactory for two reasons. First, lacking time machines, we are unlikely to be able to resolve such questions empirically. Neither fossil, neural, nor genetic data can tell us *why* some novel mutation or rare allele swept through an ancestral hominid population, even if today that mutation plays a role in language (or culture, or pedagogy). Second, and more important, the causal relationship between evolutionary selective pressures and genes is inevitably indirect, because survival and reproduction are tied to whole phenotypes, and only indirectly influence individual components of genotypes. This makes it very likely that, even if the spread of some novel allele was solely tied to language, or specifically syntax, that the allele would also influence other aspects of cognition pleiotropically (e.g., a taste for regular patterns, musical phrases, or mathematical abstraction—or a susceptibility to various psychological disorders). Furthermore, completely unrelated alleles neighboring the selected "target" allele on the chromosome will be swept along by "hitchhiker" effects (Maynard et al. 1974). In neither case, unless these accompanying traits bring strong enough negative consequences to swamp the positive ones, will selection "know" or "care" about all this. Thus it is very unlikely that invoking natural selection and the argument from design will help us to understand the specific effects of genes, and whether they evolved for cultural, linguistic, technological, or other reasons (cf Fitch 2010).

Philosophers have debated nativism and modularity for centuries, and perhaps they will continue to do so. But as I have suggested above, these debates tend to conflate multiple issues, concerning neural, genetic, and selective specificity, that we know today to be quite separate. In today's world, the DNA of humans, chimpanzees, and many other species has already been sequenced. We know what the genetic differences unique to our species are, and anyone with sufficient interest can roll up their sleeves, log on to various publicly available servers (e.g., www.ncbi.nlm.nih.gov/genbank), and generate their own hypotheses about which genetic differences really make a difference in language (or culture) acquisition. Some such hypotheses can be tested in animal models (e.g., knock-out mice, many of which already exist, or in song-learning birds). In the coming individual genome era, hypotheses can be tested using the genetic variability that already exists among living humans today (with six billion humans and only 20 thousand genes, most mutations compatible with life probably exist at present, somewhere on the planet).

Thus I find little justification for continuing oversimplistic theoretical arguments about nativism, or contrasting language and culture in this new era.

Language effects culture, culture effects language, and both are built upon a genetic basis that is part of our birthright as humans. The genetic differences underlying our difference from other species are already out there, catalogued and waiting to be understood, and concerted effort and trans-disciplinary collaboration will be needed if we are to do so in biologically, psychologically, culturally, and linguistically sensible ways. The papers in this current special issue provide clear evidence that this can, and will, be done. Some of the most fundamental and interesting questions about our species will be answered in the process. It would truly be a shame to let old misconceptions, hoary philosophical battles, and inter-disciplinary miscommunication stand in the way.

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