Epigenetics, Semiotics, and the Mysteries of the Organism

Chris Sinha
Department of Psychology, University of Portsmouth, UK
chris.sinha@port.ac.uk

The launch of *Biological Theory* is, for those whose main interest is in human cognition, development, and evolution, exciting and timely. It takes place at a time of increasing convergence between the biological and cognitive sciences in the quest for a resolution of the apparent paradox of human evolution. The paradox is one of discontinuity in continuity: the biological characteristics of the human species display no dramatic discontinuities with those of other species, while human cognitive capacities, and human cultural constructions, appear from our current vantage point to be as exceptional in the living world as they did to Descartes. It can, of course, be argued that the discontinuity is merely a symptom of a gap in the available evidence—there are no living representatives of the human lineage since it diverged from the ancestors of our closest living primate relatives. If there were, the discontinuity would, perhaps, prove to be an illusion. Even so, it is hard to resist the conviction that, however extended the event, or sequence of events in evolutionary time, “something happened” that radically transformed the evolving mind, and this transformation poses a profound and complex problem for biological theory.

To begin with continuity: the truism that the Darwinian revolution eliminated from science the idea that the human species is essentially different in biological constitution and evolutionary history from other species, received in the closing years of the last century strong confirmation in two very different domains. Succinctly stated, neither genes nor culture, singly, can account for what, if anything, makes humans different from other species.

There is no evidence of dramatic genetic discontinuity between humans and their closest primate relatives, chimpanzees. The two species share, even on the most conservative estimate, about 95% of their genetic material (Britten 2002). Taken together with initial results of the human genome project, this suggests that whatever cognitive capacities distinguish the human species from other closely related species are unlikely to be attributable to dedicated genetic material available for directly coding such capacities. This does not mean that there is no genetic component of specifically human capacities. It does mean that the ascription of differences between the cognitive capacities of humans and those of nonhumans to interspecies genetic differences alone is likely to be false. This is bad news for nativist modularity theories.

The news for those who would argue that what is unique about humans is their capacity for the social acquisition and transmission of culture, a favored hypothesis for generations past of social anthropologists, is hardly better. Culture can minimally be defined as the existence of intraspecies group differences in behavioral patterns and repertoires, which are not directly determined by ecological circumstances (such as the availability of particular resources employed in the differing behavioral repertoires) and which are learned and transmitted across generations. On this definition, there is ample evidence of cultural differences in foraging strategies, tool use, and social behaviors in chimpanzees (Whiten et al. 1999; de Waal 2001). Such a definition will also qualify, for example, epigenetically learned intraspecies dialect differences between songbird communities as cultural and culturally transmitted behavior (Marler and Peters 1982). Again, this does not mean that there is no cultural foundation for uniquely human cognitive capacities; rather, it suggests that human culture, from an evolutionary and developmental point of view, must be treated as *explicandum* as much as *explicans*.

Nearly 20 years ago, I argued that the biological and cognitive sciences were in the throes of a crisis, in which their respective then dominant paradigms of genetic determinist neo-Darwinism, and neo-rationalist cognitivism, faced a fundamental challenge from an alternative which I called “epigenetic socionaturalism” (Sinha 1988). My contention that the epigeneticist approach offered a unified theory and method for integrating development, evolution, and cognition may have seemed dubious, even rash, back in the heyday of nativist

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modular theories of cognition. I contend now, however, that the paradigm shift that I advocated and predicted is widely acknowledged as having occurred. The integration, argued for by biologists such as E. O Wilson (1998), of the study of human culture into biology, is undoubtedly occurring, but it is turning out to be more of a two-way street than was ever envisaged by sociobiology. Far from eliminating culture by absorbing it into the genotype, biology is increasingly acknowledging the role of culture in shaping the evolutionary process *at the genetic level*, by the construction of new selective environments (Laland et al. 2000).

Laland et al. (2000: 132) criticize the "human-centered" perspective of many accounts of gene-culture coevolution, pointing out that many nonhuman species behaviorally codirect genetic evolution through niche construction. This point is important, because it situates the role of culture in evolution within a wider class of processes involving adaptation to behaviorally induced changes in selective environments (niches or "artifacts" such as nests, dams, mounds, and burrows). A particular role is played in their theory by genotype/niche combinations labeled by Laland et al. (2000: 144) "phenogenotypes," which they propose as replicators functionally equivalent to organisms: a phenogenotype is a class of organisms in a bound (though not genetically determined) relationship with some aspect of a self-constructed (including culturally constructed) environmental niche.

Although Laland et al.'s model is a general one, not confined to human culture and evolution, they acknowledge that humans are "unique in their extraordinary capacity for culture" (p. 133). I interpret this to mean primarily that human cultures are unique in some fundamental respect, that is, they are different (perhaps discontinuously) from the cultures of other species; and secondarily that the capacity for creating, acquiring, and transmitting cultural forms is uniquely developed (though clearly not unique) in humans.

One evident discontinuity between human and nonhuman cultures is that human cultures are linguistic, and the capacity for human cultural acquisition and transmission is mediated by the unique human language capacity. The nativist modularist account of this capacity presupposes its inscription in the human genotype, a hypothesis vulnerable to many objections, including the difficulty stated above of locating this profound discontinuity in the continuous landscape of the primate genome. An alternative account, along the lines of the coevolutionary theory of Laland et al. (2000), would view the human language capacity as phenogenotypic. Language, in this account, is an artifact/niche, and the capacity to acquire and use it involves the evolution and replication of a phenogenotypic "biocultural complex" (Laland et al. 2000: 144).

Such an account does not require the organism to possess an internal model of the grammar of a language to account for language acquisition and use, any more than the building of a nest requires an internal model of the nest. The grammar of the language is *in the language*, just as the structure of the nest is in the nest. The capacity for language is thus a cognitive–behavioral relationship between language user and the constituents of language, just as the capacity for building a nest is a cognitive–behavioral relationship between the builder and the constituents of the nest; and it is this *relationship* that, in each case, has been selected for in evolution. This account is thus compatible with recent, usage-based, cognitive functional theories of language (Tomasello 1998).

The language artifact/niche is culturally situated, that is, dynamically embedded within a semiotic network that includes other symbolic and nonsymbolic artifacts. The class of organisms with the language capacity (normally developing humans) is thus a phenogenotypic replicator systemically associated with a wider biocultural complex of symbolic and constructive cognitive capacities, also of a phenogenotypic nature; and individual language acquisition and use is situated in the contexts of actuation of these interrelated capacities.

This account thus also accords with the view that what makes humans unique is not an innate language acquisition device plus a variety of other species-specific innate cognitive modules, but a generalized semiotic or symbolic capacity (Piaget 1945; Deacon 1998; Zlatev et al. 2006)—epigenetically developed from a suite of cognitive capacities largely shared with other species, but attaining higher levels of organization in humans.

Epigenetic developmental processes are those in which the developmental trajectory and final form of the developing behavior are a consequence as much of the environmental information as of the genetically encoded information. A genetically specified initial behavioral repertoire is subsequently elaborated through experience of a relevant environment, yielding an envelope of potential trajectories and outcomes. The process of elaboration is directional, and once it has taken place the initial plasticity of the embryonic, or unelaborated, repertoire is largely (though not necessarily wholly) lost. In other words, epigenesis involves a developmental transition from relative organismic plasticity and informational openness, to relative rigidity and informational closure.

Augmented epigenesis is therefore advantageous for organisms in which phenogenotypic organism–niche couplings are both frequent and variable, which is an appropriate general description of the human cultural organism. Regulatory genes augmenting epigenetic openness can therefore be expected to have been phenogenotypically selected for in the human genome, permitting further adaptive selection for domain-specific learning in the semiotic biocultural complex, in particular for language. Note, however, that in an epigenetic perspective, any developmental predisposition for learning language is unlikely either to involve direct coding of, or to be dedicated exclusively to, linguistic structure (Mueller 1996).

The account outlined above revolves around the proposition that the evolutionary elaboration and epigenetic stabilization of the phenogenotypic semiosphere introduced the discontinuity characterizing both human culture and human cognition. Signs are both transformative cognitive tools and constitutive of specifically human cultural ecologies. The semiotic capacity is hypothesized to have triggered transformative effects across all or most cognitive domains, thereby potentiating human symbolic cultures, which constitute the niche complexes in which human cultural innovation and transmission occur. The semiotic capacity is the explanatory link binding what is unique to human cognition with what is unique to human culture.

The comparative study of the evolution and development of sign use in human and nonhuman species is thus, I suggest, a key nexus for bridging the biological with the social and human sciences in the evolutionary and developmental science of human cognition.

In conclusion, I offer the following reflections on the role of the human semiotic capacity in integrating development, evolution, and cognition:

1. Understanding the transformative role of signs presupposes understanding the evolutionary logic of the sign itself and in particular the distinction between signals (ubiquitous in nonhuman communication systems); and symbols, icons, and other signs possessing referential value in an intersubjective field, the capacity to use which is strictly limited in nonhuman species (Sinha 2004). Pavlov's insight that human cognition was distinguished by a "second signal system" can only be further developed by recognizing that the human semiotic capacity is an evolutionary and developmental acquisition which builds upon, but is fundamentally different from, the capacity to exploit signaling.

2. The proposition, derived by extension from Laland et al. (2000), that signs and sign systems are artifacts/niches can be complemented by the proposition that *all* human artifacts (that is, material as well as symbolic cultural products) are situated, and can be resituated, in semiotic fields, and are thus to be considered as having semiotic value (Sinha 1988, 2005; Moro and Rodríguez 1998; Rodríguez in press). A particular case is that of the "material anchoring" of cognitive processes dependent upon symbolic notations in instrumental artifacts (Hutchins 2005). Frequently, the human body serves as such a material anchor (Enfield 2005); to this extent, the body itself can be viewed as an artifact with semiotic value, that is, as *embodying* semiotically mediated cognition (as well as aesthetic value).

3. It is increasingly recognized that human cognitive processes extend "beyond the skin," involving intersubjectively shared mental states and cultural-cognitive technologies. This presents a conceptual problem not only for psychology, with its traditionally individualist assumptions, but also for biology, which assumes by default that the organism as a behavioral and morphological individual is identical to the organism as bearer of genetic material. It is this general problem that the notion of "phenogenotype" is designed to address and resolve.

4. However, a further step, specific to human evolution and development, can and should be taken. The human organism, by virtue of the semiotic status of the body and the normative shaping of its activities in a cultural field, has a "dual ontology," culturally constituted both as a constituent of the semiosphere and, at a purely biological level, as a genetic individual. The body is part of the system that extends beyond the body, as well as being the originating sine qua non of that system. While nonhuman organisms are simplex, the human organism is duplex, and its coupling with constructed niches involves a developmental process of autoconstruction.

5. It is plausible to speculate that this specific dual ontology of the human body (individual-biological and sociocultural) is, in modern humans, incorporated in the genotype, and expressed, in the very early stages of postnatal epigenetic development, in the responsiveness of the human infant to the communicative actions of caretakers in the primary intersubjective semiotic circuit (Trevarthen 1998).

6. More generally, ontogenesis, and the niches of infancy and childhood, played a crucial role in the evolutionary development of the human semiotic capacity. Human infants and young children, as has often been pointed out, are extraordinarily well adapted to the demands of enculturation and the acquisition of symbolic communication (Tomasello 1999). Once established, the emergent social ontology of intersubjectivity and normativity sets up new parameters for the selection of context-sensitive and socially situated learning processes. The species-specific cognitive capacities of young humans are often conceptualized in terms of "mind reading" or "theory of mind." Such an internalist–mentalist perspective can be criticized for neglecting the epigenetically constitutive role of the semiosphere, and of its constituent artifacts, in the development of this capacity. Specifically, it pays insufficient attention to the emergent ontological property of *normativity* (Itkonen 1983), which characterizes human institutions at both micro- and macrolevels.

7. The characterization of language, following Laland et al. (2000), as a "niche/artifact," correctly emphasizes the biological continuity of the human semiosphere with the constructed niches that we find in many other species. Language is also, however, following the logic of dual ontology, a normative social institution (Itkonen 1983), and as such emergently discontinuous with nonhuman constructive niches. Although frequentist strategies may play a role in the learning of specific norms, the norms themselves, being in principle negotiable, are irreducible to frequential information. The evolutionary

emergence of normativity was fundamental in the construction of the human semiosphere, which encompasses ethical and aesthetic, as well as cognitive values.

8. The influential cultural evolutionary construct of "meme" is of limited explanatory value for understanding the emergence of, as opposed to modeling the consequences of, the human semiotic capacity. It is valid only at the high-generality, low-resolution level of population modeling. The notion of "meme," both etymologically and theoretically, and whether or not this is recognized by its advocates, is a semiotic one. As a semiotic unit of analysis and analytical tool, it is a blunt instrument, of dubious cognitive validity, comprising all varieties of signals and signs, divorcing semiotic value from communicative process and context of situation. This may not detract from its value in explaining cultural transmission and evolution at a phylogenetic level, and perhaps can be seen as a virtue in modeling methodologies. However, it has no explanatory utility in the ontogenetic and microgenetic analyses which are equally essential to the comprehensive understanding of cultural transformation and change.

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