The Development of the Mediated Mind

Sociocultural Context and Cognitive Development

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LEA LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
2004 Mahwah, New Jersey London

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The Virtues of Rigorous Interdisciplinarity

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Evolution is one thing, and development is quite another. They involve a different kind of dynamic, and their empirical methodologies are far apart. But, on the other hand, they also have important areas of overlap, especially in the domain of theory. This is due to the fact that both evolution and development use time as an organizational and exploratory principle. Only temporal analysis can reveal the details of emergent structure and dynamic processes. This is especially important in the case of human cognition, which defies reduction to a static model.

Cognitive processes unfold on two time scales, the first (development) measured within fractions of a single lifetime, and the other (evolution) measured in multiples of many lifetimes. Evolution is ruled by mechanisms that are distinct from those that govern development; the former act on entire populations, whereas the latter act on individual organisms. However, there are direct linkages between evolution and development. Developmental processes are subject to natural selection, and development must be an integral component of any comprehensive theory of evolution. Evolutionary theories must be compatible with developmental facts, because it is the developing organism in the real world that undergoes evolutionary change.

There is a feedback loop from development to evolution. Baldwin (1896) argued that developmental plasticity might acquire fitness value under certain circumstances, and become subject to natural selection in its own right. This was the basis of what became known as the "Baldwin Effect." Baldwin was a Darwinian, concerned with the possibility that the activities of organisms might actually affect their own evolution. He understood that the Lamarckian notion of inheriting acquired characteristics (e.g., the notion that increased exercise of the vocal tract might lead to the evolution of an improved vocal tract) could not work. But he realized that learning might provide a potential feedback loop from development to evolution, because learning allows certain species to modify their evolutionary environments. In the case of human beings, whose main adaptive "environment" is human culture itself, Baldwinian logic seems to apply particularly well.

Cultural evolution profits from the collective cognitive power of the group, or network. In the case of hominids, cultural evolution was probably very slow and limited, as it is in primates. It was essentially a secondary byproduct of cognitive evolution, never gathering any momentum as an independent force. But cultural evolution became more important as hominid cognition became more closely interlinked with the challenges that culture provided. As competition between hominids became more important than coping with the environment, culture eventually took the lead in hominid evolution, seeking out and rewarding (with better reproductive success) those genotypes best equipped to handle its accelerating demands. These demands weighed more and more heavily on developmental plasticity, and on abstract capacities and skills that were transmitted and cultivated in communities of mind, or cultures. This amounts to an elaboration of the classic Baldwin Effect. As hominid culture became more complex, cognitive adaptability to this increasingly unpredictable aspect of the environment became more crucial for survival and reproduction. A coevolutionary spiral had been triggered.

As hominid culture turned more toward innovation and change, it placed yet more importance on plasticity and flexibility. This spiraling coevolution of culture and cognition might explain the extraordinary expansion of the hominid brain during the past half million years: Hominids were becoming symbiotically dependent on culture, and this produced more selection pressure favoring brains that were well designed for living in close-knit cultural groups. As this process unfolded, the nature of the cultural demands driving the process continued to change, placing new selection pressures on the hominid genotype. This tension culminated in the arrival of modern humans, and the emergence of high-speed linguistic communication.

Deacon (2003) deconstructed the Baldwin Effect and proposed a much more biologically detailed version of this idea. Deacon noted the well-documented phenomenon that certain genes may become "redundant" after a major environmental change. Say there is a drastic climate change, and a species suddenly finds that its environment provides fruit, where it formerly did not. It now has a ready supply of Vitamin C, formerly a scarce commodity. Prior to the climate change, the organism had to manufacture its own Vitamin C by means of an innate mechanism, but now the vitamin is provided by the environment, and the need for this innate mechanism has evaporated. Formerly, an absence of these Vitamin C-producing genes would have been very maladaptive, probably fatal. Now, with an abundant supply of Vitamin C available, these genes are "redundant." As a consequence, they are no longer subject to selection pressure, and there is no constant correction on their precise reproduction. Thus, they become subject to reproduction errors. They wander, and become "unmasked." Over time, this unmasking process leaves an entire region of the genome open to wider and wider variation. Any trait associated with that region becomes subject to unmasking.

Cultural evolution can accelerate this effect, especially in human culture, because it can introduce changes into the environment at a much more rapid rate, and these changes can accumulate, as in the evolution of technology. Cultural innovation can effectively make certain genes redundant, and help unmask areas of the human genome. Such a mechanism could be potentially revolutionary in its genetic effects, changing the adaptive landscape rapidly. This could have changed the hominid genome much faster than, say, random mutations or classical gradualistic evolution. Deacon argued that human language must have originated in this way. The same logic applies to a much wider arena than language: human culture itself. Cultural evolution set the stage for language, and language itself emerged out of the network, that is, out of many minds engaged in a collaborative culture. The brain was adapting to this communicative culture as it evolved. Thus, the cultural environment might have contributed mightily to the final evolutionary push that created modern humans. Human beings are now a "hybrid" species, tethered to biology on the one hand, and to cultural change on the other.

However interesting and exciting this idea may be, it still awaits detailed verification and elaboration. But the benefits of considering developmental and evolutionary logic as part of the same theoretical enterprise go far beyond the specific case of the Baldwin Effect and cultural evolution. They are but one illustration of the benefits to be gained from applying interdisciplinary thinking to cognitive science.

THE CONVERGENCE OF ONTOGENETIC AND PHYLOGENETIC FACTORS

Katherine Nelson is unusual in having examined in detail both cognitive development and cognitive evolution. Her work has much to offer anyone interested in how the complex relations between evolution and development work together to shape the adult human mind. Nelson set out her agenda with remarkable clarity and candor, examining the convergences of ontogenetic and phylogenetic processes in cognition. This is not to imply that she holds recapitulatory views. She made it very clear from the start that this was not the case. But there are major areas of agreement between developmental theory and the emerging field of human cognitive evolution. The latter may lack the vast empirical enterprise that nourishes developmental theory, but has amassed a comparative database on humans and their closest primate relatives, and can also draw on an enormous amount of functional anatomical evidence. Nelson (1996) draws on both of these literatures, with considerable success.

Language in Cognitive Development (Nelson, 1996) is one of the best examples of the theoretical benefits of interdisciplinary convergence in cognitive science. Interdisciplinarity is not always a good idea. Attempts at putting together ideas drawn from disparate areas of research do not always work well. In fact, too often the label "interdisciplinary" simply implies that a work so labeled lacks any discipline whatever. But done well, and in the right historical context, interdisciplinary convergence is a very powerful theoretical strategy.

In the case of human cognition, it may be argued that the human mind is too complicated for any single field to master, and in this case, interdisciplinarity is not a luxury but a necessity. The question is how and where to find a method powerful enough to approach this particular kind of interdisciplinary problem. The mind is a super-complex system. The rules that govern the dynamic self-assembly of the human mind are not going to be solved by simple models or straightforward technological advances, such as more powerful microscopes. Human cognitive systems have all the complexity of living systems, plus the complications added by the need to plug into a cultural network.

This implies that cognitive theory must account for more than the individual mind. It must also account for the emergence of the cognitive community itself, which is a complex network. The network, after all, helps form the individual mind, and ultimately generates and preserves cultural representations. The biological side of a human mind may be confined within the boundaries of an organic being, but the collective side of cognition is distributed across many minds, and is supported further by a variety of communication and memory technologies that are subject to cultural evolution and have no fixed form. Humanity's cognitive "mechanism" is thus both an organic and a distributed process. Science is only beginning to comprehend the scale of the conceptual and methodological challenges involved in the study of dynamic systems of this complexity.

Thus, the really difficult research question in this field is: What is the question? Researchers really do not know how to approach the topic, and the dilemma is not technical, but rather theoretical. They are close to having the technical capacity to track every neuron, and label every chemical transaction in the brain simultaneously, and this exposes an Achilles' heel: Researchers do not know what to ask of this technology. Given such powerful methods of investigation, what should they look for? The answer is not at all clear.

However, one thing is clear. The answer will not come from blindly collecting more data, or by automatically applying whatever technology the engineers come up with next. Cognitive theory must develop a strategic approach on its own level, and construct useful hypotheses, not only by following each technological trend as it appears (although this is inevitable), but also by absorbing all the substantive material that might prove relevant and formulating a better theoretical framework. This is how astronomy and biology progressed. At many points in the history of these sciences, theory was far ahead of their empirical databases. It was a vital source of guidance in deciding what kind of evidence to seek. One should not expect to arrive at the cognitive equivalent of a Copernican or Darwinian synthesis in cognitive science after the fact, that is, by collecting data and then deriving a theory from it. That has virtually never been the case. Theory has led the way, making its own breakthroughs, focusing investigation, and enabling empirical researchers to ask the right questions. To achieve this, theory did not follow a narrow path. Integration and convergence have been the order of the day.

The basic principles of theoretical convergence are conceptually simple, but difficult to implement effectively. Convergence involves seeking evidence that points to a common conclusion across several disciplines. Thus, for instance, a researcher might look across all possible sources of knowledge about memory in order to build a better theory of memory. Questions of "scientific taste" often come up in doing this. Is it good taste to search too widely, or prematurely, or too narrowly? How do researchers decide where to draw the line? This is admittedly difficult, and hard to judge until after the fact. The most successful applications of convergent evidence are judged ultimately by the canon of parsimony, which demands the simplest and most general solution. The most efficient path to such a solution is to map out any new territory by placing it in the major coordinates of a wider theoretical world, to define the space within which new evidence will have both location and meaning.

This principle applies to cognitive theory. When lines of evidence are brought together from several different cognitive research areas and point to the same conclusion, time is saved because theories in each area are prevented from wandering off in directions that contradict evidence from other areas. Theories are thus made stronger and wider. A spatial metaphor might help here. Early mapmakers could infer a great deal by finding convergence points that would link together two databases that were far apart (say, two provinces of ancient Greece). The basic coordinates of early maps were established by fitting together initially disconnected observations from many places, and looking for convergent information that would allow them to be placed on a single map.

The same idea applies to nonspatial models of the world. The theory of evolution was constructed by applying the principle of convergence on a very large scale. At first, it relied on rather thin evidence, but the overall theory proved quite robust because it drew together so many disparate bits of information from fields as far apart as geology and anatomy. In the 20th century, the theory was confirmed and extended by its convergence with findings from many other disciplines, including morphology, taxonomy, ecology, geography, mineralogy, cell biology, and finally, genetics.

Darwin was trying to simplify extreme complexity, and he succeeded. The domain of cognition involves, if anything, even more complexity. Cognitive theory has to start with Darwinian theory. Mind emanates from living things; and all the complexities of evolutionary biology are present in the problem. But, in the case of the human mind, the problem also encompasses the additional complexities of culture, which leads directly, among other things, to the problem of anthropocentrism. Darwin started with a set of specific observations that showed the functional convergences of anatomy, environmental conditions, and specific behavioral traits. He knew that such coincidences were extremely unlikely to occur unless there was a compelling underlying process to explain them. The same principle applies to the human mind. In this case, researchers should be seeking convergences, not only with the human sciences, but with the natural sciences as well.

One reason for the robust nature of convergent theoretical syntheses is that they are not paradigm bound. Single research areas within disciplines are often dominated by a few narrow paradigms, and theories based exclusively on such a narrow evidential base do not easily generalize to the larger world of other paradigms. This is particularly true in the field of cognitive research. Classical laboratory studies of, say, short-term memory, phonology, or speech recognition were limited in their applicability to theories of mental development because the paradigms were so particular to each field. They could not easily be extended to the complex world in which children lived and developed, and their methods often overlooked the real problems with which a growing child must deal on a day-to-day basis.

This should not be taken as a criticism of specialized research. Specialization is here to stay. Cognitive science is a complex business, and it requires highly trained specialists, because its methodologies are very difficult to master. But it is not only the collection of data that demands methodological rigor and special training. Theory also demands it, and the discipline of theory building does not follow simply from mastering the demands of design and data collection. It follows from mastering the specific skills of the theoretician. These are different skills and require a distinct kind of preparation.

In physics, this fact of life was formally recognized long ago; as a result, theoretical physics involves a different kind of training, in a different academic program, from experimental physics. But in cognitive science this distinction is not made, and theoreticians are apparently expected to emerge as if by magic, without any special training. Moreover, in cognitive research, laboratory workers in particular can become so deeply committed to a specific paradigm that they see such "invasions" of their turf as a threat to be resisted, rather than as a positive source of new insight to be embraced. As a result, their ideas may remain vulnerable to the possibility that evidence from another field might eventually invalidate them. A good case in point was Behaviorism's theoretical collapse in the face of persuasive ethological evidence. For 50 years, the laboratory methods of Behaviorism dominated most North American departments of psychology, and relied on one set of approved paradigms, while rejecting important sources of evidence on the same subject matter, the animal mind, simply because they were drawn from other fields. The result was disastrous and wasteful. Convergent theory building across fields would have worked better. It would have avoided many of the naïve propositions that emanated from that field.

Theories constructed from a wider survey of evidence are less likely to fall victim to the same kind of error. Of course, this is true only if theorists take pains to acquire sufficient expertise in all the empirical fields from which an argument is being constructed. But the expression "sufficient expertise" does not imply that theorists must always have a technical mastery of every field they survey. Rather, they must have enough knowledge of the strengths and weaknesses of various methodologies to be able to evaluate properly the claims emanating from a given area.

Multidisciplinarity is far from a new idea. It proved its effectiveness as a theoretical strategy long ago, as far back as the 18th century. At that time, theoreticians in a variety of fields drew their evidence from many different sources, and systematically compiled a massive database from which they extracted patterns that were otherwise not in evidence. This was true of the chemical table of elements, and of the first great geological classification systems, which integrated a massive amount of evidence from the study of fossils, rocks, environmental change, climate, mining, and biology. These great scientific achievements involved a vast exercise in theoretical synthesis across bodies of evidence that were obtained with many different methods. The approach was a convergent one, and the result was robust theory, which later led to finer and finer differentiation of both theory and method. This kind of synthesis has always been one of the pillars of science.

However, this kind of integrative thinking has become very difficult to practice in the professional environment of experimental psychology. This is partly due to a tremendous increase in the number of paradigms, but also to a certain ideological resistance to psychological theory as an end in its own right. Cognitive research tends to cluster itself into small panels and groups that are self-defined by their methodologies, rather than by their place in a larger theoretical world. Thus, there are "brain imaging scientists," "human short-term memory researchers," "theory of mind researchers," "simulation science," and so on, defined largely by paradigms. This is fine, as long as theory escapes any attempt to confine it narrowly to the data of any single paradigm. Unfortunately, this is not easy to achieve when researchers are trained as they are.

Despite this trend, out of scientific necessity, theory in cognitive science has become more interdisciplinary. The message implicit in Darwin's early multidisciplinarity is the following: When pursuing the theoretical Big Picture, a quick and effective way to eliminate potential theories and hypotheses is to look for failures of convergence. Use the data drawn from one field as a verification check on the interpretation of data from another. *For instance, reject out of hand any psychological theory that does not make physiological or biological sense, and vice versa.* And reject any evolutionary interpretation that does not converge with what is known of development.

Above all, in the case of living organisms, this caveat implies that science should not ignore how animals (including humans) live in the real world. Researchers should try to account carefully for the impact of the real world on the evolution and development of humanity as a species. This is the normal condition of developmental theory, but it is rare elsewhere in cognitive science, because it immerses the theorist in a vast and at times impenetrable morass of data from many fields. But there is no choice.

There could be no better rationale for insisting that every cognitive scientist have extensive training in theories of mental development. The alternative is to pursue blindly some line of cognitive research or simulation that may prove, in the long run, to be uninteresting or even misleading. The early history of experimental psychology should have provided cognitive science with many unforgettable examples of this danger, but this seems to have been forgotten. All those thousands of papers in psychophysics and animal behavior, with their equations, esoteric terminology, and aspirations to the precision of particle physics were left mouldering on library shelves because their proponents failed to take into account what science already knew of ethology, physiology, and cognition. A significant segment of modern cognitive research is leaving itself vulnerable to the same disease. Developmental theory is one of the cures. It forces scientists to synthesize across paradigms. It should be a required part of every cognitive science curriculum. But it is not, nor, incredibly, is the theory of evolution.

ACHIEVING BALANCE

How does a budding interdisciplinary thinker decide where to draw the line in constructing a synthesis? How much is too much? It is not possible to include absolutely every field that might be relevant to a subject as broad as the nature of the human mind. There are no good written guidelines to aid aspiring theorists, and they must depend largely on good examples.

Katherine Nelson's theoretical work is a canonical example of how to balance the demands of width and depth. Nelson started with a complete mastery of her own field (or fields—her developmental theories represent a significant multidisciplinary synthesis within the subdisciplines of developmental psychology) when she decided to enter the treacherous waters of human evolution. This she did carefully, and with panache. Her key insight was that cognitive processes that were scaffolded during development might have a similar vertical scaffolding during their evolution, and vice versa, even though the underlying mechanisms of change were very different. She showed how the patterns of the developing mind were revealed in its unfolding, and then how those patterns resonated with what is thought to have occurred on the evolutionary time scale. This perspective afforded her an opportunity to find things that were otherwise blurred or hidden in noise. And this exercise paid off. The key to her success was that she had a firm agenda, and applied a rigorous standard of verification.

I tried a somewhat similar exercise in my home discipline of neuropsychology, where there was a similar skepticism about the value of integrative theory. In my early studies of case histories documenting the cognitive sequelae of brain injury, I found that the breakdown of the adult mind after brain damage often reveals a confusing mix of cognitive disorders, all simultaneously present (these tend to be the cases that are not mentioned in the literature). It is extremely difficult, if not impossible, to factor out from such a disordered mind the discrete "modules" of the mind solely on the basis of clinical observations and tests.

The underlying cognitive organization of the brain is hidden below the observable behavioral surface, because the adult clinical case presents symptoms that are the end result of a very complex developmental (and evolutionary) history. This imposes a frustrating limitation on what can be said about neuropsychological evidence taken in isolation. Theories of modularity proliferated in early neuropsychology, but nobody could agree on which modules were real and which were imaginary. The only escape from this frustrating theoretical trap was to recognize the necessity of going outside the field, examining other evidence on modularity, and looking for convergences between disciplines (Donald, 1991).

The same problem was even more acute in cognitive neuroscience. Methodological innovation during the 1970s and 1980s was focused on event-related potentials (ERPs), with a special emphasis on their relation to language and selective attention. As long as researchers in this field stayed close to their data, their results were plagued with ambiguities, due partly to the limited cognitive paradigms that could be used with such recording methods, and partly to the limitations inherent in surface electrical recording. It was extremely difficult to build theories of any depth or breadth based exclusively on such evidence. The only way to reduce the number of plausible theories was to look for convergences between evidence collected with these methods with data from other fields. Given the nature of the questions being asked (e.g., What is the internal architecture of the language brain?), this required not just a synthesis of adjacent areas of neuroscience and cognitive science, but a much more ambitious program seeking a broader synthesis that reached out to biology and anthropology.

Surely, the best ruling paradigm for such a broad synthesis should be an evolutionary one. The interdependencies and complexities inherent in the mental structures of human adults could only be understood better in the light of a comprehensive evolutionary scenario of human emergence. Nelson decided to take a similar theoretical course in her own field, for somewhat similar reasons. A qualitatively different perspective on the essentially static paradigms of cognitive neuroscience could be sought by adding evolutionary time as a major variable and narrowing down theoretical alternatives by using convergence as an eliminative device. The longer term objective of such an exercise would be similar to Nelson's: theoretical unity. Just as physics must seek to make the theory of the very large (relativity) compatible with the theory of the very small (quantum mechanics), so psychology might make the theory of slow-moving cognitive dynamics (evolution) compatible with the theory of fast-moving cognitive dynamics (development).

THE ORIGINS OF COGNITION IN THE INTERACTIONS OF BRAIN, MIND, AND CULTURE

Evolutionary and developmental processes are both part of the same dynamic cognitive system. Many of the most abstract and uniquely human abilities of the adult mind are neither inborn nor automatic, but rather are the result of a hybrid brain-culture developmental process that interweaves the phenotype with cultural evolution. In effect, as cultural evolution has gathered momentum, the balance of power in cognitive development has shifted to culture, and the evolving human brain has tracked the changing cognitive demands imposed by it.

Human beings are thus cognitive hybrids, tethered to both biology and cultural environment. Another way of phrasing this is that humans were the first species to evolve a truly "distributed" cognitive system, that is, a system in which thought and memory are carried out in a community of minds. In a network, individuals are joined to a larger cognitive architecture that can have powers (e.g., deep memory resources and diverse expertise) that are not available to single individuals. Networks can also serve as generators of novel and powerful cognitive tools (e.g., languages, instruments, and symbolic notations). Languages in particular are network-level phenomena. They come into existence only on the network level. They are negotiated, like treaties. They are inherently conventional systems that are created only in groups.

Language is the most salient and distinctive mental capability of the human species. But in its origins, language is more like an ecosystem than the individual organisms that make up ecosystems. Lexicons and grammars emerge at the group level, not in isolated individuals. They exist in the spaces between people, and regulate their cognitive transactions. This has enormous consequences for the kinds of developmental theories that can reasonably be constructed. If the network comes first in development, then humans must have had networks, or proto-networks, long before they had languages. This observation led to my "culture-first" theory of human cognitive evolution (Donald, 1991). A sophisticated form of high-speed communication, like language, could not have evolved unless some kind of cultural network was already in place. That network was undoubtedly based on unique human communicative skills such as gesture, mime (including role playing), and imitation. These establish the invisible mimetic dimension of human culture, which apes find so difficult to understand, and which still provides a very efficient platform for the development of language. These processes are the precursors of language in children.

It is fair to say that the human brain cannot realize its design potential outside of culture. It is designed to serve as a component in a distributed system, rather than to operate solipsistically, as a stand-alone device. This has many implications for the kind of theory researchers should be constructing. If humans had evolved as self-contained creatures capable of solving the world entirely on their own, they would have a very different design from the exiting one. For one thing, the resources needed to understand the human world would have had to be built-in. But they are not. Symbolic systems and codes, and the basic habits of rational thought are assimilated from culture. Thus, the developing human mind follows a strategy that is radically different from that of any other species. In order to achieve its mature form, it is dependent on information that is held in something external to both genome and brain: culture.

Culture is an integral component of humanity's evolving distributed cognitive system (Donald, 2001). This vast and complex system encompasses both the human genome and various external sources of replicative information. Culture is equipped with a variety of memory media, and follows its own independent course of evolution. Culture can store and transmit many kinds of specialized programming, and even impose specific cognitive architectures on the brain, such as those of reading, writing, and speaking English. It achieves this through a process of deep enculturation that modifies the developmental process. Culture thus amounts to a massive offline network resource that recreates in the brains of individuals a virtual operating system that they will use in thinking, judging, and remembering all their lives. Human brains have adapted to the presence of this unique enculturation process for hundreds of thousands of years. This explains why human brains are set up the way they are, and why the human species has evolved more epigenetic plasticity, amodal integrative ability, and uncommitted memory capacity, rather than a novel armamentarium of new mental modules.

In this context, it is obvious why the human brain is so malleable, to a degree unknown in other species. The developing human brain "assumes" that it will receive basic operating instructions from a culture—any culture. Those will enable it to develop fully-human cognitive capabilities. Of course, culture is unpredictable, but it is only from culture that the mind can acquire a mature adult shape. The adult form of a human mind is highly uncertain, and dependent on the particularities of culture. An adequate model of the human cognitive process will have to explain the entire cultural ecosystem within which the human mind lives and reproduces itself, as well as the internal organismic processes that are joined to the ecosystem.

This idea affects the theoretical framework in which the human mind must be seen. The hominid brain did not need to evolve a language module, any more than it needed a logical thinking module, or an artistic intuition module, or a mathematics module. Rather, it needed the things that responded to the cognitive demands of culture: a wider and deeper working memory system, much better attentional skills, and the various metacognitive skills essential for navigating the complexities of culture. The major evolutionary demands imposed by a burgeoning culture insisted on widely applicable, amodal capacities, not rigid encapsulated modules.

Human life has much in common with animal life, but the overwhelming influence of culture in development gives the mental lives of human beings an extra dimension. Human sensory and basic perceptual capacities are almost identical to those of apes and monkeys. But culture cannot be read by those mechanisms. Culture is invisible to any mind not equipped to decipher its complex codes, and especially to track intentionality in other minds. The capacities that enable human children to decipher such things are broad metacognitive and integrative skills that are normally identified with conscious processing. The remarkable proficiency of human beings in this regard sets them apart from other species. Human children can cope with the invisible "second world" of culture only because they can find, track, locate, and remember aspects of the human social world that completely escape their closest ape cousins.

The codes of human culture amount to an encryption device that conceals the meaning of much that people do from other species. What underlies the extraordinary cognitive capacities that enable human children to read these codes so easily? This is the central question that cognitive science must answer. And to answer it, researchers must become more interdisciplinary in their thinking. An ecologically valid ethology of the human mind requires immersion in cultural studies, as much as it demands training in the natural sciences. The complexity and subtlety of the human mind is evident only in its cultures, just as the complexity of many other species is evident only in their natural habitats. To build an adequate model of this process, scientists have to pay close attention to the work of theorists such as Nelson. Developmentalists are perhaps the only cognitive scientists who acknowledge fully the three central facts of the field: the human mind is a dynamic process, whose realization is harnessed to the creative engine of culture, and whose structure is solidly planted in brain physiology. Most other subdisciplines tend to acknowledge only two of these, and some only one. But there will not be a convincing theory until all three are accounted for. This presents a challenge that science has never had to face before, but in facing it, scientists will almost certainly redefine human nature.

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