SOCIAL BRAIN MATTERS

Stances on the Neurobiology of Social Cognition

Edited by

Oscar Vilarroya
and
Francesc Forn i Argimon

Rodopi

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EVOLUTIONARY ORIGINS OF THE SOCIAL BRAIN

Merlin Donald

Human beings are cultural entities. We share mind. We construct cognitive collectivities called symbolic cultures. Raised in isolation from such collectivities, we have quite limited, nonsymbolic minds. Culturally isolated human beings are not much different from their large-brained anthropoid relatives. However, embedded in a cultural network from birth, human beings become something unique in the biological world: symbolizing intellects bonded to a community of minds.

Cultural networks are a vital link in the human cognitive process. They greatly affect the way we carry out our cognitive business. Cognitive scientists often portray culture as a secondary factor in cognition, a mere "content provider" for most of our conscious experience as adults. But this superficial account ignores the fundamental importance of culture in forming the mind. The deepest effects of enculturation are responsible for the basic structure of the unconscious and all conscious representational domains. Many of the surface phenomena of cognition, such as the specifics of gesture and language, tacit knowledge, archetypes, oral histories, and social ritual, come from culture. But so do the underlying cognitive foundations that make these possible, including the detailed algorithms that define habits of thought, the retrieval paths that direct memory, and even the functional systems that micro-manage attention. We acquire the most important of these from cultural immersion. Modern cultures also provide technologies that amplify cognition. External symbolic devices, such as books or computers, can relieve the brain's biological memory systems of some of their traditional burden and speed up mental processing, allowing the mind to build powerful representations of reality. All this changes how we think. The existence of fast, efficient external memory systems enables us to construct elaborate knowledge-networks and institutional structures that interlock many minds into social meta-organisms or mega-machines. These function as "distributed" cognitive networks, which are legitimate objects of study for cognitive science.

Unfortunately, cognitive science has generally ignored or denied the importance of culture, subscribing to what I have called "the myth of the isolated mind," the belief that minds are self-sufficient monads bounded by their physical container (usually the brain). Monads are isolated entities that supposedly look out at the world, and "solve" it, while remaining independent from it. Jean Piaget's approach to child development epitomized this ap-

proach; he viewed infants as budding scientists who observe and act on the world, remember the results of their experiments, and use this evidence to construct personal universes of considerable complexity.[1] As these (hypothetical) children pass through successive stages of development, they construct more and more complex concepts of time, space, and causality, achieving all of this alone. Although many of Piaget's experiments were brilliant, these solipsistic axioms proved to be wrong. The Russian developmentalist Lev Semenovich Vygotsky came closer to the truth, showing that many of the operations that Piaget thought essential for self-construction were not innate, but acquired from culture.[2] The mind gains much of its structure from culture. This is true especially of language and thought, which tend to develop in quite specific social contexts.

1. The Primacy of the Mimetic Adaptation

What type of cognitive change would have enabled a group of archaic hominids to start developing a communication system that led eventually to the invention of highly variable and arbitrary gestures and words, distinctive grammars, and symbolic cultures? When we consider the cognitive capacities of modern apes, which probably resemble those of our common Miocene ancestors, the most fundamental cognitive component missing from their repertoire would appear to be a generalized capability to refine action deliberately. Gestures and intentional vocalizations are ultimately actions of the musculature. In order to generate a variety of arbitrary gestures and sounds, primate motor behavior must somehow have evolved into a system that was more plastic, less stereotyped, and most importantly, subject to deliberate rehearsal and refinement. Languages must be learned and invented. Given the limitations of primate motor behavior, this called for an evolutionary breakthrough in hominid motor control.

In most species, the range of possible behaviors is largely fixed in the genes and closely attuned to its ecological niche. This results in what is sometimes called a "specialist survival strategy."[3] Specialization in evolution creates a remarkable diversity of behavior across species, but it produces virtual stereotypy on the behavior of any single species. This is even true of the higher mammals, where most species do not have enough variability in motor behavior for individuals to deviate significantly from an inherited standard motor repertoire and motor options are confined within a narrow morphological envelope.

Human beings have broken out of this morphological straitjacket. This is especially evident in the variety of human spoken languages. But it is also obvious in the range of styles, customs, sports, crafts, and games that human beings invent. Where would such flexibility have begun to evolve? This question leads us logically back to the fundamentals of human motor skills and procedural learning. To learn, vary, or refine any action, including speech, an individual must carry out a sequence of basic cognitive operations. Traditionally, these include rehearsing the action, observing its consequences, remembering these, and then altering the form of the original act, varying one or more

of the parameters dictated by the memory of the consequences of the previous action, or by an idealized image of the outcome. We might call an extended cognitive sequence of this sort, whose inherent complexity should not be underestimated, a "rehearsal loop." This rehearsal loop is combined with an active process of metacognitive review, whereby actors direct their attention away from the outside world, and toward their own actions. In performing metacognitive review of a precise skill, such as speech, we must aim the focus of attention at the form of the act itself, not merely at its consequences.

Apes appear to be quite poor at rehearsal and metacognitive review. We can get them to repeat actions, as a function of reinforcement contingencies, and they can engage in socially facilitated imitation, But they cannot independently initiate and rehearse actions accurately for the sole purpose of refining their movement sequences. On the other hand, at some point in their early history, human beings developed a skill sequence known as throwing. Different species of primates can throw projectiles, but they do this crudely, and never practice deliberately to refine their accuracy and power. As a result, they do not create systematic variations or improvements on the way they throw. In contrast, even young children routinely engage in practicing and refining such skills, often for endless hours, and for no pragmatic purpose. It would be no exaggeration to say that this capability is uniquely human, and serves as the background for the creativity of human cultures and languages.

Early hominids presumably began their evolution with the same basic motor repertoire as most primates. They broke out of the limitations imposed by that repertoire, and eventually evolved the rich variability that served as the basis for inventing, among other things, the morpho-phonology of language. Language is the most complex learned skill in the human repertoire, and it is reasonable to infer that a capability for the purposive rehearsal and refinement of skill had to come into existence long before language, to support less complex skills, such as tool making and throwing. A cluster of more basic capacities, including gesture, imitation, and voluntary rehearsal itself, appears to have a common underlying neuro-cognitive architecture, and quite possibly evolved as a series of components of a single complex adaptation. Elsewhere, I have called these components "mimetic skill."[4] Mimetic skill, or mimesis, has its own evolutionary rationale, and its own representational principles.[5]

Mimesis involved a revolution in motor skill, but it also rested on a major change at a higher level of processing in the nervous system, that of metacognition, or self-review. In addition, it involved a corresponding modification of primate memory retrieval capability. The key to purposive rehearsal and morphological variability is voluntary recall: Hominids had to gain access to the contents of their kinematic memories. Apes appear quite poor at this. Presumably, they cannot rehearse actions, partly because they cannot recall them at will, and must depend on external cuing (from a trainer) to acquire a complex skill-sequence. If an animal depends on environmental cues to remember when and how to produce a particular action, skill development is extremely difficult and slow, because the animal cannot self-trigger the mem-

ory systems supporting the skill, and effectively hangs in suspended animation until the environment provides the necessary cues for the retrieval of a designated pattern of action. It usually takes thousands of trials to establish a reliable signing response in a chimpanzee.[6] In general, primates and other mammals have great difficulty in self-triggering their motor memories. Even enculturated apes, such as those described in the studies of E. Sue Savage-Rumbaugh and collaborators, rely heavily on their human caretakers for memory cues to trigger signing.[7] Human beings, in contrast, are able to "think about" or "imagine" things that are totally unrelated to the immediate environment, and seek out particular kinematic memory items without the need for the environment to come up with the relevant retrieval cues.

This suggests that mimesis resides in an imaginative capability unique to human beings. To be able to focus selectively on their actions, actors must assemble motor sequences in their imaginations. We recognize that this highly evolved capability is common among human beings. Coaches of professional athletes and teachers of musicians and actors rely heavily on this capability. For rehearsal to result in improved performance, imagining is insufficient. The subject must be able to edit the imagery generated in kinematic imagination before implementing it.

Human mimetic skills cut across all major sensory and motor modalities. In human beings, it is a domain-general capability. Neurophysiologists sometimes refer to a domain-general system as supra-modal. Supra-modal means "above modality," able to take inputs from many sources, and to implement an output in many sets of voluntary muscles. We can find a classic example of this capability in the action of writing. A writer may write the letter *a* with finger, wrist, elbow, lips, head, legs or trunk, or any combination of these. The motor template for the letter *a* can be mapped onto virtually any subset of the voluntary musculature. This is an example of supra-modal motor control in an action system producing an output that is culturally arbitrary in its form.

This type of control implies the existence of a modeling process in the brain that can generate variations in imagined actions, and try them out in performance, measuring them against a second-order motor model, or more accurately, an abstract "model of models." This evolutionary innovation would have had great adaptive value, in a variety of survival-related areas, because the entire range of voluntary action can be refined. This capability extends to such apparently non-utilitarian actions as standing on one's foot, making faces, or skipping stones.

The process that generates these kinds of action patterns relies on the same principle of perceptual resemblance that drives imitation, mime, and gesture. These are all components of mimetic skill. Mimesis is metaphoric, or holistic, in its cognitive style. We cannot easily reduce mimetic action to discrete or digital algorithms combined according to rules. Instead, it appears fuzzy in its logic, more like the visual recognition of faces. The "Gestalt," or overall pattern, is the primary driver.

Mimesis is the direct result of this fuzzy capability to generate variations of action under voluntary executive control and the logical first step toward language. Hominids could not have evolved a capability for language, even in its most elemental form, without meeting the cognitive preconditions for inventing a morpho-phonology. Mimetic capability would have allowed hominids to vary and elaborate upon the entire voluntary motor repertoire they inherited from the primate line. In addition, it provided a capability for considerable additional morphological invention. At this preliminary stage in the evolution of hominid motor capability, the expressive use of mimesis was probably restricted to action metaphor, mime, and rudimentary gesturing. Vocal skills would have been restricted at this stage to prosodic modulations of existing cries and calls.

On present evidence, this level of mimetic skill would have sufficed to explain the major cognitive achievements of archaic *Homo,* from about two million years ago until about 60,000 years ago. Mimesis would have served as a cognitive foundation for evolving a set of shared expressive customs and for triggering a legacy of nonverbal culture, which is still evident in human infants. In human infants, communication begins in mimetic exchanges with the mother. In adults, forms like dance, pantomime, and a public "theatre" of expression still play a major role in human life.

We should consider the evolutionary origins of the elaborate mimetically-driven systems of expression common to all human cultures to be distinct from the origins of language per se. Language was scaffolded on a mimetic foundation, but involved additional major adaptations, and, judging from present evidence, came much later in hominid evolution.

2. Bridging to Cultural Networks

The cognitive development of human beings depends upon their links with culture. The words, ideas, and habits of mind that dominate our conversations originate in cultural networks, as do the algorithms used in formal thinking and writing. Individual consciousness is a local funnel in this vast cultural landscape, receiving a narrow sample from an infinite number of possibilities. Viewed in this way, an individual mind is a wormhole in a vast culturally defined space.

To borrow a term from computing, every culture has a "network architecture" that directs the flow of knowledge among individuals, institutions, and external memory devices. But cultural networks are not minds because they have no integrative core equivalent to what we call the conscious self. They are better viewed as distributed networks, in the sense that they engage many minds and their cognitive activities are made possible only by interlinking those minds, often with the aid of technology, into large functioning networks. These are epitomized by the World Wide Web, which is only a recent variant in a long tradition of smaller, slower cultural networks, typified by the oral traditions of Stone Age society.

All cultural networks, even those of oral cultures, harness the cognitive resources of many individuals and impose a larger organization, often with a technological dimension, on the mental functioning of individuals. This greatly affects what an individual can achieve. Just as the powers of a computer are amplified when connected to a network, a human mind becomes more powerful by its connection to a cultural network. The extent of this amplification depends on the resources held by the culture. The cognitive properties of cultures can vary widely, due to differences in their network-level resources. In this sense, cultures are not all equal. Quite the contrary, some cultures confer a huge advantage on their members in cognitive matters.

The most important network-level resources of culture are undoubtedly writing and literacy, the invention of which revolutionized human cognition at the individual and network levels. Cultures equipped with a full range of literacy skills and technologies have an insuperable advantage over those that lack a writing system (the vast majority of known cultures have no indigenous writing). Literacy dictates a great deal about the cognitive powers of a culture. Some kinds of knowledge cannot develop without a writing system, and some kinds of formal thought-operations cannot happen without appropriate notations or technologies. Oral cultures are limited to the biological memories of their members and must rely on individual specialists, such as shamans and bards, to transfer their knowledge across generations. This imposes limitations on what such cultures can think and remember.

Once a culture has some form of writing, many new kinds of intellectual representations and transactions become possible, and institutional structures may become more complex. The earliest literate cultures, such as those of Egypt, Mesopotamia, and China, resembled one another in their style of cognitive governance, despite great differences in the substance of their traditions, because of the administrative options offered by writing technology. They evolved into highly centralized hierarchies with powers focused by a system of governing myths, which regulated every aspect of daily life. In such cultures, the cultural memory system slowly moved away from its traditional dependency on single individuals to assume a life of its own, sustained by institutions and symbolic technology.

Many kinds of memories, especially those related to agriculture, population, wars, and trade were stored in written records and other nonbiological memory media, such as monumental architecture. Eventually, the material records held by such societies greatly exceeded biological memory capability, and by about 1500 BCE, the first substantial libraries came into existence. This development gradually revolutionized the process of thought itself, which interlinked with formal institutions and a public process of scholarship and review. Metacognition, a self-supervisory skill that is the foundation of human individuality, became a community enterprise.

Institutions and social organizations are not conscious entities and we cannot say they have minds. But they are cognitive entities and they do perform cognitive work. They have beliefs, perceptions, and plans. They evaluate

situations, and react creatively to challenges. Although they cannot function without the individuals that make them up, institutional structures rarely depend on single individuals over the long run. They dominate the minds of their members, and individuals assimilate institutional values to such an extent that they rarely violate them.

Institutions are real-world distributed networks, as opposed to the more limited ones created in computer simulations. They preserve particular problem-solving strategies (such as legal and scientific procedures), decision-making systems (such as corporate and parliamentary institutions), and representations of reality (such as works of art and scientific theories). These are stored and transmitted across generations with the aid of writing.

Some technologies amplify the intellectual powers of a society. These include systems of weights and measures, monetary systems, and cognitive machines, such as observatories, slide rules, sextants, clocks, and computers. Such technologies are crucial in defining the real intellectual power of a culture. They not only allow cultures to preserve more complex ideas and traditions, but change how they achieve this. Systems of external symbols can mediate some forms of thought. New notations (for instance, the zero, or the equal sign) can make possible some kinds of thought that were formerly impossible. Breakthroughs in the technologies of the visual arts or music, or revolutions in the public cognitive process, can produce the same revolutionary effects, as in the Greek habit of recording successive critical commentaries on texts, which created an institutionalized process of reflection on thought itself.

Viewed in this way, we might regard the culture of, say, France as an invisible knowledge-gathering apparatus that reaches over time and space into the minds of millions of people. The emerging global English-speaking culture is an even grander example of this, a sort of cognitive octopus with invisible tentacles into billions of minds. In some degree, we are all tethered to such a system, whether large or small. This has always been the human condition, but we have only recently become aware of the fact. It is difficult for us to accept the degree of our dependency, perhaps because intellectuals are so deeply beholden to cultural networks. We are its primary servants. We toil away in the bowels of culture, devoting entire lifetimes to some tiny region of the collective memory, or fine-tuning the algorithms of thought in some vanishingly small area. Our grand illusion of individuality is defined by its fixed place in a particular cultural network. Although it may appear that we lose our autonomy in this, we gain intellectual stature when wedded to a community of mind. All complex intellectual work results from a marriage of high-level neural circuitry with the algorithms of culture. We could not be the entities we are without this union. Even ideas that claim to subvert our cultural linkage, such as the annihilation of self, or the withdrawal of self from the world, are part of a specific cultural tradition, and have meaning only in that context.

Notes

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4. Donald, Merlin, *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition* (Cambridge, Mass.: Harvard University Press, 1991).

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