In G. Hatfield and H. Pittman, eds. Evolution, Mind, Brain and Culture, University of Pennsylvania Press (in press)-
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Mimesis as a complex evolutionary adaptation

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This paper focuses on one aspect – mimesis – of a comprehensive theory of human cognitive evolution (Donald, 1991). A mimetic act is a performance that reflects the perceived event structure of the world. It has three behavioral manifestations: (1) rehearsal of skill, in which the actor imagines and reproduces previous performances with a view to improving them; (2) mime, in which patterns of action, usually of others, are reproduced – for example, a child pretending to act like a puppy; and (3) nonlinguistic gesture, where an action communicates an intention through resemblance – for example, miming a facial expression of disgust. The contents of mimetic acts are observable by others, which makes them a potential basis for a culturally accepted "mimetic" vernacular, enabling members of a group to share knowledge, feelings, customs, skills, and goals, and to create group displays of emotions and intentions that are conventional and deliberate – for example, of shared aggression or grief.

Mimesis was conceived as an archaic (approximately -2 Mya) neuro-cognitive adaptation that formed the initial foundation of a distinctively human mindsharing culture. This innovation enabled hominids to break out of the solipsistic mode, and to create the rudiments of a community of mind (or more properly, a community of brains). It was the first step away from the primate mindset toward the formation of shared cognitive-cultural networks that could serve as a means of accumulating culturally stored knowledge and skill. This had consequences for the future evolutionary trajectory of the hominid brain and the eventual shape of human culture. It also established the social conditions in which the later evolution of language became possible.

This review will cover the current status of the theory of mimesis, and attempt especially to clarify two issues: (1) the very broad nature of the adaptation that resulted in mimetic capacity in hominids, and (2) the particular importance of metacognition – that is, executive and supervisory skills – in the evolution of mimetic capacity and cultural evolution.

A methodological caveat

The human evolutionary scenario is well documented, and dotted with new hominid species. Australopithecines, archaic Homo, and Homo sapiens each generated several subspecies. The line that led to modern humanity generally favored the most gracile subspecies, but there were many false starts, and many twists and turns, in the human lineage. Speciation is not a small thing. New species typically emerge along many different dimensions, and the outcome of this particular sequence, anatomically modern humans, demonstrates that almost every aspect of the hominid ancestral species (anatomy, diet, mating behavior, energy generation and consumption, heat dissipation, social life, and, of course, cognition) underwent modification in the process. This is normal. Organisms adapt to selection pressures in very complex ways, and single variables are seldom, if ever, adequate to account for speciation events. An adequate theory of human cognitive evolution should begin with this realization.

In fact, theories of cognitive evolution should be subjected to a mandatory methodological caveat: Avoid oversimplifying the nature of major adaptations that culminate in a new species. Unfortunately, despite this much repeated caution, there has been a strong tendency to try to reduce human cognitive uniqueness, so dramatic and obvious even on a superficial examination, to the evolution of a single variable; that is, to one parameter of a complex system. It has been common for theorists in this field to propose any one of the following variables as <u>the</u> breakthrough that “explains” the special cognitive abilities of modern humans: imitation, generativity, spoken language, universal grammar, altruism, shared intentionality, prosociality, gesture, anticipation, mental time travel, skill, theory of mind, joint attention, blending, latching, symbolization, or even representational culture itself. Previous generations singled out other variables for their fifteen minutes of fame: stone toolmaking, speech, the opposed thumb, symbol use, the descent of the larynx, voluntary vocal control, and erect posture were all proposed as key variables that somehow typified or epitomized human uniqueness. Many single-variable neuroscientific theories have also been proposed;

and they have emphasized variables such as encephalization, mirror neurons, spindle cells, increased cerebral plasticity, fourth-order dendritic arborizations, expanded fronto-cortical executive capacities, the re-differentiation of perisylvian and fronto-cortical regions, and so on.

In fairness, many of these variables were proposed with a narrower aim than a comprehensive theory, and it may well be that many, or most of them, will prove relevant to the definition of human uniqueness. In fact, many variables show major differences between apes and humans, and the list grows longer every year. Within the relatively narrow domain of executive brain functions alone, I was able to list at least a dozen significant differences between apes and humans – the so-called 'Executive Suite' (Donald, 1998a). All of these, and probably many more that have not yet been identified, may play a role as useful defining features of the human species. However complex our adaptation may have been, the bottom line for theorists is simple: Take an inclusive approach to human cognitive evolution, with a sufficiently theoretical broad reach to accommodate change along many dimensions.

This is consistent with Darwinian principles. The most salient aspect of Darwinian thought has been the complexity of the details of evolutionary change, especially of the massive patterns of change that lead to new species. The principle of natural selection is simple enough; but the details of any adaptation are usually extremely complex, and there is simply zero evidence for one-dimensional saltations in hominid evolution, especially at the level of speciation.

My initial proposal for an archaic mimetic adaptation was pitched at the broad integrative level of human cognitive-cultural co-evolution, with accumulated cultural knowledge gradually being drawn into the heart of the cognitive evolutionary scenario. The transitions and stages of cognitive hominid evolution listed in that proposal were all multi-dimensional adaptations that led to speciation, and involved many parameters that impinged on the survival strategies and social lives of hominids, including modifications to the brain, body anatomy, diet, survival strategy, and cognitive system. The targeted outcome of this complex adaptative process may have been a qualitative change in cognition, but the evolutionary changes that accompanied this development involved many other defining aspects of the species as well (bipedality is perhaps the most salient of these, but there were many others, such as heat dissipation and basal metabolism).

The central thrust was both social and cognitive: Human beings evolved a cognitive survival strategy that gradually made the species better able to perform cognitive work in groups (including the work of managing the increasingly complicated political intrigues of human society). This strategy involved so many radical changes from the primate template we inherited that there is no alternative but to view it as a multi-staged adaptive process, in which each stage had to be self-justifying and self-sufficient. Since the evolutionary process lacks foresight, every stage must convey some immediate and enduring advantage. While such a process could (and did) involve preadaptation, this only becomes clear in hindsight; each stage must have conveyed a complete adaptive scenario, with a credible survival strategy for each species as it emerged. Those constraints cannot be avoided, and they served as a selection standard for developing every stage of the theory.

I am emphasizing this at the beginning of this article, because my theory has at times been caricatured as something that is was never intended to be: a series of one-dimensional adaptations. Rather, it was designed as a comprehensive adaptive scenario that placed cognition at the top of the hierarchy of selection criteria. At each stage, hominids had a complete and self-sufficient survival strategy. At each stage, they were moving closer to group cognitive strategies – symbolic communication, cooperative cognitive work, and public sharing and trading of ideas.

We know, from comparing humans with our closest relatives (gorillas, bonobos, and chimpanzees), that hominid evolution has been characterized by many changes, including such diverse adaptations as altered skeletal morphology, a greatly modified digestive apparatus, novel ways of generating the metabolic energy needed to support a larger brain, radically different mating strategies, and a novel emotional repertoire (for primates) that includes laughing, grieving, and long-term pair bonding. The cognitive dimension of our adaptive process is diverse and complex, touching on virtually every aspect of mental function, from attention, memory and thought, to gesture, imitation, and, of course, symbolic communication. This massive pattern of change developed over a very long time, in a complex, changing ecology that engaged all the variables listed above, and undoubtedly many more.

For this reason, my theory explicitly embraced the full complexity of the adaptive process that led to the modern human mind. There is no single variable that can be said to constitute the irreducible cognitive 'atom' of a uniquely human mental substance. Hominids went through a series of evolutionary changes that were especially evident at the level of shared culture, but that also involved many detailed changes in anatomy, cognitive function, and social structure. The archaeological record testifies that, at certain key times in the 6 million year scenario of hominid emergence, those changes coalesced into the massive speciation events that gradually and cumulatively defined human nature. For this reason, and for the very good reason that the evidence is compelling only at this level, I felt it necessary to focus on transition periods that led to speciation events.

Core proposals

The central proposals for an archaic mimetic adaptation were a response to three basic questions, all related to hominid uniqueness or exceptionality. (1) Humans have special mental powers, in particular those related to symbolic processing, which are barely detectable, or completely absent, in wild-reared apes: What is the nature of the neuro-cognitive adaptation that made the hominid brain capable of these achievements? (2) Human culture is unique in its cognitive aspect, especially in its important epigenetic role in mental development, when compared to the cultures of other species: What is its appropriate place in theories of human cognitive evolution? (3) Unlike any other known species, humans are able to think and remember in organized groups, aided by technology, and this arrangement constitutes a distributed cognitive system with special properties, an unprecedented "hybrid" arrangement of mind, brain and culture: Can we specify the origins of this distributed cognitive system, its evolutionary trajectory, and its key features?

Although we are a long way from having detailed answers to these questions, some of the original proposals might be evaluated in terms of current progress in various relevant fields. I make no pretence at comprehensiveness here; there is far too much exciting research going on, and too many competing unresolved issues, for anyone to track in detail at this point.

My model is the outcome of a cross-disciplinary project that attempted to trace the broad features of the cognitive trajectory from Miocene apes to modern humans. It was constructed from "big facts;" that is, the most enduring, and relatively stable, knowledge emanating from such fields as cognitive science, evolutionary biology, developmental psychology, comparative neuroanatomy, paleontology, archaeology, psycholinguistics, and anthropology. The notion was to maximize return, and minimize risk. Convergences between so many disciplines, themselves so far apart in their methods and theories, are unlikely to be accidents, and very likely to point the way to an optimally robust theory (see Donald, 2004). And, most importantly, it was not a one-dimensional theory. The stages proposed were all complex and multi-dimensional in cause and effect.

The chronology of the model lies in the internal logic of the phylogenetic sequence, rather than in specific dates. The latter have yet to be firmly established, although the paleontological database on human origins has produced a remarkably stable core body of facts. Judging from these, and accepting the fact that there is some serious disagreement about the details of succession of various hominid species, the basics of the human story have not changed in a fundamental way in the past 17 years. In general terms, the line of descent of the human species is much better established now than it was then, and, for the most part, it confirms and fills in the wider trends discovered by an earlier generation. This is reassuring.

While the fossil record tells a fairly stable story, the question of mental origins is a more difficult one. We do not have direct access to soft tissue in fossils, or to the past behavior of extinct species, and there are no surviving hominid species that evolved between Miocene apes and modern humans. However, we know a lot about the intervening hominid species that are human ancestors, especially about their life style, diet, technology, and survival strategies. We also know much more about paleoclimatology and paleoecology than we did 17 years ago (cf Richerson and Boyd, 2005), and it has been possible to construct better theories of the ecological factors that contributed to the selection pressures affecting hominid adaptation.

Moreover, our comparative theories of cognition have progressed. We cannot measure the mental skills of human ancestors directly; nor are we ever likely to be able to achieve such a thing. But we know a great deal more about both primate and human cognition, about the brains of chimpanzees, monkeys and humans, and by extension, about the hominid ancestors of anatomically modern humans. In addition, recent genetic research has proven to be quite consistent with our established knowledge, while refining and deepening it, and has added significant depth to our speculations.

Overall, there is less uncertainty in this field than may seem to be the case to the outside observer, especially on first impression. First, the functional anatomy of the primate brain has changed very slowly, and the basic brain design of humans remains close to that of other primates. For this reason, neuropsychological comparisons of apes and humans can be quite informative, greatly narrowing the range of feasible theoretical options available to those who build models of nervous systems. Second, there is significant overlap between the behavioral repertoires of primates and humans, and this reinforces the utility of cross species comparisons that employ behavioral and cognitive testing, and helps us single out those cognitive features that are species specific. Third, the mapping of primate and human genomes promises to yield a great deal of information about the complex triadic relationships between genes, functional neuroanatomy, and behavior in the primate line. Finally, the range of social cognitive behaviors available to humans is clearly derivative of equivalent behaviors in primates. This allows us to build reasonably convincing, biologically based, models of human culture, with roots in evolution. By putting together specific findings from these and other fields of research, it is possible to build a larger view of human cognitive emergence that will have both heuristic and theoretical value.

At the time my theory was initially formulated, both cognitive neuroscience and genetics were much less well developed than they are today, and there was more urgency to some issues than may be the case today. For example, mental modularity was a major concern at that time, and I took a strong stance against the Chomsky-Fodor notion that language was effectively a new module in the mental apparatus of the primate line (Chomsky, 1984; Fodor, 1983). In my view, that battle has been won, not only due to the efforts of such developmental researchers as Tomasello (1999) and Nelson (1996), but also because the facts of modern cognitive neuroscience strongly support the idea that most brain regions, including those normally engaged in language, serve multiple functions. In effect, the hominid adaptation for language looks increasingly like a "kluge" cobbled together from various modifications to the existing primate brain apparatus.

The focus of my model was not on language as the ne plus ultra of hominid evolution. On the contrary, it was on mental models and knowledge representation, and particularly on the ability to capture, or express, that knowledge in public, or potentially public, motor actions. Language was one way of advancing this agenda, but not the only, or even the primary, way. Social-cognitive skills were more important in establishing the intersubjective cognitive domains out of which language eventually emerged. Moreover, I was convinced that hominid mental capabilities could not have improved in a narrow manner, but that they were part of a much broader adaptive shift, in the direction of increased hominid interdependency and sociality. This idea, that language emerged from a broad advancement in primate cognitive skills, rather than from a new language module, has been strengthened by Savage-Rumbaugh's demonstration of nascent linguistic capacities in her bobono protegé Kanzi (Savage-Rumbaugh et al, 1998).

These shifts toward a cooperative and much more complex society were the surface outcome of tremendous changes in the way early hominids thought and acted; and the criterion for identifying the major "stages" of hominid evolution was to conceptualize major changes to hominid survival strategy, to the level involved in speciation itself. Hence, the key transitions in the scenario were speciation events. They were inevitably complex, and closely allied to changes in the early evolutionary environment of hominids. A shift on such a global level, leading to a new species, is always more than purely cognitive. This is true of all species; cognition does not usually change in a major way without corresponding changes in life style, anatomy, sexual behavior, and social life.

The stages of hominid emergence also had to be durable, because any major shift away from the cognitive repertoire of ancestral apes must have been self-sufficient, and effective for the long-term survival of the species without further major modification, under the conditions of hominid life at that time. Thus, although pre-adaptations are a logical possibility from a retrospective vantage point, they cannot be projected into the future; every change had to stand on its own when it emerged.

Table 1 illustrates the basic proposal, which has been presented in various other publications (e.g. Donald, 1998b), and is reproduced here for the convenience of the reader. The three stages were each the outcome of a transition period. These were inferred, or more accurately, massively induced, from a very broad evidential base. The theory made use of any and all data, and of a range of other theories that might yield insights into the human mind's emergence over time. The cognitive core of the representational model driving the three-stage theory was social, and focused in particular on the process of social event-perception and social event-knowledge, which are highly developed in both chimpanzees and gorillas, and thus likely to have been present in the Miocene ancestors of hominids.

[Insert Table 1]

Confirming the chronology of mimesis: Stone toolmaking

The most important confirmatory proof of the chronology of mimesis in the past decade has perhaps been our improved understanding of the difficulty of learning, teaching, or imitating through observation, the craft of stone toolmaking. Chase(2006), and Toth, et al(1993; 2003) have shown that the making of relatively simple Oldowan cutting tools similar to those identified with habilines is a challenge, and typically takes numerous rehearsals over a period of weeks to perfect, even when the student is a biologically modern human being.

The earliest Oldowan artifacts, reliably dated to 2.3 million years ago, have finished edges that cannot be manufactured simply by the trial-and-error banging together of two rocks. Moreover, the chosen materials matter. Certain types of rock do not yield a sharp edge. Nor can a hammer stone be softer than a core. In addition, the correct sequence of knapping must be learned, so that a second round of strikes will sharpen, rather than dull, the first-struck edge. Chase (2006) has argued that the correct angle of striking the stone is particularly critical, and requires considerable practice before the learner can produce a useful cutting edge. The fact that this skill was successfully transmitted over countless generations so long ago testifies to the mimetic capacity of the first toolmakers. On present evidence they were either habilines or late australopithecines; the data linking a specific species to the earliest stone tools is not yet sufficiently clear to resolve this issue.

The skill gap between humans, even archaic Homo, and present-day apes, in fashioning stone tools, is not trivial. The enculturated ape Kanzi learned how to produce crude but serviceable stone tools (Toth et al, 1993), and Kanzi has continued to manufacture and use these for 16 years, in order to gain access to food. However, even in this highly unusual single case, Kanzi never mastered the principle of striking the stone at the optimal angle, so as to enhance the resulting sharpness of the flake and produce it more reliably. Kanzi still relies on happenstance outcomes that work. He does not practice systematically to improve his skill. As a result, his tools have never reached the level of refinement found in the earliest Oldowan tools. In contrast, ancient hominids invented and transmitted their toolmaking skills in the wild, and also learned to select the right materials needed for butchering. In this domain, hominids had already surpassed other primates two million years ago (Toth et al, 2003).

The spread of stone toolmaking throughout archaic hominid culture suggests that they were much better that their ancestors at all aspects of this particular skill, and that they did not rely on chance outcomes, but rather refined their skills over time. This involved (1) planning and imaging the motor act; (2) executing it under conscious metacognitive supervision; (3) analyzing the outcome and noticing the conditions for a better outcome; (4) practicing and refining the final form of the action-pattern, and (5) if necessary, copying and profiting from the skill of others. Above all, stone toolmaking was their own innovation, achieved in their natural environment. This fact, combined with evidence of the extraordinary sustainability of this skill over many millennia, suggests that some pedagogical capacity accompanied the emergence of mimetic skills, as suggested in my initial proposal. This would have distanced these hominids even further from their primate forebears. Premack (1993) has suggested that pedagogy is one of the traits that distinguishes human beings from other primates.

Stone toolmaking was further advanced within the Ergaster branch of the hominids. Ergaster produced Acheulian tools, starting about 1.8 - 1.6 million years ago, in Africa. These tools were significantly more complex to manufacture. The Acheulian industry did not appear in European or Asian branches of Homo until much later, approximately 1 million years ago. In the absence of evidence for a major biological difference between the Eurasian hominid subspecies and Ergaster, this suggests that Acheulian toolmaking skill was culturally transmitted.

These findings confirm the following conclusions about mimesis. (1) At this early stage (2.3 million years ago), hominids could rehearse and refine action. (2) The species could also transmit and maintain skills accurately across generations, through a combination of imitation and practice, and possibly pedagogy as well. (3) The species was already moving toward a group cognitive strategy, in which the talents of individuals were transformed into shared resources within a group of hominids. (4) Because mimetic expression is produced by essentially the same neuro-cognitive system that produces skill, it is very likely that hominids at this early stage had a degree of communicative capability, especially in the domain of vocal modulations and whole-body gesticulation. Thus, the research of the past fifteen years strengthens and enriches the original proposal for an archaic mimetic adaptation very early in the hominid scenario.

Event-representation, metacognitive functions, and mimesis

What of the underlying cognitive mechanism of mimesis? My proposal focused on two cognitive mechanisms in particular. The first is sophisticated event-representation, which implicates the tertiary regions of the parietal lobes, and the second is metacognition, or self-monitoring, which depends upon the executive or supervisory systems of the prefrontal cortex. Working together, these two cortical regions are essential, inasmuch as their breakdown causes executive supervision to deteriorate greatly.

Event-representation is the cognitive foundation of mammalian social life. The cognitive "atoms" of social life consist of events, or complex dynamic stimuli, batched in episodes that can extend over a considerable period of time. An example of an episode would be a fight with a particular adversary, or an attempt to mate. Both of these behaviors can involve a considerable amount of judgment and negotiation, and take time, sometimes a relatively long time. Such episodes consist of brief sensory stimuli and motor acts strung out in a series of micro events – growls, bites, attacks, withdrawals, and so on. These are the source of numerous dynamic sensory stimuli that unfold over time. They often involve several simultaneous streams of events, because many social events engage several players, as well as a variety of other elements in the environment related to goals, terrain, and the larger social context. While engaged in a fight, participants must track time, place, and context, while keeping in mind what they have learned from previous encounters. They must also remember exactly what was done, and by whom, because these have important future implications.

The survival imperative is paramount here. In a social mammal such as a dog or an ape, the political ramifications of a fight must be understood and remembered, since they can have life-threatening importance. Social events are important in securing food and shelter, resolving rivalries, asserting dominance, and forming affiliations, among other things. In other words, understanding them is a vital survival skill. For this reason, event-representation is highly evolved in all social mammals. Humans are, in many ways, the culmination of this trend, the ultimate social mammals. We appear to be the most social creatures in the Biosphere.

The development of event-representation has been thoroughly studied in human children in the pioneering developmental work of Nelson (1986). She has explicitly acknowledged the close similarity of her observations on the unfolding of cognitive ontogenesis with the evolutionary unfolding of mimetic skill (Nelson, 1996). The additional work of Tomasello (1999) and others has further reinforced the importance of interrelating research on human child development, with studies of ape cognition.

Social event-representation is the most abstract and complex achievement of the brain's perceptual systems. It is a necessary, but not sufficient, condition for mimetic event-representation, as seen in the fact that most social mammals are incapable of any degree of mimesis. They lack the ability to "read out" their social insights on to their action-repertoire, even in the form of the simple event repetition needed to practice a skill.

My human evolutionary model was really about how the hominid event-representational hierarchy evolved, over a period of five millions years, in such a way as to enable human beings to express their knowledge about events in actions of the musculature. A succession of evolutionary changes kept increasing the power and range of the event-representational machinery of hominids. This evolutionary trend began with the emergence of mimesis, and later expanded greatly with the advent of speech and language. It evolved even further with the advancement of material culture, and particularly with the invention of various forms of external symbolic representation, including writing. This sequence of changes equipped human beings to represent events that were more abstract and extended in space and time than the sensory and perceptual system alone could capture.

The starting point of this process was to transform the simplest event-perceptions of archaic hominids into actions, in the form of simple re-enactments. Rehearsal of skill is a re-enactive capacity, and one that cannot be limited to a single modality, on either the perceptual or the motor side. Skills typically engage several sense modalities simultaneously, including both interoception and exteroception. Once this capacity had evolved, it produced a byproduct, or exaptation, inasmuch as the same system can reduplicate a wide variety of events, including social events. Very young children manifest this ability long before they have language; in fact, it is a prerequisite for practicing speech and other forms of language. Human children copy and mime their parents and their peers, and reflect the mimetic expressions of their social environment with remarkable accuracy, without always understanding the wider social implications of what they are doing.

A key consideration in any theory of mimesis is that human mimesis is not modality-specific, like, say, birdsong. It is not even limited to one cognitive domain. It exploits the whole body as an expressive device across any number of expressive domains, including emotional, locomotor, and object-oriented action. The epitome of mimetic expression in modern humans is probably the art of dance, or acting, where the whole body is used to portray the characters of a scenario. Pantomime is the prototypal, and most ancient, form of theatrical performance. It is pure mimesis.

Executive supervision of behavior is at the heart of mimesis, and this implicates the prefrontal cortical regions and the cerebellum. The whole-body, or supramodal, nature of mimesis fits in well with the broad reach of the dorsolateral prefrontal system. The well documented expansion of the prefrontal executive system in the hominid brain is consistent with this unique cognitive advantage of Homo. The prefrontal system is widely interconnected with many brain structures, and is coordinated from the lateral prefrontal regions of the cerebral cortex. This interconnectivity is wider and deeper in humans than in apes. Moreover, the pathway between the frontal lobes and the lateral cerebellum, which is crucial in motor learning and the refinement of skill, is many times larger in humans than it is in apes.

This is a crucial factor in terms of brain mechanisms, because mimesis is basically a capacity for selective event re-enactment, or pantomime, using the whole body, including the voice. Mimesis builds on the entire voluntary motor repertoire of the primate line, and entails an embodied style of expression, which produces actions that reflect and vary the patterns of previous actions, whether of self or others. It must be regarded as high-level action system that is mapped systematically onto an abstract imaginative model of events. This places the cognitive control of mimetic action very high up in the hierarchy of neural function, and the prefrontal area is well situated for this role, since it receives inputs from the event-sensitive parietal cortex, and sends outputs to the premotor and motor systems, which are richly connected to the lateral cerebellum (Stuss and Benson, 1986; Thatch, 1998).

For the mammalian brain, the emergence of mimetic capacity in hominid evolution was not a small innovation. It was a radical change. Previously, in every known mammalian species, the brain's action systems were focused outside, on the environment, rather than internally, on action itself. Animals could move, chase, hold, chew, and so on, in flexible and clever ways. But they could not focus back on their own actions in detail, in order to evaluate and improve them. In effect, mimesis requires an actor to attend to the exact form of his own actions in fine detail, and to parse his own movements, in order to bring a performed action sequence into conformity with an imagined ideal. This imagined ideal of movement might originate in the acts of another actor, or in the event structure of the environment. It could even originate in an event structure that was completely imaginary. In either case, in order to achieve this, the anterior and posterior cerebral cortices of a human being must interact in a way that was evolutionarily new.

A possible clue to how this happened has emerged out of the work of Deacon (1997). He proposed that the human prefrontal cortex evolved in such a way as to develop far more connections, both within the cerebral cortex (especially with the posterior association regions), and with various subcortical nuclei. This places the human prefrontal region in a powerful location, relative to other high-level cortical integration zones. Prefrontal expansion was apparently achieved through a relatively straightforward modification of the genes regulating cortical epigenesis. Although Deacon did not propose this idea in the context of a theory of mimesis, but rather of language, it seems a better fit to existing neuroscientific evidence on mimetic action than it does to language proper, which seems tied more to the expansion of the perisylvian regions.

Another clue comes from the literature on so-called 'mirror' neurons (Rizzolati et al, 1996; Gallese et al, 1996). These neurons are present in large numbers in primates that have very limited imitative ability, so we may conclude that they are not sufficient for mimesis, let alone language. However, mirror neurons, or more properly the neural networks in which they are embedded, appear to have been a necessary preadaptation for the later evolution of mimesis in the primate phylum, since such neurons are the first step toward integrating the larger cognitive context of a movement sequence into the planning of specific acts. However, as Chaminade (this volume) has pointed out, their presence in humans is still not confirmed, and very little is known about their specific role in mimetic action.

Regardless of the final details of the brain mechanism involved, it has been well documented by primatologists that humans outperform modern apes on a wide variety of metacognitive tasks. Some of these are listed in Table 2, in order of difficulty for apes, with the most demanding tasks at the bottom of the list. Note that apes have some success at all these tasks. This provides an evolutionary wedge in the direction of mimesis, and makes the proposed first transition quite feasible, given the right selection pressures. Even though it still constituted a very major change, the raw materials on which natural selection could act were already there in primates. This set of evidence, when combined with Deacon's evidence on frontal ontogenesis, and the reliably dated stone tools found in various African sites, makes a good case for an archaic mimetic adaptation early in hominid evolution.

[Insert Table 2]

Mimetic Culture

The concept of mimetic culture was first developed in the context of building a co-evolutionary theory that took into consideration the social and cultural implications of cognitive evolution. Mimesis was first conceived while I was trying to construct a theory of how language evolution might have become possible. At first, the gap between humans and apes seemed too large to bridge. A necessary first step in the direction of language would have been to change the evolutionary environment in such a way as to increase the importance of culture, indeed to change its role qualitatively, so that culture would become a major influence in shaping the cognitive demands imposed by the environment. Such a development would have generated the kind of selection pressure that would favor a more powerful and precise mode of communication, namely language.

The hypothesis of an archaic mimetic stage was thus initially a largely unwanted and unanticipated necessity on the way to the evolution of language capacity. I was trying to find the cognitive "missing link" that might bridge the enormous gap between ape vocalization and human speech. Condillac and Darwin had earlier made some useful suggestions about this necessity; both suggested gesture as the precursor to language. Apes are known to gesticulate, and their rather stereotyped gesticulating serves their purposes well enough; but it was not at all obvious why ape gestural ability, per se, would have been under the kind of selection pressure that would lead to a major cognitive change, such as language entailed. Moreover, in terms of the genome, language was far too complex an adaptation to emerge suddenly.

On reflection, from examining the organization of the human nervous system, it became clear that an improved capacity for the refinement of skill would have provided the neural foundation for much more than skill. It was potentially the basis for a cultural shift of some magnitude, a change in the hominid survival strategy that led to a highly social cognitive approach to cognition itself. This included the transmission of skill, which might have been the first way in which there was a purely cultural accumulation of detailed knowledge that was important for survival. But, because skilled rehearsal requires an elementary form of event-representation, the representational genie would have been let out of the bottle, albeit inadvertently. This very basic form of event-representation would, in itself, improve the social coordination of behavior, and lead to mutual cognitive activities, such as demonstrating a skill to children to teach it, and eventually, to the conventionalization of simple voluntary emotional expressions, creating the possibility of local traditions that would have distinguished the nonverbal culture of one local community from another. For example, there would have emerged different and idiosyncratic ways of communicating deference to authority, marking status, and expressing intimacy or approval. While not yet language, this would have added greatly to the existing primate repertoire, and made hominid social life more complex and cognitively demanding. All of this is a good match to the way of life identified with early hominids.

Mimetic culture endures within modern human society. Human social life still begins with role playing. Role playing begins with simple mimetic action, and gradually expands to include more elaborate social scenarios, such as becoming a mother, a soldier, a doctor, a victim. All these are modeled by role-playing children. Humans are unique in their tendency to experiment with the potential forms a given action might take in the future. This is especially evident in children, who routinely play with creating variations on their routine action patterns. An example might be to practice standing on one foot; making faces; crying; laughing attractively; or generating aggressive or intimidating sounds. Many games, even adult games, capitalize on this spontaneous motor generativity, and one of the consequences is the existence of mimetic "wit" as seen, for instance, in games such as peek-a-boo, or in generating funny ways of falling down when struck. The facial exaggerations of silent film are perfect examples of mimetic wit. Such scenarios are common among children, and even adults, in human society.

The capacity for this kind of expressive play, and for refining skills, implies a major change in the executive management of action. This change created a channel, or mechanism, for the generation of a different kind of hominid culture, one where there was an incipient mechanism for capturing intentions and emotions in action, and thus "escaping" the solipsism of the central nervous system, through public action-modeling. This provided a means of achieving some degree of coordination and ritualization of group behavior. It also created the potential for rudimentary iconic and metaphoric gestures, including vocal gestures, which, in groups, can create elementary rituals, as in demonstrations of grief or triumph. Long before hominids had a need for a powerful phonetic mechanism, they could produce voluntary modifications on their hereditary primate vocal repertoire mimetically, using their powerful amodal executive brain systems. These abilities necessarily preceded the evolution of speech, for the simple reason that they were preconditions for generating any kind of morpho-phonology, even in its simplest form (Donald, 1998a). Language could not have evolved without having a mimetic capacity already in place.

Finally, the adaptive cultural scenario that accompanied the emergence of mimetic skill is outlined in

Table 3, which is a slightly modified version of the table presented in the original 1991 proposal (Donald, 1991, 198). Note that mimetic culture evolved on the platform of episodic culture, on the assumption that basic primate cognitive skills, shared by all modern primates, are already in place in the Miocene ancestors of humans. I will not try to recapitulate the properties of episodic culture here; suffice it to say that it is an abstraction drawn from common characteristics shared by modern chimpanzees, bonobos and gorillas.

[Insert Table 3]

Added to an episodic mind and cultural context, mimetic skill would immediately alter the array of available action patterns and collective cognitive strategies available to the members of a group of hominids. Reciprocity is at the heart of this; mimetic interactions would engender replies and reactions. Reciprocal mimetic exchanges would ensue, leading to customs, informal games, novel skills, and representations. Added to a pre-existing episodic culture, mimesis would necessarily lead to cultural innovation. It would also necessitate new forms of social control. Some of the properties of mimetic culture are listed below.

1. Modeling of Social Structure. Mimetic skill results in the sharing of knowledge about society, without every member of a group having to re-invent that knowledge. Mimetic skill, extended to the social realm, results in a collective conceptual "model" of social behavior, expressed in shared ritual and play, and in social structure. To quote from my original proposal:

> 'Social roles, in a complex society, can only be defined with reference to an implicit model of the larger society. Mimetic representations would thus be tremendously important in building a stable social structure. All higher mammals possess social knowledge; young chimps learn about dominance hierarchies in their play, for instance. But chimps only learn how to react to each individual in the larger group; human children model the group structure. A significant part of childhood is spent rehearsing and modeling society, and children can act out, not only their own roles, but those of other players. Human children can "model" an interchange between parents, for example, taking either role; or play act a game with friends, taking various sides.

> This is clear evidence that they are implicitly modeling the larger social structure. Once again, this demands a break with the egocentric episodic view of the world." (Donald, 1991, 173-174)

This insight has been strongly reinforced by Katherine Nelson's (1996) comparative review of research on children's acquisition of social skills, especially on their use of mimetic expressions prior to their mastery of speech and language.

2. Reciprocal Mimetic Games. Reciprocal games involve a minimum of two players. One player generates a mimetic act, and another replies with the same, or another, mimetic act. Someone invents a move; the next one imitates it, and perhaps adds something new. And so on. People in every culture, especially young children, indulge in this type of play. Mimetic games often help to define roles, especially gender roles. Such games can be played in the absence of language, as seen in non-signing deaf children, who play essentially the same games as hearing children. With mimetic games, it is possible to model adult roles and activities. This affords a very efficient way to acquire important social knowledge.

3. Conformity and Coordination. Mimetic cultures are highly conformist. Reciprocal mimetic exchanges can lead to regular, repetitive patterns of group behavior that resemble ritual.

4. Group Mimetic Acts. Mimesis can take the form of a collective, or group, action. One common form of group mimesis is found in mass displays, such as war cries or ritualized grieving. Ritual differs from most other forms of mimetic representation in that it is a collective act in which individuals play out different roles. The carefully orchestrated action of a crowd can be interpreted as a mimetic act, representing such things as the consensus, fury, or power of a group.

5. Innovation. A purely mimetic culture can evolve. Mimetic acts are expressive and thus inherently inventive and creative. The implicit model of the social world projected by the customs and rituals of a society may change from one generation to the next. However, such societies, especially in the absence of language, would change slowly. The mimetic dimension of culture, even as manifest in modern human society, tends to be conformist and conservative, as seen in such things as religious ritual, royal coronations, and deep cultural habits such as ways of greeting, attitudes to authority, and so on.

6) Pedagogy. In mimetic culture, some degree of pedagogy is likely, given that one of the defining advantages of such cultures is precisely their success at transmitting skills and knowledge across generations. This would complicate the process of acculturating the young, and require more time. Practical skills would have been the basic reason driving pedagogy: the use and manufacture of domestic tools and weapons, methods of hunting, construction of simple shelters, the use of fire, weapons, and fighting. Rituals, games, folkways, and mores would also have required the systematic mimetic transmission of knowledge. Pedagogy requires not only some form of mimetic skill, but the ability of the adult to sense what the child can, and cannot, learn. In Vygotsky's (1978) words, the teacher must estimate accurately the student's "zone of proximate development," that region, close to what is already known, where the probability of new learning is optimal.

The research carried out by archaeologists and cognitive scientists during the past two decades suggests that we have probably underestimated the capacities of early hominids. The demands of the early evolutionary environment of hominids were daunting, to say the least, and mimetic culture seems a reasonable and conservative proposal to make about early Homo. There has been no strong evidence that language itself was either necessary to explain the cognitive achievements of archaic hominids, or likely to have been present in their society. The latter seems especially unlikely in view of their slow cultural evolution for more than a million years.

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Table 1. Three stages of human cognitive evolution, tracing the path from the Miocene primate ancestors of hominids to anatomically modern humans in literate societies.

Stage	Species/period	Novel forms of representation	Manifest change	Cognitive governance
EPISODIC	primate	complex episodic event-perceptions	improved self-awareness and event-sensitivity	episodic and reactive; limited voluntary expressive morphology
MIMETIC (1st transition)	early hominids, peaking in *H. erectus*; 4M-0.4 Mya	nonverbal action-modelling	revolution in skill, gesture (including vocal), nonverbal communication, shared attention	mimetic; increased variability of custom, cultural "archetypes"
MYTHIC (2nd transition)	sapient humans, peaking in *H. sapiens sapiens*; 0.5 Mya - present	linguistic modelling	high-speed phonology, oral language, oral social record	lexical invention, narrative thought, mythic framework of governance
THEORETIC (3rd transition)	recent sapient cultures	extensive external symbolization, both verbal and nonverbal	formalisms, large scale theoretic artifacts and massive external memory storage	institutionalized paradigmatic thought and invention

Table 2. The executive suite: A comparison of basic features in related species. In Homo all these features are fully evolved.

FUNCTION	Monkeys	Wild apes	Enculturated apes
Self-monitoring	Yes	Yes	Yes
Divided attention	No	Maybe	Some
Self-reminding	No	Maybe	Maybe
Autocuing	No	No	Yes
Self-recognition	No	Yes	Yes
Rehearsal/Review	No	Maybe	Yes; limited
Imitation	No	Partial	Yes; limited
Mindreading	Minimal	Minimal	Yes
Pedagogy	No	Maybe	Yes
Gesture	No	Doubtful	Some
Symbolic invention	No	No	Proto-gesture
Skill hierarchies	No	No	Some

Table 3. Elements of an archaic hominid mimetic adaptation, in which language is completely absent. In a group context, the presence of mimetic skills in individuals would combine and interact to produce mimetic culture.

EPISODIC CULTURE (Primates)

+

MIMETIC SKILL

- intentional representations
- generative, recursive capacity for mime
- voluntary, public communicative system
- differentiation of reference
- unlimited modeling of episodic events
- voluntary, autocued rehearsal

+

SOCIAL CONSEQUENCES

- shared model of social customs
- reciprocal mimetic games
- conformity/coordination
- group mimetic acts
- slow-paced innovative capacity
- simple pedagogy and social attribution

=

MIMETIC CULTURE

- toolmaking, eventual fire-use
- coordinated seasonal hunting
- flexible, rapid adaptation to ecology
- more complex social behavior
- primitive ritual (group mimetic acts)
