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# Précis of *Origins of the modern mind: Three stages in the evolution of culture and cognition*

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**Abstract:** This book proposes a theory of human cognitive evolution, drawing from paleontology, linguistics, anthropology, cognitive science, and especially neuropsychology. The properties of humankind's brain, culture, and cognition have coevolved in a tight iterative loop; the main event in human evolution has occurred at the cognitive level, however, mediating change at the anatomical and cultural levels. During the past two million years humans have passed through three major cognitive transitions, each of which has left the human mind with a new way of representing reality and a new form of culture. Modern humans consequently have three systems of memory representation that were not available to our closest primate relatives: mimetic skill, language, and external symbols. These three systems are supported by new types of "hard" storage devices, two of which (mimetic and linguistic) are biological, one technological. Full symbolic literacy consists of a complex of skills for interacting with the external memory system. The independence of these three uniquely human ways of representing knowledge is suggested in the way the mind breaks down after brain injury and confirmed by various other lines of evidence. Each of the three systems is based on an *inventive* capacity, and the products of those capacities – such as languages, symbols, gestures, social rituals, and images – continue to be invented and vetted in the social arena. Cognitive evolution is not yet complete: the externalization of memory has altered the actual memory architecture within which humans think. This is changing the role of biological memory and the way in which the human brain deploys its resources; it is also changing the form of modern culture.

**Keywords:** cognition; cultural evolution; culture; distributed representations; external memory; human evolution; knowledge; language origins; mimesis; motor skill; neuropsychology; symbols; working memory

This book (Donald 1991) was an attempt to synthesize various sources of information – neurobiological, psychological, archaeological, and anthropological, among others – about our cognitive origins, in the belief that the human mind coevolved in close interaction with both brain and culture. I should make clear from the start that I have no illusions about my ability to become expert in all of the disciplines touched on by this enterprise; accordingly, my effort should be regarded with suspicion by all; at best, it will probably prove to be no more than a guide to some of the important questions that remain to be settled. This Précis focuses on my core theory and disregards most of the background material reviewed at length in the book itself.

My central hypothesis is that there were three major cognitive transformations by which the modern human mind emerged over several million years, starting with a complex of skills presumably resembling those of the chimpanzee. These transformations left, on the one hand, three new, uniquely human systems of memory representation, and on the other, three interwoven layers of human culture, each supported by its corresponding set of representations. I agree with multilevel evolutionary theorists like Plotkin (1988), who believe that selection pressures at this stage of human evolution were ultimately expressed and tested on the sociocultural level; hence I have described the evolutionary scenario as a series of cultural adaptations, even though individual cognition was really where the main event was taking place, since it provides the link between physical and cultural evolution. [See also Plotkin & Odling-Smee: "A Multiple Level Model of Evolution and its Implications for Sociobiology" *BBS* 4(2) 1981.]

In one sense the proposed evolutionary sequence is an exercise in interpolation not unlike many other efforts to construct a credible case for the emergence of particular morphological and behavioral features in various species. But in another sense it is a structural theory that confronts the question of how many processing levels must be interposed between the nonsymbolic cognitions of animals and the fully symbolic representations of humans. Symbolic representation is the principal cognitive signature of humans and the main phenomenon whose arrival on the scene has to be accounted for in any scenario of human evolution.

The theory posits a series of radical evolutionary changes – the punctuations, as it were, in punctuated equilibrium – rather than a continuous or unitary process. I do not rule out the possibility, indeed the likelihood, of smaller graduated changes that might also have occurred during the long period of human emergence; but judging from the anatomical and cultural remains left by hominids and early humans, the most important evolutionary steps were concentrated into a few transition

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periods when the process of change was greatly accelerated, and these major transitions introduced fundamentally new capacities.

I have made certain hard choices – for instance, I have opted for a late-language model, placing language near the end of the human evolutionary story rather than much earlier, as Parker and Gibson (1979) and Bickerton (1990) have. [See also Bickerton: "The Language Bioprogram Hypothesis" *BBS* 7(2) 1984.] For another, I have opted for a lexically driven model of language evolution, rather than placing the main emphasis on phonology, as Lieberman (1984) has, or on grammar, as Bickerton (1990) has. In fact, I have portrayed our capacity for lexical invention as a single pivotal adaptation capable of evolving into an instrument of sufficient power to support all of the higher aspects of language.

Moreover, I have postulated an early motor adaptation, intermediate between ape cognition and language, that gives primacy to the unique motor and nonverbal cognitive skills of humans. In this I am in basic agreement with Kimura (1976) and Corballis (1989; 1991), who have also argued for an early motor adaptation that preceded speech. However, I differ from these two authors in that I am much less concerned with the issue of cerebral laterality, and more focused on the representational possibilities inherent in an early motor adaptation. Moreover, I do not agree with them about the close qualitative linkage between language and serial motor skill; I see the two as qualitatively different, albeit interdependent, adaptations.

I have also tried to build a theory in such a way that specific details of chronology are not crucial to its central hypothesis, which is essentially concerned with cognitive *succession*, and consequent modern cognitive *structure*. Finally, I have chosen to construct my succession hypothesis around a fairly simple unifying theme, that of evolving cognitive architecture. This is based on my belief that brains store memories in and around their functional processors rather than somewhere else, as most computers do; and therefore that radically new representational strategies signal the likelihood of a change in the underlying neuropsychological architecture (keeping in mind that such changes may be anatomically complex).

**Chronology, succession and transition.** Chronology is important in that it helps us establish an order of succession and determines how many major cognitive steps were taken, and roughly when. This issue was not as difficult to resolve as one might have expected, given the controversy that seems to pursue archaeological finds. There is considerable stability in the basic number of hominid species that are currently interposed between humans and Miocene apes and in their order of appearance. Moreover, there is agreement that although australopithecines undoubtedly underwent massive anatomical and cultural change in adopting erect posture, they did not leave any evidence suggesting major cognitive evolution. There appear to be only two strong candidates for a major breakpoint in hominid cognitive evolution and these coincide with the transition periods leading to the speciation of *Homo erectus* (about −1.5 M years) and archaic *Homo sapiens* (roughly −0.3 M years), respectively. Four recent books on this subject (Bickerton 1990; Corballis 1991; Donald 1991; Lieberman 1991) have all agreed on this basic point.

The relative brain size of *Homo erectus* was much larger than that of previous hominids, eventually exceeding 70% of the modern human brain. The upward linear trend of hominid brain size accelerated sharply during the transition to *Homo erectus* and was sustained until *Homo sapiens* emerged (Lieberman 1991). This rapid increase in cerebral volume was concentrated in the association cortex, hippocampus, and cerebellum. Even taken in isolation of cultural artifacts, these anatomical facts would suggest a significant cognitive change. But the cultural evidence left by *Homo erectus* strongly confirms the presence of major cognitive evolution: *Homo erectus* manufactured quite sophisticated stone tools, devised long-distance hunting strategies, and migrated out of Africa over much of the Eurasian landmass.

A second major transition period preceded the speciation of *Homo sapiens* and was marked by another large brain expansion and the descent of the larynx. As Lieberman (1984) has argued, the latter probably coincided with the emergence of spoken language as we know it, that is, with the arrival of a high-speed vocal communication system driven by a large lexicon containing thousands of entries. Our exact lineage is still not known, but modern humans appear to have reached our present form some time prior to 45,000 years ago. All modern humans have a fully developed speech capacity, as well as complex oral cultures that incorporate myth, religion, and social ritual. This would suggest that our final period of major biological change extended over the late Middle and early Upper Paleolithic periods.

My decision to postulate a third transition in human cognitive evolution takes this scenario out of the realm of purely biological evolution toward a definition of evolution that is at once broader and more purely cognitive. If the descriptive criteria for major cognitive transitions are held constant throughout human history and prehistory, it is obvious that there have been some very major changes since the Upper Paleolithic. The likelihood that the specific mechanism of such recent change is nongenetic should not distract us from making that observation and exploring it to the fullest. Recent cognitive change is evident primarily in cultural artifacts and might have been classified along many different continua; I have singled out the development of external memory as the critical issue. The third transition seems to have started in the late Upper Paleolithic with the invention of the first permanent visual symbols; and it is still under way.

**Structural issues.** Here the main structural questions are: What new cognitive features were introduced at each of these three stages? And how do these three developments coalesce in the modern brain and mind and express themselves in culture? In my proposal all three stages introduced new memory features into the human cognitive system. One important consequence has been greatly improved voluntary access to memory representations; in effect, humans have evolved the architecture needed to support what Graf and Schacter (1985) have called "explicit" memory retrieval.

The first transition introduced two fundamentally new cognitive features: a supramodal, motor-modeling capac-

ity called *mimesis*, which created representations that had the critical property of *voluntary retrievability*. The second transition added two more features: a capacity for *lexical invention* and a high-speed *phonological apparatus*, the latter being a specialized mimetic subsystem. The third transition introduced *external memory* storage and retrieval and a *new working memory architecture*.

The structural arrangement of these uniquely human representational systems is hierarchical, with mimetic skill serving as a necessary but not sufficient condition for language, while language capacity is a necessary condition for the invention of external memory devices. All of these representational systems are at the high end of the system and are aspects of what is sometimes vaguely called the "central processor" (see especially Fodor 1983; see also multiple book review: *BBS* 8(1) 1985). This proposal therefore implies that the human version of the central processor has evolved through a series of major changes and is now complex and quasimodular in its internal structure.

## 1. The starting point: The abilities of apes

Apes are brilliant event perceivers; as I have acknowledged in my book, they have a significant capacity for social attribution, insight, and deception, and great sensitivity to the significance of environmental events. In the latter category, I include the signing systems provided by human trainers; these are best treated as complex environmental events or challenges to which apes respond with their usual perspicuity (see, e.g., Savage-Rumbaugh 1980).

I agree with Olton's (1984) suggestion that apes have episodic memory, that is, the ability to store their perceptions of specific episodes (a position that Tulving [1984] evidently agrees with). However, they have very poor episodic recall, because they cannot self-trigger their memories: that is, they have great difficulty in gaining voluntary access to the contents of their own episodic memories *independent of environmental cues*. Thus they are largely environmentally driven, or conditioned, in their behavior, and show very little independent thought that is not directly related to specific episodes. I have called their style of thought and culture "episodic."

The limits of ape intelligence seem to be especially evident on the production side of the cognitive system. Bright as their event perceptions reveal them to be, they cannot express that knowledge. This limitation stems from their inability either to actively shape and modify their own actions or to voluntarily access their own stored representations. This might be why they cannot seem to invent gestures or mimes to communicate even the simplest intention (see, for instance, Crawford, cited in Munn 1971). They can learn signs made available by human trainers but they do not invent them on their own; nor do they seem to consciously "model" their patterns of movement, in the sense of reflecting on them, experimenting with them, and pushing them to the limits, the way humans do. This seems to indicate that they are far less developed than humans in at least two areas of motor control: the construction of conscious action models, and the voluntary independent retrieval of such models.

Without easy independent access to voluntary motor memories, even simple operations like self-cued rehearsal and purposive refinement of one's own skill are impossible, because the cognitive system remains primarily reactive, designed to react to real-world situations as they occur, and not to represent or reflect on them. Thus apes are not good at improving their skills through systematic rehearsal. The contrast with human children in this regard is striking: some apes might throw projectiles in a fight, but they do not systematically practice and improve their throwing skill the way human children do. The same applies to other kinds of voluntary action; children actively and routinely rehearse and refine all kinds of action, including facial expressions, vocalizations, climbing, balancing, building things, and so on. Although apes may have the same basic repertoire of acts, they do not rehearse and refine them, at least not on their own. In fact, it takes an incredible amount of training – on the order of thousands of trials – just to establish a single reliable naming response in chimps, and even those very context-specific responses remain reactive and episodic: for example, 97% of Kanzi's signing consists of direct requests (Greenfield & Savage-Rumbaugh 1990). Until hominids were able to model their actions and their episodic event perceptions and access those representations independently of environmental stimulation, they, like all higher mammals before them, were locked into an episodic lifestyle, no matter how sophisticated their event perceptions had become.

## 2. First transition: Mimetic skill and autocueing

The rationale for the first transition is based on several premises: (a) the first truly human cognitive breakthrough was a revolution in motor skill – mimetic skill – which enabled hominids to use the whole body as a representational device; (b) this mimetic adaptation had two critical features: it was a *multimodal* modeling system and it had a *self-triggered* rehearsal loop (that is, it could voluntarily access and retrieve its own outputs); (c) the sociocultural implications of mimetic skill are considerable and could explain the documented achievements of *Homo erectus*; (d) in modern humans, mimetic skill in its broadest definition is dissociable from language-based skills and retains its own realm of cultural usefulness; and (e) the mimetic motor adaptation set the stage for the later evolution of language.

**(a) The primacy of motor evolution.** The first really major cognitive breakthrough and the appearance of the first truly human-like species seem to have occurred with *Homo erectus*. The question commonly asked is: Do we need to attribute some language capacity to this species? This is inherently a structural question, since it asks whether language – rather, symbolic thought – is primary in the human cognitive hierarchy. Placing language this early in evolution, giving it this primacy, is a vote for a symbol-based, computational model of all human thinking.

The evidence supporting the premise that *Homo erectus* was unlikely to have had language has been reviewed in several places (most extensively by Lieber-

man 1984; 1991; but also by Corballis 1991; and Donald 1991). No modern investigator has argued that *Homo erectus* had speech or anything like it. However, to explain achievements like toolmaking and social coordination, several authors have attributed to *Homo erectus* a limited degree of linguistic capacity, usually labeled "proto-language" (Bickerton 1990; Parker & Gibson 1979). The current form of this notion is that *Homo erectus* had the linguistic capabilities of a two-year-old child, namely, one- and two-word utterances and intentional gesturing, but no grammar (Bickerton 1990). This seems feasible, since there have been claims that apes are very close to achieving this (see, e.g., Greenfield & Savage-Rumbaugh 1990).

There are serious problems with this position, however. For one thing, it puts the cart before the horse; it leaves out a prior motor adaptation without which language could never have evolved. In reality, apes are not even close to two-year-old children in the way they use symbols, except perhaps in their perceptions of the utility of symbols. On the motor side, they cannot even match what infants achieve during the babbling phase, let alone later on when children acquire reference, because apes cannot rehearse and refine movement *on their own*, or create models of reality *on their own*. Early language theories of evolution are seeking a "quick fix" solution, a rapid leap to some form of language without attending to the more fundamental motor changes that must have preceded it. (In the process, of course, these theories also sustain the AI agenda that attributes all higher cognition to a symbolizing process; Dennett 1992; Donald 1993.)

The primacy of motor evolution is central to any credible phylogenetic account of language. Before they could invent a lexicon, hominids first had to acquire a capacity for the voluntary retrieval of stored motor memories, and this retrieval had to become independent of environmental cueing. Second, they had to acquire a capacity for actively modeling and modifying *their own movement*. Without these two features, the motor production system could not break the stranglehold of the environment. Any language system assumes the ability of the speaker both to actively construct communicative acts and to retrieve them on demand. In other words, the system must first gain a degree of control over its own outputs before it can create a lexicon or construct a grammatical framework governing the use of such a lexicon.

This is critical from the viewpoint of cognitive theory, but one might still ask, given that an early motor adaptation was a logical necessity, couldn't it have occurred much earlier, perhaps in the australopithecines, and don't we still need language in some form to account for *Homo erectus*? I argue that a revolution in nonverbal motor skill would have had immediate and very major consequences in the realms of representation and social expression. These alone, without any further evolution, can account for the kinds of skills that have been documented in the culture of *Homo erectus;* they can also account for many of the nonverbal skills of modern humans.

There is another good reason for asserting the primacy of motor evolution: language is not the only uniquely human attribute that must be explained in an account of cognitive evolution (cf. Premack 1987). A good theory of the first cognitive evolutionary steps of humans should try to account for as many human nonverbal skills as possible. This leads to the first proposal of my theory: the first major cognitive transition broke the hold of the environment on hominid motor behavior and provided hominids with a new means of representing reality. The form of the adaptation was a revolutionary, supramodal improvement in motor control called "mimetic skill."

**(b) Mimetic action as a unified supramodal system.** Mimetic action is basically a talent for using the whole body as a communication device, for translating event perceptions into action. Its underlying modeling principle is perceptual metaphor; thus, it might also be called action-metaphor. It is the most basic human thought-skill, and remains fundamentally independent of our truly linguistic modes of representation. Mimesis is based in a memory system that can rehearse and refine movement voluntarily and systematically, guided by a perceptual model of the body in its surrounding environment, and it can store and retrieve the products of that rehearsal. It is based on an abstract "model of models" that allows any voluntary action of the body to be stopped, replayed, and edited under conscious control. This is inherently a voluntary access route to memory, since the product of the model is an *implementable self-image*.

The principle of voluntary retrievability, which might be called "autocueing," was thus established at the top end of the motor system. Autocueing is perhaps the most critical unifying feature of mimetic skill. Only humans can recall memories at will; and the most basic form of human recall is the self-triggered rehearsal of action, the refinement of action by purposive repetition. Purposive rehearsal reveals the presence of a unified self-modeling process, and most important, the whole body becomes a potential source of conscious representation. Retrievable body-memories were thus the first true representations, and also the most basic form of reflection, since the mimetic motor act itself represents something: systematic rehearsal "refers" to the rehearsed act itself, comparing each exemplar with a sort of idealized version of itself.

The human mimetic mechanism is supramodal at the output: that is, it can employ any part of the skeletal musculature in constructing a representation. It is supramodal at the input as well, since it can also utilize input from any major sense modality or perceptual system for its modeling purposes. A mimetic reenactment of an event – say a toolmaking sequence – might use the eyes, hands, feet, posture, locomotion, voice, or any combination of these, and the event itself might have been experienced through a variety of sensory modalities. Moreover, a given event can be mimetically represented in various acted-out versions. It follows that a mimetic act is a manifestation of a highly abstract modeling process.

The existence of a unified central "controller" for body mimesis is revealed most clearly in the unique human propensity for rhythm. Humans seem unable to resist rhythm; and even very young children spontaneously imitate, rehearse, and modify the rhythmic sounds and actions around them, with varying degrees of sophistication. The transferability of rhythm to virtually any skeletomuscular system in the body reveals the abstractness of human mimetic action-modeling: rhythms can be transferred from one muscle group to another, singly or in combination. For example, a sound rhythm initially mod-

eled by the fingers can be transferred to the feet, or to the axial locomotor systems (as it is in dance), or to the head, face, eyes, tongue, voice; or to any subset of these in combination. Rhythm is thus an excellent paradigm for mimetic skill, in which an abstract perceptual event (usually a temporal pattern of sound) is "modeled" by the motor system.

Note that this modeling process relies on a principle of resemblance by which some property abstracted from sound is reproduced in motion; but these "resemblances" can be very indirect and elaborate, and innovation and mimetic "wit" are evident in more sophisticated human rhythmic games. Thus the modeling process is metaphoric or holistic: many variants of the basic rhythm may meet the criterion of resemblance, and the rhythm itself is not easily reduced to digital or discrete units combined according to "rules"; rather, it is the Gestalt, or overall pattern, that is primary.

Human mimetic capacity extends to larger time scales; it extends to the purposive sequencing of larger chunks of body movement over much longer periods of time. This assumes an extended mimetic imagination capable of imagining a series of actions in environmental context. If hominids could visually track and "parse" a complex event, as well as apes, say, then given the location of the mimetic controller at the top end of the event-perception system they should have been able to reenact complex events once large-scale action-modeling was within the capacity of the motor system.

**(c) Sociocultural implications of mimetic action.** An improvement of this magnitude in primate motor skill would inevitably have resulted in changes to hominid patterns of social expression. Existing repertoires of expressions would have become raw material for this new motor-modeling mechanism. By "parachuting" a supramodal device like mimesis on top of the primate motor hierarchy, previously stereotyped emotional expressions would become rehearsable, refinable, and employable in intentional communication. This would allow a dramatic increase in the variability of facial, vocal, and whole-body expressions as well as in the range of potential interactive scenarios between pairs of individuals or within larger groups of hominids. It is important to note that since a supramodal mimetic capacity would have extended to the existing vocal repertoire, it would have increased selection pressure for the early improvement of mimetic vocalization, a skill whose modern residue in speech is known as prosody.

Given a mechanism for intentional rehearsal and refinement, constructional and instrumental skills would also have moved to another plane of complexity through sharing and cultural diffusion. Improved toolmaking was in many ways the most notable achievement of *Homo erectus*, but it is important to realize that the manufacture of a new kind of tool implies a perceived need for that tool and corresponding advances in both tool use and pedagogy. Mimetic skill would have enabled widespread diffusion of new applications as well as supporting the underlying praxic innovations that led to new applications.

In addition to toolmaking and emotional expression, motor mimesis would have allowed some degree of quasi-symbolic communication, in that it would have allowed hominids to create a very simple shared semantic environment. The "meaning" of mimed versions of perceptual events is transparent to anyone possessing the same event-perception capabilities as the actor; thus, mimetic representations can be shared and constitute a cognitive mechanism for creating unique communal sets of representations. The shared expressive and social ramifications of mimetic capacity thus follow with the same inevitability as improved constructive skill. As the whole body becomes a potential tool for expression, a variety of new possibilities enters the social arena: complex games, extended competition, pedagogy through directed imitation (with a concomitant differentiation of social roles), a subtler and more complex array of facial and vocal expressions, and public action-metaphor such as intentional group displays of aggression, solidarity, joy, fear, and sorrow. These would perhaps have constituted the first social "customs," and the basis of the first truly distinctive hominid cultures. This kind of mimetically transmitted custom still forms the background social "theater" that supports and structures group behavior in modern humans.

Greater differentiation of social roles would also have been made possible by mimetic skill. The emergence of mimetic skill would have amplified the existing range of differences between individuals (and groups) in realms such as social manipulation, fighting and physical dominance in general, toolmaking, tool use, group bonding and loyalty, pedagogical skill, mating behavior, and emotional control. This would have complicated social life, placing increased memory demands on the individual; but these communication tools would also have created a much-increased capacity for social coordination, which was probably necessary for a culture capable of moving a seasonal base camp or pursuing a long hunt.

It is important to consider the question of the durability of a hominid society equipped with mimetic skill: adaptations would not endure if they did not result in a stable survival strategy for a species over the long run. Mimesis would have provided obvious benefits, allowing hominids to expand their territory, extend their potential sources of food, and respond more effectively as a group to dangers and threats. But it may also have introduced some destabilizing elements, especially by amplifying both the opportunities for competition and the potential social rewards of competitive success in hominid culture.

**(d) The dissociability of mimetic skill in modern humans.** The neuropsychological dissociability of mimesis can be demonstrated from neuropsychological studies of modern humans with brain injury. Certain paroxysmal aphasics manifest a unified, coherent strategy for dealing with reality that has the properties of a purely mimetic strategy. Their cognitions have a style that is often (I believe simplistically) termed a "right-hemisphere" strategy; it shows a degree of unity and a complete independence from language that must be explained.

One well-documented case, Brother John (Lecours & Joanette 1980), suffered from seizures lasting as long as ten or eleven hours, during which all aspects of language – including inner speech – were "excised" from his mind. Nevertheless, he remained fully conscious, able to find his way around, able to operate an elevator or a radio (he used the news station on the radio to test whether he was regaining speech comprehension), and capable of com-

municating with gesture and mime. Most important, he retained perfect episodic recall for most of these seizures; he could remember what went on during the spell, including who entered and left the room and what he had done with his time. This implies that neither his formation of retrievable episodic memories nor his subsequent retrieval of them could have depended upon having a functional language system at the time of storage. Nor could his functioning mimetic skills have depended on language. There are other neurological syndromes that produce a somewhat similar profile – some cases of global aphasia, for instance – but most patients suffer from other disabilities as well as permanent impairments and this makes clear distinctions between language and nonlanguage symptoms difficult to derive. The uniqueness of paroxysmal cases lies in their lack of nonlanguage symptoms such as apraxia, agnosia, amnesia or dementia, and their ability to return to normal after the seizure.

Further evidence comes from documented histories of deaf-mute people raised in hearing communities without formal sign language training. Such individuals could have had none of the lexical, syntactic, or morphological features normally associated with language. They obviously lacked a sound-based lexicon of words; they couldn't read or write, and had no access to a community of other deaf individuals who signed, and thus also lacked a visually based lexicon. Yet, by some accounts (e.g., Lane 1984) such individuals retained a capacity for all aspects of what I have identified as mimetic cognition: a full range of human emotional expressivity, gesture, mime, dance, athletic and constructional skills, and an ability to participate in reciprocal mimetic games.

The persistence of mimetic skill is evident in modern society. In fact, the realm of mimetic representation is still relatively autonomous from that of language and remains essential to the training of those who work with the body, such as actors or athletes, as well as to those who practice traditional constructional skills, such as arts and crafts. It is central to human social effectiveness and to the practice and teaching of games, competitive skills, and many group expressive customs, as for instance in the intentional use of group laughter as punishment, or the signaling of deference, affection, manliness, celebration, and grief; or the maintenance of group solidarity (see, for instance Argyle 1975; Ekman et al. 1969; Eibl-Eibesfeldt 1989). [See also Eibes-Eibesfeldt: "Human Ethology" *BBS* 2(1) 1979.]

**(e) Mimesis as a preadaptation for language.** Mimetic skill was, fortuitously, an important preadaptation for the later evolution of language. It allowed hominid tool technology and social organization and the shared realm of custom and expression to become more complex. Given the inherent fuzziness and ambiguity of mimetic representation, it would eventually have reached a level of complexity where a method of disambiguating intended mimetic messages would have had immediate adaptive benefits. Thus it created conditions that would have favored a communication device of greater speed and power.

On a more fundamental level, however, the principle of self-triggered voluntary retrieval of representations had to be established in the brain before the highly complex motor acts of speech would have been possible. Phonetic skill has been called "articulatory gesture" by various investigators (Brownman & Goldstein 1989); the whole higher apparatus of speech depends on the basically mimetic ability of individuals to create rehearsable and retrievable vocal acts, usually in close connection with other mimetic acts. In a word, language per se is layered on top of a mimetically skilled phonological system.

Language is not confined to the phonological system, however, because mimesis is inherently supramodal; thus, when phonology malfunctions, other mimetic subsystems may be harnessed by the language system. This is particularly visible in Petitto and Marentette's (1991) elegant documentation of infant babbling in sign-language environments, which occurs at exactly the same time as phonological babbling and has the same properties. Deaf infants growing up in deaf-signing households showed themselves to be very good at miming the motor *principle* behind signing, if not the signs themselves; that is, their manual "babbling" reflected the conditional probabilities of their expressive environments on a purely mimetic level. This is exactly what babbling infants do in hearing households: they model, in their actions, one of the most obvious dimensions of motor behavior to be observed in their families: repetitive, and to the infant, apparently random production of phonological acts.

Babbling, whether oral or manual, is reference-free in the linguistic sense – that is, it has no linguistic meaning – but it is nevertheless truly representational, in that babbling patterns are (eventually) excellent motor models of the expressive patterns the infants observe around them. They reproduce not only the elementary units of language, but also the larger mimetic envelope of expression as well: for example, prosody, and the habit of alternation, or "waiting one's turn" in expressive exchanges. Since babbling is free of linguistic reference, the brain mechanism that supports it does not have to be linked to language per se; rather, these eight- to ten-month-old infants look very much like good supramodal mime artists. And the supramodal nature of their babbling is very revealing: the fact that babbling isn't confined to phonology suggests that a supramodal mimetic adaptation evolved first, with phonology developing later as a specialized subsystem of mimetic capacity.

There are other theories that view early advances in praxic skill as preadaptations for language (Corballis & Beale 1976; Kimura 1976). Kimura observed that oral and manual apraxia and aphasia often result from the same left-sided lesions; from this she inferred that language and voluntary movement control are linked, possibly to a common processor. However, the neuropsychological case for linking pantomime and language to the same left-sided serial processor has since disintegrated (see Poizner et al. 1987; also Square-Storer et al. 1990).

These authors did not provide any theoretical justification of why praxis should have been an essential preadaptation for language, but Corballis's more recent (1989; 1991) hypothesis faces this problem squarely. His idea is that the left hemisphere acquired a general-purpose capacity for "generativity" that served as the common substrate for image generation and praxis and later for language. Generativity requires categorical perception (Harnad 1987), or the decomposition of the object world into elementary units; and it also requires the ability to recombine these units, as in both phonology and image

generation (Kosslyn 1988). In Corballis's view, these two aspects of generativity evolved for improved praxis, forming a preadaptation for the later emergence of language. A closely related theory has been proposed by Greenfield (1991), who argues for a common left-sided mechanism for combinatory praxis and phonology, at a prelinguistic level.

The concept of mimetic skill proposed here differs fundamentally from both Corballis's idea of generativity and Greenfield's left-sided praxic "module" in its reduced emphasis on cerebral laterality; as pointed out at some length in my book, mimetic skill is probably bilateral (which is not to say that it is symmetrical) in distribution. More important, it differs in the nature of the proposed underlying mechanism. Generative praxis is conceived of as categorical, rule-governed, and serial in its manner of operation, whereas mimesis is basically a holistic or analog system that can model over time as well as space. A capacity for serially recombining categorical units would not easily account for the complex, fuzzy, holistic process of comparing movements against their idealized versions (cf. Moerck 1989), or of producing event reenactments, as in charades or pantomime. The generative modeling of the mimetic action-patterns that humans create and refine (including phonology) seems far too metaphorical and analog in principle to fit easily into this kind of quasisymbolic computational framework.

## 3. Second transition: Lexical invention

The rationale for the second transition is, briefly, as follows: (a) since no linguistic environment yet existed, a move toward language would have depended primarily on developing a capacity for *lexical invention;* (b) phonological evolution was accelerated by the emergence of this general capacity for lexical invention, and included a whole complex of special neuronal and anatomical modifications for speech; (c) the language system evolved as an extension of lexical skill and gradually extended to the labeling of relationships between words and also to the imposition of more and more complex metalinguistic skills that govern the uses of words; and (d) the natural collective product of language was narrative thought (essentially, storytelling), which evolved for specific social purposes and serves basically similar purposes in modern society.

**(a) Lexical invention.** Lexical invention is not yet understood in terms of mechanism. There is no viable computational model of this process and neural network models have not yet reached the point where anything so complex could be simulated. The process mapping the "lemma" or meaning-based side of the lexicon onto the form of the symbol – whether it is phonological or manual – involves much more than the association of a discrete signifier, or form, with a discrete meaning. The previous section argues that phonology, like any mimetic system, works according to a metaphorical principle; but so does lexical invention, if Wittgenstein (1992) or Johnson-Laird (1983) are to be believed. In other words, both word forms and meanings tend to be fuzzy, and neither side in the lexical entry is cleanly defined or discrete. Nevertheless, the tension between word form and meaning is a creative one that greatly increases the range of things that can be represented.

As discussed at some length in the book, the invention of a symbol is a complex process that involves labeling and differentiating our perceptions and conceptions of the world, including other symbols as parts of that world. Form is mapped onto meaning, but meaning is *defined* by that same process, in a reciprocal tension. This reciprocal tension is evident even now, after at least 45,000 years of lexical invention. Languages are constantly changing their particular mappings of form onto meaning; for instance, all of the tremendously diverse aboriginal American languages derived from three root Asiatic languages within the past 15,000 years (Greenberg & Ruhlen 1992); and the entire Indo-European group of languages, including language groups as diverse as Sanskrit, Gaelic, Latin, and Greek, have all evolved from a common ancestor within the past 7,000 years (Renfrew 1989). This incessant pattern of change suggests that the driving force behind lexical invention – the need to define and redefine our maps of meaning onto word forms – is more fundamental and considerably less rigid than the specific forms and rules of language at any given moment.

**(b) The phonological adaptation.** Phonology was not *the* primary language adaptation, but rather a specialized mimetic subsystem that supported the primary adaptation, lexical invention. The specialized anatomical subsystem that supports phonology evolved after the evolution of a supramodal lexical capacity, or more properly perhaps, concurrently with it, in a mutually reinforcing manner. As a mimetic subsystem, phonology has the same basic properties as all mimetic action, such as rehearsability, autocueing, and purposive refinement. The fact that language can be offloaded to other motor modalities, as it is in the sign languages of the deaf, is evidence of the secondary position of phonology in the evolutionary chronology. Phonology by itself could not have created a lexicon, and without lexical invention it is doubtful whether humans would have been subjected to selection pressures favoring such a powerful phonological system.

Nevertheless, it was a very complex and important adaptation, and without it, archaic sapient humans may not have been able to sustain the expansion of lexical capacity that they subsequently did. The great survival value of phonology to archaic humans is evident in the fact that it evolved despite the great respiratory dangers associated with a descended larynx, and in the sheer anatomical complexity of the adaptation. Included in the phonological adaptation were (as a minimum): the descent of the human larynx and the redesign of the supralaryngeal vocal tract, with corresponding central motor programming devices; a specialized auditory device for achieving improved auditory object constancy, which feeds back directly onto speech production; the articulatory loop, for immediate literal recall of articulated messages; and a specialized, large-capacity auditory memory system of word forms (see Levelt 1989; Lieberman 1975; 1984).

The importance of phonology should not be underestimated. There is little alternative to the notion that the original form of language is spoken language. There is an easy relationship between vocalizing and language, per-

haps because phonology is fast, highly portable, and less likely to interfere with locomotion or praxis: in this sense it is a special "channel" of communication that can float freely above the largely visuomotor world of events, constructing commentaries unimpeded. Moreover, it works at a distance and in the dark, two features that have great adaptive value.

Phonology also has the special virtue of being able to generate a virtually infinite number of easily retrievable sound patterns for symbolic use. Human retrieval capacity for oral words is extraordinary; we carry around tens of thousands, and in the case of some multilinguals, hundreds of thousands of words; most other species, from bees to the Great Apes, seem to be limited to a few dozen expressions at most in the wild; and this limitation even applies to Cheney and Seyfarth's (1990; see also multiple review: *BBS* 15(1) 1992) vervet monkeys.

The natural dominance of phonology over manual signing is evident in experimental settings where subjects are encouraged to tell stories about specific experiences and their gestures are videotaped. In such experiments (cf. McNeill 1985), facial and manual gesture fall into a secondary support role, their timing ruled to the millisecond by spoken words; even the mimetic dimension of voice, prosody, remains secondary to the expressed meaning. Phonology is thus clearly the medium of choice for language itself. It should be added, however, that this pattern of dominance is often broken, especially in humor (including the humor of children), where the semantic counterpoint between what is said and what is gestured or done can become a powerful means of expression in itself. The ease with which humans can parallel-process two contradictory messages – mimetic and linguistic – has been long known to playwrights.

It is important to note that these new representational acts – speech and mimesis – can be performed covertly as well as overtly. Covert speech has been called "inner speech" by Baddeley (1986), who considers it to be equivalent to the activation of the central aspects of articulation, without actual motor execution. The mental operation we call "imagination" can similarly be seen as mimesis without motor execution of the imagined acts. The control of mimetic imagination (probably even of visual generative imagery, which is facilitated by imagined self-movement) presumably lies in a special form of kinematic imagery. Autoretrievability is just as crucial for covert imaginative or linguistic thought as it is for the overt, or acted-out equivalent. Thus, given a lexicon, the human mind became able to self-trigger recall from memory in two ways: by means of mimetic imagination and by the use of word symbols, either of which could be overt or covert.

**(c) Grammar and metalinguistic skill.** I have opted for a lexically driven, rather diffuse model of language evolution partly because it fits in well with the preceding evolutionary scenario and partly because I judge this to be a scientific "best bet" on the basis of an extensive review of neurolinguistic research. The main issue here is whether grammar and metalinguistic skills such as those which operate at the level of discourse and logic require a separate adaptation in addition to phonology and lexical invention. If one were to try to envisage language in such a way as to meet all of Fodor's (1983) requirements for a true linguistic "module," a separate grammar module would surely fail on a number of counts (as Fodor has acknowledged), especially inasmuch as it appears to be completely interpenetrable with the rest of language, and closely tied to semantics.

Moreover, the neurological case for a separate grammar module is weakened by recent cross-linguistic studies of aphasia, which strongly suggest that there is no specific brain lesion, nor any specific pattern of grammatical deficit, that is universally found in agrammatics of all languages. According to the "competition" model proposed by Bates and MacWhinney (1987), the whole perisylvian region of the left hemisphere is diffusely dedicated to language, function words and grammatical rules being stored in the same tissue as other kinds and aspects of lexical entries. However, I readily admit that this issue, like many others in this field, is still not conclusively resolved; there is electrophysiological evidence that function words – those most relevant to grammar – might have a different cerebral representation from open-class words (Neville 1992).

A related issue is whether it seems necessary a priori to posit a separate adaptation for the invention and transmission of grammar and the metalinguistic skills that support extended discourse. I have cited some biographical accounts of symbolic invention in mathematics as examples of how difficult it is to invent any new word or symbol. Once a concept has been "captured" lexically for the first time, it seems to become much easier to transmit it to others, but its original invention is generally difficult; and every new invention must then be subjected to the shared linguistic market for acceptance or rejection. All original lexical invention is difficult and collective. This applies to all classes of words, and there is no compelling reason why closed-class, or function, words might not be viewed as a product of the same skill that enabled the invention of nouns and adjectives. If the lexical inventor can isolate and define an abstract concept like "run" (including the exclusion rules for its correct use), it is not clear why that same mind could not isolate and define a function word like "with." Grammatical concepts do not seem to demand special treatment in their invention and, presumably, their transmission.

It would certainly make good evolutionary sense to attribute language to one core adaptation whose further evolution could account for all the attributes of language and language-based thought. Part of the reason is, simply, time; there wasn't enough time in the human story for more radical cognitive adaptations, and a capacity for lexical invention is the obvious *sine qua non* of language, and hence must be put first. If we put lexical invention earlier in the scenario, as Bickerton (1990) did, there might have been time for a separate adaptation for grammar; but then we must explain why a powerful capacity like lexical invention would have evolved when it was apparently not needed 1.5 million years ago, and then failed to develop further for over a million years. If we put lexical invention late, as I and many others do, there doesn't seem to be enough time to allow for a second adaptation for grammar.

**(d) Sociocultural ramifications.** Spoken language increased the number and complexity of available words and grammars and altered human culture by introducing

a new level of shared representation. My hypothesis is that mimetic skill continued (and continues) to serve its traditional social purposes perfectly well: it still provides the cognitive foundation for institutions like dance, athletics, craft, ritual, and theater. Oral language initially carved out its own sphere of influence within mimetic culture, eventually assuming a dominant and governing role in human culture, but never eliminating our basic dependence on mimetic expression. Oral language remains focused on the human world, particularly on relationships (Dunbar 1993), and this pattern extends to a wide range of cultures, from technologically primitive hunters and gatherers to highly urbanized modern European societies.

The natural product of language is narrative thought; in this sense, language, like mimesis, evolved primarily as a method of modeling reality. Dunbar (1993) has argued that the normal social use of language is storytelling about other people – gossip – and he has produced observational data to prove this. But day-to-day storytelling in a shared oral culture eventually produces collective, standardized narrative versions of reality, particularly of past events; and these become what we call the dominant "myths" of a society. It is interesting that all documented human societies, even the most technologically primitive ones, have elaborate systems of myth, which appears to reflect the earliest form of integrative thought. These socially pervasive constructs continue to exert a major influence on the way oral societies – and indeed most modern societies – are run: thus I have suggested that many cultures might be labeled "mythic," after their governing representations.

## 4. Third transition: The externalization of memory

The case for a third cognitive transition is based on arguments, partly structural and partly chronological, that are similar in principle to those used for the first two; but the physical factors that supported the third transition are a little different, inasmuch as the latter was driven primarily by technological rather than biological developments. The chronological evidence is based on the rapid emergence of whole new classes of memory representations – external memory records – as well as a major change in the types of symbolic artifacts produced by humans. The structural argument is based partly on neurophysiological and neuropsychological evidence bearing on localization and plasticity and partly on an analysis of cognitive architecture in the context of our new relationship with external memory.

The historical case for a third transition rests on evidence that since the Upper Paleolithic humans have gradually developed three new representational devices. The first was *visuosymbolic invention*, which advanced through various well-documented stages, culminating in a variety of complex graphic and numerical conventions and writing systems. The second was *external memory*, which evolved to the point where external memory records, mediated by a "literate" class, started to play a governing role. The third was the emergence of very large, externally nested cultural products called *theories*. I will not reiterate the voluminous historical evidence for this, partly for reasons of space, but mostly because my chronology is neither original nor in dispute. The real argument for grouping together these historical trends into a so-called third transition is a structural one.

The structural case can be stated as follows: (a) external memory has introduced radical new properties into the collective storage and retrieval systems of humans; (b) the use of these external storage systems is difficult and requires a major redeployment of cerebral resources toward establishing literacy-related "modules" in the brain; (c) the physiological basis for this reorganization probably lies in neuronal epigenesis and plasticity; and (d) the role of biological working memory has been changed by the heavy use of external memory.

**(a) New properties.** Early humans, like their primate predecessors, depended heavily on their natural or biological memory capacities. Even though mimetic skill and language enabled humans to create a shared representational culture, the actual physical storage of that collective knowledge depended on individual memory. Thought was dependent on biological working memory, and whatever was seen or heard had to be remembered and rehearsed either in imagination or in speech. The contents of our long-term store were accessible only by means of the limited associative strategies available to biological memory, such as similarity and contiguity; thus, the need for oral mnemonics, extensive literal oral recitation, and a dependence on specialized individuals, like shamans, to preserve particularly important memory material.

The advantages of external memory are easily documented. External symbolic storage systems allow humans to circumvent, at least partially, the limitations of biological working memory, while creating a wide range of new storage, retrieval, and processing possibilities. By changing the physical medium of storage, human memory systems have acquired new properties, especially retrieval properties. I have suggested the term "exogram" to complement the notion of a biological "engram." As shown in Table 1, exograms introduced new possibilities into the human representational universe.

Exographic storage constitutes a hardware change just as real as the biological hardware changes that mediated the first two transitions; and its effect on overall memory structure may have been even greater. The exportation of memory storage has literally meant that the human race, as a collectivity, can now evolve new memory systems at the accelerated rate of technological change, as opposed to the relatively slow rate of genetic change. Perhaps the most important new features introduced by external storage are radically different options in memory retrieval, and the fact that exograms are easily reformattable. Extensive reformatting can modify the kinds of ideas and images that are available to store in biological memory, and so on, in iterative loops. This iterative crafting of complex memory records has produced completely new types of symbolic representations that had no equivalents in preliterate oral cultures – examples might include the servicing manuals for a rocket engine, the equations proving the Pythagorean theorem, a corporate income tax handbook, a heat-map of the troposphere, or the libretto and score for *Eugene Onegin*.

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Table 1. *Some properties of engrams and exograms*

| Engrams | Exograms |
|---|---|
| internal memory record | external memory record |
| fixed physical medium | virtually unlimited media |
| constrained format | unconstrained and reformattable |
| impermanent | may be permanent |
| large but limited capacity | virtually unlimited |
| limited size of single entries | virtually unlimited |
| not easily refined | unlimited iterative refinement |
| retrieval paths constrained | retrieval paths unconstrained |
| limited perceptual access in audition, virtually none in vision | unlimited perceptual access, especially in vision; spatial structure useful as an organizational device |

*Source:* From Donald, M. (1991, p. 315).

**(b) Cognitive reorganization.** External memory has introduced new cognitive skill-clusters that are generally referred to as "literacy" skills, but full symbolic literacy extends well beyond the traditional Western definition of literacy, that is, alphabetic reading competence. The neuropsychology of various acquired dyslexias, dysgraphias, and acalculias has revealed a cluster of functionally dissociable cognitive "modules" in the brain that are necessary to support these skills (see, for instance, Morton 1984; Shallice 1988 [see also multiple book review: *BBS* 14(3) 1991]; Shallice & Warrington 1980).

The localization of these neural modules seems to vary across individuals, as might be expected, since the whole structure must have been imposed by cultural programming rather than by any specific genetic predisposition built into the nervous system. There is a great deal of evidence in single-case neurological histories that these "literacy support networks" are anatomically and functionally distinct from those that support oral-linguistic skills, as well as from those brain regions that support basic perceptual and motor functions (see especially Shallice 1988).

There are at least three dissociable high-level visual interpretative paths involved in symbolic literacy. The most basic is "pictorial," and is needed to interpret pictorial symbols such as pictograms and visual metaphors; even at this level there are numerous interpretative (mostly metaphoric) conventions to master. The second is "ideographic," and is sometimes called the direct visual-semantic path in studies of reading (see Coltheart et al. 1980; Paradis et al. 1985); it maps visual symbols directly onto ideas, as in the case of Chinese ideographic writing, most systems of counting, or many street signs and analog graphic devices like maps, histograms, and charts. The third is "phonetic," and serves to map graphemes onto phonemes, as in alphabetic print. These three paths emerged at different historical phases of visuosymbolic evolution and remain functionally independent of one another; moreover, each path feeds into a distinct visual "lexicon" of thousands of recognizable symbols.

**(c) Physical basis.** How could the highly complex functional subsystems necessary for reading, writing, and other visuosymbolic processing skills be accommodated by the human brain without genetic change? The answer seems to lie in the increased neocortical plasticity that came with the final expansion of the human brain. This increase in plasticity might be partly a function of greater cortical asymmetry, which allows nonredundancies of function between homologous association regions in the two hemispheres, in effect creating twice as much "extra" neuronal space as a comparable expansion in primary cortical regions, which tend to be more symmetrical in function. Moreover, the immense tertiary neo-neocortical subregions of the human brain have so many competing input pathways that epigenetic factors such as those described by Changeux (1985) and Edelman (1987) could create a very great range of potential functional arrangements. In effect, it is probably because of the plasticity of this arrangement that the human brain can invest so heavily in the decoding baggage needed for using large numbers of novel external memory devices.

In addition, there is evidence that even in adults the cerebral cortex is constantly readjusting and fine-tuning its assignment of processing space, reflecting the constantly changing use patterns imposed by the environment. The somatosensory regions of neocortex may be reorganized by a prolonged increase in stimulation; in fact, the area dedicated to fine touch discrimination expands and contracts in response to imposed load changes (see, for instance, Merzenich et al. 1987). This sensitivity to use pattern may even extend to functions quite different from those that normally occupy a given region, as in the case of the auditory cortex of a congenitally deaf person, which in the absence of auditory stimulation will eventually assume visual functions (Neville 1990). If the relatively hard-wired primary sensory regions are this flexible then tertiary cortical regions ought to show even greater flexibility in their function, given the additional degrees of freedom added by moving two synapses or more from the many sensory, motor, and association regions that impinge upon them.

There appear to be tradeoffs inherent in this flexible arrangement – that is, "invasions" of a given region by an environmentally or culturally driven function will displace other functions that may potentially have depended on that region. This suggests that high levels of literacy skill may entail considerable costs, as indeed has been suggested by the literature comparing the cognitive competences of oral cultures with those of literate ones. Oral memory and visual imagery are often listed among the skills that may have been traded off against literacy (Cole et al. 1971; Richardson 1969).

**(d) Changed role of biological memory.** One of the most interesting effects of external memory devices is the way they alter human working memory. Working memory is generally conceived as a system centered on consciousness; and although there are many alternatives in the literature, Baddeley's (1986) model was adopted for the purposes of this discussion because it is fairly representative and maps very well onto a neurobiological model.

The tripartite working memory structure proposed by Baddeley includes two slave memory systems, the articulatory loop and the visual-spatial sketchpad, and a central executive. According to this model, when we think, we either imagine, via the sketchpad, or verbalize, via the articulatory loop (the latter may be covert, in the form of "inner speech"). The central executive handles the intermediate-term semantic context – for instance in a conversation it might keep track of what was said, by whom, and in what context. This working memory structure provides the basis for consciousness, although not everything held in working memory is consciously experienced; rather, it is easily available to consciousness.

In preliterate cultures this arrangement, or something close to it, was all that humans had to work with, and its limitations are well documented. A society that relies on this type of memory mechanism would accordingly have to depend upon a variety of social arrangements and mnemonic skills to maintain its accumulating knowledge base: rote verbal recitation, preferably in groups; specialized individuals whose task was to learn and retain knowledge (for instance, shamans and bards); formulaic recital by individuals in an undisturbed, special place; rigidly formal and repetitive group ritual; and various forms of visual imagination as a means of understanding and retaining quite complex memories.

This situation has changed with the increased use of external symbolic storage. The larger architecture within which the individual mind works has changed; in fact, the structure of internal memory is now reflected in the external environment: there is now an external memory field that serves as the real "working memory" for many mental operations, and there is also an external "long-term" store. The external equivalent of the long-term store has very different storage and retrieval properties from those of our internal long-term store. Similarly, the external working memory field has completely different properties from the internal working memory system. Whenever an individual is "plugged in" to some part of the external store, that interaction is mediated by certain items displayed in the external memory field; the latter may consist of a variety of display devices, including print, graphs, monitors, and so on, usually arranged in visual space. The conscious mind is thus juxtaposed between two memory structures, one internal and the other external.

The external display projects directly to the visual regions, which now become the locus of a new kind of internal working memory, one which utilizes the power of the perceptual systems. In effect, because the perceptual systems are displaying *representations* (as opposed to nonsymbolic objects), the user's brain can move through "information space" just as it has always moved through the natural environment, with the difference that processing occurs on two levels, instead of only one. The items displayed in the external memory field are treated first as natural objects and events and second as memory representations that can externally program the user's brain, that is, create specific states of knowledge that were intended by the creator of the particular external device on display.

This second level of analysis, which is the prerequisite for literacy, imposes a great load on visual as well as semantic processing. The process of reading a book, where meanings literally pop out of the script (or the graphs, numbers, ideograms, or other types of symbols it uses) requires a tremendous amount of additional high-level processing. This second level of processing, wholly automated in the expert reader, requires rapid access to thousands of internally stored pictorial, ideographic, graphemic, and visual-lexical codes, along with various specialized grammars, scanning conventions, and a great deal of interpretative knowledge. In effect, this second-level visual system produces knowledge states that are directly driven from the external memory field; it thus becomes the internal display device for a very complex external memory trace. The literate brain thus becomes externally programmable.

But unlike the constantly moving and fading contents of biological working memory, the contents of this externally driven processor can be frozen in time, reviewed, refined, and reformatted. Moreover, all of this can be done intentionally, online, and in real time, in constant interaction with the external display mechanism. In biological working memory, the possibility of this kind of iterative refinement of mental representations is very limited. Neither of Baddeley's (1986) slave systems can support such reflection: the articulatory loop needs constant rehearsal and has a decay time of a few seconds, whereas the visual sketchpad is even more ephemeral, vaguely defined and vulnerable to interference. The central executive is able to hold quite a large amount of information, but in order to consciously modify that information, its contents apparently need to be displayed in one of the slave systems, usually in a covert manner (for instance, inner speech). This imposes a serious limitation on the amount of conscious reflection that can be done on any material that is stored exclusively in biological working memory.

Breaking out of this limited working memory arrangement in itself was a very major change. But it potentiated another important new development: new metalinguistic skills, which expressed themselves in the kinds of symbolic products and cognitive artifacts (Norman 1990) humans could produce and maintain. Producing a single new entry in the external storage system is not a trivial occupation; it never has been, from Ice Age cave paintings to modern science. As artifacts have become much more complex, and the knowledge environment itself has grown, the specific skills needed to become a serious "player" has also taken much more specific preparation, in the form of extended apprenticeships and higher education. There is a trend in the kinds of "metalinguistic" thought skills that have been taught in Western academies over the past few thousand years, moving from an early emphasis on oral and narrative skills, toward visuosymbolic and paradigmatic skills. Denny (1991) has suggested that the major new thought pattern attributable to literacy is a property called "decontextualization," and Olson (1991) has suggested that writing allowed the "objectification" of language, and consequently the development of formal thought skills. These proposals are compatible with my suggestion that literacy allowed the thought process itself to be subjected to iterative refinement through its stable display in the external memory field, and its subsequent incremental refinement, like any other external symbolic product.

The modern brain must accommodate not only these

new working memory arrangements and all the coding demands imposed by symbolic literacy, but also a number of metalinguistic skills that simply did not exist a few thousands of years ago. The latter are socially entrenched; for example, an enterprise like modern science is very much a collective endeavor, in which the individual mind is essentially a node in a larger networked structure supported by external memory. Humans have been part of a collective knowledge enterprise ever since mimetic skill permitted us to break with the limitations of episodic cognition, but external memory has amplified the number and variety of representations available in human culture and increased the degree to which our minds share representations and rely on external devices for the process of thought itself. Cognitive studies of the modern workplace (e.g., Hutchins 1990; Olson & Olson 1991; Suchman 1987) testify to the way that electronically distributed knowledge representation, and computer-coordinated planning and problem-solving, are affecting the relative roles of individual minds and external memory devices in this collective enterprise.

# Open Peer Commentary

*Commentary submitted by the qualified professional readership of this journal will be considered for publication in a later issue as Continuing Commentary on this article. Integrative overviews and syntheses are especially encouraged. All page references are to Donald's* Origins of the Modern Mind *unless otherwise indicated.*

## From cooperative computation to man/machine symbiosis

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In an early target article in *BBS*, Arbib and Caplan (1979) offered a view of neurolinguistics that is in many ways concordant with that offered by Donald in Chapter 3, "Wernicke's Machine." However, where Donald turns to Fodor's (1983) "modules" – which are so large that "language" occupies a single module – we offered a finer-grained analysis that uses the "cooperative computation" of interacting entities called schemas to reveal the salient patterns of interaction embedded in the neural network dynamics of the brain. This intermediate-grain approach to modularity (in the general sense that antedates Fodor) not only encourages computational modeling and neuropsychological analysis of such Fodorian modules as language and vision but it also allows one to embark upon a similarly insightful analysis of the "central processes" that Fodor argues are unanalyzable (Arbib 1987).

Donald, although he uses Fodor's large-scale notion of modules, does take the argument further by analyzing the "central processes" in terms of evolutionary stages. To the basic mechanisms for exploiting episodic memory he adds (1) the "mimetic controller" (Fig. 6.1, p. 190), (2) the "linguistic controller" at the peak of a vertically integrated speech system (Fig. 7.2, p. 260), and (3) the metalinguistic skills which coevolve with the development of increasingly sophisticated "external memory fields." Such "large-module" language leads Donald to characterize the second transition as "one vertically integrated adaptation, ultimately unified under a 'linguistic controller,'" (p. 259) even though elsewhere he reminds us that: "Just as in the case of mimesis, the language adaptation had to involve many different parts of the brain. . . . Once again we are looking at mosaic evolution" (p. 261). (One may note, for example, that a key point in the use of language is to negate a statement and then gather evidence as to which of the alternatives is true. Another is the flexible expression of goals and the ability to analyze various paths to attain them.)

Donald's argument may be strengthened if "schemas" are seen as the units on which evolution may act. Fodor's "modules" then disappear, to be replaced by patterns of schemas which provide a coherent style. As Arbib and Hesse (1986, p. 50) note, "Though processes of schema change may certainly affect only a few schemas at a time, such changes may 'cohere' to yield a mental 'phase transition' into a pattern of holistic organization. [Such transitions may include] stage changes in the sense of Piaget [and] paradigm changes in the sense of Kuhn."

To these examples I would here add "evolutionary transitions in the sense of Merlin Donald." This forces us to spell out more carefully a view of evolution as a form of punctuated equilibrium that goes somewhat as follows: Existing species have reached a local quasi-optimum of fitness in relation to their ecological niche. By quasi-optimum, I mean that the expected effect of a random mutation is a decrease or negligible change in fitness. Thus the species can remain stable for long periods of time until there is either (1) a catastrophic change in the environment so that species fitness is no longer optimal or (2) a very rare mutation does occur that yields a heritable improvement in fitness. The key point is that a successful mutation does not yield a new quasi-optimum. Rather, many different mutations can now effectively yield changes that increase fitness. The biological changes in both bodily and neural structure and function are manifested in new schemas which provide the "mental phenotypes" on which selection acts. We can then seek to see how these changes might be small enough in the genetic metric to be the plausible result of mutations, yet large enough in their functional expression to yield adaptive improvements that can build upon one another to yield a coherent pattern of change. (I would appreciate pointers to scholarly treatments that either support or refute this approach.) Such incremental changes in brain and body are not "unidirectional." Arbib (1989, sect. 7.2) gives a concrete account of the "evolution" of schemas in a computational model for visual motion perception that has strong resonances with a Jacksonian view of brain evolution (Jackson 1874; 1878/1879). This example stresses that "older systems" are not fully encapsulated but can themselves further evolve to take advantage of changes in the "informational environment" afforded by the new brain regions.

Donald's work thus poses two challenges: to understand why the transitions to each of episodic, mimetic, and mythic culture yielded relative stability after a multitude of coadaptive changes (over 50 to 100 generations?) had cohered to yield a new "species style"; and to understand why what Donald calls theoretic culture (marked by man/machine symbiosis; cf. Arbib 1973; 1982) is a stage of explosive cultural change. I do not know the answer, but I think it worth recalling the extension of schema theory that Hesse and I introduced to place "schemas in the head" (cf. stage changes in the sense of Piaget) and "schemas in society" (cf. paradigm changes in the sense of Kuhn) in an integrated perspective.

> An "ideology" is expressed within the whole structure of interactions among the individuals of a society, their institutions, and their artifacts; it can only be vicariously and imperfectly represented within the head of any individual within that society. . . . we use the term "social schema" to denote any such network, whether an ideology, a language, or a religion. . . . Such schemas are not external, like the physical world, but they shape the development of our

> individual schemas at least as powerfully as the patterns of physical reality shape the development of our sensorimotor schemas. (Arbib & Hesse 1986, p. 129)

Such ideas find computational expression in a model of language acquisition (Hill 1983) in which the child actively forms the schemas of language whether the child's experience is based on one speaker or a whole community. What is more to Donald's point, however, is that we discuss the conditions under which one individual will assimilate such a social schema while another will "rebel."

The point of the above orgy of self-citation is not to claim that my work anticipates Donald's. It does not, and I have learned much from his fascinating book. It is rather to suggest that schema theory may provide a framework in which the implications of Donald's ideas may be fruitfully elaborated into a form testable by the methods of computational and cognitive neuroscience. These methods themselves must be augmented by the tools of evolutionary theory if they are to fully meet this challenge.

## Putting cognitive carts before linguistic horses

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*Origins of the Modern Mind* gets off on the right foot by taking two steps seldom conjoined in approaches to human cognition. Merlin Donald accepts that cognition can only be understood from an evolutionary perspective, and sees the representational function of language as marking an essential stage in the development of mind. It is all the more disappointing that his book should be seriously marred by misunderstandings of the nature of language.

Take Donald's treatment of Brother John (pp. 86–89), an epileptic monk whose severer seizures temporarily deprived him of all language functions, but who could still cope with a variety of social situations. According to Donald, this means that language, despite the significance he accords it, cannot play a central role in cognition – otherwise Brother John would have been "confused" or "disoriented" by those situations. But what does Donald think happened, in these fits, to the knowledge of language underlying Brother John's normal performance? Did it vanish, to be magically reinstated once the fit was over? Surely it remained present throughout. And if language is indeed central to human cognition, then a temporary blockage of its peripheral output-input mechanisms would have no consequence for any automatic (and quite unconscious) computational processes in which it might be implicated. Brother John in seizure is not, contra Donald, a man without language – but a man without full use of language. That he could remember and verbally describe his experiences should have alerted Donald to inconsistencies in the description given.

But Donald himself gives conflicting accounts of Brother John's status. On p. 86, Brother John, even in his severest seizures, is "fully aware, with no breakdown of basic conscious functioning." On p. 253, however, he has "no symbols, no symbolic thought." How he could be conscious and aware without symbolic thought, or whether (and if so, how and why) his consciousness differed between conditions of seizure and normalcy, apart from mere changes in the ability to give synchronous verbal descriptions, are just two of the things Donald fails to explain.

Without a clear understanding of language and how it functions, further confusions inevitably arise. Consider the following passage:

> The apparently impossible complexity of linguistic constructs at the level of word and sentence might well be secondary phenomena. The primary objects of language and speech are thematic; their most salient achievements are discourse and symbolic thought. Words and sentences, lexicons and grammars, would have become necessary evils, tools that had to be invented to achieve this higher representational goal. . . . Above all, language was a public, collective invention. (p. 216)

If ever there was a case of putting the cart before the horse, this is it. The claim that language was invented so as to achieve higher representational goals entails that such goals must somehow have been envisaged in advance of language – first you think it, then you dress it in words. But in that case, where did this advanced thinking come from, and why does it seem so different from the thinking of even our closest relatives?

Donald is rightly suspicious of brain-inflation and high encephalization quotients (or at least seems to be: a persistent problem with his style is uncertainty about just what positions he holds on a variety of issues). But if neither brain size nor language bootstrapped us into higher cognitive realms, what is left? The mimetic stage he invokes as the sole phase between episodic apes and linguistic humans hardly bears the burden, well-adapted though it may be for "customs, games, skills" (p. 173) and the like.

As for language as invention, collective or otherwise – although Dante and Spenser may have added grammatical constructions to Italian and English (p. 235), they could do so only by exploiting hitherto-unused spaces within the linguistic envelope made available by biology. To make the most obvious point, a poet cannot invent a nothing, still less assign places for that nothing to be in, or create principles that give each nothing a semantic interpretation. And yet any language is full of such nothings, and needs no rare genius to establish them. Take the following sentences from Aucaans (Djuka), a language "invented" by the children of African slaves who had escaped into the South American jungle (the position of each referential "nothing," or empty category, standing for an unexpressed agent or recipient in the situations described is indicated by *e*):

(1) Kofi kai Samo e kon e gi en fisi
(2) Kofi kai Samo e kon e gi e fisi

(1) can mean either "Kofi called Samo to come and give him, Kofi, a fish" or "Kofi called Samo to come so that he, Kofi, could give Samo a fish." (2) can mean only "Kofi called Samo to come so that he, Kofi, could give Samo a fish." Why (1), with the overt pronoun *en* ("him"), should be more ambiguous than (2), with a gap in the same place, and how the different semantic references are assigned in each case, is a matter too long and technical to deal with in the confines of a *BBS* commentary, but I can assure Donald that these questions are fully answerable within the framework of a generative grammar (e.g., Chomsky 1986). My point is that although it is vanishingly unlikely that the processes underlying (1) and (2) could have been invented by individual or collective ingenuity – and equally unlikely that children could subsequently acquire constructions produced in this way, without long and explicit training – both creation and acquisition are unproblematic if the processes involved stem from biologically specified mechanisms.

One syntax is accepted as biological rather than cultural, one can hypothesize a two-stage evolution of language: first an unstructured protolanguage – in effect, lexicon without syntax – characterizing *Homo erectus*, then an autonomous syntax arising to create the complex structures characteristic of full human language. This way of accounting for the *habilis-erectus-sapiens* speciations, proposed in Bickerton (1990), satisfies the numerous boundary conditions of the problem far better than Donald's mimetic stage. There is no evidence, even of an indirect nature, that *erectus* possessed mimetic skills, and no evidence for selective pressures toward such skills; the mimetic hypothesis cannot help to explain, except in terms so vague as to

be vacuous (e.g., "enhanced co-operation"), how *erectus* made fire, coped with sabertooths and cave-bears, or spread through three continents; and although apes can be trained in primitive protolanguages, no one, to the best of my knowledge, has yet taught them mimesis in Donald's sense, even though their very name has become a byword for imitation!

It seems more probable that, like representational drawing (another species-specific characteristic), mimesis is a spin-off from language rather than a precursor of it. Alas, failure to appreciate the dual nature of language (here, a culture-driven word-store, there, a biologically driven system of abstract structures), when coupled with the wholly legitimate goal of distinguishing cognitively between hominid species, leaves Donald no alternative but to hypothesize this or some equally fictitious Rubicon between two of our species' ancestors.

## "Pop science" versus understanding the emergence of the modern mind

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The question of how the human mind came to achieve its extraordinary power is obviously of great interest to those sciences that take human beings as the focus of their attention – to say nothing of its interest to human beings in general. Nevertheless, fields such as anthropology have made only modest progress toward providing illumination. As an anthropologist, then, I looked to Merlin Donald's book with the hope and expectation of gaining major insights that had failed to come from the contributors to my own area of effort. My disappointment, then, may stem from the level of my expectations, but I still feel that a more considered treatment of the part of the picture about which I am qualified to comment would have given me more confidence in the treatment of those aspects of cognition that are beyond the scope of my professional expertise.

Although Donald makes a laudable if inept bow to the contributions of archaeological and anthropological data, he has elicited approval for his stress on the role played by the cognitive sciences in dealing with the question of how the human mind came to acquire its unique characteristics. On the other hand, a reviewer of his book noted that, despite the claims for novelty, his book does not represent a departure from "old-fashioned cognitive psychology" (Longuet-Higgins 1992, p. 20).

The nonspecialist, then, should be able to read *Origins of the Modern Mind* with the expectation of finding out something about the nature of the science of cognition. Everything proceeds as though that were going to happen until one gets into Chapter 3 and is suddenly confronted with a series of postulated "input modules" that are described as being "isolable" and characterized by defined "properties" coordinated by a "superordinate integrator." The definition of input modules is said to be "a subtle and intricate one, which cannot be done easy justice," so it is not attempted. A list of modules is provided with their "properties" indicated by almost incomprehensible juxtapositions of words. To be sure, "domain-specific (dedicated computational resource)," "mandatory (automatic, obligatory processing)," and "inaccessible to consciousness" are less objectionable than "amativeness," "philoprogenitiveness," and "concentrativeness"; and the modules are not associated with identifiable "bumps" on the skull. But the baffled noninitiate finds it a little hard to see how the typology differs from nineteenth century phrenology in much more than the nature of the jargon. So we are left with a whole series of black boxes and not a single clue concerning their actual locus or means of operation. The reader has to take on faith that somewhere there is a justification for this categorizing and labeling. In my own case, that faith is seriously undermined by the cavalier misuse of information available from anatomy, anthropology, and archaeology.

I should hasten to say, however, that, beyond the sloppy scholarship, there are some major and laudable aspects to Donald's presentation. The broad Darwinian perspective is admirable indeed. The link between the development of language and the evolution of the human mind, although hardly original, also has everything in its favor. For me, the use of the available evidence to postulate a three-stage sequence of mental development – episodic, mimetic, and symbolic – seems like a very useful scheme. Similar things have been suggested by linguistic scholars in the past – Swadesh's *epiglottic, paleoglottic,* and *neoglottic* comes to mind (Swadesh 1971, pp. 182–83). Donald makes no mention of this and its relatives (see the discussion by Hockett 1978), but his own formulation has all of the useful implications of those others and more as well.

Although Donald's cognitive stages seem intuitively reasonable, he keeps shooting himself in the foot as he attempts to provide evidence to illustrate the time and nature of their emergence. His treatment of the evidence for the appearance of articulate speech is a case in point. Although he realizes that since cancer patients can learn to speak through a simple throat tube "it is the brain, not the vocal cords, that matter most," he then goes on to cite Lieberman's far-fetched reconstruction of the Neanderthal larynx as evidence for a difference in the cognitive capacities of Neanderthal and "modern" forms of *Homo sapiens* (Lieberman & Crelin 1971; Lieberman et al. 1972).

Curiously enough, Donald even cites the definitive demonstration that Lieberman's conclusions have no basis in anatomical fact (Falk 1975), but this does little to dampen his enthusiasm for those claims. The discovery that the completely preserved hyoid bone – the voice box – of a 60,000-year-old "classic" Neanderthal from Kebara in Israel is indistinguishable in form from that of living humans has been offered as evidence that the Neanderthals were just as capable of articulate speech as we are (Arensburg et al. 1989; 1990). To be sure, Lieberman has continued to deny the obvious implications from the anatomical evidence (Lieberman et al. 1992), but the most recent assessment of all the available data concludes that the Neanderthals were not prevented by their anatomy from speaking just like "modern" human beings (Houghton 1993).

Having accepted Lieberman's view that the Neanderthals' ostensible lack of vocal capabilities indicated cognitive limitations, Donald goes on to claim that "modern" humans and Neanderthals "co-existed" in Europe for some 5,000 to 7,000 years during which time Neanderthal culture remained stagnant while "Cro-Magnon culture was evolving at a steady rate." There is not a single citation to support this allegation and it is simply incorrect. It has long been recognized that the cultural tradition associated with the Neanderthals is the Mousterian (Bar-Yosef 1992a; Bordes 1961; Bordes & Bourgon 1951; Dibble & Mellars 1992). The late Neanderthals at Hortus in southern France were in fact identified as Neanderthals because the archaeological tradition was recognized as Mousterian (de Lumley-Woodyear 1973). On the other hand, the late Neanderthal specimen from Saint-Césaire in southwestern France was called "Neanderthal" because of nuances of brow-ridge form that are more robust than typical "moderns" in spite of the fact that the cultural tradition was a form of Upper Paleolithic called Châtelperronian.

The Châtelperronian, however, was identified by the late François Bordes as being an evolved derivative of the local Mousterian (see the treatment by Harrold 1983). Furthermore, the dentofacial dimensions of both Hortus and Saint-Césaire are identical with those of the early "moderns" from the Aurignacian site of Předmost in Czechoslovakia (Brace 1979; in press; Matiegka 1934). Since both the cultural transition from Mousterian to Upper Paleolithic and the morphological transition from Neanderthal to "modern" is so gradual that it is impossible

to say where one stops and the other begins, Donald's undocumented claim that "Neanderthals underwent a drastic, rapid extinction between 45,000 and 35,000 years ago" is just an unsupported assertion based on a kind of current "folk-wisdom" that has to be relegated to the realm of "pop science."

In instance after instance, Donald displays the same cavalier disregard for fact in the treatment of the human archaeological and fossil record. To cite one of the more obvious examples, he refers to the supposedly "modern features, such as a larger, rounder cranium" in the 200,000 to 350,000+-year-old skull from Petralona in Greece (Stringer 1988). I include a drawing of the Petralona specimen here (Figure 1) to show that there is no hint of the "features of . . . modern sapient humans" despite Donald's undocumented assertion (Brace et al. 1979, p. 81). I won't even go into Donald's unsupported misuse of mitochondrial DNA beyond noting that grave problems plague the conclusions on which he evidently based his claims (Spuhler 1988; 1989) and that the credibility of the whole model has been called into question by the most recent independent appraisals (Hedges et al. 1992; Maddison et al. 1992; Templeton 1992).

If Donald's narrative has assumed the character of pop science in his treatment of prehistory, the same is true when he turns his attention to recent anthropology. With condescending ethnocentrism, he refers to "the monotony and redundancy of the hunting-gathering lifestyle." An employee in a garment shop or on an automobile assembly line might offer a few choice words here. In similar fashion and without benefit of any documentation, he asserts that the cultures of the San of South Africa and the aboriginal Australians had "remained unchanged for tens of thousands of years." But the mortars and pestles, bows and arrows, poisons, nets and snares of the Kalahari hunters; and the fish hooks, spear-throwers, traps, netting techniques, and grinding and leaching procedures used in Australia are all recent acquisitions that are radically different from the "type of tool culture associated with the very earliest modern human remains" (Bowdler 1976; Davidson 1933; Golson 1974; Klein 1984; Lee 1979; Meggitt 1957; Sampson 1974; Wilmsen 1989).

Donald's denigration of "autochthonous totemic dance rituals" in Australia as "still essentially mimetic" as though they indicated a pre-*sapiens* level of cognitive development equivalent to that of *Homo erectus* in the Middle Pleistocene is particularly regrettable. I want to close my review with a recounting of how one Australian group managed to transcend the "monotony" of their humdrum existence and avoid the "redundancy" of starvation during the drought of 1943 in the outback of Western Australia.

As things got bad, one of the tribal elders led his band off toward a fall-back waterhole at the extreme northwest corner of the tribal territory. He had only been there once previously, over half a century earlier, but he remembered how to get back. Resources began to fail even there, however, and he led them off again westward through country that he had never visited. Their trek took over half a year and eventually brought them out to Mandora Station on the coast of Western Australia more than 600 kilometers from the point of their start. During its course, they had proceeded via a string of between 50 and 60 waterholes (the account was collected by Norman B. Tindale in 1953 and related by Birdsell 1979, pp. 147–48).

Even though the old man had never been to as many as half of those waterholes, it was neither superior bushcraft nor dumb luck that led him to them. He had learned of their existence and location via the account of the wanderings of the supposedly mythical totemic ancestors intoned in the song cycle that accompanied the "essentially mimetic" "totemic dance rituals." Donald evidently assumes that these are occasions when the quaintly primitive Australians hop around mindlessly for hours imitating kangaroos and other creatures of the bush.

The rigors and discipline associated with Australian initiation rituals and ceremonies are famous in anthropological circles, although the lore that is transmitted on those occasions is often treated as arcane and irrelevant. As the saga related above will indicate, however, there are times when that information is literally of vital importance. If the old man had forgotten a verse or gotten one wrong, the consequences could have been fatal for the whole group.

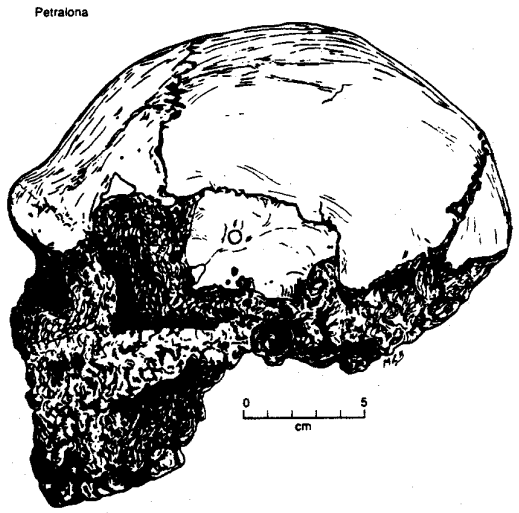


Figure 1 (Brace). The Petralona skull, an *erectus*-level specimen from the Middle Pleistocene of Greece, which is clearly not "modern" in form (Brace et al. 1979, p. 81).

The cognitive sciences may indeed have a better handle on the emergence of mind than does anthropology. However, so long as they continue to treat anthropological data in the offhand and undocumented fashion of pop science, they are not going to promote much more understanding than the phrenology of 150 years ago.

## Mimetic culture and modern sports: A synthesis

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Merlin Donald's division of hominid evolution into three phases – australopithecine, *Homo erectus*, and *Homo sapiens* – and his correlation of these three biological stages with episodic, mimetic, and symbolic cultures, respectively, is a daring if not entirely unique step. His prediction that each of these stages should leave remnants in modern humans can stimulate a search for those remnants, increasing our understanding of how modern humans are put together. Our symbolic capabilities have been studied extensively in the context of language, logic, and problem-solving, and our episodic properties are the subject of most work in the psychology and neurophysiology of perception. The mimetic phase has received less attention.

We write this on the weekend of the Superbowl, the American professional football championship. A hundred million people will watch the game, and billions of dollars will change hands in tickets, promotions, advertising, and other commodities. And this is just the tip of a spectator sports iceberg that pays its stars more than professors, presidents, or prime ministers. How could such a phenomenon develop and why are similar activities so widespread around the world?

The roots of this phenomenon may lie in our mimetic past, when imitation was the most important method of transmitting

culture and acquiring the skills needed for survival. Imitation works best if it is experts who are imitated, rather than the less skilled. For imitation to work, one needs not only models to imitate, but a motivation to bother with the whole business. Thus, fitness would have been increased in those members of the population who were not only capable of imitating skilled performance in hunting, for instance, but who were also intrinsically motivated to observe the most skilled hunters in action. Observing performances of the less skilled would have been less productive.

Such an imitative culture would be facilitated if simply watching a skilled task being performed, as opposed to doing it oneself, could improve performance. This is indeed the case in modern humans, as revealed in the phenomenon of mental practice. The effect has been observed and replicated many times (reviewed by Decety & Ingvar 1990), and it works even in mentally retarded humans (Surburg 1991); retardedness, of course, is determined with symbolic rather than mimetic tests. Mental practice can increase the speed of acquiring a skill (Maring 1990), an important consideration when a dangerous task such as hunting is involved. And just imagining a skilled performance can improve motor skill once the activity has been modeled (Hall et al. 1992). Mental practice seems to work by improving the motor programs or plans, for it can lead to an increase in the apparent strength of a practiced movement even before muscle hypertrophy begins (Yue & Cole 1992).

A motivation to observe the most highly skilled physical activities seems to be built into us. In the modern world, we no longer imitate spear-throwers or bowmen, but spectator sports have exploited this motivation to witness peak physical performances and have formalized it into an elaborate cultural system. Only the very best players command top attention and top salaries. Combined with a mixture of tribal loyalty to the local team, the system is powerful and widespread. The fact that teams hire players from anywhere they can, and that whole teams occasionally move from one city to another, does not seem to affect the motivation and the loyalty very much, for only appearances are important.

The case of sports reveals an aspect of *Homo erectus* culture that remains in us, and implies that love of sports, or some precursor of them, is older than humanity itself. Is there any other evidence of Donald's three stages of phylogenetic development? Human development may provide a source of such evidence. Although contemporary developmental research challenges the biological dictum that ontology closely recapitulates phylogeny, there are several broad points of correspondence between them.

The episodic, mimetic, and symbolic stages proposed by Donald correspond loosely to Piaget's (1970) sensorimotor, preoperational, and operational (concrete and formal) stages respectively. This correspondence may stem, at least in part, from Piaget's early training as a biologist. Biological homeostasis is represented in Piaget's concept of equilibration, which is the mechanism through which humans adapt to environmental challenges. Each stage represents a particular form of adaptation that derives from the child's current cognitive competence. Like the apes that create episodic cultures, the sensorimotor infant knows the world through sensation, perception, and action but is unable to represent it symbolically. Because the frontal and parietal areas of the cortex are not fully functional, the infant is tied to the here and now. Sensorimotor development concludes with the beginnings of deferred imitation and language around two years of age. The preoperational child learns from imitation, and research shows that preoperational children are drawn to the behaviors of those who have slightly more advanced skills, and are more likely to imitate them (Morrison & Kuhn 1983). Finally, with operational thought comes logic, and with logic comes the ability to imagine possibilities, anticipate challenges, and isolate causal variables. Regardless of whether they are college professors or superbowl impresarios, members of symbolic cultures can use these powerful mental algorithms either to conceptualize brilliant research or to make a buck.

The analogy is not a tight one, for even at the preoperational stage children are developing language far in excess of anything *Homo erectus* would have possessed, and some other symbolic capabilities are already developed. The direction and sequence of the development, however, clearly traces our Pleistocene and pre-Pleistocene past.

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## Archaeology and the cognitive sciences in the study of human evolution

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Donald has produced a model for the evolution of human cognition that is of considerable interest. It is beyond my own competence as an archaeologist to evaluate most of Donald's ideas. However, parts of his book (most of which are not reproduced in the accompanying Précis) do touch on the archaeological data, and given the relevance of his work to Paleolithic archaeology and vice versa, some comments from an archaeologist may be of interest.

Donald's model involves changes in cognition that in some cases result from or involve biological changes in the brain and in some cases do not. It would be nice to link the behavioral changes reflected in the archaeological record with the biological changes reflected in fossil hominid anatomy. Unfortunately, this is more difficult than one might expect. Archaeological assemblages are usually classified in terms of stone tool typologies, but the behavioral meaning of stone tool morphology is not always self-evident. Fossil hominids are classified in terms of their morphology, but usually neither the genetic, the functional, nor the behavioral meanings of these morphologies are clear and there is considerable disagreement even about how many species or subspecies there are (see, for example, articles in Delson 1985; Mellars & Stringer 1989). Beyond this, it is no longer possible to identify one archaeological tradition with one hominid form (*pace* Foley 1987). Lower Paleolithic stone tool industries traditionally associated with *Homo erectus* and Middle Paleolithic industries traditionally associated with Neanderthals are now known to overlap in time (Tuffreau 1982). Modern *Homo sapiens* appeared in Africa and the Near East before the Upper Paleolithic industries traditionally associated with them, and in neither location is their appearance accompanied by archaeological evidence of significant behavioral change (e.g., Bar Yosef 1992b, pp.196–99). Even in Europe it now appears that Neanderthals coexisted for millennia with modern *Homo sapiens*, producing an essentially Upper Paleolithic archaeological record (Lévêque 1989; Lévêque & Vandermeersch 1980).

As Donald correctly points out, at the Middle to Upper Paleolithic boundary (formerly considered to be coincidental with the Neanderthal to modern *Homo sapiens* boundary), certain rather striking changes in behavior (especially the origins of undeniable art) do take place in Europe (see Chase & Dibble 1987; 1992). Evidence for the same changes does not appear until much later in other parts of the world, however, despite the indisputable presence of fully modern humans. It remains to be determined whether this is due to the vagaries of preservation or to the fact that art, like written language, did not come automatically with biological change and is something even modern humans can do very well without. Thus, although

at a certain level links between biology and behavior undoubtedly exist, when one considers specific links, caution is necessary.

The behavioral implications of later Lower Paleolithic archaeology (the period Donald uses as his model of the behavior of *Homo erectus*) are also less clear than was generally believed until only recently. In particular, the characterization of Lower Paleolithic peoples as regular hunters of very large game, such as elephants, has come under attack (Binford 1987; Klein 1987, pp. 11–32), although in my opinion even elephants were probably hunted, at least on occasion (Adam 1951; Scott 1980 – also see Villa 1990). What is not clear is how much social complexity this hunting required. I doubt that the need for communication in hunting would have played a very big role in the evolution of mimesis. In fact, the one thing that would be most useful in cooperative hunting, the ability to discuss future and conditional events with precision, would probably not be possible without the syntactic structures provided by language.

Inferring sexual division of labor and cooperation on the basis of (1) hunting or (2) the clustering of stone tools and animal bones into the concentrations we call sites has also come under very serious attack over the last two decades, although the primary arena for this debate has been the basal Paleolithic sites of East Africa (usually attributed to *Homo habilis*; see Isaac 1983 and Klein 1989, pp. 170–80, for summaries). It is possible (but not demonstrated) that division of labor was common by the later Lower Paleolithic. By the Middle Paleolithic of Europe there is little doubt that Neanderthals were at the very least transporting meat from place to place on a regular basis (e.g., Chase 1986, pp. 46–57) and it may be that this reflected sharing (1) between hunting/foraging parties and those remaining at home, (2) between different hunting/foraging parties, or (3) between hunting parties and foraging parties.

Many scholars have drawn conclusions about intelligence or symbolism from Middle Pleistocene stone tools. However, their cognitive implications are not entirely clear. Donald may overestimate the difficulty of making stone tools. It is true that it takes practice, but a few months of practice should be seen in terms of a young hominid growing up doing what the surrounding grownups are doing. In fact, it is doubtful that pedagogy is necessary for Lower Paleolithic stone tool technology. After all, the making of Paleolithic-style stone tools was a lost art, reconstructed by archaeologists working without even the benefit of someone to observe. On the other hand, it is also true that the skills involved are apparently beyond the ability of chimpanzees to master. However, exactly what new cognitive abilities are required has not been analyzed in the kind of detail the subject deserves. The only in-depth study has been done by Wynn (1979; 1981; 1985; 1989), using a Piagetian perspective, and for the most part he considered secondary attributes of stone tools such as the relative placement of different flake scars rather than the fundamental problem of learning how to remove a flake from a stone core. It is thus difficult to evaluate the need for a new cognitive structure such as Donald's mimesis.

Another old archaeological belief coming under increasing attack is the idea that the stone tools of the Lower or Middle Paleolithic (or even, for that matter, many of the tools of the Upper Paleolithic) required a great deal of time to manufacture and were made for specific purposes well in advance of actual need. Some lithics specialists (Dibble 1987; 1988; Rolland & Dibble 1990, pp. 482–86, see also Chase 1990) feel that such tools were often if not usually *ad hoc* in nature, and even more elaborate tools such as bifaces were probably usually multipurpose tools not destined for a particular purpose.

Not all of these comments are critiques of Donald's book, and certainly none go to the heart of what he has to say. The most important point is that, in general, the meaning of archaeological data in psychological terms is either unclear or controversial or both. One reason is a lack of communication between archaeology and psychology. If more researchers follow Donald's example in the future, there is every reason to hope that the dialogue between archaeology and psychology will benefit both disciplines.

## Symbolic invention: The missing (computational) link?

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There is much to applaud in Merlin Donald's careful and imaginative reworking of our collective cognitive history. The head-on confrontation of so many major puzzles concerning how any sequence of individually viable transitions might bridge the abyss between ape and man is a delight, as is the author's sensitive and balanced treatment of the powerful role of external symbol systems in reconfiguring human cognition. My purpose in this commentary is merely to draw attention to what I see as the major cognitive scientific problem which Donald's discussion isolates, and to make a suggestion concerning how best to view it.

The key unsolved mystery, if we accept the bulk of Donald's discussion, concerns what he calls "symbolic invention." The problem of symbolic invention (which may or may not be identical with what the author calls "the problem of reference," p. 368 – I found the latter usage puzzling) concerns how we achieve the spontaneous and repeated development of new symbols. It is this ability which both distinguishes our use of symbolic media from that of the apes (p. 160) and which the author depicts as the vital innovation of the so-called mimetic mind ("mimesis is fundamentally different . . . in that it involves the *invention* of intentional representations," p. 169). Again and again in the book Donald comments on the important difference between the spontaneous and repeated *invention* of symbols and the mere ability to exploit them once they are available (see, e.g., pp. 134, 160, 169, 368). Once symbolic invention is achieved, the organism is on the royal road to the third transition and genetic evolution can be replaced by cultural evolution grounded in the exploitation of a burgeoning series of external symbol systems and external memory systems. Symbolic invention thus seems to be the real "missing link." But what exactly is missing? How best to conceptualize this pivotal issue?

One possibility (which I think of as pretty much Daniel Dennett's view of the problem – see Dennett [1991] and especially Dennett [forthcoming] is to try deflationary tactics. [See also Dennett: "Intentional Systems in Cognitive Ethology" *BBS* 6(3) 1983; "Précis of *The Intentional Stance*" *BBS* 11(3) 1988; and Dennett & Kinsbourne "Time and the Observer" *BBS* 15(2) 1992.] One key deflationary tactic is to reverse Donald's order of events. Instead of depicting some complex of biological adaptations as the root of a capacity for symbolic invention and public language as an *effect* of symbolic invention, the presence of public language is itself depicted as the root of symbolic invention! This sounds paradoxical. But a story can be told. A tortuous sequence of chance discoveries (e.g., of the usefulness of using some external items as labels for others) eventually puts a kind of protolanguage in place. Exposure to this new kind of input reconfigures the next generation's cognitive architecture in a way which promotes the development by them of a *little* more language. And so on, until we reach the present state of affairs in which the average child is exposed to the fantastically potent reconfiguring forces of the whole external symbolic apparatus of the "theoretic mind." Children's rich abilities of symbolic invention are, in this scenario, then *explained by* their experience with the symbols of public language. Public lan-

guage is seen as the software which reconfigures the mind so as to make symbolic invention possible.

The deflationary response is, I think, interesting and deserves some careful consideration. My own view is that Donald is right to opt for the other scenario, in which there is a computational "missing link" which puts a capacity for symbolic invention in place and thus *primes* the onset of public language. I close, however, with the suggestion that it may be fruitful to broaden the notion of symbolic invention, for, as Donald uses it, symbolic invention implies the spontaneous and repeated creation of new *external* symbols. But a prior question concerns the ability of a system already capable of episodic thought to recode those thoughts in a series of increasingly abstract ways which support more flexible (but still nonlinguistic) behaviors. This notion of progressive recoding is the heart of Karmiloff-Smith's (1979; 1992) theory of representational redescription. Its computational implications are further discussed in Clark and Karmiloff-Smith (forthcoming) and Clark (forthcoming).

The simple suggestion I want to make here is that instead of focussing directly on external symbolic invention as the central issue, we may see the creation of new external symbols as continuous with the progressive creation of new *internal* symbols and structures. Thus refocussed, what emerges as crucial is the ability to engage in forms of computation that construct higher and higher orders of representational content. And one fascinating feature of the recent connectionist work which Donald later mentions is that such systems *are* able spontaneously to construct new (higher order) internal representations, although they do so only in quite limited ways (see e.g., Rumelhart et al. 1986). Understanding the nature of these abilities and finding ways to overcome these limitations may provide a practical means of one day illuminating the much more opaque issue of how we invent and use new external symbols. The key issue thus construed is *representational* invention: symbolic invention is best seen as a special case.

## A natural history of the mind: A guide for cognitive science

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Cognitive science seeks to understand how the mind emerges from the brain. Artificial intelligence seeks to implant a mind within the machine. To their detriment, both have largely ignored work on the natural history of the mind. They would do well to pay close attention to Merlin Donald's account of mental evolution.

The archeology of mental evolution is of course a difficult project since the mind leaves no fossils. Only the artifacts produced by brains containing minds controlling bodies are available for examination. Not until the advent of writing do we apparently have direct access to the thoughts of others. Looking back to the dawn of history, Snell (1960), comparing the language of Homer's *Iliad* and *Odyssey*, concludes that mentality changed between the periods represented in the two works. In the *Iliad*, there is no word for the modern concept of mind. The stormers of Troy seem to be sleep walkers controlled by godly visions. But after the fall of Troy, clever Odysseus appears a modern man, fully self-aware and introspective.

The more controversial Jaynes (1977) also finds a phase change when comparing earlier written records with more modern. His evidence is Biblical; the book of Amos sounds alien to a modern ear, whereas the more modern book of Job is fully modern (it is even the basis for contemporary song). Jaynes seeks reasons for the change within the structures of the brain, but his explanations involving the formation of laterality in the brain do not ring true.

Although ancient literature hints at a different style of thinking, ancient artifacts do not. Allowing for a more primitive technology, the equipment of the Neolithic hunter recently found frozen in the Alps does not seem strange to a modern backpacker. Donald's *Origins of the Modern Mind* provides a natural explanation for these observations.

Briefly, Donald divides the evolution of mind into four stages. First at about 2 million years B.P., ape becomes hominid. The hominid mental culture is an extension of the episodic culture characteristic of apes. The penultimate ape, the hominids are able to respond to very complex sets of stimulus scripts or episodes, but they do not plan ahead.

Around 700,000 years B.P., *Homo erectus* appears. The *Homo erectus* mental culture is mimetic; they think and plan ahead, but do so without language. As a modern example, Donald cites the case history of Brother John. When epileptic attacks deprive Br. John of language, he is nevertheless able to plan and carry out quite complex scenarios. *H. erectus* brings the ability to manipulate the environment through tool use to modern levels. Properly educated, a *H. erectus* could make a living through manual labor in the modern world.

Around 60,000 years B.P. modern man, *Homo sapiens*, appears. *H. sapiens* has spoken language and has a mental mythic or linguistic culture. Communication is oral and societal structure is maintained through ritual. Perhaps the peak of mythic culture was reached with the world-wide rule of Roman oratory. Nevertheless, the fully modern mind does not appear until after the advent of writing. Early systems of writing, cuneiform and so on, however, access the linguistic part of the brain only indirectly, through the earlier episodic and mimetic portions. As a result, these systems implemented linguistic storage and communication imperfectly, and were not widespread among *H. sapiens* culture.

The breakthrough into theoretic culture comes with the invention of the phonetic alphabet. The direct mapping of visual, physical symbols to phonemes enables the linguistic portion of the brain to begin directly processing writing. Phonetic writing provides an organizing center, linking external memory storage to all three portions of the brain – episodic, mimetic, and linguistic. The brain plus external storage is thus more capable than what came before; the modern mind has been born. A feel for the brain/phonetic writing synergism can be gotten from Donald's metaphor for reading. In reading, the contents of the book take control of the brain of the reader. The book is the source material and the brain is merely the player. The brain/written word is thus something more than the brain alone.

Thus, our modern manual skills date back to the era of *H. erectus*, and similarly, our rituals and icons originate in the Paleolithic. Only in historic time, however, does the synergistic combination of brain and environment occur that is the modern mind. As Snell and Jaynes argue, traces of this change can be found in written literature.

Donald's mental architecture is quite different from the computational paradigm much used in cognitive science. His architecture makes explicit allowance for the external environment through the central organizing principle of phonetic written language. The architecture is also vastly different from the low-level approaches advocated by connectionists. Although Donald does discuss neurophysiological features such as Broca's area, this is mostly to argue that natural selection has worked on the brain. Donald's work suggests new approaches based on the natural history of the mind. It deserves close attention by both cognitive scientists and AI researchers.

On a final speculative note, echoed by Donald himself in his final sentences, the ideas in *Origins of the Modern Mind* should be applied to the present. The current developments in interactive, networked, multi-media, and virtual means of communica-

tion based on computers and electronics may be pushing *H. sapiens* toward another shift of mental architecture. Participants in the old theoretical culture, reading these words, can only dimly guess what form the next culture will take.

## The place of cognition in human evolution

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Modern science remains deeply committed to the project of localization, be it the attempt to locate development in the genes, society within the individual, or cognition within the head (see Still & Costall 1991). Merlin Donald claims that cognition is "the engine, as well as the locus," of human evolution (p. 2). My purpose is to question the "locality" of this proposed locus. For although Donald himself takes us some way towards a distributed conception of cognition, he does not go far enough.

The idea that cognition must be "in the head" has been encouraged by the mythology of "cognitive mechanisms" and the promise that these would eventually be localized within the brain. One of the important messages of Donald's review of the neuropsychological literature is that many of the anatomical structures "underlying" human cognition have not merely been "coopted" to serve new functions (cf. Gould 1991), but arise – *post hoc* and *ad hoc* – along with those functions (see pp. 11–14). Cultures, as he puts it, "reconfigure" the brain (p. 14). Yet surely even when so reconfigured, cognition has not itself become lodged inside the head. To quote Bartlett's apt critique of Head's lesion studies:

> Head gives away far too much to earlier investigators when he speaks of the cortex as "a storehouse of past impressions". All that his experiments show is that certain processes cannot be carried out unless the brain is playing its normal part. But equally those very reactions could be cut out by injuries to peripheral nerves or to muscular functions. One might almost as well say that because nobody who is suffering from raging toothache could calmly recite "Oh, my love's like a red, red rose," the teeth are a repository of lyric poetry. (Bartlett 1932, p. 200)

The point, of course, is more general. Performance would also be disrupted if the environment, too, were not playing "its normal part." So the consistent (if incorrigible) localizer will need also to "localize" the function in question *out there* as well.

Donald's own departure from an internalist approach to cognition is most clearly indicated by his emphasis upon "external memory technology" in human evolution. Despite his references to a multilevel approach to evolution (pp. 157 et seq.), he does not fully explore the radical implications of the distribution of intelligence. On the one hand, in his emphasis upon stages, he neglects the important place of traditions in many nonhuman groups; cognition is distributed in shared skills and in the very structure of the (structured) environment. Yet he also underplays the real difference that language and literacy make. Consider Donald's remarkable example of a monk, Brother John, who, whilst suffering a temporary attack of aphasia, nevertheless manages to book into a foreign hotel (pp. 82 et seq.). Donald presents this as an example of regression to a stage of prelinguistic if distinctly human intelligence. Yet the world in which Brother John exists does not itself regress. His success relies upon a world in which there remain passports, other people who understand their significance, *and* his own appreciation of these facts.

To theorize our human world requires more than to turn the internalist scheme of cognitivism inside out. Donald himself presents many astute criticisms of standard cognitive psychology. It is all the more surprising therefore that he allows his own account of the distribution of cognition to become hijacked by the misleading metaphors of memory and storage. For in talking of the externalization of memory he commits himself to a "privatized" metaphor of memory where our shared practices of storage are transferred to the individual and stripped of their social dimension. When this conception of memory is transferred back out into the world, computer technology and much else besides appears as a purely "technical" affair: "Individuals in possession of reading, writing, and other visuographic skills thus become somewhat like computers with networking capabilities; they are equipped to interface, to plug into whatever network becomes available" (p. 311).

The technical metaphor of networking surely masks the fundamental issue raised by Donald's wider argument, that of the transmission of culture. Our relation to culture is reduced to finding the right password and accessing an appropriate store. The social dimension disappears. Given, however, that cognition does not (just) occur within any one of us, psychologists had better ensure that they once again make the issue of cultural transmission their business (cf. Bartlett 1929) and seek fresh metaphors that capture more fully the implications of the distribution of cognition.

## Human evolution: Emergence of the group-self

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The study of human evolution reminds me of the puzzles that are so popular nowadays. We have an undefined set of knowledge-pieces consisting of past changes of human morphology and behavior, and we try to assemble a coherent, meaningful, logically defensible pattern for the evolutionary process. It is an advantage in this game if somebody can minimize the number of pieces remaining in hand and Donald has certainly done this.

Not only has he used most of the known pieces, but he has designed a configuration that shows some strikingly interesting patterns. The mimetic culture of *Homo erectus* is an elegant idea, a "missing link" indeed (a similar train of thought appears in Csányi 1992a; 1992b). Mimesis fits well between the episodic culture of apes and the mythic culture of *Homo sapiens*. Puzzles differ, however, from studies of human evolution in that we sometimes cannot even be sure of the reality of the pieces used for construction; accordingly it is worth considering other candidate syntheses (Csányi 1989; 1990; 1992a; 1992b).

We can assume an evolutionary change in the human brain, be it a new solution for mimetic representation or the emergence of the language "organ" localized or distributed, only if we suppose that a pattern of selective forces provided by the environment was available to enforce the change. The evolutionary puzzle can be solved if we dissect the changes into smaller units and find a plausible explanation for the sequential emergence of these units in time. Donald emphasizes the individual changes, but in human evolution we have to account for the phenomena on at least two organizational levels. Simple group formation and cooperation can be explained satisfactorily by individual selection in animals. Many animals cooperate successfully at a very high level without having a language or any special cognitive mechanism. A wolf pack or the lioness's in a pride can catch prey by concerted action. Each member of the hunting group knows exactly his place and function during the joint action. This kind of cooperation occurs on the basis of a species-specific "schema" that is flexible but strongly constrained genetically. There is no need for explanation or reconciliation and there are neither roles to distribute nor actions to concert in time. On the contrary, among humans cooperation almost always occurs on the basis of

an individually designed schema or plan requiring prior elaboration (Rumelhart 1980). The key word here is the *individuality* of the schema. Individuality represents an enormous adaptive value whatever forms it takes during evolution (Sterrer 1992). Sexuality made genetic individuality possible, making available high variability to the changing conditions of the environment. A neural individuality was made possible by the various mechanisms of learning and also enhances individual variety. Both genetic and neural individuality are constrained in animals living in groups. Genetic individuality is constrained by the gene reshuffling in each generation. Neural individuality is constrained by the lack of language, because the complexity of the species-specific schemata of cooperation could not be increased beyond a certain limit by individual learning mechanisms. This is the key problem of human evolution.

Further evolution of animal cooperation would have been possible only by introducing individual group-schemata, which was not conceivable without a language of a human type. The necessity of individual group-schemata of cooperation forced the cognitive ability of the early *Homo* lines to reach a higher level, including the emergence of language.

From the study of primates and apes we know that individuals in groups constantly watch each other's activity, try to predict future actions of important individuals, and use their social skill to manipulate others (Byrne & Whiten 1988). [See also Whiten & Byrne: "Tactical Deception in Primates" 11(2) 1988.] They can interpret each other's actions in their modeling process (Csányi 1992b). The next big step could really be the mimetic culture, which is in essence the development of a *social super-model* as a cognitive device: in its most primitive forms this could be based on common learning processes (Csányi 1989). Such processes are the simple rituals in the form of gestural and vocal signaling of the subsequent common actions. Mimetic culture has its own animal roots. For example, primitive forms of ritual can be observed in present-day highly socialized predators such as the African wild dog. These gather before the hunt and the alpha male initiates a "ceremony" which involves various forms of social interactions such as "kissing," tail-wagging, and mutual licking of muzzles. These activities spread through the group and synchronize the mood of the individuals. Excitement builds up and the dogs are then ready to go off together (Chinery 1979).

Memory traces of such rites connected to the group's vital actions become part of the environmental model of each individual, but they also represent a *super-model*, a group entity, because this model can be activated and processed only during a group action (Csányi 1989). (Apart from rituals, other mechanisms serving to entrain action include the "comprehensive interactional synchrony" [CIS] observed during hypnosis; Bányai 1985; 1992; Csányi 1992b.)

The super-model, independent of its internal mechanisms, is an *individual structure*. Each of the small groups of early *Homo* confront its environment with a unique individual super-model. As communication developed among group members their super-models became more individualistic. This generated the high selection potential for language evolution. A group of apes with individual species-specific brain models could survive only in a very narrow niche. Group-based super-models made radiation possible and *Homo* groups spread over the whole planet because they could find the appropriate adaptive responses for any conceivable environment.

The emergence of the super-models corresponded to the appearance of the *group-self*. Animal group formation is possible because of dyadic interactions. In *Homo* groups the group-self and its group representation appear. Human personality and the group-self mutually define each other. The emergence of the group-self created a new organizational level. Further evolution depended on the structure and competition of these new group-individuals. Formation of the group-self needed several changes in the "hardware" of the *Homo* brain. We can understand human behavior only if we suppose that humans are genetically able to recognize, accept, and represent group-selves. We have many reasons to assume this (Eibl-Eibesfeldt 1989; see also Eibl-Eibesfeldt: "Human Ethology" *BBS* 2(1) 1979).

A second problem on which I would be happy to have the reaction of the author concerns whether, with the emergence of language, those genetical changes which led to the emergence of group-self and culture at last come to a close. Is the formation of "theoretic culture" only a "software" problem, as Donald assumes, or do we have to consider the thousand-year rule of Lumsden and Wilson (1981; see also multiple book review: *Genes, Mind and Culture*, *BBS* 5(1) 1982), which involves formative genetical changes? This is a very important question; and the answer, whether positive or negative, calls for solid evidence.

## Ethological foxes and cognitive hedgehogs

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The cognitive sciences often suffer from their lack of ties to ethology and evolutionary biology. Questions of memory, attention, language, and learning are approached as if one were back-engineering a computer chip. There is no interest in where the chip came from or its relation to the creation of other chips. This may be well and good for silicon devices, but it seems wrong-headed in the biological sciences. Donald's book is a treatise concerned with making strong links between cognition and its evolutionary origins. He is asking this question in the face of the overwhelming tendency of cognitive science not to make links with anything in the direction of evolution. Many cognitive scientists are in a mad rush to go the other way, toward even more proximal causes. His sanguine indifference to this neural reductionism is commendable. Many cognitive scientists pay lip service to evolution with Just-so stories but fail to provide anything substantial. The question is whether Donald has provided links between cognition and evolution or has offered up another, extremely elaborate, Just-so story.

First, it should be noted that the difficulty of reconciling cognition with evolutionary theory has already both been commented on and studied. Perhaps the most acerbic comments came from B. F. Skinner, who likened cognitive psychologists to creationists who scorn Darwin's theory of evolution (Skinner 1978). [See also *BBS* special issue on the work of B. F. Skinner: Canonical Papers *BBS* 7(4) 1984.] In his view, cognitive science ignores the historical, contingency laden aspects of behavior – which means to him that it ignores just about everything. Donald is an apostate – but of a different heresy than cognitive scientists. In Skinner's view, Donald would correctly have identified a schism, but thinks incorrectly that the sects can be reconciled.

***Cognitive ethology.*** Those who have sought some form of unification have, by and large, not been cognitive psychologists but ethologists. For example, Yoerg and Kamil (1991) provide an extended discussion of this issue. This may account for the curious fact that Donald seems largely unaware of the research. Ethologists are keenly aware of the difficulty in contemplating the evolution of cognitive structures. Donald Griffin and other cognitive ethologists, as they have been labeled, have struggled both with this question and the question of animal consciousness (Ristau 1991). Many of the issues Donald raises have experimental data. For example, Peter Marler (Marler et al. 1991) and many of his colleagues, including Cheney and Seyfarth (1990), have studied how animals represent and communicate such things as predators and food. Some animals may be more or less

truthful or deceitful depending on what is to be gained. These studies speak directly to Donald's notion of the evolution of mimetic representation. As ethologists, we find it very unclear whether one can safely say that this ability to re-represent, or mime events, can be phylogenetically localized in the way Donald wishes. This evolutionary question is dealt with below.

***Episodic memories.*** Donald seems intent on preserving the idea of episodic memories largely for primates: "Episodic memory is apparently more evolved in apes than it is in many other species . . ."(p. 151). As far as we know, this notion is unfounded. He does cite studies on how some birds hide and relocate food as an episodic memory system. What he does not discuss is the complexity of this avian memory system. Some species of birds can remember the location of thousands of items. Likewise, pigeons can remember hundreds of slides after as little as one presentation per slide. A more parsimonious view is that evolution has opportunistically availed itself of different forms of memory, depending on the needs of the animal in its niche (Shettleworth 1993). There is no comparative evidence for Donald's view of the progressive evolution of episodic memory systems.

Some of the comparative statements to make this claim are unfounded or require the overinterpretations of data. Lesioning certain brain nuclei in song birds will render the birds unable to sing. Other birds, when given hippocampal lesions, lose the ability to cache food. Donald interprets this to mean that (1) food caching is an episodic memory task and birdsong is a procedural memory task, and (2) episodic and procedural memory systems involve different neural mechanisms (p. 150). This is wrong for a number of reasons. First, it is doubtful that either food caching or birdsong relies on only one type of memory. Both of these behaviors are complex and require the animals to integrate long-term procedural information as well as short-term, dynamic, episodic information. Second, there is no evidence that lesions to the song system nuclei cause memory deficits. The bird's inability to sing could be a motor deficit. Third, there is no evidence that the hippocampus is not involved in song learning. For all we know, the song system may require the hippocampus. Donald's speculations seem dangerous, as they rely on the outcome of yet unperformed experiments. We can only presume that Donald's interest is not to understand birdsong and avian food caching, but to hold these systems hostage to his interpretation of the evolution of the human mind. Another comparative approach to the neurobiology of cognition (Kesner & Olton 1990) begins with a chapter that warns of the dangers of interpreting animal studies in this manner (Hodos & Campbell 1990).

***Evolution.*** Donald's approach is to check for evolutionary plausibility when considering scenarios for the origins of mind. The dangers of this adaptionist approach have been discussed elsewhere (Gould & Lewontin 1979). From his arguments we infer that, to Donald, evolutionary plausibility means that intermediate forms in the evolution of a trait must be adaptive and that one should see "vestiges" of earlier forms. Although we agree with the first point, the necessary occurrence of vestiges, mentioned by Darwin, is not a tenet of modern evolutionary theory. He refers to human behaviors, such as baring the teeth in anger or wailing, as vestigial (p. 3). Some clinical psychologists would argue that any human without these capabilities is not lacking in vestiges of nonhuman animals, but is deficient in essential human qualities. Donald refers to a "continuum" from reptiles to mammals to primate to human and to the "gains" of our hominid ancestors. These all connote a *scala naturae*, a notion of evolutionary progress that has been thoroughly discredited (Hodos & Campbell 1969; 1990).

Donald's argument often suffers because he seems unaware of or uninfluenced by modern developments in evolutionary theory. When discussing whether language arose as a consequence of the evolution of a single cognitive module or several independent modules, Donald argues that the unitary theory only requires a single selection pressure while the modular theory requires multiple selective agents. This need not be the case if a genetic covariance exists between the genes underlying each of the modules: in that case a single selection pressure could drive the evolution of multiple modules.

A great deal of Donald's argument centers on the influence of culture on cognition and cultural evolution. Here again, Donald seems unaware of the extensive and rigorous literature on this subject (e.g., Boyd & Richardson 1985; Cavalli-Sforza & Feldman 1981; Lumsden & Wilson 1981; Pulliam & Dunford 1980). Some of the quantitative models contained in these references might improve Donald's thesis. For example, Donald argues that the appearance of language would lead to more cultural innovation and thus speed up the rate of cultural/cognitive evolution. This is analogous to arguing that the rate of mutation determines the rate of genetic evolution. This view was held by some early evolutionists but refuted by J. B. S. Haldane (1964). It seems unlikely therefore, that the rate of "cultural mutation" limits cognitive/cultural evolution.

***Conclusion.*** We commend Donald's objectives but we object to the anthropocentric and therefore insular nature of the book. Almost all of psychology has suffered from anthropocentric tendencies (Staddon 1989). Donald has not successfully escaped this trap. This is evident in his casual use of evolutionary and ethological terms and concepts. In terms of a commonly used allegory, cognitive psychologists by and large remain hedgehogs, viewing the world in respect to one thing, that is, humans. This is contrary to the approach of ethologists and evolutionary biologists, who, like foxes, grapple with the complexity of human and animal behaviors in terms of evolution (Berlin 1957; Marler 1969).

## What about pictures?

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Merlin Donald has written a scholarly yet pleasurable book; a rare achievement. In it he traces the development of the human mind through four stages which he terms episodic; mimetic; mythic; and external symbolic storage and theoretic. The evidence for these changes is derived from archaeology, anthropology, neuropsychology, primatology, and above all, cognition. The contributions of these approaches are unevenly spread; notably, and not surprisingly, archaeological evidence dominates the more distant and shadier stages, but the theme that runs through them and unifies them is derived from cognition. This is as it should be in a book dealing with the mind. An episodic culture whose carriers were incapable of abstraction, a "here and now" culture, changed into a mimetic culture wherein deliberate communication was possible and which in turn developed into mythic culture, in which invention and the development of language advanced symbolic thought; finally came externalisation of symbolic operations by the adoption of material symbols.

Since this is a multiple review the reviewers are permitted greater freedom than usual to view the book mainly from the stance that their expertise provides. My modest expertise is in the realm of pictures as means of communication. [See Deregowski: "Real Space and Represented Space" *BBS* 12(1) 1989.] Donald postulates (on good archaeological evidence) that the art of picturemaking developed rather late, that the art was *invented*, and that pictures chronologically followed language and were "The critical innovation underlying theoretic culture" (Donald, p. 275). This argument raises two queries, the principal one being: Why did pictures have to be *invented* when it was much easier to *discover* them? Kennedy (1975) made this point explicitly but it is useful to review it.

The essence of the argument is that a depiction of an object is not arbitrary, as its name (the noun) is; it derives directly from the object's appearance. It may not present all the details of appearance but only a selected few, and it may stress those few and thereby distort them, as in caricatures; but the information encoded in a picture and available to the viewer always overlaps with the information provided to the viewer by the depicted object. The depicted object and the depiction thus have much in common. The perceptual task the observer has to perform is that of recognition of the communication of information derived from these two sources. The task is not as cognitively formidable as it might appear *prima facie* because 3D objects seldom provide viewers with information that is invariant; for example, such information varies with direction of illumination and with the orientation of the object relative to the viewer, so that objects are easier to recognize in some circumstances than in others.

In short, the "ding-dong" theory, which Jespersen (1922) rightly rejects as an inappropriate explanation of the origins of language, the theory that there is a harmony between sound and sense in the world, does apply *mutatis mutandis* to depictions. This thesis is supported, paradoxically, by Kennedy's (1982) work on the blind, which shows that they readily accept certain "pictorial" images, thus demonstrating the readiness of the cognitive system to regard them as appropriate. If this is accepted then a question must be asked: Why did drawings not appear at the mimetic stage at which we are told our ancestors could deliberately communicate by representing an object or an action? It seems unlikely that the obstacle lay in their poor motor skills so that, although cognitively capable of drawing, they could not execute drawings. Did it lie in the absence of a *need* for this kind of representation? This might have been the case, and the existence until recently of pictureless cultures (e.g., Fortes 1940; 1981) suggests that (in some instances, at least) language development was not followed by the development of pictorial representation. The two phenomena appear to be mutually independent. This conclusion, however, does not agree with the thesis put forward by Davidson and Noble (1989) and elaborated by Noble and Davidson (1991) according to which the development of language is intimately linked with the development of art. This thesis, if correct, would argue for revising the relationship between mythic and external symbolic storage cultures postulated by Donald.

There is yet another point which ought perhaps to be made, namely, that the sequence of development from depiction to writing may not be linear. It is possible to argue (Deregowski 1990) that there are two perceptually distinct and quintessentially different modes of pictorial representation, one concerned with the depiction of individual objects and the other with characteristics of attributes shared by objects of a particular category. These two distinct modes are exemplified by, say, a portrait of a man and a stick-figure drawing of a man, respectively; the former identifies a particular individual within a group (men), the latter shows attributes. This bifurcation complicates the scheme put forward by Donald because only the latter form seems a likely candidate for fostering the development of writing. It is therefore of interest to consider the origin of the bifurcation. Were men driven into this division of symbols or did they stumble upon it by accident? Did the fact that to an observer unfamiliar with an individual the portrait of that individual has a broader meaning than it has to an observer familiar with the person portrayed contribute to the split? Were early depictions portraits of individuals rather than depictions of members of certain groups (say, of certain species)? If the former, then presumably this would reflect the strength of social bonding, and it would perhaps have implications for other cognitive attributes such as language.

In Joseph Conrad's *Typhoon*, Captain MacWhirr, when taking charge of a new steamer, the Nan-Shan, notices an ill-fitted door lock and has it replaced. He does not question the soundness of the ship, and subsequent events show he was right not to do so. I feel that in this commentary I have acted likewise. I have questioned one small aspect of a bold thesis which, on the whole, seems to me well constructed and certainly merits very careful consideration.

(Yet another minor point: Donald refers [p. 25] to Adam Smith's [1804] work as done "in England." If my supposition is correct that the work referred to, but omitted from the bibliography, is the "Dissertation on the origin of languages," then it was *not* done in England. Adam Smith was a Scotsman born in Kirkcaldy; the work in question was first published as an addendum to the 1761 edition of his *The theory of moral sentiments* based on the lectures delivered at the University of Glasgow, where Smith held the Chair of Logic.)

## The modern mind: Its missing parts?

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Biologists find other disciplines' parochialism frustrating. The very nature of their subject matter has forced organismic biologists to recognize that phenomena have to be approached at four (and maybe more) very different levels. Questions about mechanisms, function, development, and history are logically independent of each other (at least in principle), yet a proper answer to the question "Why is *X* the case?" ultimately requires all four kinds of answers.

Merlin Donald's book is greatly to be welcomed in this respect because it represents one of the first attempts by psychologists to move beyond questions of mechanism and ontogeny to consider other levels (in this case evolutionary history). History, however, suffers from all the worst faults so beloved of the sociologists of knowledge: our understanding of it is limited by the information we happen to have available, thus making it especially susceptible to "just-so" storytelling. This is no criticism: it is simply a fact we have to cope with as best we can. It does, however, place cautionary markers against some of Donald's interpretations of the sequence of events.

Among the elements in the story Donald tells which I would regard as doubtful are: Lovejoy's (1981) claim (p. 105) that monogamy evolved early in the hominid lineage, possibly even as early as 4 million years ago (the anatomical evidence makes monogamy implausible before the appearance of *Homo sapiens* 250,000 years ago, and Lovejoy's argument in any case conflates pairbonding with monogamy); the claim that *Homo erectus* engaged in organized group hunts (p. 175) is very doubtful (and in any case, if true, it refers only to the very latest members of this species at the point of transition to *H. sapiens*); the claim (p. 186) that rhythm is unique to humans (gelada baboons clearly exhibit it in their contact call exchanges, as shown by Richman [1987] – though I accept the point that only humans use movement of body parts to maintain rhythm); and the claim (p. 215) that language evolved as a tool for thinking about the universe.

This last claim, I believe, conflates two rather different features of language, namely, the fact that we use language to exchange a great deal of information about ourselves and other people (the exchange of *social* knowledge) and the fact that (occasionally) we use language to formulate and exchange knowledge about the nature and structure of the physical world in which we live. We are undoubtedly impressed by the achievements we have produced with the latter (it has, after all, given us religion, philosophy, and science). But our self-congratulation overlooks the fact that these activities are the products of an insignificantly small number of individual minds. It is quite clear from a great deal of research on conversational analysis (including my own) that ordinary people do not often talk about

such lofty topics (indeed, the great majority probably neither care nor concern themselves with the findings of science or the disputations of theologians). What ordinary men and women talk about most of the time is the social world in which they live. Language, as I have argued elsewhere (Dunbar 1993 [target article, this issue]), surely evolved to facilitate the bonding of social groups. The symbolic content of language is essentially a byproduct of a window of opportunity opened up by the evolution of a large computer intended to perform another (social) task. To argue otherwise is to demand the biological equivalent of a jumbo jet to assemble itself spontaneously within the grounds of a medieval castle.

This is not to suggest that I think Donald is wrong in his general account: on the contrary, I believe he has the story more or less right, and it is a story that makes a great deal more sense of the available evidence than any others so far proposed. My point is simply that I believe he has left out a major component of the story, and that is the extent to which the social world dominates the cognitive lives of primates. Primates, as Cheney & Seyfarth (1990; see multiple book review, *BBS* 15(1) 1992) among many others have repeatedly pointed out, are very good natural psychologists, but rather poor ecologists: their understanding of the social world is much better than their understanding of the physical world. Similar claims have of course been made on behalf of humans (e.g., by Cosmides & Tooby 1989).

I found Donald's emphasis on abstract and objective thinking and his failure to consider social thinking one of the few really disappointing features of the book. This failure, I think, leads him to assume that (symbolic) language (as a product of stage 3 mind) evolved at a rather early stage in human evolution (namely, about 250,000 years ago). I think this implausible, if only because the archaeological record shows no evidence for symbolic thought until the Upper Palaeolithic Revolution some 200,000 years later. A more plausible argument (elaborated in detail by Aiello & Dunbar 1993) is that language (as a medium for the exchange of social information) evolved with the appearance of archaic *Homo sapiens* 250,000 years ago, but that language in the symbolic sense did not evolve until the appearance of anatomically modern humans 150,000 or so years later.

My only other criticism of the book really stems from Donald's failure to address the last (and in many ways most important) of the four questions that biologists always ask; namely, *why* did language and the modern mind evolve? Functional questions are all but absent from this otherwise stimulating account. Why did early hominids (but not other apes) require stage 2 minds? Why did modern humans need a stage 3 mind? These questions are fundamental with respect to understanding both evolutionary history (the sequence of events: why then and not later?) and the constraints imposed on further evolutionary change (why are we so limited in many of our cognitive abilities?).

These are mere quibbles with the details, however. Merlin Donald has clearly done a splendid job in synthesizing and making sense of a substantial scattered literature. His is a book that we will all, biologists and psychologists alike, benefit from reading.

## From mimesis to synthesis

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I will review Donald's book from two perspectives. One is as a computer scientist with general interests in intelligence. The other is a much more focused view based on a current project on the acquisition of natural language spatial concepts and grammars. From my generalist perspective, the book is an ideal choice for a *BBS* multiple review because it is unlikely that anyone besides Donald has tried to synthesize the same slice through the relevant disciplines. In the areas most familiar to me, the book is usually not exactly right and not fully current – in short, not authoritative. I plan to return to the book after seeing reviews from experts in other fields. But only one of the weaknesses I noticed seemed fundamental to the points being made and my working assumption is that Donald got it basically right in other fields as well. If so, the book is a major contribution to our thought about the origins of language. The claims and the reasons for making them are presented clearly and with an appropriate degree of qualification. I found the mimesis hypothesis and the role of external storage in the third phase quite plausible but the mythology story totally unconvincing – nothing like an adequate selectional advantage for myths is demonstrated. But it doesn't much matter; the book provides a framework for continuing interdisciplinary work on the origins of language that was previously missing, at least for me.

From the perspective of my current research on language acquisition, the book was less satisfying. For many of us, the central question is how to reconcile neurobiological reality with the information processing models of traditional computer and cognitive science, corresponding roughly to Donald's "external symbolic storage" chapter. It eventually occurred to me that the book was incoherent on this issue because Donald just retells each story in its original framework. Simply put, the book is a scholarly survey rather than a scientific synthesis. I look forward to a sequel, by Donald or anyone else, that attempts to formulate a consistent model of the modern mind that respects its origins. The current book is still at the mimetic stage.

The major computational error of the book lies in its overestimation of the state of distributed computing systems. Computer networks are currently used almost exclusively for communication and no one knows how to use a network effectively in concert on general tasks. In fact, one suspects that Donald has never tried to construct a distributed system or to manage anything of scale. His vast underestimation of the difficulties of coordinating multiple agents (human, machine, or hybrid) might be part of the reason he misses the obvious and traditional explanation of the second stage of language development – the support of ever more complex group action.

## Evolution needs a modern theory of the mind

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*Origins of the Modern Mind* appears to suffer from at least three basic limitations. First, distinctions Donald draws between episodic, mimetic, mythic, and theoretic are neither fully developed nor adequately justified. Second, the referential (or "propositional") model of language he adopts needs to be replaced by a more adequate "speech act" conception. And third, no theory of the origins of the modern mind can succeed without an acceptable conception of the nature of mind. Since I have addressed the first two problems elsewhere (Fetzer 1993), in the present context I want to focus upon the third.

Although Donald does not elaborate the precise nature of the mind, he does provide examples of the kinds of functions he takes to be characteristic of cognition. These include imitation, focused attention, memory, dreaming, imagination, reasoning, caution, tool usage, abstract intelligence, self-consciousness, and various social and moral capacities, encompassing social cooperation, mutual defense, social bonding, and social intelligence (pp. 28–31). Among these, the one on which Donald places greatest emphasis is memory, where his "stages" in the

emergence of the modern mind involve increased memory storage and retrieval capacities.

Donald's use of these specific aspects of human and animal activities may be appropriate as examples of human and animal cognition, but without an explicit conception of the nature of mind (which he does not provide), it is impossible to tell. A more adequate account of the emergence of the modern mind, therefore, might benefit from the introduction of a modern conception of the nature of the mind. An account that promises to serve the function of providing a framework for understanding cognition as an evolutionary phenomenon can be developed on the basis of the theory of signs proposed by Charles S. Peirce (Fetzer 1988; 1989; 1990; 1991; 1992).

According to Peirce, a *sign* is a something that stands for something (else) in some respect or other for somebody. Inverting and generalizing Peirce's account makes available the conception of a *mind* as a something for which other things can stand for other things. Minds thus become the kinds of things that are capable of utilizing signs. Indeed, since Peirce suggested there are three basic kinds of signs – where *icons* stand for other things because they resemble them, *indices* because they are their causes or effects, and *symbols* because they are habitually (or conventionally) associated with those other things – there seem to be at least three corresponding kinds of iconic, indexical, and symbolic minds.

Things that are capable of utilizing signs that stand for other things because they resemble those other things (as different instances of the same shapes and sizes, for example) thus have the most basic kind of *iconic mentality*. Things that are capable of utilizing icons and signs that stand for other things because they are causes or effects of those other things (such as food standing for satiation of hunger, for example) have a higher grade of *indexical mentality*. Things that are capable of utilizing icons, indices, and signs that stand for other things because they are merely habitually associated with those other things (such as words in ordinary language) have an even higher grade of *symbolic mentality*.

An extension of Peirce's view suggests that there are higher modes of mentality: the capacity for formal reasoning, especially inductive and deductive reasoning on the basis of rules of inference, distinguishes *transformational mentality*, and the capacity for criticism (of ourselves, our methods, and our theories) exemplifies the highest grade of *metamentality* within the scope of this conception. For all five kinds of mentality, the same criterion serves as a usually reliable but not infallible indicator of the presence of mentality, namely: *the capacity to make a mistake*, because, in order to make a mistake, something must have the capacity to take something to stand for something, while doing so wrongly.

This framework can be applied to Donald's examples of cognitive functioning. Mental functions such as focused attention, memory, and dreaming could be properties of iconic minds (of type I), since the objects of focused attention, memories, and dreams might be merely images – perhaps sequences of images – that resemble what they stand for. Functions such as tool usage, imitation, and self-consciousness, by comparison, seem to require indexical minds (of type II), because they involve comprehending cause-and-effect relations of various kinds. Imitation is an interesting example; it also appears to involve some analogical reasoning capacity.

Social cooperation, mutual defense, and social intelligence (which ants, termites, wasps, and bees display) may or may not require mentality that goes beyond the indexical, especially when they are instinctual behaviors. Indeed, the difficulty encountered in evaluating whether and to what degree functions of these sorts involve mentality is that it depends on the character of their sign-using (or "semiotic") ingredients. Without information of this kind, it is difficult to say. Abstract intelligence and reasoning seem to go beyond indexical mentality to the level of symbolic minds (of type III). Indeed, when reasoning takes the form of dependence upon rules of inference (as in the construction of deductively valid or inductively proper arguments), then transformational minds (of type IV) are involved.

What turns out to be most intriguing about caution, from this point of view, is that it appears to exhibit the exercise of the critical capacity indicative of metamentality (of type V). Since prudent behavior can result from behavior-shaping experiences (of the kind that operant conditioning, especially, can produce) as well as from critical reflection on alternative beliefs and behavior, however, this case too requires further contemplation. The distinctive feature of metamentality is the use of signs to stand for other signs (using words to talk about movies, for example). Unless signs are being used to stand for other signs, prudent behavior need not be of type V.

If birds can mistake the shapes and sizes of vinyl owls for the shapes and sizes of the real thing, if dogs can salivate at the sound of a bell as if it were going to satiate their hunger, and if pigeons can press bars in the false expectation of receiving pellets, for example, then things of each of these kinds can make mistakes and have minds. From this perspective, I would suggest, the concept of minds as semiotic (or "sign-using") systems affords a framework for understanding the evolution of minds of successively stronger and stronger kinds that promises to go far beyond the distinctions Donald has drawn in his extremely stimulating work.

It seems plausible, for example, that different species have distinct semiotic abilities in the form of distinctive ranges and capacities for using signs of various kinds. Some of these semiotic abilities may be inborn (or innate), whereas others are learned (or acquired). Presumably, if the semiotic systems conception is right-headed, lesser forms of life should exhibit lesser kinds of mentality and higher forms of life higher forms of mentality, where their exact range and variety depends upon specific social and environmental variables. The semiotic abilities distinguishing various species may even turn out to be the key to their behavior.

## Cultural transitions occur when mind parasites learn new tricks

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Donald suggests that the history of human culture should be classified on the basis of cognitive stages instead of in terms of technology or religion or manner of obtaining food. I find this suggestion sensible, as enhanced ability to build internal representations underlies progress in any of these realms. Donald proposes that human culture has undergone three fairly sharp transitions during periods of reorganization of brain architecture, characterized by the emergence of increasingly sophisticated modes of representation. These are (1) mimesis (the ability to represent knowledge through voluntary motor acts), (2) spoken language, and (3) graphic invention, external memory, and theory construction. Donald's account of this process is plausible and well-documented. He could be more explicit, however, about how and why our modes of representation became more sophisticated. Showing that we had the *capacity* and *need* for more complex representations is not enough to explain why we came to possess them; it is necessary to outline the mechanisms at work that ensured their creation and evolution.

Donald's arguments might be strengthened were he occasionally to relinquish the focus on humans as the active "evolvers" of culture. Cultural evolution, like genetic evolution, involves the generation, selection, and differential reproduction of patterns. Once a pattern has the ability to self-replicate with variation,

and does so on the basis of some selection criterion, then the process of evolving has momentum. This is true whether the patterns are implemented in genetic material or as patterns of activation across neurons. One could make a good argument that there is no more reason to credit humans as the evolvers of cultural evolution than there is to credit DNA as the evolver of genetic evolution. We can be seen as mere hosts for the representation and replication of "idea-parasites"; we are the medium by which one evolutionary process has become superimposed upon another. Our relationship with idea-parasites is symbiotic, analogous to the relationship we have to the bacteria in our gut or the viruses that have inserted themselves in our genomes. Those that evolve in directions that benefit us flourish, whereas those that evolve in directions that harm us lose the hardware upon which their livelihood depends. Our well-being provides idea-parasites with the fitness landscape that guides their evolution. When we view ourselves as the substrate for a relatively autonomous process, we see why there is a close relationship between the architectural complexity of the brain and the complexity of culture. Much as the products of biological evolution adapt and evolve without top-down instruction in response to changes in their environment or in the stuff that encodes or implements them, ideas adapt and evolve in response to changes in the needs and skills of their hosts or in their hosts' brain architecture. Extending this line of thought: during each of Donald's cultural transitions, as the representational capacity of the brain expanded, idea-parasites acquired the opportunity to travel new evolutionary trajectories, broadening the space of viable "conceptual niches" to encompass events that could be communicated through mime, through speech, and through artifacts and theoretical analysis. This is not unlike the spread of seeds to regions with different climates and different resident flora and fauna, which exposes them to new selective pressures that broaden the space of viable genotypes.

Donald argues that the difference between human culture and that of the great apes is vast (p. 161) and that humans are unique in evolving a "generalized capacity for cultural innovation" (p. 10). Apes are capable of mimetic representation, but this remains strictly episodic, whereas for young children, "the practice, rehearsal, and refinement of action takes on a generative property; the same elementary actions . . . may be combined and recombined into sequences that represent events" (p. 172). The same is true with language. Although apes can link signs to signifiers they do not have the capacity for linguistic innovation. By contrast, for children, "the first word inventions . . . have the quality of an intellectual adventure . . . capturing a chunk of episodic experience, or a concept, with a word requires experimentation" (p. 218). Donald states that the crucial difference between apes and humans is that humans are capable of semantic memory, which depends upon a distinctively human representational system (p. 160). However, he does not relate the absence of semantic memory to any breakdown or bottleneck in the cultural evolution process (the generation, selection, or differential reproduction of patterns).

Although this might also be clarified by drawing upon our analogy between culture and biology, what is interesting here is the way in which the analogy breaks down. In biological evolution, the generation of variants is largely random and *precedes* selection. The success of the process can be attributed to the sheer number of variants generated. In cultural evolution randomness plays a smaller role; innovation is guided by an internalized model of the world that is continually honed by experience. The success of *this* process can thus be attributed to internalization of the fitness landscape, enabling the variation phase to be merged with the selection phase so that only need-fulfilling variants are generated. This merging is made easier by the nature of brain-style representation. Distributed networks naturally complete partial patterns and generate prototypes by tweaking and combining patterns from memory, and the patterns they draw upon – the ones that are most easily activated – are likely to be relatively successful, as they will have been used most recently or frequently. Thus not only do newly generated idea-parasites "play new tricks," but they tend to play tricks that are useful or satisfying to their hosts. Perhaps apes lack the necessary feedback loops, control mechanisms, or whatever it takes to carry this off successfully, whereas humans, with practice, learn to do it with ease.

## Working memory and its extensions

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Cognitive psychologists are frequently exhorted to look beyond the laboratory and Donald has done so on a large scale in his fascinating exploration of cognitive evolution. Many of the concepts used in this speculative but much-needed endeavor derive from laboratory studies. Working memory is a prime example and I will focus on Donald's proposals regarding working memory and the role of external symbolic storage systems (ESSs) and external memory fields (EXMFs) in thinking.

Recently there has been a growing interest in the role of working memory in thinking and particularly in problem solving. Hitherto, it has tended to be simply assumed that working memory limitations constrain possible strategies in problem solving; there has been no detailing of how working memory is used on the way to a solution. From the work of Baddeley (1992) and colleagues it seems clear that working memory needs to be considered as a composite system involving specialized memory subsystems (visuospatial scratchpad and articulatory loop) plus a coordinating central executive mechanism. Thus, in considering working memory in thinking, one must address the roles of the subsystems. Dual task methods assist such detailed investigation; we have some sample results that indicate roles for the articulatory loop and central executive in syllogistic reasoning but not for the visuospatial scratchpad (Gilhooly et al. 1993). It has also become clear that the limits and fragility of working memory as shown in memory tasks pose great difficulties for its effective use in problem solving. As Newell (1992) and Broadbent (1993) have recently commented, no AI problem solver succeeds with such extremely limited working memory capacity as has been attributed to humans.

Of course, the apparently narrow limits of working memory fit well with Donald's stress on the role of ESSs and particularly of EXMFs in problem solving. Simon (1981, Ch. 4) has also pointed out the benefits of external memory; and Suchman's (1987) situated cognition approach, too, stresses the role of external props in complex real-life problem solving. It would indeed be difficult to deny that external memories are in practice of great importance; however, the balance may need redressing in that internal means of extending working memory have not been given much weight in Donald's treatment. It should be noted that the low values often reported for working memory capacity are based on short-term memory tasks involving the presentation of meaningless sequences of items. If the items can be meaningfully structured by the subject then short-term memory performance can be enhanced dramatically, as in Ericsson's (1985) studies of expert memory, in which digit spans of over 80 were obtained. Furthermore, even without specific mnemonic training, experts, when compared to novices, always show superior memory for new material in their field after a brief exposure. This suggests a greatly expanded effective working memory capacity for material in the domain of expertise. This result is highly robust and has been found over many domains since De Groot's (1965) well-known pioneering demonstrations in chess. It is plausible to suppose that during problem

solving too, experts can effectively extend their internal working memory capacity and store intermediate results generated internally. In that way extensive search is possible for experts without reliance on EXMFs. Blindfold chess is perhaps an extreme example of extensive mental search without external memory.

An explanation for extended working memory has been put forward by Ericsson and Kintsch (1991) in terms of Ericsson's (1985) Skilled Memory Theory. Essentially, the explanation is that material is efficiently coded into long-term memory in such a way that rapid retrieval into short-term working memory is facilitated. The expert overcomes the limits of working memory by frequent swapping of information between long-term and working memories as problem solving proceeds. Thus, before ESSs and EXMFs were widely available, archaic experts could still make progress in their domains by using internal extended working memory.

## Mythos and logos

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The stages Donald proposes for the evolution of the modern mind seem basically sound in outline. His suggestions are not altogether new. Gordon Hewes, for example, has for twenty years been advocating a mimetic-gestural stage in human evolution (Hewes 1973; 1974), and Goody (1977) has long emphasized the importance of external symbol storage in the transformation to theoretic culture. Fairservice (1975) outlined a similar three-stage theory of cultural evolution, labeling the stages enactive, ikonic, and symbolic after Bruner's developmental sequence. But Donald's exposition is richly embellished, particularly from the literature of the cognitive sciences, and lucidly argued. There are, however, some weaknesses in the presentation which, though not seriously damaging to the overall scenario, are perhaps worth pointing out. I would mention first the characterization of the Upper Paleolithic and "mythic culture" generally, and second, the imputed causes of "theoretic culture."

In the few pages discussing Paleolithic art (pp. 279–84) there is hardly a sentence that is not dubious or merely wrong. Whether any of the decorated caves had ceremonial or ritual significance is completely unknown (in the case of Altamira perhaps, for hundreds of others unlikely). That hunting and fertility constitute "the two major themas" is a very outdated notion, for which there is virtually no evidence. That these themas are "usually cast in mythic or narrative terms" is a generalization that has no basis in the art itself: before the Mesolithic paintings of the Spanish Levant, there are at best but a handful of depictions, out of many thousands, that even suggest a narrative content. And of Paleolithic myth we have absolutely no knowledge at all. Yet Donald asserts that these pictorial representations "appeared in the context of an existing oral-mythic culture."

Upper Paleolithic culture in general, he claims, "had a rich social and religious life, marked by the use of dance, chants, masks, and costumes for various religious performances." People had "capacious verbal memories, capable of long, highly formalized verbal exchanges." They also had political structures and "various semiotic devices to indicate clan, status, and totemic identification" (p. 211). All of this is possible, but there is no archeological evidence to warrant any of these confident declarations. Then where do they come from? Clearly from ethnographic analogy, the characteristics of modern "Stone Age" societies being retrojected on the Upper Paleolithic. If the Kalahari Bushmen and the Australian Aborigines have myth, ritual, and the rest, the Cro-Magnons must have had them too. Needless to say, this is a precarious reconstructive procedure.

Similarly, we read, "Language, in a preliterate society, . . . is basically for telling stories . . . . Narrative is so fundamental that it appears to have been fully developed, at least in its pattern of daily use, in the Upper Paleolithic" (p. 257). Moreover, "Myth is the inevitable outcome of narrative skill and the supreme organizing force in Upper Paleolithic society" (p. 258). It is true that storytelling is a common use of language in oral societies, but it has many other uses as well. How can we conclude that this is what language is basically for? And again we have unjustified extrapolation from ethnography to the Paleolithic. The fact is, we do not know whether the Cro-Magnons even had a fully developed, grammaticized *language*, let alone a mythology. It may be doubted, moreover, whether myth has ever been "the supreme organizing force" in *any* society. Even in the most myth-ridden cultures, it seems pretty clear that most people have gone about most of their business most of the time without much thought about their myths. Indeed, myths have probably always been as much a form of entertainment as anything else (as among American Indians, for instance).

But let the Upper Paleolithic rest. After all, Donald's period of "mythic culture" extends well beyond that era right up to classical Greece, and certainly all its characteristics were fully developed by then, whenever they may have begun. When myth does develop, it does often have an integrative function. But it is only one expression of that function, and I see no prima facie reason to accord it "pre-eminence" (p. 215). Donald suggests the possibility that integrative *thought* was the primary human adaptation rather than language per se, which developed in response to pressure to improve the conceptual apparatus (p. 215). Alternatively, we might suppose that it developed in response to social pressure to improve the communication of concepts. Most likely, conceptual and linguistic systems evolved by reciprocal bootstrapping (Pinker & Bloom 1990; Jackendoff 1990). In any case, "mythic culture" seems a misleading designation for what might better be called "oral culture" (which in fact Donald sometimes calls it).

My second reservation concerns the external symbol storage system (ESS) and the rise of "theoretic culture." In almost any society, preliterate as well as literate, knowledge is differentially stored among its population, so that any one individual depends on others – priests, law-speakers, and bards, say – for their special memories. External storage in accessible symbol systems, especially writing, does greatly increase the holding capacity of collective knowledge, but whether the difference is more than quantitative is not clear. That the ESS played a very significant role in the Greek Enlightenment is doubtful. I think most classicists would agree that even in the fifth century Greece was very largely an oral society (Havelock 1963; Thomas 1992), and the growth of reflective thought seems not to have depended seriously on the presence of writing.

In the modern world, the EES does indeed have an enormous role in the advancement of knowledge, particularly in those many intellectual and technological enterprises that are data-driven. On the other hand, philosophical thought is far less dependent (one would hardly guess from his writings that Wittgenstein had ever read a book), and even theoretical physics, with its beloved thought experiments, does not seem powerfully beholden to such systems. Theoretic culture does exist, but to characterize it as a revolutionary "symbiosis" of individual minds and external symbol storage systems may be somewhat exaggerated.