

Cognitive Precursors to Language

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INTRODUCTION

Language is a unique hallmark of the human species. Although many species can communicate in limited ways about things that are physically present, only humans can construct a full narrative characterization of events occurring outside the here and now. By using language for social coordination, humans have achieved a remarkable level of control over their environment (Sterelny, this volume). But, given the demonstrable adaptive advantages provided by language, why have other species not developed communicative systems of similar range and power? One possibility is that the unique recursive structures of human language arose through a singular event in the recent evolution of our species (Bickerton, 1990; Hauser, Chomsky, & Fitch, 2002; Mithen, 1996). According to this view, this recent event has not been replicated in other species because it depends on certain preexisting conditions that were unique to the human species. But, then what are these unique preexisting conditions and why did they appear only in hominids?

The thesis developed in this paper is that human language depends on a quartet of characteristics found in combination only in hominids. This quartet of human characteristics worked together to constitute a unique ecological niche. This unique niche then produced ongoing evolutionary pressures (Geary, 2005) for increasingly complexity in hominid social semiotics. The four characteristics of this niche are: bipedalism, manual dexterity, neoteny, and social bonding. This

quartet of characteristics specified a niche that supported continually richer and richer communicative patterns. According to this account, language is not an accidental mutation, but rather a natural expression of what it means to be a bipedal creature that relies on tools, social chatter, and the communal support of neotenous offspring. Without the copresence of each of these four features, the coevolutionary pressure (Deacon, 1997; Givón, 1998) toward greater semiotic complexity would have been absent.

A QUARTET OF CHARACTERISTICS

Bipedalism

Within this quartet of essential human characteristics, the one that stands out most conspicuously in the fossil record is bipedalism. By 4 mya, the hips, femurs, and tibia of australopithecines had evolved to resemble those of modern man (McHenry, 1986). The presence of hominid footprints in a layer of hardened ash from about 3.5 mya indicates that, by this time, australopithecines walked much like modern man (Tattersall, 1993), although their stature was shorter. This emergence of bipedalism was not a sudden event. Before 4 mya, hominids, such as *Ardipithecus ramidus*, inhabited both arboreal and terrestrial environments simultaneously. Moreover, within both arboreal and terrestrial habitats, apes and hominids deploy a variety of methods for walking and climbing (Stanford, 2006).

Thus, there was no single moment when our ancestors abandoned the trees altogether. In fact, modern man can still climb trees when necessary.

Bipedalism brought with it a series of evolutionary costs. It placed increased mechanical pressure on the neck, the spine, and all the joints of the legs. The reliance on the hind limbs for walking made them less functional for climbing. The lungs had to adapt to support the breathing needed for running. Perhaps the most important of these costs involved the narrowing of the hips which makes parturition more difficult (Hockett & Ascher, 1964). As the infant's head grows in circumference, this problem becomes even worse. The evolutionary answer to this dilemma was to have the baby emerge earlier, before the skull could reach an unmanageable diameter. One result of this hastening of the time of birth is that basic sensorimotor systems such as vision and motor coordination are not consolidated until the eighth week of infancy (Johnson & Morton, 1991). This tendency toward premature parturition forced humans to provide heightened social support for increasingly dependent infants.

Manual Control

Despite these costs, bipedalism brought with it several advantages. With the arms free, we could use our hands for new purposes (Coppens, 1995). The hands remained useful for climbing trees and hanging from branches, but now they had a wider range of functions, including combat, manual communication, and tool production. The first evidence of tool making comes from about 2.4 mya

with the appearance of Oldowan tools from the Gona and Omo Basins in Ethiopia. The tools found there include a variety of choppers, scrapers, bone points, and diggers (Potts, 1988). Although the shaping of these tools did not require the level of planning and design required by the tools of the Upper Paleolithic, their production still requires a high level of manual dexterity and control. This dexterity was supported by the development of an increasingly refined precision grip in *Homo habilis* and then *Homo erectus* (Jolly & Plog, 1982).

Neoteny

Neoteny involves the retention of juvenile, or even infantile, characteristics in adults. For example, infants have full cheeks, soft chins, and thin hair. When we see similar facial characteristics in an adult, we say that they have a “baby face.” In human brain growth, we see evidence for neoteny in terms of the maintenance of infantile levels of cortical plasticity well into adolescence and early adulthood. In stricter terms (Rice, 1997), what we see in human brain development is neoteny combined with a secondary lengthening of the overall development process. However, during the first years of life, the primary change in developmental synchrony involves simple neoteny, including the delay of aspects of the last months of gestation into the first months of infancy.

Neoteny has wide-ranging consequences for cognitive and social development. Students of human evolution (Bjorklund & Pellegrini, 2002; Gould,

1977; Montagu, 1955) have often emphasized the extent to which neoteny can be used to explain diverse aspects of human cognitive flexibility. However, the most obvious immediate effect of neoteny is that the human infant remains dependent on parents for food, care, and guidance well into middle childhood. In this regard, the human infant is altricial, relying on support from adults, rather than raw instinct. During infancy, the baby is dependent for many months on consistent care from the mother. Once established, this reliance on parental support can then extend further and further across the life span. The exact shape of this dependence varies markedly from societies like the Ik of Kenya (Turnbull, 1972) that cease support of children by age 5 to modern urban societies that maintain support for offspring well into the college years.

This extended period of human neoteny provides rich support for teaching children manual, cognitive, and social skills (Vygotsky, 1934) and for maintaining cortical plasticity (Elman et al., 1996; Julész & Kovacs, 1995) even into adolescence. In other species with protracted childhoods, such as elephants, we see a similar rich potential for the development of flexible cultural, cognitive, and communicative structures (Lee, 1986). Neoteny also opens up the door to further selectional pressures. If the parents fail to provide support or if older children interfere with that support, children may die. When resources are limited or when the child appears to be developmentally abnormal, it may be abandoned. If the population is migratory, these pressures can be intensified. Although

pressures of this type are reduced in modern society, they were certainly operative across earlier stages in evolution.

Social Bonding

Within this quartet of defining human characteristics, perhaps the most ancient feature is the hominid emphasis on tight social organization. In this regard, humans are very much like highly social bonobo chimpanzees (de Waal, 1995; de Waal & Lanting, 1997). Dunbar (1997) has argued that the maintenance of large social groups requires a high ratio of brain weight to body weight. However, what is crucial here is not simply the brain/body ratio, but also the ability to maintain cortical plasticity well into childhood (Finlay, 2005). In effect, neuronal neoteny works to promote social bonding. Primate groups rely on a variety of mechanisms to maintain and shape social bonding, including grooming, preening, touching, chattering, copulation, play, and fighting. All of these devices are involved in face-to-face communication. However, two of these mechanisms have undergone further elaboration in humans. These are the mechanisms of face-to-face eye contact and vocal chatter.

When chimpanzees assume a sitting position, they can easily maintain continual face-to-face eye contact with the others in their group (Stanford, 2003). In the sitting position, they do not have to bend their neck up to maintain eye contact. However, if the chimpanzees leaves the sitting position, eye contact is broken. In humans, the movement to the upright posture provided fuller support

for maintaining ongoing eye contact. This, along with the freeing of the hands, provided a shared visual space for the elaboration of gestural signals. As many have argued (Hewes, 1973), it is likely that hominids went through a period of relying heavily on gestural communication. It would be difficult to imagine that this did not happen, given the fact that chimpanzees make such extensive use of facial and body gesture (Call, this volume) and the fact that they are good at learning new signs (Savage-Rumbaugh, 2000). With our eyes locked even more continuously into contact, we are better able to track facial movements expressing joy, acceptance, fear, surprise, and anger. If our gaze extends a bit more broadly, we are also able to track gestures of the head, torso, and hands.

The second form of increased support for communication and social bonding involves the increasing reliance on chatter. Dunbar (1997) argues that this reliance on chatter and gossip was crucial in permitting hominids to maintain maximum group size. In this way, the forces of social bonding directly supported the emergence of increasingly precise vocal communication.

Cognitive Consequences

Each of these four characteristics appears to some degree in chimpanzees, gorillas, gibbons, and orangutans. Chimpanzees also display some neoteny, probably for similar purposes. The orangutan also has a precision grip and a thumb not unlike the human thumb. Young chimpanzees often assume a bipedal stance. Gibbons, bonobos, and baboons all maintain rich systems for supporting

social bonding. However, within this shared framework of a basic primate emphasis on social bonding and neoteny, the human commitment to bipedalism and its consequences for parturition (Hockett & Ascher, 1964) pushed our ancestors into an even deeper reliance on neoteny and opened up promising new avenues for use of the hands.

None of these adaptations, by itself, provides direct support for the evolution of language. Rather, this quartet of characteristics led to the emergence of a new social and cognitive platform that could later support the evolution of proto-language. Donald (1998) has referred to this new platform as the “executive suite” and held that it was the basis for a “mimetic revolution” (Donald, 1991) that occurred during the evolution of *Homo erectus*. In the following sections, we will examine how the ongoing quartet of human characteristics shaped these further aspects of human cognition. We will later see that each of these additional cognition adaptations plays a role in shaping human language and facilitating language evolution. Each of these developments involved a continual refinement of the “executive suite” across the four million years of hominid bipedalism.

Consequences of Bipedalism

According to my reasoning, our ancestors’ commitment to bipedalism opened up an evolutionary pressure for refinement of the cognitive systems used to represent and navigate through space. As hominids began to rely less and less on

trees for refuge, they began to range over a wider territory, while still retaining information about trees and hiding places. This meant that they needed to develop improved means of representing spaces and distances. All species must have some way of representing their territory. However, hominids faced the task of representing a large, often changing, territory in which they were both the hunters and the hunted. To do this, they needed to develop extended methods for spatial encoding. Holloway (1995) has presented evidence from endocasts (plaster casts of the interiors of skulls) indicating that there was a major reorganization of parietal cortex after about 3 mya. This reorganization involved the reduction of primary visual striate cortex and the enlargement of extrastriate parietal cortex, angular gyrus, and supramarginal gyrus. Much of the evidence for Holloway's analysis comes from traces of the changing positions of the lunate sulcus and the intraparietal sulcus over time. According to Holloway, the areas that were expanded during these changes in the parietal cortex support three basic cognitive functions:

1. Processing in the dorsal (parietal) stream of the visual field is important for representing actions of the other in terms of one's own body image (Ramachandran & Hubbard, 2001).
2. The association areas of parietal cortex maintain a map of the environment for navigation in the new bipedal mode (Wilkins & Wakefield, 1995).

3. The supramarginal gyrus is involved in face perception. Expansion of this area would facilitate the development of social patterns and memory for social relations. However, there is evidence that the neural adaptations for face recognition have general consequences for object recognition and categorization that will eventually impact linguistic categorization.

The first two functions emerge from the adoption of bipedal gait. The third function is linked to the promotion of social bonding.

Because the move to a terrestrial environment was gradual (Corballis, 1999), hominids needed to maintain the use of the hands in both the arboreal and terrestrial environments. The arboreal environment favors the development of a specific type of motor imagery. Povinelli and Cant (1995) have noted that increases in body weight for larger apes such as orangutans make it important to be able to plan motions through the trees. To do this, the animal needs a map of the self as it executes possible motor actions. Assuming that hominids or their ancestors were similar to orangutans in arboreal navigation, the reflexes of this penchant for postural adaptation may still be evident in the human enjoyment of dance, exercise, and sport. The pressures in the arboreal environment that had favored some limited form of brain lateralization were then carried over to the terrestrial environment (McManus, 1999). This ability to shift quickly between alternative environments required neural support for competing postural and perceptual systems.

Consequences of Manual Dexterity

Apes have good control of reaching and basic object manipulation (Ingmanson, 1996). However, with both hands free, hominids were able to explore still further applications. Monkeys and other primates have “mirror” neurons in premotor cortex that respond with equal force when an action such as “grabbing” is carried out either by the self or by the other, including a human. This mechanism provides a way of equating actions performed by the self with actions or postures performed by the other. This system provided support for the learning of tool use by the increasingly neotenous hominid children. Young hominids could learn to use branches and clubs by imitating their elders. They could acquire the ability to chip one stone against another to form primitive hand axes. The adaptive value of tracking and emulating patterns of tool usage is clear.

The ability to imitate a series of actions requires construction of stored mental images of specific motor actions and postures. To plan the actions involved in chipping an axe, we must be able to call up an image of the desired product, and we must be able to sequence a long series of specific motions that are needed to locate good stones and devise methods for chipping edges. In this regard, the ability to construct a planned sequence of actions appears to be a unique property of hominids, as opposed to monkeys and apes. Studies of primate tool use (Anderson, 1996; Visalberghi & Limongelli, 1996) have shown that chimpanzees and capuchin monkeys can use tools in a productive and

exploratory way. However, they do not appear to make planful use of mental imagery to limit their search through possible methods of tool use. Instead, they apply all directly perceptible methods in hopes that one may succeed.

Consequences of Neoteny

As children's brains became more plastic, they became increasingly responsive to parental teaching. This led, in turn, to the expansion and consolidation of group norms. In accord with the operation of the Baldwin Effect (Baldwin, 1897), children who were able to pick up social norms were more reproductively successful. These good learners could then breed new generations of good learners. In effect, this gave rise to an evolutionary arms race that favored the growth of a larger, more plastic brain (Geary, 2005). Much of the support for good learning came from overall brain size and plasticity, but there was also expansion of more specific mechanisms such as statistical learning (Aslin, Saffran, & Newport, 1999), motor control through practice (Oller, 2000), and imitation (Tomasello, 1999) that provide further support for smooth learning of social norms, including language.

Consequences of Social Bonding

Increased reliance on vocalization in face-to-face interaction produced three major consequences. The first was an increased reliance on vocalization to mark group membership. For many species, vocalizations provide an effective method of signaling group membership. Song birds, parrots, and hummingbirds

have developed methods for learning songs (Konishi, 1995) to mark both individuals and membership in a territorial group. At about 2 mya, hominids moved from being the hunted to being the hunters, thereby providing a high protein diet that could fuel the metabolic requirements of the growing brain. The shift to a diet based on hunting then brought pressure to mark group control of hunting territories. One way of achieving this is through the development of a group-based vocal dialect. Monkeys do not appear to construct local dialects or otherwise structure their call system through learning (Seyfarth & Cheney, 1999). Yerkes & Learned (1925) and others have tried to condition chimpanzee vocalizations in the laboratory and have failed. Neotenous human infants, on the other hand, rely on highly plastic cortical mechanisms to control vocalization (Oller, 2000). This allows them to pick up the sound patterns of their community through mere exposure. As a result, each hominid group can build a local vocal accent that is passed on to the next generation.

The second major consequence of the rise of face-to-face interaction was the strengthening of bonding relationships. Communication has a clear role in relations between the sexes. By bringing these expressions under cognitive control, it is possible to fine-tune both courtship and sexual deception (Buss, 1999; Miller, 2001). The same gestures and vocalizations involved in sexual interactions are also operative between mothers and their infants (Harlow, 1958). Parents and their babies engage in reciprocal (Trevarthen, 1984) flirting and play,

much like adults who are in love. These interactions serve three functions. First, they can convince the mother to promote the child's physical well being. Second, they can cement the infant's secure attachment to the mother, thereby promoting a variety of other developments. Third, they can serve to acculturate the child into the conversational norms of the adult group. The learning of these conversational functions occurs smoothly because the child is locked into face-to-face vocalization (Locke, 1995). In considering the role of face-to-face vocalization in supporting prosocial relations in hominid groups, we must not forget the potentially asocial, divisive role played by aggressive males (Anders, 1994; Goodall, 1979), as well as the compensatory use of face-to-face communication to dampen male aggression.

The third consequence of increased face-to-face interaction was the growth of mechanisms for social perspective taking. Building on the basic primate ability to mirror the actions of conspecifics (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) and relying on new methods for gestural communication, humans became increasingly adept at sharing aspects of their thoughts and tracking the thoughts of others. Without language, this perspective taking was confined to the here and now, but it nonetheless provided a central cognitive support for the eventual emergence of grammatical structure (MacWhinney, 2005b).

Support for Vocalization

Each of these adaptive contexts provided pressures toward increasing flexibility in vocal communication. However, to achieve this flexibility required a fundamental restructuring of vocal control. One form of restructuring was neuronal. In macaques (Jürgens, 1979), control of the vocal system relies on the periaqueductal gray matter of the lower midbrain. Additional midbrain regions can stimulate the periaqueductal gray, but the neocortex does not control or initiate primate vocalizations. Primate vocalization relies on direct connections to midbrain motivational areas (Pandya, Seltzer, & Barbas, 1988). Human language continues to rely on this underlying limbic architecture to provide emotional coloring to vocalization. The linkage of the vocal system to limbic mechanisms provides grounding in terms of arousal (brainstem and amygdala), motivation (basal ganglion), patterning (striatal-thalamic circuits), and memory (limbic circuits) (Tucker, 2002). Humans also retain some direct links between audition and these limbic circuits, as evidenced in the directness of our responses to sounds such as infant cries or the growls of predators (and see Hammerschmidt and Fischer, this volume).

In humans, this midbrain system has been supplemented by a cortical system. Electrical stimulation of both the supplemental motor area and the anterior cingulate of the frontal cortex can reliably produce vocalization. Ploog (1992) has shown that humans have more direct pyramidal connections between motor cortex and the speech and vocalization areas of the brain stem than do

monkeys. Certain areas of the limbic system, such as the anterior thalamic limbic nuclei, have grown disproportionately large in humans. These nuclei serve the supplementary motor area and premotor and orbital frontal cortex. The expansion of these structures points to increased limbic input to the cortex, as well as input from the cortex to the limbic structures. Tucker (2002) shows that the basic adaptation here involved the absorption of the primate external striatum by the neocortex (Nauta & Karten, 1970).

The shift to cortical control of vocalization relies on adaptation of pre-existing cortical pathways for orofacial gestural control. MacNeilage (1998) has argued that the primate gesture of lip smacking is the source of the core CV (consonant-vowel) syllabic structure of human language. The CV syllable has similarities in motoric structure to lip smacking. Moreover, it is produced in an area of inferior frontal cortex close to that used for lip smacking and other vocal gestures. In addition, humans have developed additional cortical control of phonation. Because apes have so little control over the opening and closing of their larynx, they will drown if placed in water. Hominids may have developed cortical control over laryngeal function through some early exposure to an aquatic environment (Morgan, 1997), control of breathing during running, or early attempts at singing. Infants achieve control over basic phonation by three months (Oller, 2000), whereas control of CV structure is not solidified until several

months later (Oller, 2000). It is possible that this sequence follows a natural logic that governs both ontogeny and phylogeny.

THE PLATFORM

By the time of *Homo erectus*, humans had evolved a set of abilities that provided a crucial platform for the evolution of language (Donald, 1998). Many of the crucial aspects of human language, including those involved centrally in grammar, recursion, and productivity, depend directly on components of this platform. The components of this platform included:

1. An increased ability to represent space hierarchically and recursively.
2. A cognitive mechanism for remembering faces and fine within-category visual distinctions.
3. A well-developed body map, suitable for projection to the actions of others.
4. An ability to construct and rehearse plans based on the tracking of the actions and perspectives of others.
5. Emotional and attentional commitment to face-to-face interactions with attending gestures.
6. Increased learning abilities in human infants with special focus on statistical learning, imitation, and motor practice.

7. Cortical control of vocalization and an ability to acquire group vocal patterns.

None of these abilities involve a reliance on language narrowly defined. In the terms of Hauser, Chomsky, and Fitch (2002), these adaptations would all be considered to be part of the faculty of language as broadly defined (FLB). However, to dismiss these preconditions as non-decisive for the emergence of language would be to miss the point. Core features of language such as recursion and perspective marking (which invokes the concept of c-command in modern linguistic theory) rely on these specific cognitive preconditions. The attempt to separate the faculty of language broadly defined (FLB) from the faculty of language narrowly defined (FLN) glosses over the ways in which essential linguistic features depend on cognitive preconditions established millions of years ago.

Mimesis

Donald (1991) argues that *Homo erectus* had achieved a basic level of mimetic communication. He believes that it was this achievement that allowed the species to occupy all of Eurasia and Africa. Mimetic communications involve the depiction of an object or activity by using some characteristic to depict the whole. For example, running can be signaled mimetically by taking a few steps of running. An object can be signaled mimetically by pointing at it or sketching its shape. Mimesis in the vocal mode is more likely to describe sounds associated

with emotional attitudes and the sounds of actions, animals, or objects. In general, mimesis achieves reference through paronymy, or mention of a part to express the whole. Givón (2002) has suggested that, during mimesis, the gestural system “trained” the vocal system. This training would have involved the coordination of timing, content, and even hierarchical order between the two systems. According to McNeill (1985), language and gesture are parallel expressive modalities that emerge together in real time from “growing points” arising within an embodied mental model. McNeill’s account is particularly compatible with the idea that the links between language and gesture are evolutionarily quite old and well established.

It is important to distinguish the vocal imitation involved in the learning of bird song or babbling patterns from the online conceptual imitation involved in mimesis. In the learning of bird song, the introduction of variability facilitates the beginnings of communicative flexibility (Hausberger, this volume). However, mimesis takes this flexibility to a totally new conceptual level. It combines the flexibility of vocal and gestural control with the pre-existing interest in detecting and expressing intentions. Although mimetic expressions were likely to be clumsy and incomplete, they provided an initial method for achieving a co-construction of narrative events and intentions. In this way, mimesis provided support for the eventual expression of perspective taking through grammatical markings and syntax.

It seems unlikely that the storage and retrieval of conventionalized mimetic sequences could be achieved simply by linking up older areas or by reusing earlier connections. Instead, additional computational space was needed to store the multitude of new visual and auditory images. In addition, evolution favored the growth of neural systems in frontal cortex for storing and switching between perspectives (Decety, Chaminade, Grezes, & Meltzoff, 2002). Because mimesis arose in a haphazard way from earlier pieces of lip smacking, pointing, gesture, and rhythm, it was impossible to formulate a socially systematized coding method for the storage of mimetic communications. Instead, patterns and forms had to be learned and stored as holistic unanalyzed sequences. For example, when we chop wood, there is a complete interpenetration of muscle actions, visual experiences, hand positions, and sounds. We can think of this as a single merged form such as I-pull-hands-back-lift-axe-drop-split-chips-wood-cut. Mimetic forms have this same unanalyzed quality. This lack of analysis is not the result of chunking or automatization, since the Gestalt is not constructed by a system of combinatorial semantics. Instead, each chunk is a raw, unanalyzed whole that is fully grounded on direct action and perception (Gibson, 1977). Because they are fully grounded, productions of these mimetic gestalts are easy to decipher. However, mimetic gestalts provide little support for cognitive organization.

The Lexicon

The expansion of the brain in *Homo erectus* was not enough by itself to trigger the emergence of material culture. Instead, humans needed some way to systematize the growth in vocal and gestural mimetic processes that had occurred during the Pliocene. The core of the new system involved the introduction of a set of phonological contrasts (Hockett & Altmann, 1973) that could build a productive lexicon. By coding words into a compact set of contrastive features, early *Homo sapiens* was able to conventionalize, learn, store, and retrieve a limitless set of names for things. To achieve accurate articulation of these contrasts, a further set of adaptations was needed for the serial ordering of actions and the precise articulation of sounds. These adaptations included reduction in size of the canines, adaptation of the arytenoids, bending of the vocal tract (Lieberman, 1975), and shaping of the musculature of the tongue. Each of these modifications led to a separate and meaningful increment in our ability to articulate clearly a full inventory of phonetic contrasts.

Word learning depends on several of the cognitive preconditions discussed earlier. The infant must detect statistical regularities that will determine word forms. By listening carefully to the speech of caretakers, the infant can tune in to the shape of words. Then, by following the cues of gaze direction and pointing, they can pick up names for things (MacWhinney, 1998). Infants can then learn to produce these sounds themselves by matching their vocalizations to those they hear during babbling (Westermann, this volume). Gupta and MacWhinney (1997)

show how consolidation of word shapes depends on the system for phonological rehearsal (Cowan, 1992; Gathercole & Baddeley, 1993; Nairne, 1990). The final storage of lexical forms is achieved in auditory cortex, deep in the temporal lobe (König, Heil, Budinger, & Scheich, 2005). Broca's area and motor cortex are responsible for shaping the motoric form of words (Blumstein, 2001). This means that vocal rehearsal must involve coordinations between three very separate brain areas – premotor cortex, motor cortex, and auditory cortex. Li, Farkas, and MacWhinney (2004) have shown how these patterns of connectivity can be modeled through self-organizing neural networks that represent local maps in auditory, articulatory, and semantic space.

The neuronal systems for encoding these connections provided further neuronal support for the evolution of spoken language. It is difficult to determine the age of these neuronal developments. However, evidence regarding the growth of peripheral support for speech suggests that these developments were underway by at least 300,000 years ago (MacLarnon & Hewitt, 1999). The use of phonological rehearsal to consolidate memories for lexical forms is one of the first steps toward the creation of linguistic productivity (Hockett & Altmann, 1973). This system involves a level of recursive combination within individual vocal gestures. However, except in marginal cases of phonetic symbolism (Paget, 1930), the individual components of words are not linked to components of

meaning. Instead, it is the word as a whole that is linked to meaning as a whole (Li, Farkas, & MacWhinney, 2004).

Recursion and Item-based Patterns

In the human child, the joining of words into productive constructions relies on a system of item-based patterns, proposed first by MacWhinney (1982) and further investigated by Tomasello, Lieven, and Pine (Pine & Lieven, 1993; Tomasello, 2000). Given the centrality of item-based learning for child language, it is reasonable to suppose that the ability to combine words into item-based patterns constituted a major evolutionary achievement for modern man. This achievement rests heavily on the consolidation of the ability to learn individual words. Once the basic word learning ability is in place, the movement to combinations of words involves the introduction of a method of linking words to predications.

The basic mechanisms supporting predication were already existent in nonhuman primates (McGonigle & Chalmers, 1992, 2002, 2006). A chimpanzee understands that a banana is yellow or that a river is too wide to cross by jumping. The real challenge involved consolidation of a neural mechanism for expressing predications through the auditory-vocal channel.

In order to express predications, human language relies on a system of item-based patterns. These patterns associate a particular predicate such as “red” or “hit” with its argument. For example, “red” is associated with the object that it

describes which occurs in a following slot. Similarly, “hit” takes two arguments. The first argument is a “hitter” who appears in the slot before the verb and the second argument is the “thing being hit” which appears in the slot after the verb.

Children spend much of the time between about 16 and 30 months of age learning these item-based patterns (MacWhinney, 1987). They pick up these patterns by processing simple inputs provided by parents. Consider the case of a child who has learned the word “doggie.” The parent then says “big doggie.” The child notices the size of the dog and assumes that “big” refers to size. This learning episode allows the child to acquire “big” as a lexical operator that takes as its argument an entity like “dog”. The value of the argument that fills this slot is initially set to “dog”, but this value can be generalized on the basis of additional input. Crucially, the child views the operator “big” as describing the size of its head argument. Later, when the child also hears “big cookie,” the semantic range of the head (“cookie” in this case) is generalized to inanimate objects. Eventually, the item-based pattern “big + X” is linked up with other patterns such as “nice + X” to yield a generalized pattern that is no longer based on single items, but which operates across groups of lexical items that share a core feature. This new structure is called a feature-based pattern (FBP) (MacWhinney, 1982). In this account, learning begins with words, advances through item-based patterns, and then is extended through feature-based patterns.

By themselves, item-based and feature-based patterns provide predication, but not recursion. In order to generate language recursively, item-based patterns must produce intermediary structures called clusters (Hudson, 1984; MacWhinney, 1987) or phrases. Consider the sentence “your big dog chased my frightened cat.” The phrase “your big dog” is produced by the recursive clustering of two item-based patterns. First, “big” is attached to “dog” to produce “big dog”. Then “your” is attached to the cluster of “big dog.” This whole cluster then functions as the first argument of the verb “chases” which takes “my frightened cat” as its second argument. This repeated deployment of item-based patterns requires an additional processing mechanism that can store a complex item such as “your big dog” in working memory for subsequent combination with the predicate “chased.” The ability to store such memories can rely in part on existing action planning structures (Greenfield, 1991), but a system that uses item-based constructions to form combination in real time would require these systems to perform at a higher level than previously and with a greater focus on manipulating lexical objects.

This account emphasizes the unique role of item-based patterns in the recursive construction of sentences. In this view, sentences do not emerge from abstract derivational processing across multiple constraint-based modules (Chomsky, 1986; Chomsky & Lasnik, 1993), but rather through online incremental processing of simple links between lexical items. In the terms of

current dialogs in linguistics and psycholinguistics, this emergentist position (MacWhinney, 2005a; O'Grady, 2005) contrasts with minimalist formalism (Chomsky, 1995). However, both emergentism and formalism agree on the centrality of recursion in generating linguistic productivity and form. Minimalism singles out recursion as the pivotal development leading to the sudden emergence of language. In the emergentist account, on the other hand, recursion arises gradually through the implementation of memory structures based on preexisting motoric planning abilities and methods for spatial hierarchicalization that go back millions of years. Moreover, as we will see, the emergentist view treats recursion not as the final step toward the evolution of language, but as a method for facilitating the further introduction of perspective taking into grammar.

Recently, researchers (Mithen, 1996) have attempted to link the appearance of recursion to some sudden recent evolutionary event. One account focuses on the claim that 70,000 years ago there was an evolutionary bottleneck that brought the number of our direct ancestors down to perhaps 10,000 individuals worldwide (Stringer & McKie, 1996). This ancestral population coexisted with other hominids, such as the Neanderthals, who are not our direct ancestors. Eswaran, Harpending, & Rogers (2005) argue that this evolutionary bottleneck arose as successful new generations were being produced by a slow wave of expansion from Africa. This wave brought with it the seeds of modern creativity that had begun to emerge earlier in Africa (McBrearty & Brooks, 2000).

When we think in terms of a population of 10,000 individuals from whom we all may have descended, it is important to remember that it was not the case that human populations worldwide had declined to this low level. Rather, the bottleneck reflects the fact that individuals at the front of this wave were far more successful reproductively than those not in the crest of the wave.

Along the front of this wave, modern humans assimilated only marginally with the archaic populations they replaced. However, there were enough interactions to leave traces in nuclear DNA. The current distribution of populations suggests that the genetics of this new group could be characterized by the presence of a group of at least 8 genes, including the FOXP2 gene, linked to some articulatory and motor difficulties (Enard et al., 2002). The complexity of this wave model and the polygenetic determination involved in the determination of language-related features suggests that it would be best to view this wave of creative individuals as possessing a wide range of traits on both linguistic and social dimensions.

Perspective-Taking

Mithen (1996) has argued that the increased artistic production in the Upper Paleolithic resulted from new methods for linking ideas between otherwise modularized cognitive functions. Mithen's analysis, while overstated in various ways (McBrearty & Brooks, 2000), still seems to capture a core aspect of recent human evolution. The idea that language serves as a method for integrating

thought has appealed to a very diverse set of scholars from Plato and Vygotsky to Dennett (1996) and Carruthers (2002). However, it would be a mistake to imagine that the low-level mechanism of recursive combination was sufficient to trigger the creative productions found in Europe after 30,000 years ago or earlier in Africa. Instead, it seems much more likely that item-based patterns and recursion served to construct a new linguistic platform that could then support ongoing advances in social cognition, perspective taking, and child rearing.

The solidification of language as a means of expressing creative and productive thought required the social construction of a set of grammatical devices for marking perspective taking. These devices used the system of item-based patterns, along with grammatical affixes to mark the flow of perspective through agents, positions, and actions. These markers are encoded and positioned at the level of the item-based pattern. However, they work together in sentences to trigger perspective taking and shifting across recursive systems of predicates. Together, this system of markers allows us to construct embodied representations of the infinite array of meaningful combinations that can be encoded by sentences and combinations of sentences.

Let us consider some examples of the application of perspective shifting to linguistic structure. (For a fuller recent account, see MacWhinney, 2005.) For our first example, let us return to the earlier sample sentence (1).

1. Your big dog chased my frightened cat.

Here, we begin the process of interpretation with the word “your”. However, because this word is marked as possessive, we delay commitment to a point of view until hearing the subject “dog.” We then interpret “dog” as the perspective from which to understand the sentence and construct a secondary perspective in which “you” are the owner of this dog. Then, we hear “chased” and link the dog to the chasing and open up a slot for something being chased. This slot is then filled by “cat”. Although primary perspective remains on “dog” throughout this sentence, an additional secondary, social perspective is opened for attaching “my” and “frightened” as descriptors of “the cat.”

In general, perspective switching in English leads us to select the first noun as the primary perspective (Gernsbacher, 1990) and to shift away from this primary perspective only when strong syntactic cues signal a shift. Strong cues of this type appear in passives like (2) and clefts like (3).

2. My frightened cat was chased by your big dog.

3. It was my frightened cat that your big dog chased.

More subtle effects of perspective shifting and marking can be detected throughout grammar. Consider an ambiguous sentence such as (4)

4. Tim saw the Grand Canyon flying to New York.

Here, the syntax licenses a competition between “Tim” and “Grand Canyon” as the attachment sites for “flying to New York.” Although we may attempt both

attachments, only one makes good sense. Sentences like (5) through (8) show how the intervention of a perspective shift can block reflexivization.

5. Jessie stole a picture of herself.
6. *Jessie stole a picture of her.
7. Jessie stole me a picture of herself.
8. Jessie stole me a picture of her.

Reflexivization is not possible in (6). Formal UG theory explains this by holding that “picture nouns” block the c-command relation that supports the clause-mate constraint. Perspective theory interprets this instead in terms of the need for an intervening perspective shift, as in (8) to license the move away from ego perspective required for reflexives. Sentence (9) illustrates how ongoing construction of a spatial scene can lead to alternative perspectival constructions.

9. The adults in the picture are facing away from us, with the children.

This brief excursion into the theory of item-based patterns and the marking of perspective has provided only a limited sample of the phenomena involved, intended to illustrate the basic shape of these processes. The thesis is that the humans at the front of the wave of expansion from Africa (Eswaran, Harpending, & Rogers, 2005) were in possession of the postulated newly evolved ability to make recursive application of lexical structures. The cognitive ability to generate linguistic recursion must necessarily have been accompanied by a heightened ability for recursive manipulation of images and plans. By linking this

new ability to socially devised methods for marking perspective shifting in language, these new groups were able to raise the use of human language to new, more powerful levels.

As they competed with less articulate groups, more articulate groups were able to strengthen group solidarity and purpose by constructing unique cultural histories. They did this by creating totemistic myths (Freud, 1913) that formalized kinship loyalties in the terms of hunter-gatherer shamanism. The creation of these myths depended on new methods for describing the not-here and not-now in terms of coherent ontological narratives (Frazer, 1890). By articulating their visions of these myths and the spirit world, shamans and priests were able to achieve additional control (Geary, 2005) and status in their alliance with chieftains. These myths solidified the bonds between group members and their families, committing them to sacrifices in the name of the group. They also allowed the group to maintain contacts of exogamy and trade with related groups near the frontier of expansion. Although these cultural and linguistic innovations were concentrated among the population most involved in the dynamic expansion across Eurasia, they eventually diffused back to Africa itself. As this diffusion progressed into the Neolithic, it involved the spread of cultural innovations, rather than additional mutations. Throughout these developments, increasingly complex recursive sentence patterns were developed to express the details of perspective taking and perspective shifting needed for increasingly complex myths,

narrations, and speeches. These new “memes” (Blackmore, 1999) then spread to become nearly universal components of human society, fueling all of the developments of modern civilization.

SUMMARY

This paper has suggested that human language evolved gradually within a unique context that included four preconditions: bipedalism, manual dexterity, neoteny, and social bonding. The evolution of cognitive control of vocalization and gesture received support from parent-child interaction, as well as other social bonding mechanisms, and between-group identification. Once cortical control was established, *Homo erectus* was able to organize mimetic sequences for communication regarding intentions. However, these sequences lacked stable reference and were eventually supplemented by fixed items from a vocal lexicon. Then, using item-based patterns that relate arguments to their heads, speakers at the crest of a new wave of linguistic creativity constructed methods for recursive combination of words into phrases and sentences. At this point, vocal methods permitted a full mapping of embodied human perspectives through grammatical devices marking perspective shift. Together, these features of cortical control, lexical mapping, recursion, and perspective marking constitute the cognitive underpinnings for human language.

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