

# Chapter 23

## Language and Evolution

DEREK BICKERTON

### 1. Introduction

Almost all, if not all, species communicate in one form or another. Humans communicate perhaps more than any other species. Although their communications are immensely more complex than those of any other species, and convey an infinitely greater quantity of information, it has seemed to many that human language must have developed out of the communication systems of antecedent species. After all, we evolved as a single species of the primate family, and evolution is normally a gradual process, building on what is already there rather than creating novelties. One might well conclude that human language, different though it might seem from the communication systems of other species, developed out of them by a series of infinitesimal increments, the intermediate forms having been, unfortunately, lost.

However natural such an assumption might appear, there is strong evidence against it. For instance, such basic attributes of language as predication, symbolization, and displacement (the ability to refer to objects and events not physically present) are absent in animal communication systems (ACSs). Further, it is sometimes claimed that the multi-layered nature of modern human language argues against any continuity with ACSs: the basic building blocks of language are phonemes (units of sound meaningless in themselves), which are combined to form morphemes (the smallest meaningful units), which (if they are not in themselves already words) are combined to form words, which can then be combined to form phrases and sentences. But comparing this system with ACSs tell us nothing, since its type of organization may have come relatively late in the development of language. Accordingly, the discussion that follows will refer only to properties found in its most basic and rudimentary forms of language, such as “foreigner talk” (Ferguson, 1971), pidgins (Bakker, 1995), and the like – properties the absence of which would both deprive the word “language” of any meaning, and leave as mysterious as before the means through which those properties did eventually emerge. For instance, without true symbols, it would be impossible to refer to anything that was not physically present, and without predication, which is a semantic relationship before it is a syntactic one, it would not be possible to expand single-unit utterances. As for arguments that the present approach is guided by some anti-scientific or anti-evolutionary agenda, these should be treated as what they are – ways of avoiding

inconvenient facts (for arguments against language–ACS continuity see Bickerton, 1990, ch. 1).

## 2. Fundamental Differences Between Language and ACSs

The crucial differences between ACSs and language are qualitative, not quantitative. One of these involves the difference between symbolic and indexical reference (Deacon, 1997); human language has both, whereas ACSs have only the latter. If a unit is indexical, it can carry reference only if the entity it refers to is physically present. Thus the “leopard” alarm call of the vervet monkey (Cheney & Seyfarth, 1990) is meaningful only in the presence of a leopard; if uttered when no leopard is near, it is either deceptive or meaningless. It is impossible to question or negate a leopard call, since unlike a symbolic unit, an indexical unit does not “stand in place of” its referent but merely “points to” it. A symbolic unit, on the other hand, can be used to make general statements in the absence of any referent (“Leopards have spots”) and can be questioned (“Is that a leopard?,” or simply, “Leopard?,” with a rising inflection) or negated (“No leopards here!”). Deacon (1997) considers the symbolic–indexical distinction to be the major distinction between the language communication systems of our species and others. Certainly it is an absolute, not a scalar one; there cannot, in the nature of things, be any form intermediate between an indexical and a symbolic unit.

Another difference lies in predication. Every linguistic utterance that is not a mere exclamation (“Ouch!” or “Wow!”) refers to someone or something (sometimes referred to as the “subject”) and then makes a statement about that person or thing (sometimes referred to as the “predicate”). This is true of even the shortest and simplest utterances: “John left,” “Time’s up!,” “Dogs smell.” Even imperatives make the same distinction between subject and predicate, although the former is not overtly stated: if I say “Leave!” it is you that are being told to leave, and no one else. If ACSs produce a sequence of calls, each call remains a self-contained unit and its meaning is unaffected by being adjoined to another call: sequences cannot be combined in the way that subject and predicate combine in human language to produce a meaning different from that of either in combination. Even the most primitive forms of language, early-stage pidgins (Bickerton, 1981), employ true combinations where the meaning of the combination is more than the sum of the meanings of its parts. “John” by itself merely refers to a person; “left” by itself merely refers to some action of leaving in the past; but “John left” tells us what a specific person did on a specific occasion. Even the language of children, which initially passes through a one-word stage, already struggles to achieve predication (Scollon, 1974): a child will repeat a word until some grown-up pays attention, then utter another word which expresses some kind of comment on the first.

We are dealing here with another qualitative, not quantitative distinction: either an utterance involves predication, or it does not. The problem for those who believe in continuity between human language and ACSs is to show how predication might have developed from a system that lacked any vestige of predication. At least two scholars have tried to hypothesize intermediate stages between a prior ACS and language. Hockett (Hockett & Ascher, 1964) suggested a possible blending of preexisting calls: for instance, in a situation where food and danger were both present, some hominid might

have uttered half the call for “food” together with half the call for “danger.” However, sequencing is not the feature that distinguishes human language: predication is. A sequence, even a blending like the example given, is not predication, since “danger” would not constitute a comment (predicate) on a subject (“food”).

A more sophisticated proposal has recently been advanced by Wray (1998, 2000). She claims that the earliest forms of language were holophrastic, akin to calls; though they might contain only single and (at least initially) undecomposable units, their meaning would be equivalent to that of a human sentence (“That-animal-is-good-to-eat” or “I-want-to-mate-with-you,” for example). According to Wray, such units simply increased in number to a point at which they began to impose an excessive memory load. The holophrases were then decomposed on the basis of phonetic similarities. Wray’s own example (2000, p.297) makes the point clearly:

So if, besides *tebima* meaning *give that to her*, *kumapi* meant *share this with her*, then it might be concluded that *ma* had the meaning *female person + beneficiary*.

There are, however, many problems with this proposal (for a brief review, see Bickerton, 2003, and for a more thorough one, Tallerman, 2004). First, there are clearly only two logical possibilities: either *ma* occurs always and only in holophrases which also contain the meaning “female person + beneficiary,” or only some of its occurrences will bear this interpretation while others will not. In the first case, the language would be already synthetic; that is to say, the supposedly undecomposable holophrase would in reality consist of a string of separate (and separable) units combined just as they are combined in the syntaxes of contemporary languages. If it is to be taken seriously, Wray’s proposal must assume the second case. But if *ma* also occurred where a female + beneficiary reading was impossible – contexts perhaps as numerous as, or more numerous than, those that could bear such a reading – why would the hearer assume that it referred to a female beneficiary in just those cases where such a reading was possible, and how would that hearer account for the other cases?

But there is an even more basic problem with the holophrase proposal, which involves the tacit assumption that pairs of utterances like *tebima* and *kumapi* could exist in a language that had not already developed the kinds of distinction that only a synthetic language could develop. Hominids developing a holophrastic language would have had to learn that these two different utterances meant two different things. They could do this only by observing differences in the contexts where the two expressions were used. What kind of context would serve to distinguish “Give that to her” from “Share this with her”? Unless the hearer already knew the difference between “give” and “share,” and between “this” and “that” (which again assumes the prior existence of a synthetic language in which these would constitute units), the contexts where one or the other expression was appropriate would be virtually identical.

For that matter, the whole proposal depends on there being identity between each holophrase and just one particular synthetic equivalent. But this assumption is quite unrealistic. Suppose there is a holophrastic expression that could be regarded as equivalent to “Don’t come near me.” It could equally be regarded as equivalent to “Stay away from me,” “If you come nearer I’ll bite,” “Keep your distance,” or any of a number of similar expressions. If a phonetic sequence *gu* occurred within this holophrase, how

could it be given a unique interpretation? Some might assume it meant “come,” others “stay,” others “me,” others “your,” and so on indefinitely. In other words, such a holophrastic language would be highly unlikely ever to decompose into an appropriate set of units. These are by no means the only problems with Wray’s proposal, but those cited here should suffice to show that a bridge between any ACS and language is at best extremely difficult and perhaps impossible to construct. To insist on continuity without resolving the problems presented by symbols and predication is simply bad science.

### 3. Language as Adaptation

Rather than debating the form language first took, it might be more profitable to look at the kinds of selection pressure that might have given rise to it. If language was selected, what was it selected for? Early guesses included communal hunting and the making of tools. Nowadays, few if any evolutionists support these suggestions (see introduction to Hurford et al., 1998). Communal hunting is carried out by a number of species without benefit of language, while tool-making (and even instruction in tool-making) has been found to be performed through observation and imitation, rather than verbally, by the pre-literate hunters and gatherers who, we assume (perhaps even correctly), form the best models for the behavior of our remote ancestors (Ingold & Gibson, 1993). The fact that one might do something better if one had language cannot be a selective pressure – if it were, numerous other species would surely have language too. To break out of the mold of animal communication that had served all other species well since evolution began necessarily required some behavior that was impossible to perform without some language-like system.

Since Humphrey (1976) suggested that the likeliest driving force behind increased cognition and language was intraspecific competition, the search for a selective pressure has focused on the “Machiavellian strategies” (attempts to deceive others to the deceiver’s advantage) and high degree of social sophistication found among primates generally, and in particular among the great apes who are our closest relatives. The line of reasoning went as follows: when (presumably among australopithecines) social life grew more complex, intelligence increased to cope with these complexities, until either our ancestors became clever enough to invent language (Donald, 1991) or language spontaneously emerged to satisfy needs for gossip and/or grooming (Dunbar, 1996) or some other social function.

What is striking about the quite extensive literature on the supposed social origins of language is the extent to which it ignores most of what is known about hominid or pre-hominid evolution. All that most writers provide is a straight-line projection from modern ape behavior to modern human behavior, without any reference to particular species or periods of pre-history, and with little if any awareness of the ecology of species antecedent to our own. For instance, it seems to be tacitly assumed that human ancestors had just as much leisure and freedom from predation as modern, forest-dwelling apes have in which to develop and intensify their social lives. Given the size of australopithecines, both absolute and relative to the size of pre-historic predators, and their terrain of open woodland and savanna that was a prime hunting-ground for those predators, this is at best a highly unlikely assumption (Lewis, 1997). The ecological

**Table 23.1** Incongruous properties of language and ACSs

| <b>Language</b>              | <b>ACSs</b>                   |
|------------------------------|-------------------------------|
| Symbolism                    | Indexicality                  |
| Mostly objective information | Mostly subjective information |
| Displacement                 | No displacement               |

facts (McHenry, 1994) suggest that there would have been little time for the elaboration of Machiavellian strategies, and a sharply reduced tendency to indulge in them, due to the pressing need for trust, mutual support, and cooperation in the face of predation and the transient, widely scattered nature of food sources.

Moreover, those who claim social pressures as the selective force for language commit what, to many biologists, may seem a cardinal error. As numerous and highly detailed ethological studies have demonstrated (Byrne & Whiten, 1992; Goodall, 1986; Schaller, 1963; Smuts 1987; de Waal, 1982; etc.), apes already have a complex and well-developed social life. If such a life provided a selective pressure for language, how is it that one primate species and one only developed language in (eventually) a highly complex form, while none of the other species developed the least vestige of language? A unique adaptation can only result from a unique pressure. Thus in seeking for the selective pressure that resulted in language, any biologist would look elsewhere than among our closest relatives.

But where to look? The apparent uniqueness of language seems to render the task impossible. However, if instead of treating language as a whole we look at some of its specific properties, there may be a way out of this impasse. One property specific to language is that it conveys objective information – information about things other than the current affective state of the communicator. Indeed, it is almost impossible for a sentence not to convey objective information. Even in flattering someone – “That dress is a perfect match for your eyes” – we cannot avoid conveying the objective information that the dress and the person’s eyes are of similar color. In this, language differs from the vast majority of ACSs. Except for warning calls, units in such systems convey only needs, desires, or affective states; interestingly enough, the spontaneous productions of “language”-trained apes are almost all about things they want to eat or do (Terrace et al., 1979). This distinction between language and ACSs is almost certainly linked with the symbolic–indexical distinction. Unless something is a true symbol, it cannot substitute for the physical presence of its referent. However, symbolization is outside the reach of most species (Deacon, 1997) and it may well be that no species can achieve it unless that species has a pressing need to exchange information about things not physically present. Nothing in the life of other primate species provided such a need; only among human ancestors did such a need make itself felt, as will shortly be shown. The capacity kind of information exchange, known as “displacement” (see definition above), forms a basic property of human language. Indeed, three properties of language are tightly linked, and their distribution can be summarized graphically (Table 23.1).

There are a few exceptions, however, to the general rule that ACSs do not convey objective information. These are the “languages” of bees and ants – systems so limited and organisms so phylogenetically remote from humans that researchers have failed

to consider any implications they might have for language evolution. However, it may be fruitful to consider them in terms of convergence, a phenomenon familiar to evolutionary biologists (Conway Morris, 2003), on which recent work on niche construction (Odling-Smee, Laland, & Feldman, 2003) has shed much light. The classic example of convergence involves sharks, dolphins, and ichthyosaurs, all of which developed similar fins in response to the pressures of an aquatic existence. Similarly, ant and bee ACSs are adaptations selected for by choice of niche: central-point-based foraging in a fission-fusion mode, with a consequent need for reinforcement. This type of niche puts a premium on exchange of information.

Both bees and ants forage as individuals but recruit conspecifics to exploit transient (and often short-lived) food resources. Using a variety of physical movements (the so-called “round,” “waggle,” and “vibrating” dances) bees can convey to their fellows the distance, direction, and relative quality of the honey or pollen they have discovered (von Frisch, 1967). Ants also employ a type of “waggle dance” to recruit helpers but lay chemical trails to draw them to the discovered food supply (Sudd & Franks, 1987) – something obviously impossible for bees.

Apes also forage on a fusion-fission basis (Goodall, 1986). In their case, however, food sources are easily accessible, abundant, and (despite seasonal variations) relatively long-lived (von Lawick-Goodall, 1971). They neither need nor create central bases. Such was not the case for *Homo habilis*. Food sources were scattered over a wide area of open woodland and savanna, necessitating much larger day ranges; much food was transient, useless unless exploited within a period of days or even hours; and took a wide variety of forms (tubers, honeycombs, termites, birds’ eggs, and, most crucial because most nutritious, the scavenged carcasses of other mammals, see Binford, 1985). An additional problem was posed by predation (Lewis, 1997), which raised serious risks for solitary foragers and favored a central-point strategy (like that of baboons, another ground-dwelling primate, Kummer, 1968) based on a “safe haven” of tall trees or rocks that would serve as night-time protection (as with baboons, such bases may have been sites subject to frequent change rather than permanent or semi-permanent settlements). Under such circumstances, and given a plausible band size of say ~30 individuals, an optimal foraging strategy would consist of dividing the band into several smaller groups to scout resources, returning to the base (or some other pre-determined spot) if recruitment of larger numbers seemed advantageous.

In the course of niche extension (Odling-Smee et al., 2003) *Homo habilis* developed new food-seeking strategies. Their capacity for producing sharp-edged flakes and for using these as well as hammer-stones as tools gave them access to two food sources unavailable to other species. One was the still intact carcasses of megafauna whose skins were too thick to be pierced by the teeth of predators until several hours had elapsed and the skins were ruptured by normal decay processes (Blumenshine, Cavallo, & Capaldo, 1994; Monahan, 1996). The other was the bones of prey at any stage of decomposition, which could be cracked to obtain the rich and highly nutritious marrow within. The first represented a rather narrow window of opportunity, perhaps only a few hours; the second, a considerably longer one. But sources of both types required recruitment, since the first would be attended by major predators, the second by scavengers of all kinds. The scouting group that discovered either would need to recruit the whole band in order for some to fight off the predators while others attacked the

hide and butchered the carcass, or carried bones and meat to some more easily defensible site.

But how could recruitment take place? Ants and bees have little individuality and have been programmed by evolution for millions of years to carry out recruitment strategies. Human ancestors had been programmed by evolution for a very different lifestyle – that of the other great apes – and, like any other great ape, had strongly developed individualities. To convince all of them to do the same thing required information far more specific than could be provided by a food call or a scent trail (and in any case the capacity to lay the latter had vanished when still earlier ancestors had selected arboreal niches). Especially if more than one scouting group had found food sources at the same time, specific information about food-type, distance, risks involved, and perhaps other factors was vital for optimal foraging tactics.

Fortunately our ancestors could draw on a capacity widespread among organisms with relatively large brains that originally had nothing to do with communication. This was the capacity to discriminate between a wide variety of natural kinds, in particular other species, as well perhaps as certain types of action, where primate mirror neurons (neurons that fire not only when the subject performs an action but when the subject perceives another performing the same action) may have been helpful (Perrett et al., 1985; Rizzolatti, Fogassi, & Gallese, 2001). The resultant categories could have labels applied to them, resulting in a very primitive type of language (nowadays generally referred to as “protolanguage,” following Bickerton, 1990). During recent years, it has been shown that chimpanzees (Gardiner & Gardiner, 1969), bonobos (Savage-Rumbaugh, 1986), gorillas (Patterson & Linden, 1982), orangutans (Miles, 1990), dolphins (Herman, 1987), and even sea lions (Schusterman & Krieger, 1984) and African gray parrots (Pepperberg, 1987) can be taught to use simple quasi-linguistic systems that consist of little more than labels attached to concepts/categories. The additional capacity to string such labels together to form elementary propositions seems to have arisen spontaneously and without any explicit training in almost all these animals, suggesting that all they lacked of the prerequisites for protolanguage was a set of labels for preexisting concepts: the rest of the necessary machinery was already in place. This does not mean that ACSs and human language are continuous. Possession of semantic structure (giving rise to a rich set of concepts), sound recognition (enabling hearers to decide whether one sound or set of sounds is the same as, or different from, another), imitative ability and similar capacities may have existed as independent properties in antecedent species, but all these and more had first to be welded together into a single dedicated system before language could begin.

It is sometimes objected that if other species had any kind of language capacity, they would already have deployed it in the wild. Such a belief distorts the way evolution works. Every organism has latent capacities; if this were not so, it would be impossible for species to diversify by extending their niches. However, those latent capacities will never be triggered unless some immediate problem can be resolved or some immediate benefit obtained by exercising them. What would other species have needed language for? With the hindsight that many thousands of years of language development has bestowed, it has seemed to many that language is an adaptive mechanism conferring multiple and unlimited benefits on those who possess it. But we have to imagine not what “language” would confer on a species but what a very small handful of symbolic

items would confer. For that is exactly what any language must be at its inception. With a means so limited, there is actually very little one can do (a strong argument against any origin for language in social intercourse, since any kind of social use would presuppose at least a sizeable vocabulary). Apes, for instance, are capable of handling quite complex social lives without language, and of course, no species (least of all our remote ancestors) could have predicted what language might have been able to do for it once the early stages of development were past.

#### 4. The Protolinguistic Adaptation

Accordingly, the most plausible hypothesis for the origin of language is that it developed in the context of extractive foraging by sub-units of small bands, and consisted of a handful of symbolic units used to identify food sources and the location and accessibility of these. The nature of the units remains undetermined, although it has been the subject of some controversy. Some researchers, such as MacNeilage (1998), see language as emerging via the modality of speech from the very beginning. Others, such as Corballis (2002; see also Hewes, 1973) see language as originating in the form of manual gestures. However, there is no reason to regard these choices as mutually exclusive; ant “language” uses chemical, gestural, and tactile modalities, for instance. The most plausible conjecture (and it can be no more than that) is that the first protolanguage users used whatever it took to communicate their message: vocal utterances, gestures, possibly pantomime (Arbib, 2004). The nature of the units is relatively unimportant, so long as they were truly symbolic.

Protolanguage did not supersede the preceding ACS. Humans still have an ACS; the human ACS (which includes sobs, laughter, facial expressions, and manual gestures like fist-shaking and “giving the finger”) and language are controlled from different areas of the brain and use different auditory wavelengths, though both are subject to cultural modification (Pinker, 1994). The two systems exist side by side, sometimes augmenting one another but never mixing (a further argument against supposing that one developed out of the other). For reasons discussed above in Section 2.0, its units (whether vocal sounds or manual signs) were most probably discrete and particulate, having much the same kind of referents as modern words – unlike the units of ACSs, whose meanings more closely correspond to those of phrases or sentences. Short propositions (“Dead-mammoth thataway!”) could have been produced by simply stringing such units together; perhaps, in the case given, by joining a trumpeting vocalization with a directional gesture. For it would be too much to expect that the symbolism of modern language, with its typically arbitrary associations between signifier and signified, should have emerged full-fledged at the dawn of protolanguage. In all probability, the beginnings of protolanguage included both iconic and indexical units as well as arbitrary, symbolic ones (note that in the example given, a trumpeting sound – iconic – combines with a pointing gesture – indexical – to yield displacement).

Among the misconceptions that have arisen about the nature of protolanguage is that it may have had only a narrow referential domain, and may have required some separate evolutionary development in order to acquire the property, common to all modern languages, of being able to refer to anything one can think of (Jackendoff,



2002; see also Mithen, 1997). Such is, of course, the nature of bee and ant “languages,” which can specify food locations and identify outsiders, but little else. However, we must bear in mind that these “languages” are really only ACSs that happen to have acquired, for adaptive reasons, one or two of the properties otherwise found only in language. Like other, less language-like ACSs, they have a specific genetic basis, the result of countless millennia of evolution, and hence are not subject to change or extension by their users. Protolanguage had no genetic basis specific to itself; it simply and opportunistically co-opted the elaborate system of conceptual categorization that had evolved in many of the more advanced mammals and birds. This system was potentially infinite in that its possessors could extend it indefinitely; as experiments by Herrnstein (1979) and associates showed, even pigeons could be trained to recognize fish, which they had certainly never encountered in the wild. Thus, although in its first tentative steps protolanguage was doubtless confined to the domain of foraging, it had built into it from its very beginning the potentiality of reference to anything at all that human ancestors could discriminate.

There can, therefore, be little doubt that once a sufficiently large and varied vocabulary had developed, protolanguage was put to a variety of uses – gossip, alliance-building, planning the group’s next moves, and more.

At what stage protolanguage selected the vocal mode must remain a matter for speculation (see Hewes, 1973; McNeilage, 1998, for contrasting views). This, along with other features (the refinement of phonetics and the establishment of a phonemic system, the development of a complex syntactic structure) are things that we know must have happened at some stage between the origin of protolanguage and the emergence of full human language, because all human languages nowadays have such things. We simply do not know, yet, exactly when or even in what sequence these and other related changes took place. The questions most researchers have tried to answer are to what extent these subsequent developments were incorporated into the human genome, and to what extent they merely exploited cognitive and other mechanisms that preexisted language. The section that follows presents some of the approaches that have been made to this still highly controversial issue.

## **5. Modern Human Language – Innate or Learned?**

It is obvious that language cannot be wholly innate, in the way that the songs of certain (though far from all) songbirds are wholly innate. If it were, the species would have only one language (with perhaps minor regional variations), whereas in fact any human infant can learn any of the more than 6,000 (superficially, at least, quite different) human languages. It is obvious that language cannot be wholly learned, since certain aspects of it (its phonology, for instance) are highly determined, and determining factors such as the physical structure of the vocal organs, and even skeletal structure—for example, changes in the degree of basocranial flexion (Lieberman, 1984)—have undergone heavy selection and consequent language-favoring adaptation over the past couple of million years. But between the two indefensible extremes of this section’s title, almost every conceivable intermediate position has been defended.

Over the past century, the balance of opinion has undergone at least two major shifts. In the early part of last century, behaviorism was dominant, language was believed to be a purely social construct, and hence if a new language were to be discovered it might differ unpredictably from any previous language. In the second half of the century, however, this view was challenged by generative grammarians (Chomsky, 1957, 1965), who pointed out that all normal humans had similar language abilities, that there were strong structural parallels beneath the apparent diversity of human languages, that the acquisition of language followed an identical course in all normal children, that children frequently produced sentences that they could not have learned through imitation, and that the linguistic input children received was inadequate for any inductive learning of the complex grammatical system underlying that input. This last, known as the “poverty of the stimulus” argument, was believed by generativists to render inevitable the conclusion that most of the syntactic structure of sentences was not learned, but innately specified. Further evidence came from Creole languages, which show a degree of uniformity in their structure that is not predictable from the mix of languages that went into their creation, and is doubly surprising in light of the sparse and conflicting primary data from which their first-generation speakers derived these similarities (Bickerton, 1981; for alternative viewpoints see Lefebvre, 1986; Mufwene, 2003, etc., although none of these satisfactorily accounts for inter-Creole resemblances). Similar phenomena have been observed in the sign languages of Nicaragua (Kegl et al., 1999), where input was even more chaotic and radically reduced.

Belief that syntax was largely innate predominated during the 1960s and early 1970s. However, during the past quarter-century, it has been attacked from a variety of viewpoints. In 1975 the New York Academy of Sciences held the first multidisciplinary conference on the evolution of language (Harnad, Steklis, & Lancaster, 1976), in which Chomsky notoriously dismissed the origin of language as an issue of no more scientific interest than the origin of the heart. Eight years previously, in a work that clearly staked out generative claims in the field of biology, Lenneberg (1967) had professed a similar lack of interest in language evolution; since language left no fossils, the course of that evolution was, he believed, irrecoverable. Future historians of science may well marvel at how the generative movement managed for so long to combine a belief that language was biologically based with a refusal to look at the biological evolution of language (note, however, that recently Chomsky has changed his position, see, e.g., Hauser, Chomsky, & Fitch, 2002). The immediate result was that few linguists, but many scholars from other disciplines who knew little linguistics, concerned themselves with language evolution. Such scholars tended to underestimate the complexity of the data that had to be accounted for. In consequence, while understanding of other aspects of language evolution broadened and deepened, the nature of what had evolved was largely ignored, and the grammars produced by generativists were frequently treated as arcane and convoluted formulations having little to do with the realities of language.

Although prejudice and ignorance played their parts in this opposition, there were legitimate causes for concern. The grammars proposed by generativists and the evolutionary processes known to biologists seemed irreconcilable: it was difficult if not impossible to see how one could have produced the other, hence scholars in the field were

overly quick to accept reassurance from non-generative linguists that syntax was simpler than the generativists made it look. Generativists did not help matters by continually changing generative theory. To outsiders, this looked as if they couldn't make up their minds; to insiders it was apparent that each new formulation represented an improvement on its predecessor, although few were rash enough to assume that the latest formulation represented the final truth about syntax. In consequence, there arose a state of mutual incomprehension that has yet to be completely overcome.

Another attack on the generativist/innatist position came from scholars working with models of connectionist networks who carried out computer simulations of language acquisition (Rumelhart & McLelland, 1986). These purported to show that not only could such models acquire particular features of language (such as the English system of past tense), they could even mimic the stages through which, in children, the acquisition process passed. Their claims have been challenged (Marcus, 1996), but other researchers have extended this approach to include computer simulations of how language might have evolved (for a current overview see Briscoe, 2002). As with the acquisition studies, the main thrust of evolutionary simulations has been to show that once linguistic utterances commenced, processes of automatic self-organization would eventually install lexical and syntactic regularities.

There are, however, some problems with this approach. First, although some fairly simple features, such as regularity of word order, have been shown to emerge spontaneously, this has not, with one or two exceptions, been demonstrated for more complex features. Second, the emergence of isolated features, however well these processes are mimicked, is not the same as the emergence of a complex system in which features on many levels are tightly interlocked. Third, some of the researchers have made odd and poorly motivated assumptions about the nature of language. One currently popular view is that languages are "organisms that have had to adapt themselves through natural selection to fit a particular ecological niche: the human brain" (Christiansen & Ellefson, 2002, p.338; see also Deacon, 1997). This, if taken metaphorically, might seem no more than a playful inversion of the innatist view that the structure of the human brain has determined the form that languages take. If taken literally, it is nonsense: languages are not independent entities, like living organisms. How could they "adapt themselves to the brain" unless they had a prior existence outside the human brain, and were delivered to humans (by Martian spacemen, perhaps) ready-made? In fact, the brains to which they supposedly "adapt" can only be what created them in the first place. Moreover, "natural selection" can take place only if there is something to select from. Unless we assume that for every human language there were a dozen or two unfit languages that fell by the wayside, use of the term in this context renders it meaningless.

A fourth and possibly more serious problem with evolutionary simulations lies in the improbable initial conditions that most if not all such programs assume. Improbabilities in the various proposals include, but are not limited to, the following: agents (the term used for the simulated speakers) have access to one another's meanings; agents make a variety of random sounds to express the same meaning; agents employ a mixture of word-equivalents and holophrase-equivalents (see discussion of holophrases in Section 2.0 above). Not one appears to incorporate the most likely initial

conditions: speakers know what they mean but their hearers initially don't; speakers pick a single form–meaning combination and stick to it; the referent of the form–meaning combination is a single entity or action, not a state or a situation; meanings are acquired by hearers through observing contexts of use. Until simulations can grapple with plausible real-world scenarios of first-stage language evolution, they will shed little light on it.

The most threatening source of possible counter-evidence to nativist claims comes from brain imaging techniques. Before the introduction of functional magnetic resonance imaging (fMRI), Positron emission tomography (PET) scans, and other means of directly representing neurological processes, neurology, based mainly on aphasia studies, had lent credence to the view that syntax was processed by Broca's area and semantics by Wernicke's area – thus that the brain might indeed contain a localized, discrete analog of Chomsky's "language organ" (Chomsky, 1980). However, scans of actual brains performing various linguistic tasks showed that all of these tasks involved numerous areas of the brain besides the familiar "language areas" – some of them even in the cerebellum, which had previously been believed to be concerned exclusively with non-cognitive functions (Indefrey et al., 2001; Pulvermuller, 2002; Dogil et al., 2002). Note, however, that this evidence rules out only a strictly localist version of innateness. A distributed innateness remains possible. An innate mechanism could consist of a specific wiring plan for the brain, a series of neural connections (linking a variety of areas many of which are also involved in non-linguistic tasks) that are found in human brains but not in those of other species. If so, it remains unclear how such a plan might be instantiated. We need to know more about how brain structure is built up during both pre- and post-natal development. Since neurons in the brain outnumber genes by several orders of magnitude, functions cannot be genetically determined at the cell level. How they might be determined at the level of areas and/or networks remains a profound mystery. Connectionists (people who believe that language and other cognitive capacities do not depend on mental representations, but can be generated by the activities of neural networks alone) would claim that language functions in the brain are not genetically determined at all, but that an equipotential brain is programmed by the input it receives. But of course connectionists have no good explanation for why other ape species, with brains not dissimilar (except in size) to ours, cannot acquire language.

The nativist response to criticism is to state, usually correctly, that the critics simply do not know enough about language (and in particular, about syntax) and in consequence seriously underestimate both the complexity and the task-specificity of the neural machinery required to run it. Typical of the phenomena they invoke are contrasts like the following (an asterisk indicates an ungrammatical sentence):

- 1a) Who did you think that she saw?
- b) Who did you think she saw?
- c) Who did you think saw her?
- d) \*Who did you think that saw her?

If (1a) and (1b) are equally acceptable, why is (1c) acceptable but its equivalent, (1d) not?

- 2a) Bill needs someone to inspire him.
- b) Bill needs someone to inspire.

In (2a) “someone” is to do the inspiring; in (2b), “Bill” is to do it. Why should the presence versus the absence of a pronoun at the end of the sentence change the subject of “inspire,” and why should it change them in this direction, rather than the reverse direction?

- 3a) Bill and Mary wanted a chance to talk to one another.
- b) \*Bill and Mary wanted Mr Chance to talk to one another.

Why should the switch from a common to a proper noun make (3b) ungrammatical, when its meaning is simple and straightforward – Bill wants Mr Chance to talk to Mary and Mary wants Mr Chance to talk to Bill? How is it that we can’t express that meaning unless we spell it out in this way?

- 4a) Jane is a person that everyone likes as soon as they see her.
- b) Jane is a person that everyone likes as soon as they see.
- c) \*Jane is a person that everyone likes her as soon as they see.

Why is (4) grammatical with a final pronoun or with no pronouns but ungrammatical with a pronoun in the middle?

These are typical of countless puzzling aspects of syntax that are seldom considered by most scholars in the field of evolution. They are not trivial. They represent, not quirks of the English language, but phenomena found across a wide range of languages – perhaps, in one form or another, across all languages. For this to be the case, it is quite implausible that children induced rules that gave the same result in each case in every language. How would you induce a rule involving something that isn’t there, as you would have to in inducing anything from examples (1c), (2b), and (4a, b)? It seems much more plausible that examples (1)–(4) do not represent examples of four separate rules, but rather reflect one or more very deep principles that the child could not have induced from data, but that must somehow apply automatically, without any kind of learning being involved. Words have to be learned in every language because they are different in every language, but the so-called “empty categories” such as are found in examples (1c), (2b) and (4a, b) are the same in every language: gaps, where words might be expected to occur and where they can occur, that yield grammatical results in some cases and ungrammatical results in others.

If such phenomena do indeed result from deep principles, then those principles must (somehow) be instantiated both in the human genome and in the human brain, and must have evolved like every other adaptation. In that case, it is irrelevant that linguists still cannot agree what those principles are.

It must be that the brain processes syntax in one particular way, and that such a way is describable. What is known about the capacities of the brain should constrain theories of syntax, at least to the extent that no theory incompatible with such knowledge should be supported. But likewise, what is known about syntax should constrain theories about how the brain generates sentences, to an identical extent. We are still

some distance from such a level of interdisciplinary cooperation, but that level must be reached; no theory of language evolution can be complete that does not explain how the basic principles underlying sentence structure came to be the way they are, and not some other way.

Two recent developments in generative grammar have the potentiality to increase chances of arriving at the correct formulation of basic syntactic principles. The first is the Minimalist Program (Chomsky, 1995), whose professed goals are to substitute genuine explanations for mere restatements of problems in other terms, and to bring hypothesized mechanisms down to an irreducible minimum. The second is the Derivational version of that program (Epstein et al., 1998) which, in contrast to earlier versions of generative grammar, builds grammatical structures from the bottom up, instead of first building an entire abstract tree and then inserting lexical items (the Representational approach). However, it is still too early to see where, if anywhere, these developments will lead.

Thus the extent to which syntax is innate remains a highly controversial issue, with no clear signs of a resolution in sight. The question of how syntax evolved, answers to which depend at least in part on the resolution of the innateness issue, is, unsurprisingly, no less confused.

## 6. The Evolution of Syntax

Was syntax a distinct adaptation, specially selected for? Or was it an exaptation, a mere change in the function of some preexisting capacity? Or did it result, like ice crystals, automatically, due to some hitherto-unstated “law of form”? Or was it the result of a purely fortuitous mutation?

All of these sources have been proposed. The least likely is the fourth (Klein & Edgar, 2002) – that a single mutation could result in all the complexities of syntax. As Pinker and Bloom (1990) noted, these complexities resemble those of the eye, an organ produced by millions of years of natural selection. Consequently, given the gradualness and piecemeal development characteristic of evolution, the first reaction of any biologist would be to suppose that syntax too had evolved in a series of increments, each one somewhat superior to its predecessor, each one specially selected for.

Yet, as so often happens where language is concerned, the straightforward biological solution runs into problems. First there is the problem of time. The eye had tens of millions of years, at least, in which to evolve; syntax has, at most, about two million – unless, contra the balance of the evidence, we are willing to award some degree of syntax to australopithecines. Second, there is the problem of intermediate forms. With the eye, this presents no problems. Countless organisms still survive with eyes in various stages of development. No other organism, however, has anything more language-like than an ACS. In principle, one might partially overcome this deficiency by hypothetically reconstructing intermediate stages. But quite apart from the difficulty of doing this (the flaws in intermediates proposed by Premack, 1985, and Pinker, 1994, are discussed in Bickerton, 1995), there may be a much deeper problem.

The anti-evolution jibe, “What use is 5 percent of an eye?” is easily answered: “More use than 3 percent of an eye.” But what use is 5 percent of syntax? The function of

syntax is to make utterances automatically processable, hence immediately comprehensible, to the hearer. If what the hearer receives is an utterance in an early-stage pidgin, or the speech of a recent and untutored immigrant, that utterance often can't be quickly and smoothly processed: deprived of the grammatical cues that syntax provides, the hearer frequently has to puzzle over its meaning, must use additional contextual and pragmatic information, and even with the aid of these may still misunderstand the message. In contrast, a message in the hearer's own language will seldom if ever require contextual or pragmatic clues (unless it is structurally ambiguous) and will be understood immediately in the vast majority of cases. Just what, between these two extremes, could 5 percent or 25 percent of syntax do for hearers? While it is easy to see which particular additions to 5 percent of an eye would enable its owner to see more detail, or more colors, or discriminate between more types of object, it remains unclear which particular additions to 5 percent of syntax would improve quantity or quality of understanding – or, if they did, how they would do it.

If there were intermediate grammars, they would have to be individually selected for. Pinker and Bloom (1990) seem to assume that a grammar would consist of large numbers of rules, as in pre-1980 generative grammars; speakers with  $n$  rules would be replaced by speakers with  $n + 1$  rules. Yet at other times they speak as if the units of selection consisted of the constraints on rules (forerunners of the “principles” of more modern grammars) that played an increasing role in grammars from the late 1960s on. One such example they give is Subjacency, a constraint that prevents italicized words from being moved from their original positions (marked by \_\_\_\_\_) to positions outside the square brackets, as in (5):

- 5a) [What did Bill deny that he found \_\_\_\_\_?]
- b) \*What did Bill deny [the fact that he found\_\_\_\_\_?]
- c) \*What did you lose it [and Bill found\_\_\_\_\_?]
- d) \*What did Bill tell you [where he had found\_\_\_\_\_?]

Rules and constraints, however, are equally implausible as targets for selection. In the case of Subjacency, for instance, we would have to make the unlikely assumption that speakers were producing large numbers of sentences like (5b–d) and hearers were failing to understand them until a handful of speakers started limiting their production to sentences like (5a), whereupon members of the second promptly started to have more children than members of the first group.

While a large syntactic increment might secure such a result through female choice (females would mate preferentially with males who controlled a wider variety of syntactic forms and were more readily understandable), it is hard to see how the small increments envisaged by Pinker and Bloom would have any such effect, or would increase fitness in any way sufficient to alter the composition of the gene-pool. Syntacticized language may be adaptive as a whole, once established (it is quite possibly what gave our ancestors the edge over Neanderthals), but in considering how it became established, a long string of adaptations each requiring its own separate selective history hardly seems the likeliest scenario. One therefore has to consider the two remaining alternatives.

The exaptation alternative has been most clearly set forth in Hauser et al. (2002), although this paper appears to be a strange compromise between scholars who previously held diametrically opposed positions – Hauser (1996) affirming continuity with ACSs, Chomsky (1988) equally emphatically denying it. In the 2002 paper, everything in language but recursion – the capacity to expand a linguistic expression without limit, as in *the dog, the black dog, the black dog in the yard, the black dog in the yard that you saw yesterday, etc.* – is regarded as being shared with other species, and the capacity for recursion itself is seen as having been co-opted from some preexisting faculty that originally dealt with other computational problems such as navigation, number quantification, or social relationships. But this proposal is in fact no more than a promissory note. No indication is given as to how the alternatives listed (and doubtless others) would be weighed against one another, what kind of evidence would be sought, or why, given that recursion must consequently exist at least embryonically in apes, apes are quite unable to learn recursion, even though they can learn lexical items with relatively little trouble.

Explanations of the third kind, based on laws of form (Thompson, 1992), Fibonacci numbers, self-organization, and similar factors constitute what is sometimes called a “neo-neo-Darwinist” approach (Piatelli-Palmerini, 1989; Jenkins, 2000). This approach, a reaction to the current “neo-Darwinian” consensus based on the merger of natural selection with post-Mendelian genetics, regards the role of natural selection in current evolutionary theory as being highly exaggerated, and seeks for as many alternative explanations as possible. Such explanations seem more interested in discrediting natural selection than advancing hypotheses specific and coherent enough to be argued about; at least, no such hypotheses have emerged to date. However, an explanation falling into this general class may still prove valid (Calvin & Bickerton, 2000; Bickerton, 2002).

Relative to their size, humans have the largest brains of any animal. It would be strange if this fact and our unique possession of language were unconnected. To some, the connection has seemed to take the form of a causative sequence: big brains → high intelligence → capacity for language. But this cannot be right. If, as seems the likeliest possibility, human language was complete and in place by the early stages of *Homo sapiens sapiens*, it preceded rather than followed the appearance of intelligent behavior; it seems more likely that language itself created human intelligence (McPhail, 1987). However, consider the tasks set for the human brain by the requirements of protolanguage and the requirements of language, respectively. Protolanguage required the brain to send the neural impulses that represent words to the motor areas controlling the organs of speech, one word at a time (represent A, send A, execute A; represent B, send B, execute B, with A, B etc. representing isolated words). Language requires the brain to take the neural impulses that represent a word and then merge it with the neural impulses that represent another word, repeating the process as many times as is necessary to build a complex phrase or sentence (most probably, whatever would come under a single intonation contour) and only then send the entire complex of impulses to the motor areas for execution (represent A, represent B, merge representations of A and B, represent C, merge C with AB . . . send ABC . . . execute ABC). Clearly the second process is far more complex and fraught with problems than the first. Perhaps the most serious problem is to avert message decay – that is, to prevent any



parts of the message from becoming garbled during assembly and dispatch. Normal leakage that affects all electrical impulses is worsened by the fact that no given pair of neurons will ever fire with perfect synchronicity. The only way to overcome this is to have the same message sent by large numbers of neurons so that receiving centers average their output. But in all probability, brains smaller than those of humans do not have large enough numbers of neurons that can be spared from other tasks.

The foregoing hypothesis (see Bickerton, 2003 for a fuller discussion) provides an explanation for the ability of many other species to acquire protolanguage and their inability to acquire human language. It would also explain why, even if protolanguage emerged as early as suggested here, true language developed only in our species (and perhaps Neanderthals). It would explain the abruptness with which human intelligence manifested itself (only 40,000 years ago on the conventional wisdom; 90,000 years ago if we recognize recent discoveries in Africa, see McBrearty & Brooks, 2000), if language was indeed the major force in developing human intelligence (and no equally convincing candidate has been proposed).

Until messages could be reliably assembled and transmitted in the linguistic mode, it was safer to use the protolinguistic mode. In other words, even if some true-language ability existed in earlier species, its actual manifestation could have been quite abrupt, as one species (ours) switched entirely to the linguistic mode. A further advantage of the model is that it requires no additional neural machinery over and above what apes come equipped with, apart from an added number of brain cells and some novel connections between these. The phenomena of syntax would then hopefully fall out from the brain's mode of processing and assembling any complex information. But for the moment this remains a very large promissory note, and the model also requires validation from advances in neuroscience and neuroimaging.

## 7. The “Cultural Evolution” of Language

Is language evolution finished? Some would deny this. In a recent article in *Science*, the authors wrote “Language evolution has not stopped, of course; in fact, it may be progressing more rapidly than ever before” (Culotta & Hanson, 2004, p.1315). This statement reflects a profound misunderstanding. The faculty of language is based, as we have seen, on human biology. For as far back as history will take us, there are no signs of any change in this basic infrastructure, and there is every reason to believe that the languages of 100,000 years ago, though superficially different from ours in many ways, would have the same basic structure. In other words, as far as language is concerned, evolution is at a virtual standstill.

Granted, languages continue to change. Darwin was impressed by the analogy between the way in which languages diverge, diversify, and sometimes die out and the way in which species diverge, diversify, and sometimes go extinct. But this analogy is superficial and leads nowhere. Even the term “cultural evolution” is misleading. Languages change, not in response to cultural developments, but because of either internal or contingent causes. Internally motivated change may result from a variety of factors. For instance, the gradual erosion of sounds at the ends of words, where important grammatical information is often carried, results in the substitution of

auxiliary verbs for inflected tenses and pre- or post-positions for case-markers. Change may also result if the increasingly frequent use of a marked word order leads to reanalysis of this as the basic word order. Contingency-motivated change occurs when, through conquest, speakers of one language are dominated by speakers of another language, or when a small language community becomes marginalized and its speakers all die or abandon their native tongue. There is no connection whatsoever between particular types of culture and particular types of language: in the vivid phrase of Sapir (1921), “Alexander walks with the Macedonian swineherd, and Lao Tse with the head-hunter of Assam.”

In fact, once the biological faculty of language was established, all languages did, or could do, was cycle and recycle through a limited set of possibilities within the narrow envelope that the biological faculty left open for them. Thus to speak of “cultural evolution,” at least with respect to language, is a solecism we should learn to avoid.

## References

- Arbib, M. A. (2004). *From monkey-like action recognition to human language*: New York: Columbia University Press.
- Bakker, P. (1995). Pidgin languages. In J. Arends, P. Muysken, & N. Smith (Eds). *Pidgins and creoles: an introduction*. Amsterdam: John Benjamins.
- Bickerton, D. (1981). *Roots of language*. Ann Arbor, MI: Karoma.
- Bickerton, D. (1990). *Language and species*. Chicago: University of Chicago Press.
- Bickerton, D. (2002). Foraging versus social intelligence in the evolution of language. In A. Wray (Ed.). *The transition to language* (pp. 207–25). Oxford University Press.
- Bickerton, D. (2003). Symbol and structure: a comprehensive framework for language evolution. In M. H. Christiansen & S. Kirby (Eds). *Language evolution* (pp. 77–93). Oxford: Oxford University Press.
- Binford, L. S. (1985). Human ancestors: changing views of their behavior. *Journal of Anthropological Archaeology*, 4, 292–327.
- Blumenschine, R. J., Cavallo, J. A., & Capaldo, S. P. (1994). Competition for carcasses and early hominid behavioral ecology. *Journal of Human Evolution*, 27, 197–214.
- Briscoe, T. (Ed.). (2002). *Linguistic evolution through language acquisition: formal and computational models*. Cambridge: Cambridge University Press.
- Byrne, R. W., & Whiten, A. (1992). Cognitive evolution in primates: evidence from tactical deception. *Man*, 27, 609–27.
- Calvin, W., & Bickerton, D. (2000). *Lingua ex machina: reconciling Darwin and Chomsky with the human brain*. Cambridge, MA: MIT Press.
- Cheney, D., & Seyfarth, R. M. (1990). *How monkeys see the world*. Chicago: Chicago University Press.
- Chomsky, N. (1988). *Language and problems of knowledge*. Cambridge, MA: MIT Press.
- Chomsky, N. (1957). *Syntactic structures*. The Hague: Mouton.
- Chomsky, N. (1965). *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.
- Chomsky, N. (1980). *Rules and representations*. New York: Columbia University Press.
- Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: MIT Press.
- Christiansen, M. H., & Ellefson, M. R. (2002). Linguistic adaptation without linguistic constraint: the role of sequential learning in language evolution. In A. Wray (Ed.). *The transition to language* (pp. 335–58). Oxford University Press.

- Christiansen, M. H., & Kirby, S. (2003). *Language evolution*. Oxford: OUP.
- Conway Moris, S. (2003). *Life's solution: inevitable humans in a lonely universe*. Cambridge: Cambridge University Press.
- Corballis, M. C. (2002). *From hand to mouth: the origins of language*. Princeton: Princeton University Press.
- Culotta, E., & Hanson, B. (2004). First words. *Science*, 303, 1315.
- Deacon, T. (1997). *The symbolic species*. New York: Norton.
- Dogil, G., Ackerman, H., Grodd, W., Haider, H., Kamp, H., Mayer, J., Riecker, A., & Wildgruber, D. (2002). The speaking brain: a tutorial introduction to fMRI experiments in the production of speech, prosody and syntax. *Journal of Neurolinguistics*, 15, 59–90.
- Donald, M. (1991). *Origins of the modern mind*. Cambridge, MA: Harvard University Press.
- Dunbar, R. I. M. (1996). *Grooming, gossip and the evolution of language*. London: Faber & Faber.
- Epstein, S. D., Groat, E. M., Kawashima, R., & Kitahara, H. (1998). *A derivational approach to syntactic relations*. Oxford: Oxford University Press.
- Ferguson, C. A. (1971). Absence of copula and the notion of simplicity: a study of normal speech, baby talk, foreigner talk and pidgins. In D. Hymes (Ed.). *The pidginization and creolization of languages* (pp. 141–50). Cambridge: Cambridge University Press.
- Frisch, K. von. (1967). Honeybees: do they use direction and distance information provided by their dancers? *Science*, 158, 1072–76.
- Gardener, R. A., & Gardener, B. T. (1969). Teaching sign language to a chimpanzee. *Science*, 164, 664–72.
- Gibson, K. R., & Ingold, T. (Eds). (1993). *Tools, language and cognition in human evolution*. Cambridge: Cambridge University Press.
- Goodall, J. (1986). *The chimpanzees of Gombe: patterns of behavior*. Cambridge, MA: Harvard University Press.
- Harnad, S. R., Steklis, H. D., & Lancaster, J. (1976). *Origins and evolution of language and speech*. Annals of the New York Academy of Science, vol. 280.
- Hauser, M. D. (1996). *The evolution of communication*. Cambridge, MA: MIT Press.
- Hauser, M. D., Chomsky, N., & Fitch, W. T. (2002). The language family: what is it, who has it, and how did it evolve? *Science*, 298, 1569–79.
- Herman, L. M. (1987). Receptive competences of language-trained animals. In J. S. Rosenblatt, C. Beer, M. C. Busnel, & P. J. B. Slater (Eds). *Advances in the study of behavior* (Vol. 17; pp. 1–60). San Diego, CA: Academic Press.
- Herrnstein, R. J. (1979). Acquisition, generalization, and discrimination reversal of a natural concept. *Journal of Experimental Psychology (Animal Behavior Processes)*, 5, 116–29.
- Hewes, G. W. (1973). Primate communication and the gestural origins of language. *Current Anthropology*, 14, 5–24.
- Hockett, C. F., & Ascher, R. (1964). The human revolution. *Current Anthropology*, 5, 135–68.
- Humphrey, N. K. (1976). The social function of intellect. In P. P. G. Bateson & R. A. Hinde (Eds). *Growing points in ethology* (pp. 303–17). Cambridge: Cambridge University Press.
- Indefrey, P., Hagoort, P., Herzog, H., Seitz, R. J., & Brown, C. M. (2001). Syntactic processing in left prefrontal cortex is independent of lexical meaning. *Neuroimage*, 14, 546–55.
- Jackendoff, R. (2002). *Foundations of language: brain, meaning, grammar, evolution*. New York: Basic Books.
- Jenkins, L. (2000). *Biolinguistics: exploring the biology of language*. Cambridge: Cambridge University Press.
- Kegl, J., Senghas, A., & Coppola, M. (1999). Creation through contact: sign language emergence and sign language change in Nicaragua. In M. DeGraff (ed.). *Language creation and language change: creolization, diachrony and development* (pp. 179–237). Cambridge, MA: MIT Press.
- Klein, R. G., & Edgar, B. (2002). *The dawn of human culture*. New York: John Wiley & Sons.

- Kummer, H. (1968). *Social organization of hamadryas baboons*. Basel, Switzerland: Karger.
- Lawick-Goodall, J. van (1971). *In the shadow of man*. New York: Dell.
- Lefebvre, C. (1986). Relexification and creole genesis revisited: the case of Haitian Creole. In P. Muysken, & N. Smith (Eds). *Substrata versus universals in creole genesis* (pp. 279–300). Amsterdam: Benjamins.
- Lenneberg, E. (1967). *Biological foundations of language*. New York: Wiley & Sons.
- Lewis, M. E. (1997). Carnivore paleoguilds of Africa: implications for hominid food procurement strategies. *Journal of Human Evolution*, 32, 257–88.
- Lieberman, P. (1984). *The biology and evolution of language*. Cambridge, MA: Harvard University Press.
- McBrearty, S., & Brooks, A. (2000). The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution*, 39, 453–563.
- MacNeilage, P. F. (1998). The frame/content theory of the evolution of speech production. *Behavioral and Brain Sciences*, 21, 499–546.
- Marcus, G. F. (1996). Children's overregularization of English plurals: a quantitative analysis. *Journal of Child Language*, 22, 447–59.
- McPhail, E. M. (1987). The comparative psychology of intelligence. *Behavioral and Brain Sciences*, 10, 645–95.
- McHenry, H. M. (1994). Behavioral ecological implications of early hominid body size. *Journal of Human Evolution*, 27, 77–88.
- Miles, H. L. (1990). The cognitive foundations for reference in a signing orangutan. In S. Parker & K. Gibson (eds). *"Language" and intelligence in monkeys and ape: Comparative developmental perspectives* (pp. 511–39). Cambridge: Cambridge University Press.
- Mithen, S. (1997). *The prehistory of the mind*. London: Thames & Hudson.
- Monahan, C. M. (1996). New zooarchaeological data from Bed II, Olduvai Gorge, Tanzania: implications for hominid behavior in the early Pleistocene. *Journal of Human Evolution*, 31, 93–128.
- Mufwene, S. (2003). *The ecology of language evolution*. Cambridge: Cambridge University Press.
- Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (2003). *Niche construction: the neglected process in evolution*. Princeton: Princeton University Press.
- Patterson, F., & E. Linden. (1982). *The education of Koko*. New York: Andre Deutsch.
- Pepperberg, I. M. (1987). Acquisition of the same/different concept by an African Grey parrot. *Animal Behavior and Learning*, 15, 423–32.
- Perrett, D., Smith, P. A. J., Mistlin, A. J., Chitty, A. J., Head, A. S., Potter, D. D., Broenniman, R., Milner, A. P., & Jeeves, M. A. (1985). Visual analysis of body movements by neurones in the temporal cortex of the macaque monkey. *Behavior and Brain Research*, 16 (2–3), 153–70.
- Piatelli-Palmerini, M. (1989). Evolution, selection and cognition: from "learning" to parameter setting in biology and the study of language. *Cognition*, 31(1), 1–44.
- Pinker, S. (1994). *The language instinct*. New York: Harper/Collins.
- Pinker, S., & Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences*, 13, 707–84.
- Premack, D. (1985). Gavagai, or the future history of the animal language controversy. *Cognition*, 19, 207–96.
- Pulvermuller, F. (2002). A brain perspective on language mechanisms: from discrete engrams to serial order. *Neurobiology*, 574, 1–27.
- Rizzolatti, R., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Reviews Neuroscience*, 2, 661–70.
- Rumelhart, D., & McLelland, J. (1986). *Parallel distributed processing. Explorations into the micro-structure of cognition*. Cambridge, MA: MIT Press.
- Sapir, E. (1921). *Language: an introduction to the study of speech*. New York: Harcourt & Brace.

- Savage-Rumbaugh, S. (1986). *Ape language: from conditioned response to symbol*. New York: Columbia University Press.
- Schaller, G. B. (1963). *The year of the gorilla*. New York: Ballantyne.
- Schusterman, R. J., & Krieger, K. (1984). California sea lions are capable of semantic interpretation. *The Psychological Record*, 34, 3–23.
- Scollon, R. (1974). *One child's language from one to two: the origins of construction*. Unpublished doctoral dissertation, University of Hawaii.
- Smuts, B. (Ed.). (1987). *Primate societies*. Chicago: University of Chicago Press.
- Sudd, J. H., & Franks, N. R. (1987). *The behavioral ecology of ants*. New York: Chapman & Hall.
- Tallerman, M. (2004). *Analyzing the analytic: problems with holistic theories of protolanguage*. Paper presented at the Fifth Biennial Conference on the Evolution of Language. Leipzig, Germany, April.
- Terrace, H. S., Pettito, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science*, 206, 891–900.
- Thompson, D'A. W. (1992). *On growth and form*. Cambridge: Cambridge University Press.
- de Waal, F. B. M. (1982). *Chimpanzee politics: power and sex among apes*. London: Cape.
- Wray, A. (1998). Protolanguage as a holistic system for social interaction. *Language and Communication*, 18, 47–67.
- Wray, A. (2000). Holistic utterances in protolanguage: the link from primates to humans. In C. Knight, M. Studdert-Kennedy, & J. R. Hurford, (Eds). *The evolutionary emergence of language: social function and the origins of linguistic form* (pp. 285–302). Cambridge: Cambridge University Press.
- Wray, A. (Ed.). (2002). *The transition to language*. Oxford: Oxford University Press.

### Further Reading

- Bickerton, D. (1998). Catastrophic evolution: the case for a single step from proto-language to full human language. In J. R. Hurford, M. Studdert-Kennedy, & C. Knight (Eds). *Approaches to the evolution of language: social and cognitive bases* (pp. 341–58). Cambridge: Cambridge University Press.
- Bickerton, D. (1990). *Language and species*. Chicago: University of Chicago Press
- Bickerton, D. (in press). *Adam's tongue: how humans made language, how language made humans*. New York: Farrar, Straus & Giroux.
- Briscoe, T. (Ed.). (2002). *Linguistic evolution through language acquisition: formal and computational models*. Cambridge: Cambridge University Press.
- Christiansen, M. H., & Kirby, S. (Eds.) (2003). *Language evolution*. Oxford: Oxford University Press.
- Deacon, T. (1997). *The symbolic species*. New York: Norton.
- Hurford J. R., Studdert-Kennedy, M., & Knight, C. (Eds). (1998). *Approaches to the evolution of language: social and cognitive bases*. New York: Cambridge University Press.
- Knight, C., Studdert-Kennedy, M., & Hurford, J. R. (Eds). (2000). *The evolutionary emergence of language: social function and the origins of linguistic form*. Cambridge: Cambridge University Press.
- McBrearty, S., & Brooks, A. (2000). The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution*, 39, 453–563.
- Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (2003). *Niche construction: the neglected process in evolution*. Princeton: Princeton University Press.
- Terrace, H. S., Pettito, L. A., Sanders, R. J., & Bever, T. G. (1979). Can an ape create a sentence? *Science*, 206, 891–900.