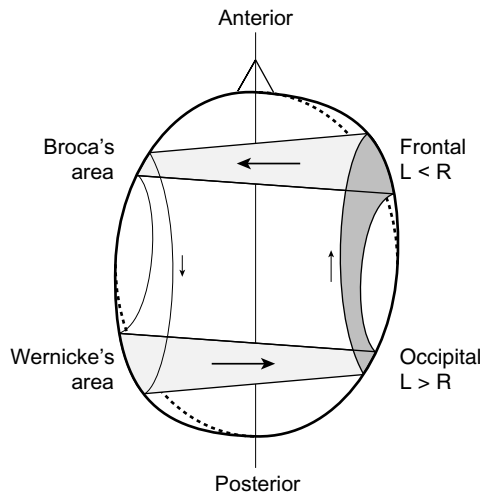


II

LANGUAGE AND THE EVOLUTION OF THE BRAIN

Asymmetry as the defining characteristic of the human brain



The right-frontal to left-occipital 'torque' of the human brain and its influence on inter- and intra-hemispheric connectivity of areas of heteromodal association cortex (from Crow TJ. Nuclear schizophrenic symptoms as a window on the relationship between thought and speech. *Brit J Psychiat* 1998; 173: 303-309).

From Protolanguage to Language

DEREK BICKERTON

Summary. Although evolution is normally conceived of as a gradual process, it can produce an appearance of catastrophism where functions change ('pre-adaptation') or where gradual changes in two or more components impinge on one another. The fossil and archaeological records argue strongly for some such development in the case of human language. It is argued that language as we know it requires the conjunction of three things: (1) an event structure derived from reciprocal altruism; (2) the capacity to use unstructured symbolic units (protolanguage); and (3) sufficient 'spare' neurones (i.e. neurones uncommitted to any single function) to maintain the coherence of internally generated messages in brains designed by evolution to attend primarily to the environment. These developments co-occurred only in the human species, accounting for the uniqueness of human language.

INTRODUCTION

GRADUALISM is to be expected in evolution. Adaptations that arise from within the existing pool of variation do not, almost by definition, stray far from current norms. Mutations also occur but, broadly speaking, the more extreme the mutation the more likely it is to be dysfunctional: the two-headed calves and similar 'hopeless monsters' usually do not even reproduce.

Accordingly, it is normal to assume that language and cognition also evolved gradually, that there was a steady and progressive increase in these faculties within the hominid line. Many (for example Hauser, 1996) still assume, despite the surely unanswerable (and certainly unanswered!) arguments of Bickerton (1990, 1995), that language is somehow continuous with other animal systems of communication, and evolved seamlessly out of them. Even those who accept discontinuity between language and other systems

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(Pinker & Bloom, 1990; Newmeyer, 1991; Pinker, 1994; Bloom, 2000) argue that language must have developed over a series of stages, each more complex than the last.

In taking this stance, writers on the evolution of language are simply taking their cue from those who have studied the evolutionary record. For instance, according to Falk (1993: 226):

The fossil and archaeological record picks up around two million years ago in East Africa. And what a record it is! Brain size 'took off' and subsequently doubled ... Recorded tool production also accelerated in Homo, spanning from initial clunky stone tools to contemporary computer, space and biological engineering.

Tobias (1971) states that:

Long continued increase in size and complexity of the brain was paralleled for probably a couple of million years by *long-continued elaboration and 'complexification'* ... of the culture. The feedback relationship between the two sets of events is *as indubitable as it was prolonged in time*. [emphasis added]

According to Deacon (1997):

[*Homo erectus*]'s brains and their symbolic communication were undoubtedly co-evolving together, *even if the tools they were using were not progressing at a comparable pace*. [emphasis added]

One might, if ignorant of prehistory, assume from Falk's (1993) account that the harpoon was invented about 1 million years ago, bridges and boats about 500 thousand years ago, and the wheel perhaps 200 thousand years ago; even such a scenario would leave a fearsome amount to be invented in the last 50 thousand or so years. Nothing in this account suggests that in the first 1.95 million years of Falk's astounding record almost nothing happened: the clunky stone tools became less clunky and slightly more diversified stone tools, and everything beyond that, from bone tools to supercomputers, happened in the last one-fortieth of the period in question. Similarly, for the 'long-continued elaboration and complexification of the culture' envisaged by Tobias (1971), and for the 'co-evolution of brains and symbolic communication' envisaged by Deacon (1997), there is simply not one scintilla of evidence: simply a blind faith that, if evolution is gradual, and we are where we are, we must have got here, far as it may seem, in a series of incremental steps.

At least some writers are prepared to give us the actual facts. According to Jellinek (1977), reviewing the Lower Palaeolithic, the tools that 'were not progressing at a comparable pace', comparable, that is, to the mysterious and wholly unevidenced 'culture' and 'symbolic communication', serve as a perfectly reliable index of our ancestors' capacities:

We invariably make assumptions relating to the cognitive abilities of the hominids who produced the artefacts. Some of these assumptions can be based on the uniformity of the industries over periods of hundreds of thousands of years. The absence of evidence of innovation and differentiation in the tool forms that can be observed over these prolonged intervals *can be taken as evidence against the presence of the conceptual abilities relating to abstraction and synthesis that characterize modern Homo sapiens.* (Jellinek, 1977: 15; emphasis added)

It is, of course, possible to claim that humans had these abilities, or were gradually developing them, but had not yet put them into practice. But there is absolutely no evidence for such a claim, which goes against common sense: if a species has capacities that would increase its adaptive fitness, then the norm is that it utilises such capacities from the beginning.

There is an argument from the few surviving groups of hunter-gatherers that I would like to defuse here. Because these are undoubtedly modern humans, but have a technology that has not changed appreciably over the last few tens of thousands of years, it is argued that our ancestors could have similarly gone for hundreds of thousands of years without expressing their cognitive capacities in their culture. Any such argument ignores some crucial facts. First, modern humans who lack an elaborate material culture are in a small minority. Secondly, they are mainly people who have been forced into less productive regions by more complex societies; indeed, in the opinion of some anthropologists, they may not be the preservers of some antediluvian 'state of nature', but former agriculturists who have regressed, or been regressed, to a marginal condition that may reflect very inaccurately true pre-agricultural societies. Thirdly, we should consider not what some marginal minority does, but what a species as a whole does. One might be prepared to accept that some pre-*sapiens* hominids may have failed to heed the imperious call to progress from an enhanced cognition, but surely not all of them!

Yet it is clear that the refusal to implement these alleged gains from gradual cognitive evolution was universal in pre-*sapiens* *Homo*:

The overriding impression of the technological evidence in the archaeological record is one of almost unimaginable monotony. Perhaps the most overwhelming example of this is Acheulian of Olduvai Gorge, where for approximately a million years no significant innovation is discernible ... We are talking about tens of thousands of hominids maintaining patterns of technological traditions without discernible change. (Jellinek, 1977: 28)

Moreover, cultural diffusion was clearly at work: Acheulian hand axes have recently been discovered as far east as Japan. Is it possible to think of any *sapiens* innovation that has travelled for the best part of 10 thousand miles without undergoing the slightest change?

The mismatch between the fossil and archaeological records forms an acute embarrassment for those who believe that human cognitive capacities,

including language, developed gradually. Certainly brain size increase continued throughout the period and, although its pace may have varied, there are no obvious discontinuities in the record. In culture, the reverse is the case. There is an almost level plateau for almost 2 million years, then a rapid and dizzying ascent to our present state, an ascent which seems far from over. When a scientific puzzle of this magnitude relates so closely to ourselves, one would expect an enormous concentration on solving it. Far from it, most writers in the field have gone into denial, exaggerating pre-*sapiens* achievements, minimising our own, attempting always to explain away rather than to explain. One is irresistibly reminded of the reactions of a Victorian family when one of its members conceived an illegitimate child.

However, many are agreed that the emergence of language has contributed greatly to the increased intelligence and creativity of modern humans. Also, as Jelinek pointed out in the excerpts above, one normally expects increments in creativity and intelligence to be somehow reflected in the traces hominids invariably left behind them. The result is a paradox, the paradox of gradualness. On the one hand, language must have developed gradually because every complex adaptation in evolution (the eye, for example) has developed gradually. On the other, language cannot have developed gradually, because the combined record of fossilised remains and hominid and human artefacts is wholly inconsistent with gradual development. The question then simply is, is it possible to get from protolanguage to language without invoking some kind of saltation, or without denying one or other of the two halves of the paradox?

PRE-ADAPTATION

There is a rather obvious way in which apparently sudden evolutionary developments can be accounted for. That is pre-adaptation, to give it its traditional term, although 'exaptation' (Gould & Vrba, 1982) may well be preferred, avoiding as it does the faint flavour of teleology that the traditional term drags with it. If some prior (and of course gradual) development could be co-opted to serve the ends of language, then we can dispense with gradual development (which, in so far as it involves language, has more arguments going against it than there is space for here; for a summary see Bickerton, 1998). As has been set forth elsewhere (Bickerton, 1998; Calvin & Bickerton, 2000), a crucial development in social intelligence could have supplied the infrastructure that would, in a single step, have changed structureless protolanguage into a highly structured (although morphology-poor) human language. This development is briefly summarised below.

Reciprocal altruism (Trivers, 1971) is widespread among primates (de Waal, 1982; Strum, 1987; Smuts, 1987). Reciprocal altruism generally takes the form of dyadic relationships in which the partners cement their alliance by the exchange of favours (mutual grooming, food sharing, support in conflict situations, etc.) on the principle of 'I'll scratch your back if you scratch mine'. But reciprocal altruism is subject to exploitation by cheaters (Cosmides & Tooby, 1992). If reciprocal altruism is not to collapse, individuals involved in alliances must have some way of telling whether they are being cheated or not. In other words, they have to be able to keep score, approximately, not necessarily with absolute mathematical accuracy, in order to ensure that they do not waste their energy by giving more than they receive. For clearly, the animal or person that does not waste effort on a cheater is a fitter person or animal, and therefore more likely to reproduce his or her genes than are those who allow themselves to be cheated.

But in order to 'keep score', the individual has to set up a rough calculus to show that that individual has been the agent in doing favours not significantly oftener than the other, and has been the recipient of favours at least as often as the other. Also, as some actions involve a third entity, food, for example, in cases of food sharing, three abstract roles have to be considered: agent, who performs the action; recipient or goal, who is the object of it; and sometimes the third thing, which we may call the theme or entity affected by the action. It has been suggested that other things beside reciprocal altruism may have been implicated in setting up these roles. Indeed they may, but to concede this is not to deny the importance of the role of reciprocal altruism, or even to diminish it. For in no context other than that of reciprocal altruism is it necessary to set up abstract roles like agent, goal, theme; roles that must at one time be occupied by animal X, at another by animal Y. It has also been pointed out that reciprocal altruism is not limited to primates; vampire bats engage in reciprocal exchanges of blood ('so why don't vampire bats have language?' is sometimes the implied, or even explicit, follow-up). Vampire bats do not have language because, in the first instance, they only exchange blood; because they do not (unlike primates) exchange other things, there is no need for them to set up the abstract category 'action' (covering things as diverse as grooming, fighting and food exchanging) to join the abstract role categories into what will turn out to be a template for the most basic language structure. In the second instance, reciprocal altruism only provides syntax, not language *per se*, and in order to make any use of syntax you have to have at least words (or signs) that can be mapped into syntactic structures. As vampires have no protolanguage, cheater detection remains for them (as it has done for non-hominid primates) cheater detection and nothing more; its potentialities for giving structure to language must lie latent until there is some sort of language to give structure to.

Thus, probably even before hominids began (and certainly by the time they began), there was a system developed for keeping score that involved casting the memories of any given event into a single mould, a mould that resembled a small play with a single action and one, two or three participants (agents, goals and themes). Lo and behold, a unique set of circumstances provided one brand of primate with symbolic utterances (for an account of how this came about see Bickerton, 2002), some of which described actions (verbs) and some of which described the kind of entities that might be agents, goals or themes of these actions (nouns). All that remained was to take each utterance and cast it in the mould already formed for it by episodic memory. Instead of a purely pragmatic mode of mapping thought to utterance, there would be a rigid framework that enabled automatic recovery of meaning on the part of the hearer and made possible the construction of ever longer and more complex sentences. There would be syntax, where there was none before.

But at this point one may well ask, why was there none before? Why, if cheater detection was in place in a variety of antecedent species, if events were already being cast into the agent–theme–goal mode, did not protolanguage become language as soon as it appeared, 2 million years ago?

WHAT BRAIN SIZE DOES

One might, of course, claim that language did appear, much as we know it, 2 million years ago. But that merely makes more enormous the delay in implementing (in terms of concrete artefacts) the cognitive advantages that a true language made available. Moreover, it leaves the history of our species as unexplained as do most other scenarios. Any adequate account of how our species came into existence has to explain how it was that the brain grew to at least its present size without changing the hominid way of life in any significant manner, and then, without further increase, made possible the stunning explosion of creativity that characterised our species. (The complaint, quite often heard, that our species spent more than half its lifetime without changing much is, again, another way of trying to hide the illegitimate baby: there are a number of factors that would have inevitably yielded a slowish start, small numbers, lack of competitive pressure, need to fine-tune and explore the new medium, and so on, quite apart from the fact that earliest dates for novel artefacts are continually being pushed back as investigations spread out of Europe into areas that we occupied at an earlier date. See the chapter in these *Proceedings* by Paul Mellars.) So far, no convincing explanation of the brain–culture mismatch has been produced.

One way to deal with this is to suppose that brain size increased for reasons that have nothing to do with intelligence: for example, the ‘radiator theory’ of Falk (1990), according to which the brain’s venous drainage system, enlarging in

parallel with overall brain growth, prevented the brain from overheating during long chases across the savanna in hot sunlight. The theory remains controversial, but if correct provides a neat explanation of how the brain could have vastly increased in size without, apparently, adding very much to cognitive capacity.

Another proposal suggests how increase in brain size for specific purposes might have little to do with general cognitive processes. Calvin (1983) has pointed out the problems presented by aimed throwing over distance, which probably played a significant part in the foraging activities of early hominids. Throwing encounters a problem in exact timing: to determine accurately the launch window for a throw of 8 metres, firing of the neurones involved has to be accurate to within a millisecond. Such accuracy is impossible unless timing is averaged out over a large number of neurones. But extra neurones added for such a purpose do not in and of themselves guarantee any cognitive increment.

We might also propose that there was some degree of cognitive improvement, but not of a kind that would generate the creativity that characterises modern humans. For instance, Wynn (1999: 275) considers that our ancestors of 300 thousand years ago may have had Piagetian 'operational intelligence' but that the nature of their artefacts, unchanged over hundreds of thousands of years and virtually identical from Britain to Japan, suggests that 'whatever ... makes modern symbolic systems volatile ... was missing ...'.

None of these approaches are, of course, mutually exclusive. Their combination would indeed have yielded bigger brains, but need not, in and of itself, have made us the kind of animal we are today.

Still, only half the equation is solved by such developments. They suggest how our brains might have grown radically without correspondingly radical cognitive gains; they are silent on the issue of how, once brains had reached a certain size, immense changes in behaviour became possible. Nor have we dealt with the problem that closed the last section: why, if some primitive form of language has been around for 2 million years or more, and if the cheater-detection template had been around even longer, did language not become syntactic almost immediately. For if language as we know it began so early, we have to explain two further things: how it failed, for nearly 2 million years, to enhance significantly our cognition, and what additional factor, entering on the scene only with modern humans, caused us to start behaving so differently from other animals.

In order to understand what is happening, we have to consider what brains were built to do. Brains were built to serve the purposes of the animals that contained them; to preserve their lives, help them find food and mates, spread their genes. As such, they were (and for other creatures, still are) primarily reactive mechanisms. Animals observe their environment, detect within it features that are associated with dangers and opportunities, and react appropriately to these. Those reactions range from automatic reflexes to quite varied and

sophisticated responses. But while they can draw generalisations from environmental features, learn, in fact, to a greater or lesser extent, nothing obliges us to believe that they are capable of reflecting on them. There is no evidence that they consciously compare newer with older experiences, recast their strategies in accord with those comparisons, or perform any of the many other reflective activities that are a constant commonplace of human life.

The difference between what brains normally do and what ours can be made to do lies simply in this: while the mental activities of other species are driven largely and perhaps almost exclusively by external stimuli (dreaming in some mammals is an obvious exception, but this is unguided and uncontrolled activity), ours may in addition be driven by internal stimuli. The idea of school shootings may suddenly come uppermost in my mind (there is no need for it to have been explicitly triggered by any particular newscast or op-ed piece) and I can thereupon elaborate a policy, even a whole series of policies, for combating them; I may not hit on a very effective policy, but that is not the point. The point is that I can do it. And should it be argued that I can do such things merely as a consequence of being immersed in a rich culture, then I can ask, how is it that I, but not chimpanzees, dolphins and hominids, have such a rich culture to be immersed in?

Whether the capacity to have internally generated thoughts preceded proto-language, or arose as a result of it, I do not propose to argue here. Suffice it to say that once one has the most minimal protolinguistic ability, the capacity must be there. Linguistic acts may be, but do not have to be, the result of external stimuli. If I tell you that your fly zip is open, your fly zip does not have to be open, I may merely want to embarrass you or throw you off balance while I pursue some social agenda of my own. I have internally generated the sequence, 'I say, don't look now [he will of course] but your fly is open'.

In order for me to say this, I must have dispatched a sequence containing three clauses, 10 words and at least (depending on how you analyse it) 26 phonemes to the organs of speech. I only have to garble that message slightly, 'don't lick now, but your flaw is open', in order to make complete nonsense of it. But to send that message, I have somehow (we still do not really have more than a skeletal idea how) merged and blended dozens of neural signals from different parts of the brain and yet maintained them as a series of coherent signals so that the motor organs of speech could execute them precisely and accurately.

All of this would be wonderful enough if the rest of the brain, all the bits and pieces engaged in other tasks, not to mention all the bits and pieces that want to talk but would like to say something different, would just shut down and listen up as soon as the Imperial 'I' announced His Imperial Intention of saying something. But of course there is no 'Imperial I', no 'executive suite' (Dennett, 1990), there is no-one in there but neurones, each doing its own thing, and trained by hundreds of millions of years of brain evolution to attend to a

world outside, a world laden with life-threatening and life-enhancing phenomena, rather than to its own internal natterings. Given this situation, the fact that I can get from a set of firing neurones to a comprehensible utterance is nothing short of miraculous.

In short, what I am saying is that the emergence of protolanguage imposed on the brain tasks of a kind that no brain had ever been required to perform before, tasks beside which the accurate timing of launch windows becomes trivial. And assuredly, when the brain began to perform such tasks, it was not very good at them. At the beginning, this would hardly have mattered, because the earliest meaningful utterance probably consisted (like those of young children) of single symbols, so few in number that they could be uttered with a good deal of variation and still, usually, be understood. The problem arose when longer messages had to be assembled.

If the already-existing template was to be imposed on unstructured, protolinguistic, output, this meant that a coherent neural signal had to be maintained throughout the merging of the neural signals that coded for each unit (word) of the message. But maintaining a coherent signal through a series of merges was something that no previous brain had been built to do. (Note that other systems of animal communication are marked by their inability to combine units.) The problems involved in timing a launch window were added to the problems involved in maintaining a coherent internally generated message over what, for the brain, were protracted lengths of time (hundreds, if not thousands, of milliseconds).

And why was internal generation a problem? Because the brain was built to attend to stuff coming in from outside, not to stuff coming out from inside, certainly not to stuff coming from wherever in the neocortex words started to be stored, by a devious route that remains to be traced, to the organs that controlled vocal articulation. Before the complex problems arising from linguistic communication could be solved, two things had to be achieved:

- 1 enough spare (recruitable) units to be able to maintain a coherent and complex message over time against all the competing neural activity in the brain;
- 2 enough of the right kind of connections to allow such a message to travel unhindered and uncorrupted to its destination.

Let us look more closely at each of these in turn.

By 'recruitable' units I mean individual neurones or assemblies of neurones that are not irrevocably committed to some existing function (sight or hearing, for example) but that, while they might at various times perform various other functions, could, when required, be co-opted (Calvin, 1996) to serve linguistic functions. Such units would in fact be in Darwinian competition with one another (Calvin, 1998). Rather than a model in which 'I' decide what 'I' want to

say, then say it, we must accustom ourselves to a model in which, at any given moment, a number of different sentences are trying to say themselves, one captures sufficient neurones to put it together, and afterwards 'I' convince 'myself' that that was what 'I' intended to say all along. Under such conditions, a quite substantial 'critical mass' of recruited neurones must be assembled for any one potential sentence to win out against the competition.

The connection problem cannot be solved until enough neurones are in place. Neuronal connections are to a very large extent epigenetic; their formation (and certainly their strengthening, when they exist) is driven by the amount of information they are required to carry. Fortunately everywhere in the brain is (remotely, somehow) connected to everywhere else, otherwise a novelty like language could never have got off the ground. But constant use is necessary to maintain and strengthen these connections, so a large enough quantity of spare neurones must be in place before the connections can be perfected (not to say that there has not been, for some time, a beneficial spiral of advancement between added neurones and improved connections). But what do we mean by 'a large enough quantity'?

In terms of absolute numbers, we have no way (at present) of answering this question. All that can be done is to show the neuronal increment required by adding an additional unit to a message. That way, we can get at least a rough idea of the brain size required if complex sentences are to be produced.

Let us assume that to merge two lexical units into a single message (as distinct from sending lexical item one, uttering it, then sending lexical item two and uttering it) doubles the time required for sending the message and also doubles the number of spare neurones required to keep the message coherent (Figure 1). So doubling brain size (or rather, doubling that part of brain size devoted to spare neurones) gets you very little; there is no point in creating a unitary message, you might just as well keep sending words one at a time.

Suppose you want to add a further unit. Assuming that the number of additional neurones required for a coherent signal incorporating an additional unit



Figure 1. One merge. W = word, sign or other symbolic unit.

is a constant; call that number x . Then adding a further unit will require going from x to $2x$. But this will not simply make possible three-unit utterances. The brain is not a linear computer; it can conduct any number of operations simultaneously, in parallel. Accordingly, it can carry out two merges simultaneously, then merge the result, thereby obtaining the capacity to produce strings of up to four units (Figure 2).

But let us consider a moment what is at issue here. We are now faced with competition between two possible ways of sending a message. The first is the existing protolinguistic way, in which words are dispatched singly to the organs of speech. The second is the new linguistic way, into which the neural signals representing the units of a message are pre-assembled into a single complex signal before being dispatched to the organs of speech. The first way is unstructured, therefore there is no principled way of determining what relationship the words have to one another (pragmatic knowledge must suffice). The second way is structured. The longer the messages sent by the first method, the greater the danger of misinterpretation as possible ambiguous readings pile up. The second method can transmit much longer messages than the first with an almost negligible risk of ambiguity.

However, if the message is short, the first method has a lot going for it. Provided the message is firmly rooted in the here and now, messages of up to four or five units will be reasonably unambiguous in context. Moreover, as each word is separately executed, signals will not have to be maintained for long, therefore there is a good chance that each signal will be faithfully executed. However, as soon as signal time is prolonged, there is the risk (which may have been quite high until the second method became fully established) that part of

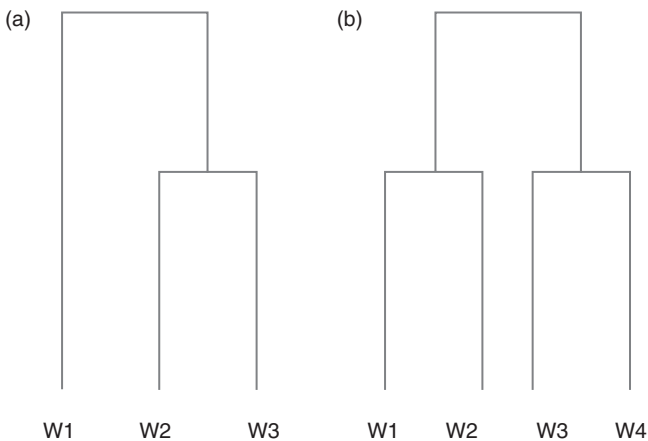


Figure 2. Two merges.

the message may be corrupted and, instead of incongruity, blank incomprehension will result.

In other words, for a species that cannot perform more than two merges, it is probably safer to rely on protolanguage than to try casting utterances into the linguistic mould. The significance of this fact is that a species could be capable of syntactic structures sharply limited in length and complexity and yet continue to employ protolanguage until a threshold, the threshold that allows for creation of utterances with five or more units, has been reached and passed.

That threshold comes with the capacity to perform three successful merges (Figure 3). As Figure 3 shows, that capacity, thanks to the brain's parallel processing, allows utterances of five to eight words to be assembled and produced. Capacity to produce utterances of up to 16 words results from only one additional merge (Figure 4). At this point we have, to all intents and purposes, reached the level of normal human discourse. Seldom, if ever, do we utter sentences of more than 16 words; if we do, they almost certainly consist of detachable portions that can be assembled separately and dispatched separately, while written sentences can, needless to say, be constructed in a much more leisurely and disconnected manner.

Now let us consider what this involves in terms of incremental brain growth, and see if there is any way in which, even very tentatively, we can tie that growth to the fossil record. Elsewhere (Bickerton, 1990; Calvin & Bickerton, 2000) I have suggested that protolanguage probably originated with *Homo erectus*. We assume that, to have this capacity, there must have been a portion of the brain potentially available for it (and probably for other tasks as well); a portion, in other words, that was not irrevocably committed to monitoring digestion or blood flow, recording input from peripheral cells, controlling motor activity, and so forth. In the beginning, if its value is x , that will have to be augmented to $4x$ to make syntax worthwhile, but only to $5x$ to yield full human capacity: a very steep threshold. Or, to put it another way, the brain would require a substantial increase to bring it even within reach of syntax, but only a small additional increment to make full human syntax potentially available.

What follows cannot, for the moment, go beyond pure speculation, yet it may be worthwhile in that it at least provides a target that can be shot at, in a landscape that still remains entirely unexplored. Let us arbitrarily suppose that at the beginning of the process, roughly 10% of the brain consists of recruitable neurones. The figure is arbitrary, but it cannot be massively less than this (otherwise no cognitive processes would be available) nor massively more (otherwise not enough neurones would be left to perform basic functions).

The brain size of *H. erectus* was 950 cubic centimetres (cm^3) (Tobias, 1987). Assuming that approximately one-tenth of this volume was recruitable, the value of x is 95. Therefore $4x$ is 380. Then 380 plus 950 is 1330. The average brain size of our species is 1350 cm^3 .

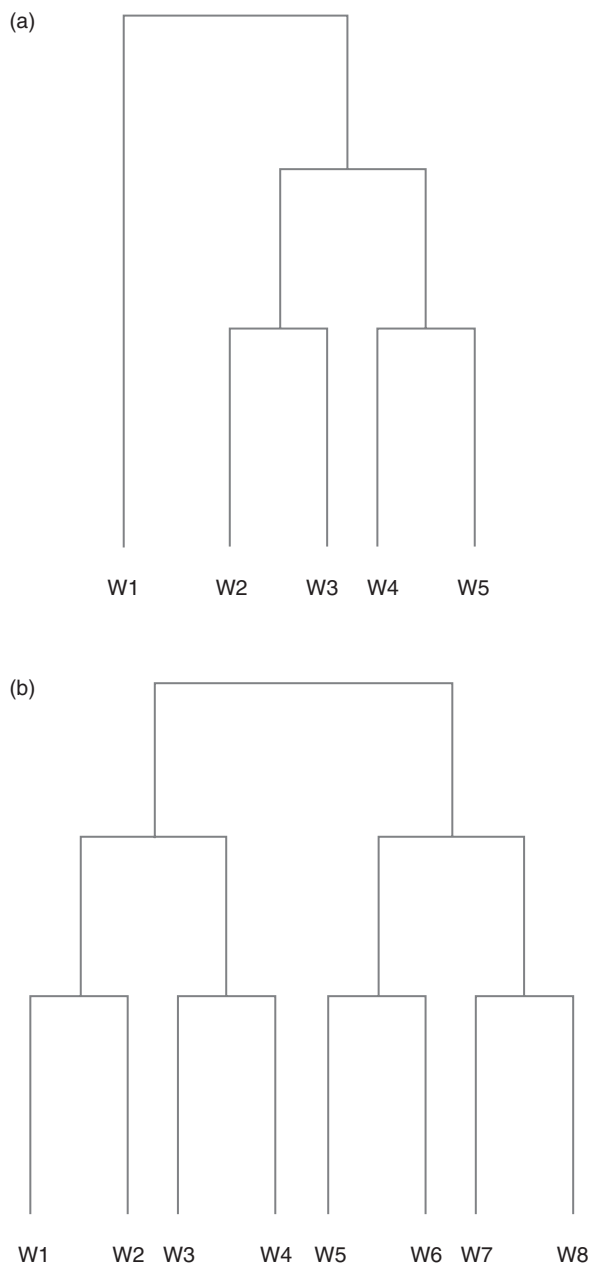


Figure 3. Three merges.

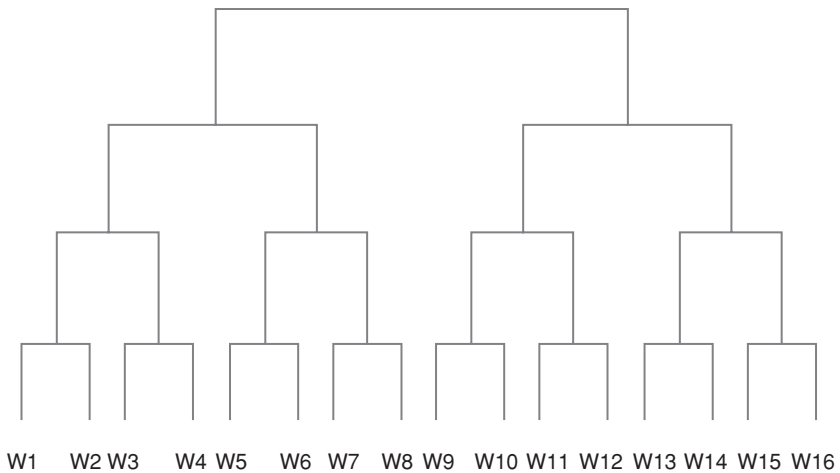


Figure 4. Four merges.

A wild guess? A numerical trick? Obviously such a result should be treated with the greatest caution, if not outright scepticism. Its value is not as a precise calculation: it is heuristic. It shows one way in which it might be possible to solve the problem with which this chapter began: that our brain expanded enormously with very little to show for it, then without expanding any more it suddenly became capable of (almost!) anything.

Until we can resolve this problem, we shall understand next to nothing about how we evolved.

THE REST OF THE STORY

There is one obvious objection to the story I have outlined. This is, that the brains of Neanderthals were larger than those of our immediate ancestors. If the explanation I have given is the correct one, how is it that we are here now instead of the Neanderthals? Why did Neanderthals not achieve language before we did, and all the cognitive benefits that came with it, leading inevitably to their victory in the interspecies competition in glacial Europe?

There are several matters that such a response ought to take into account. First is the fact that total brain size is not at issue here. It is the amount of brain that contains recruitable neurones. This amount may well have been less in Neanderthals than in modern humans.

Supporting this is the robust–gracile distinction. Neanderthals were much more robust than Cro-Magnons, and therefore could be expected to devote more of their larger brain to housekeeping matters. Therefore it is not unreasonable to suppose that, although in gross size their brains may have exceeded ours, they were at least a merge or two behind us, and were therefore limited to protolanguage, while our ancestors enjoyed the benefits of full human language.

However, there is no need even to invoke a difference in merger capacity. As noted in the previous section, number of disposable neurones does not alone determine the issue. Once those neurones are available, the connections between them have to be direct and robust enough to carry messages with the required speed and accuracy. Those connections would have taken time to forge. It follows that Neanderthals and modern humans could have been on a par merger-wise, yet the latter could have had a more developed system of connections. This could have occurred if there had merely been a difference of a few tens of thousands of years in reaching the merge threshold.

This argument acquires greater force when one considers that improved connections were not necessarily limited to the pathway between cortex and motor organs. The motor organs themselves had to undergo a good deal of refinement. There would be little point in achieving the capacity to produce sentences of up to 16 units if the execution of such sentences had been muddled, blurred and difficult to process by hearers. The achievement of syntax must have exercised a very strong selective pressure towards improved vocal abilities; again, a relatively short time-lag would have given modern humans an edge in intergroup communication, if not necessarily in thinking. That edge, however slight, might have been sufficient to extinguish the competition.

There is yet a further possibility of reconciling the present account with human–Neanderthal comparisons. Although language has long been a favourite among explanations of human victory, it is far from the only contender. It could be that humans and Neanderthals were linguistic equals; the structure of their vocal organs, their artefacts, and their behaviour do not encourage this view, but it cannot be ruled out. Some factor of cultural organisation, or introduced diseases, could then have made the crucial difference.

Thus there is nothing in human–Neanderthal relations that excludes the scenario presented here. On the positive side, it presents the only explanation I know of for the curious trajectory of our ancestors. Thus, despite the unavoidable elements of speculation it contains, it merits serious consideration as a rough sketch, rather than a sophisticated roadmap, of a way into the mysteries of our past.

DISCUSSION

Questioner: About a threshold of neurones in the brain, Neanderthals have large brains, but you always said that Neanderthal's lacked speech ...

Bickerton: I'm not sure about that anymore. The Neanderthal is a problem. It's not enough to just have a big brain. It's not so much a threshold of neurones as it is developing long massive pathways. Once you have the brain size, then you have to develop the pathways from generation to generation. We don't really need anything as critical as language versus protolanguage to explain how we won out and the Neanderthal didn't. All that is basically needed are other things that could tip the brain toward language, that is some speculation about social life, Neanderthals lived very different isolated social lives.

Questioner: Take the use of the harpoon and the symmetrical hand axe? Wouldn't everything you said apply to these as well?

Bickerton: I don't think so: the harpoon changed rapidly and the hand axe didn't change.

Questioner: Apes have tools. If you will make a hand axe, you need to have a plan. Is there any difference between the skills of apes and humans? For example, no ape can thread a needle.

Bickerton: You may be right. But my guess is that no hominids could do that as well.

Comment: Well then that's the essence of being human.

Bickerton: When you're making a tool, no one else is making it. Language is different: sometimes you're the agent, while other times he's the agent.

Questioner: Why did you upgrade the Neanderthal?

Bickerton: I can't see why if their brain size is big, they couldn't stumble through a few sentences. Think of it this way: there could be two parts of the brain not talking to each other and then lo and behold there is a connection formed between them. Is it a mutation? Epigenetic? Clearly there is different parcellation but these things have to interact and to specify where they go. It's not enough to have parcellation.

Questioner: Words are processed in 200 milliseconds, it shows that many parallel processes decipher the words to form communications; if you speak on and on how does this cascade work?

Bickerton: It seems to me that what is actually happening, once you get the brain in its original mode, is that it can't say sentences all the time. I don't see how this has a bearing on what I am saying.

Questioner: There is a threshold brain size, by which we have humans. Why are you not saying there is a threshold brain size for language? Then Neanderthals might have language.

Bickerton: Then why, if they had language, didn't they do more with it? When you have the brain capacity, you can manipulate the environment to suit yourself. If you want your genes to reproduce you are going to have to use your capacity to make things easier for yourself. We don't see any evidence of serious valuable creative activity in the Neanderthals or early on.

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