Article

The giant leap to humankind

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Penny (2009) urges that biologists stress more strongly the biological continuity between great apes and humans. Besides stressing genetic similarities, he suggests that great apes also share psychological capacities, including language and tool use. I argue that he underestimates the psychological differences. There is no evidence that great apes have anything approaching human language, or human technological capacity. A main ingredient of human cognition is recursion, which lifted communication to true combinatorial language and simple tool use to advanced combinatorial technology. Recursion may also explain the combinatorial structure of human memory, imagination, and theory of mind. Part of the key, as Penny recognises, may lie in the trajectory of human brain growth, but there is still much to understand in how micro-tweaking of the genome achieved such dramatic differences between ape and human.

Introduction

In his article 'Charles Darwin as a scientist', David Penny (2009) rightly states that biologists need to stress more strongly the continuity between apes and humans. It is now clear that we share a common ancestry with chimpanzees and bonobos dating from 6 to 7 million years ago, and that all three species have diverged from each other through incremental changes. Genetically, we are very similar to the chimpanzee, and the differences are simply the result of normal microevolutionary processes; there are no additional genes to provide us with the qualities we like to think of as uniquely human. In this, Penny echoes Darwin's (1896) contention that …*the difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind* (p. 126).

Nevertheless Penny, and perhaps Darwin, oversimplifies the task of understanding the changes that gave us our humanity. I consider here a few of the qualities which may be present in primitive form in great apes, but in which the leap from ape to human is so immense as to suggest qualitative changes.

Language

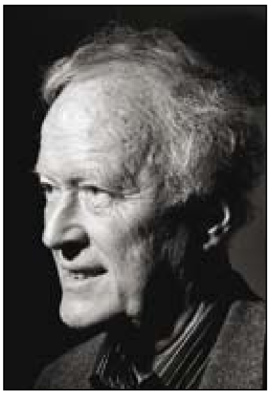
In 1871, Friedrich Max Mueller, who held the Chair of Philology at Oxford University, took exception to Darwin's theory of evolution:

> *There is one difficulty which Mr. Darwin has not sufficiently appreciated. … There is between the whole animal kingdom on the one side, and man, even in his lowest state, on the other, a barrier which no animal has ever crossed, and that barrier is—**Language*** (Mueller 1873, emphasis added).

Mueller here expresses the widespread view of philosophers and linguists, from Descartes to Chomsky, that language is uniquely human.

Contrary to this, Penny states that great apes can be taught sign language. Sign language is indeed a true language, permitting people to gossip, tell stories, lie, reminisce, and argue. It is incorrect, though, to suppose that great apes are capable of anything approaching true language, whether signed or spoken.

In a landmark article, Hauser *et al.* (2002) examined the differences between animal communication, including the gestural communication that great apes use either in captivity or in the wild and human language. They concluded that human language does have many surface features in common with other forms of animal communication, but that what they call 'the faculty of language in the narrow sense' (FLN) is unique to humans. That faculty, though, is what gives language its power of generativity—the recursive ability to construct sentences of any degree of complexity. Even the signing chimps and bonobos are restricted to combinations of two to three signs, and hardly ever generate new combinations. These communications are devoid of syntax; there are no parts of speech, no tenses, no moods, no diathesis, and in effect no sentences. As Steven Pinker (1994, p. 340) once remarked, the signing apes simply 'don't "get it"'.



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That said, there are good reasons to suppose that language probably did evolve from bodily gestures rather than from vocal calls (Corballis 2002; Rizzolatti & Sinigaglia 2008). Primate vocal calls are largely involuntary and impervious to learning, whereas human speech is highly flexible and is rapidly learned. Considerable anatomical and neural changes were required to move from one to the other. Manual gestures, in contrast, provide the ideal platform for the evolution of language, because primates are highly manipulative creatures, capable of gestures that are both intentional and susceptible to learning. We now know too that the communicative gestures of apes in the wild have more language-like properties than do their vocalisations (Tomasello 2008). Even so, the communicative interactions between apes bear little resemblance to the compulsive, varied, and information-packed human language, whether spoken or signed.

Tools

Penny also cites the work of Boesch *et al.* (2009) as showing that chimpanzees are capable of elaborate tool use. Work of this kind is indeed beginning to show greater sophistication than hitherto recognised, but it is still vastly different from human capability. The chimpanzees studied by Boesch *et al*. use up to five different tools shaped from sticks or twigs for different processes in the extraction of honey out of hives. There is a huge gap between this and human technology, both in the number and variety of tools used, and in combinatorial structure. As with language, it is recursive structure that sets human tools apart. Just as human language permits the generation of an unlimited number of possible sentences, so human manufacture has proliferated to the point of suffocating the globe.

Let's compare the tools used by the honey-loving chimps with the structure of a product that has become fairly commonplace in our lives:

> *… a jet engine has a main assembly that consists of an air intake system, a compressor system (to compress the inducted air for combustion), a combustion system (to provide high-energy gas flow for the turbine), a turbine system (to drive the compressor and provide reactive thrust), and an exhaust section. Each of these in turn is controlled, supplied, and monitored by other subsystems: the compressor system requires a variable vane actuating system (to set the vane angles appropriate to airflow velocity), and an anti-stall bleed system to control pressure surges (the tendency of the compressed air to blow backwards); the turbine system requires a blade cooling system, and a complicated set of shrouds and seals to prevent high-pressure gas leakage* (Arthur 2007, p. 277).

And that's just the engine. The whole plane, of course, adds more layers of recursion—not to mention the vast network that controls the international flight-paths of aeroplanes in our skies.

Mental time travel

A recent contender in the 'uniquely human' stakes is mental time travel, the ability to insert past or planned future episodes into consciousness (Suddendorf & Corballis 2007). We can relive in our minds events that happened days, months, or even years ago, and also play out possible scenarios in the future, such as a planned dinner party, or an appointment with the boss. Of course non-human animals also have memory, but there is no convincing evidence that their memories or plans have the combinatorial complexity of human memory. Although our memories are often elaborate and detailed, they are also often wrong, even unwittingly fabricated, leading to the suggestion that human memory evolved not so much as a record of the past as a vocabulary for future planning, aiding survival. This elaborative function is also expressed in fiction, the generation of scenarios that are the products of imagination rather than fact. We humans are compulsive purveyors of actual and possible human activity.

My own view is that language itself was driven by the emergence of mental time travel, allowing experiences and plans to be shared, thereby enhancing survival of individuals within groups (Corballis 2009). In short, language began as a way of relaying personal memories and plans, for the benefit of the group. This may also explain our predilection for gossip, and the nearly universal existence of fables, creation myths, and stories—not to mention the streets, *Sesame*, *Shortland,* and *Coronation*, that feature endlessly on our television screens.

How to explain the leap

Although the gap between the minds of apes and humans is large, I cannot but agree with Penny that we must appeal to Darwinian principles to explain it. Past philosophers, such as Descartes, have supposed that God must have played the decisive hand, and more recent commentators have appealed to some fortuitous biological event, such as a mutation (e.g. Crow 2002). Given the complexity of human cognition, though, it seems much more likely that it resulted incrementally through natural selection, probably involving many small adjustments to the genome. The problem is perhaps similar to that of explaining the evolution of flight from ground-based animals.

Perhaps the most obvious ingredient that lifted human cognition is recursion, which involves the embedding of structures within structures to create any desired level of complexity (Corballis 2007). Once recursive principles are embedded in language, messages can proliferate and achieve the complexity required to describe activities in the physical world. Recursive, combinatorial principles have also allowed manufacture to advance beyond simple purpose-built tools to combinatorial structures of untold complexity. Simple memories can be combined to form imaginary scenarios, whether elaborated as reconstructions of past episodes, or as future plans, or as stories.

Recursion also underlies what is known as *theory of mind*, in which we can not only know what others know, but know that they know what we know. Recursive theory of mind can serve as a basis for cooperation, as well as for deception in the poker game of life. The anthropologist Robin Dunbar has even proposed that it was recursion that allowed us to find God. Since religion is a shared system of beliefs, Dunbar (2004) suggests that the reasoning runs as follows: *I suppose that you think that I believe there are gods who intend to influence our futures because they understand our desires* (p. 185). That's fifth-order recursion.

Recursive thinking involves extended short-term memory and the capacity to form hierarchical mental structures, and these in turn may have led to selection for increasingly larger brains. Relative to body size, the human brain is some three times larger than the chimpanzee brain. An additional factor, correctly identified by Penny, is the prolonged growth of the brain in human development, relative to that in other primates and mammals. Prolonged growth may have supported the growth of hierarchical structures necessary for recursive thinking. Locke & Bogin (2006) argue more specifically that the period of childhood, ranging from age 2½ to about 7, is unique to the genus *Homo*, including *Homo sapiens*, and is absent in other apes and earlier hominins. This is the period during which children acquire fully grammatical language, mental time travel, and theory of mind.

Another factor critical to the evolution of the human mind is culture. Different groups of chimpanzees display different cultural norms with respect to such activities as tool use, play, or feeding. Unlike human culture, though, chimpanzee culture seems not to be cumulative (Whiten *et al.* 2009). There is probably no human alive who could put together a jet engine and all its parts, as described above. Sir Isaac Newton (1675) wrote, in a letter to Robert Hooke, *[if] I have seen further [than others] it is only by standing on the shoulders of giants*. With respect to everyday technology, we are all standing on the shoulders of our forebears. Of course, the transmission of culture depends on those other human qualities described above, including language and technology.

We humans are indeed great apes derived from micro-tweaking of the genome. The challenge, though, is to explain how those small steps created the giant leap to humankind. We are a species whose products—words, technologies, weapons, noxious emanations—threaten to dominate and perhaps ultimately destroy the planet, while the other great apes, our closest relatives, are confined to ever-diminishing regions, and are in danger of imminent extinction.

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