Article

The continuity of mind, from great apes to humans

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It is a central prediction from mainstream evolutionary biology that there is a continuous set of intermediate states in the mental abilities from an ape-human ancestor to modern humans. A quick analysis is given to the problem introduced by Rene Descartes of the supposed gap between mind matter and physical matter, the former distinguishing humans from all other animals. A three-pronged analysis is then given that revolves around: (1) the continuity of mind from young children to adults; (2) the similarity of measured mental abilities between young great apes and young children at similar stages of development; and (3) the observation that there appear to be no unique genes in the human genome for mental abilities (including for 'wisdom and intelligence'). The components that are required for language are then analysed, and important precursors found in the great apes. The conclusion is that the best supported hypothesis, especially in a Bayesian framework, is for a continuum in mental states between an ancestral ape and modern humans. There are a range of predictions from this model that can, and have been, tested.

Michael Corballis (2010) has raised one of the most interesting and fundamental issues in modern science; is there anything about humans (especially in our mental abilities) that cannot be derived from our ape-ancestor by normal micro-evolutionary mechanisms? As Corballis correctly points out, it has been a fairly general consensus in Western philosophy (and some other disciplines) since around the time of Rene Descartes (1637) that there is a major gap between the human mind and that of all other animals. I have given some of my reasoning for supporting the continuity of mind in Penny (2009a), but Michael obviously wishes me to go further.

I find it very important when talking about humans and our ape-like ancestors to make it quite clear that this in no way denigrates the achievements that are unique to humans. Figure 1 shows a range of accomplishments that no chimpanzee, for example, is going to achieve – such as sequencing a chimpanzee genome (only humans have done that)! Once this aspect of human uniqueness is out of the way we can then get to the fundamental issue of whether we can infer continuity of intermediate mental states. But we certainly should not understate human achievements as illustrated in Figure 1.

A second important item when discussing evolutionary understanding is that any Darwinian mechanism requires a continuous set of functional intermediates. It is not possible to evolve directly a complex new feature that requires several quite new components before the collection of them as a whole suddenly develops the novel function. The processes of microevolution can only work on functions that have a benefit here and now, not something that will only be useful in a few million years. The simplest solution to this limitation is to consider existing functions that can be recruited or co-opted into an extended or modified role.

As an example, I will use the ribosome, a large RNA structure that joins amino acids in a precise order (specified by a messenger RNA, mRNA) to make a protein. If the ribosome did arise just 'for' protein synthesis then it appears that at the very minimum we need to evolve *de novo*:

- a large ribosomal structure (rRNA),
- many modifications to that rRNA,
- many transfer RNAs (tRNAs),
- a code relating triplets of RNA sequence to a specific amino acid, and
- a specific sequence of RNA (the mRNA) that when translated with the above code would give a specific a protein that was functional!

These would all have to evolve *de novo* and in parallel because all are required for a protein to be synthesised; but this relies on a coincidence that defies the most optimistic imagination. However, there are much simpler alternatives (e.g. Poole *et al*. 1998) where the proto-ribosome was involved in replicating RNA by adding three nucleotides at a time – thus increasing accuracy but at the same time setting the length of the triplet code (tRNAs were adding the triplets). The amino acids would assist in both recognition and the chemical equilibria. This is given here as an example of how, in an evolutionary context, we need to look for all the components functioning in a present day process, and see what these components may have been doing before they were recruited into their current role. Later, I will consider some of the components that were likely to have been necessary for human spoken language.

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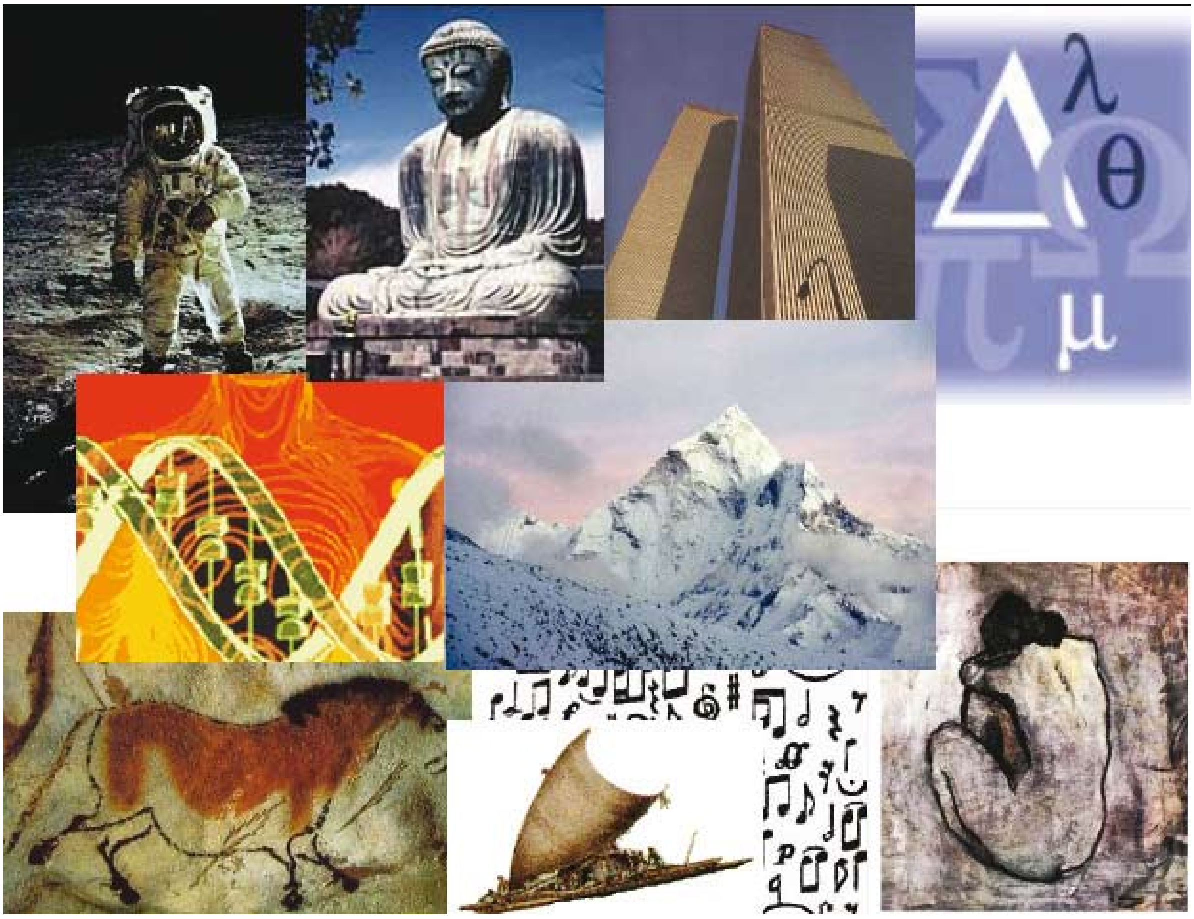

Figure 1. Human achievements. Assuming a continuity of mind from an ape ancestor to humans in no way denigrates human achievements. From left to right they include: (top row) walking on the moon, a giant Buddha from 13th century Japan, technology – the Twin Towers (destroyed by religious hatred – another human achievement?), mathematics; (middle row) the human genome project, and ascent of Mt Everest; (bottom row) ancient cave paintings, Polynesian exploration, music, and art (Picasso).

The third background aspect that is making the acceptance of continuity of mind easier for many researchers is the increase of Bayesian, as compared to frequentist, statistics. Put briefly, Bayesian statistics allows a broader range of evidence to change our perception of 'posterior' probabilities, that is, changes in support for alternative ideas that result from experiments or observations. Traditionally, under frequentist statistics, we started with a 'null model' that in this case might be that humans are 'quite different'. We may feel that each piece of evidence is not sufficient to 'disprove' our null model; perhaps it is not quite in the right format to be repeated many times, and so we keep on accepting our original model – even though each individual piece of evidence may contradict it. Perhaps that is a bit simplistic, but now we are more used to a range of models, with increased or decreased support for each of them. Although there are still difficulties with some Bayesian interpretations, the general approach allows us to change our views incrementally. Even if we started off with no prior knowledge, and assessed the likelihoods of 'big difference to humans' versus 'many small differences to humans' as 50:50, we can still increase or decrease our support for a range of models, given all the evidence. We can also include unique, and often unexpected, observations that affect our posterior probabilities.

A fourth background item that is very important from an evolutionary perspective is that we certainly expect variation in a feature within a population. Put another way, we would certainly reject any argument that simply argued that one species 'had a feature', or another species 'didn't have the feature'. We need always to check the extent of variability. A recent example is in Senju *et al*. (2009) who showed that young children with Asperger syndrome may lack a 'spontaneous' theory of mind (as measured by an eye-tracking task), even though they could learn it under other circumstances. The implications here are that we cannot oversimplify things to a species 'has some feature', or 'doesn't have some feature'. Especially when considering 'continuity' we need to know the range of variation within a population.

For the final piece of background, I find it important to emphasise that there is virtually always a spectrum of views/possibilities, and we should never allow ourselves to be forced into overly-simplistic binary choices. A classic example is the uniformitarian/catastrophism distinction of the 1830s, that has misled people for nearly 200 years (see Penny 2009b). A range of views, with many intermediate positions, certainly holds for ideas about the origin of human mental abilities and for the origin of spoken languages; some of these are illustrated in Figure 2. Despite my concern about avoiding strictly binary choices, I will start off by commenting on the Descartian view that has been central to much of Western thought over the past 350 years. Only later will I address the much more advanced and moderate position raised by Corballis (2010).

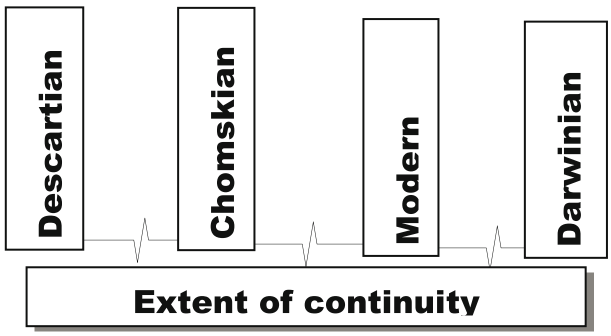

Figure 2. Part of a spectrum of views of the continuity of minds between the great apes and modern humans. 'Descartian' is the traditional late-Medieval European view. 'Chomskian' assumes human languages cannot be derived from any animal communication system. 'Modern' is a more recent view that fully accepts microevolutionary processes as sufficient for almost all aspects of human evolution – but still emphasises a gap in the origin of spoken language. 'Darwinian' is the claim of a continuous set of intermediate states. The spaces along the x-axis scale are arbitrary.

The Descartian tradition

Traditionally, most indigenous knowledge (including European Indigenous Knowledge, EIK) assumed both continued spontaneous generation, and transmutations between living (and even non-living) forms. Under such understanding, there was really no problem; some humans could turn into werewolves, depending on the phase of the moon. The classic book by Oparin (1959) includes a short introduction to some of the mediaeval ideas about continued spontaneous generation.

However, during the 17th century there were major changes, and for present purposes, Rene Descartes' introduction of mind matter and physical matter was important, and he proposed a major discontinuity between humans and all animals (that were basically automata). This is illustrated by extracts from his *Discourse on Method* (1637) (the first of which certainly puts evolutionists in their place). … *there is none that is more powerful in leading feeble minds astray from the straight path of virtue than the supposition that the soul of brutes is of the same nature with our own;* ... (Descartes 1637, p.46). Animals were basically automata (machines), and Descartes discusses two 'most certain tests' of how they (animals, but also any other robot/machine) will always be distinguishable from 'rational' humans. ... *[T]here would still remain* ***two most certain tests*** *whereby to know that they were not therefore really men. Of these the first is that they* ***could never use words or other signs*** *arranged in such a manner as is competent to us in order to declare our thoughts to others ... The second test is ... for while reason is a universal instrument that is alike on every occasion, these organs, on the contrary,* ***need a particular arrangement for each particular action***. (Descartes 1637, p.44–45, emphases added).

This hard division between humans and other animals is certainly an extreme position, but the implications of Descartes' mind/matter separation have been very influential in mainstream thinking in Western thought for over 300 years. It certainly helps understand the importance of studies of both wild and 'domesticated' communities of great apes (chimpanzees, gorillas, and orang-utans). There are many classic studies that, for example, showed that the great apes could use sign language (e.g. Patterson & Linden 1981; Gardner *et al*. 1989), thus bypassing any requirement for vocal cords. In addition, the great apes can learn to use modified keyboards with symbols, and operating through a voice synthesiser, to communicate (Matsuzawa 2009). Combining all such studies certainly showed that great apes could use 'words or other signs' to convey information about a wide range of issues – contradicting Descartes dictum on which much of modern Western philosophy and theology used to be based. Similarly, their responses are context dependent, and not a *particular arrangement for each particular action*. We will come back to the issues raised here, under the components of language; but it appears now that there are many components of language present in the great apes, but that are improved further in humans – but how many?

In defence of Descartes, his physical matter/mind matter distinction gave an area of study (physical matter) where scientists were the authorities, and as far as I know, scientists were thereafter never burnt at the stake for having obtained the theologically-incorrect answers from their research. We probably all agree now that Descartes was far too extreme in his separation of great apes and humans, but the existence of the extreme viewpoint is part of the background of establishing mental continuity.

To continue with the theme of a spectrum of views (and not simply black versus white binary choices) there was also a standard anti-Darwinian position common in the mid-20th century. For language evolution this was exemplified by Noam Chomsky, and the following illustration is taken from his early work. (As an aside, it appears that a very famous chimpanzee, Nim Chimpsky, who was very well known as a master of Ameslan – American Sign Language – was named after Chomsky). Returning to the extracts, we find Chomsky saying, *[w]hen we ask what human language is, we find no striking similarity to animal communication systems ... human language, it appears, is* ***based on entirely different principles****. This, I think, is an important point, often overlooked by those who approach human language as a natural, biological phenomenon.* (This is an early Chomsky view; cited in Miles 1983, p.43, emphasis added). 'Entirely different principles', indeed! Miles calls this a 'non-evolutionary' perspective, and suggests Chomsky only considered 'a part of the evidence'. I am not aware of any evidence for 'different principles'; everything that has been measured seems based on similar principles, but we will come back to this question under the components of language.

A more modern position – humans are still different

The reasoning of Descartes or the early Chomsky is certainly extreme by current standards. It is certainly a major improvement to have a much more interesting and advanced position that accepts that evolution has occurred (by whatever mechanism, mostly micro-tweaking of enzyme functions) but to still assume there is something 'quite different' about humans (especially our language). Yes, humans are special (Figure 1), but that is a separate issue from the Continuity of Mind; I will outline my reasoning in three steps:

1. We all fully accept the continuity of mind from young children to adults.
2. At comparable stages of development (say 2–3 years old)

there are remarkable similarities in mental performance of great apes and children.

3. The human genome has no special new genes for mental abilities, such as for 'wisdom and intelligence'.

The first step in the reasoning is on the continuity of mind, or mental states, from young children to adults; the reasoning is both simple and straightforward. We see young children continuing to develop their mental abilities without any sudden and unexpected 'phase change' when, without warning, they gain new mental powers. Just one example of this is the development of an insistence on 'fairness' in young children between the ages of 3–7 (Fehr *et al*. 2008). This is interesting for other reasons as well; humans have for several decades been called the 'cooperative apes' because early hunter-gatherers apparently collected their food (via hunting or gathering) and returned to a central place to share it with other members of the group. This ready 'sharing' with others is much more characteristic of humans than of other great apes and, as we see in the next section, this sense of fairness arises during a phase of development that occurs later and longer in humans.

Thus there is no problem in accepting the 'continuity of mind' between a child and an adult. So, is there any difficulty, in principle, in accepting it between 2-year-old great apes and 2-year-old children? This comes next.

The second step of reasoning is based on the growth curves of brain and body weight shown in Figure 3; these growth curves are highly informative. Each line represents a 'trajectory' of the growth of an individual from a fetus, to a juvenile, to an adult. It appears that old-world monkeys (*Semnopithecus* and macaque [rhesus]), chimpanzees, and then humans show similar trajectories in the earliest part of growth, but in macaques the brain keeps growing longer than for *Semnopithecus*, then longer again for chimpanzees, and longest of all for humans. Of course, different parts of the brain will be growing at different stages. Nevertheless, it is striking that there does not appear to be any fundamental difference in 'kind' between brain growth in these different primates, especially given the lack of new protein genes between chimpanzees and humans (see third step below).

Thus an important conclusion from Figure 3 is that we will almost certainly learn more by comparing species at comparable stages of growth – for humans and chimps this is indicated as the 'area of comparability'. Certainly, we could compare mental capacities of adult chimps and adult humans, and we are not at all surprised that they are 'different'; we knew that already from Figure 1. But to measure how they differ at earlier but comparable stages of growth is much more informative. Just one example will be given here, the application of appropriate IQ tests developed for young human children and given to the young of great apes. Several authors have given 'selected' IQ tests for young children (for example, Patterson & Linden 1981, p. 127, from which Figure 4 is taken), and the young of great apes can often be in the range of 85–95 compared with young children of the same age. 'Selected' is used because the tests that are chosen do not require a verbal response; rather, pointing to the answer is sufficient. (Great apes could obviously not give such verbal responses – we knew that already.) Similarly, young gorillas also did worse than children if fine motor control was required – such as tracing a line through a maze with a pencil. Of course, that can work both ways; some quite young orang-utans do very well on tests that require dexterity – but they are born at a developmental stage where they have better

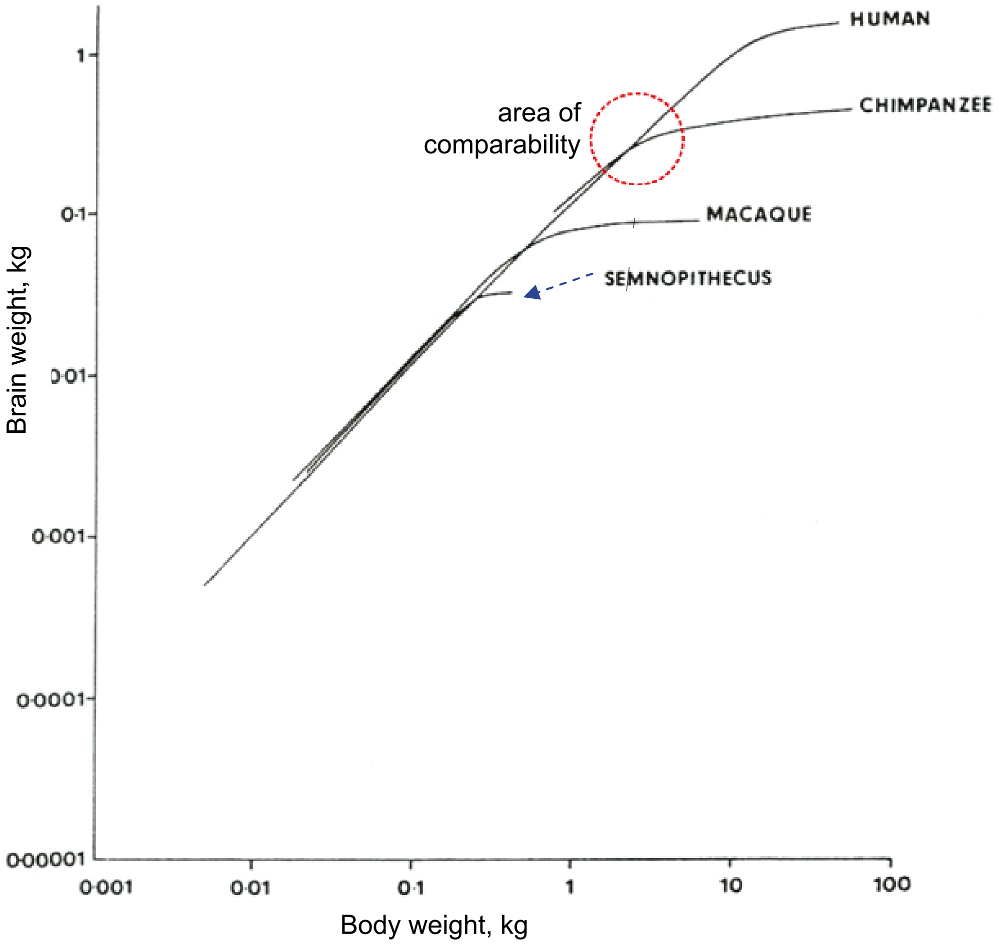

Figure 3. Brain versus body weights during growth in four primates. In general there is a common pattern (or ratio) of brain and body growth during foetal and early juvenile growth for all four primates, but macaque continues the juvenile phase longer than* Semnopithecus*, chimpanzees longer still, and humans the longest. Note that the data are not all from the same stages of growth –* Semnopithecus *points are mainly for foetal growth, chimpanzees mostly for juvenile and adult growth. The equivalence of patterns of growth is important, and it is much more likely to be informative to compare mental capabilities of great apes and humans at comparable stages of growth. Do they have similar capabilities at similar stages? (Derived from Holt* et al. *1975).

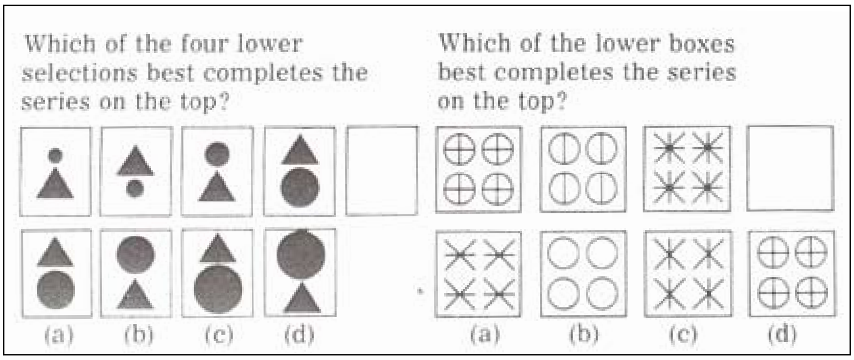

Figure 4. Examples from an IQ test carried out on both young children and young great apes; answering only requires pointing to the appropriate answer. It is claimed that young chimps and gorillas are within the range of young humans (say 85–95) even though adults (humans and gorillas) are markedly different. (Diagram from Patterson & Linden, 1981).

co-ordination than children, although that does not tell us about mental capabilities.

The main point of this section is that, mentally, young children and the young of great apes are surprisingly comparable in general mental abilities. Given their high genetic similarities, perhaps that is not too unexpected? This is extended in the next section, but it is a very strong statement to be able to say that the mental abilities of children as 2–3 year-olds and young of the great apes are at least comparable; given also that we see continuity of minds from young children to adults.

The third step of reasoning is that there are no special genes for human wisdom and intelligence.

The first two arguments above are probably sufficient, but the genetic argument considerably strengthens the reasoning. If there really were different genes, and different proteins, that made up brain and nerve tissue in humans, then there could be a *de facto* argument that human mental abilities are non-comparable – that they are genuinely different. But as far as we know, the proteins that make up brain and nerve tissue are basically the same in all great ape species, including humans. In Penny (2009a) I have already commented that at the genomic level there do not appear to be any really novel genes in humans for anything, let alone genes for ‘wisdom and intelligence’. Rather, our genes appear to be an extension of what was already there in our common ancestor. In order to achieve the differences in growth trajectories, I expect that there will be interesting changes in regulatory elements that lead to the extended growth of the human brain (for example Kouprina *et al*. 2004). These regulatory elements could even include new microRNAs. But this only emphasises that the underlying brain structure and functions are highly similar.

Similar results that reinforce this conclusion are recent work, possibly a little over-hyped, on the FOXP2 gene – sometimes called the ‘language gene’. This is a very highly conserved transcription factor (a gene involved with the level of expression of genes in different tissues). There are two significant differences between the chimpanzee and human proteins, and some mutations in humans lead to significant speech defects. However, the effects are probably not specific only to the mental abilities of ‘language’; rather, the changes may also allow finer motor control. Recently, a copy of the chimpanzee FOXP2 gene was expressed in human nerve cells in tissue culture, and led to changes in the level of expression of around 160 genes (Dominguez & Rakic 2009). Clearly, there is no one gene ‘for’ speech, in that changes to regulatory genes (such as FOXP2) produce many physiological differences, one of which might give better control of sound production. That is just micro-tweaking the amino acid sequences of proteins, almost the simplest mutation in micro-evolution. In general, we know too little about protein regulation and interactions in cells, for example, the variety in coat colours in dogs appears to arise from interactions of genetic variants of just three genes (Cadieu *et al*. 2009). However, the important point in the present context is that it is just micro-tweaking of interactions in protein networks, and is still an example of continuity of function.

So to summarise this section, the three-part argument is that we accept continuity of mind from children to adults, there is strong comparability in the mental abilities in young children and young of the great apes, and there are no new classes of genes in humans related to mental powers. Thus, at this level, I see no major division between modern humans and their ape-ancestor; but we can go further.

Components of language

It would also be easier if we understood the intermediate steps during the development of full language capabilities in humans. We know from the archeological record that, for example, there were many intermediate stages (over thousands of years) in the development of stone and wooden tools and weapons (e.g. Wadleya *et al*. 2009), and similarly during the domestication of crops such as wheat (Brown *et al*. 2009). The latter started with diploid species ($2n = 2$), then tetraploid ($2n = 4$, one hybridisation), and then hexaploid ($2n = 6$, a second hybridisation). We would certainly expect language to follow similar evolutionary principles, starting from the ‘words’ (sounds) that chimpanzees use to communicate in nature. We know that even monkeys can add sounds at the ends of words and modify the meanings (Endress *et al*. 2009). A ‘null hypothesis’ might be that we expect that there were many protolanguages of intermediate complexity. Finding direct evidence for these may be difficult because (again from standard evolutionary principles) we expect that there would have been strong competition between simpler protolanguages, and more advanced, information-rich, languages. However, finding the many components of language should be more straightforward.

Two consequences of hearing

So where does this leave us with language? Perhaps the most important aspect is that there are many components required for language to function. Considerable emphasis used to be placed just on the spoken element of language, and the lack of the necessary vocal chords in the great apes. However, there are many other important preconditions, the first of which is hearing, and perhaps the biggest surprise of all is that great apes can ‘understand’ words in spoken English. One example was a visitor asking verbally, ‘what is the sign for good’, and before the trainer could respond, the gorilla gave the appropriate sign (Patterson & Linden 1981).

The first thing we learn from such examples is that the necessary methods for processing sound are already present. In general, it was a major goal of early artificial intelligence studies to get computers to understand spoken language; and chimps and gorillas could do it all along! A difficulty with computers understanding spoken language is that, although we hear discrete sounds, in reality there is a continuous spectrum of sounds being uttered, and we break this spectrum up into discrete sounds. So to be able to decipher continuous sounds into discrete 'words' is a major achievement in terms of artificial intelligence. This illustrates the point that, in an evolutionary context, we would need good aural processing before we could have spoken language – it seems to be a necessary precondition.

A likely explanation is that the great apes (and other animals) had to be constantly listening to sounds from their environment, separating them (for example) into wind rustling the leaves, to a known conspecific letting off steam, to an approaching predator, to a particular infant in distress. The main point here is that it is an extremely powerful conclusion that the great apes already had the ability to analyse sounds, well before those aural abilities were co-opted into decoding spoken proto-languages. We get a glimpse of this today in that our aural abilities apply to any spoken language, once we know that language. The fact that we lose the ability to discriminate some sounds by about a year of age (if they are not used in our language) reinforces both the generality of our aural abilities, and also points out that aural sensitivity is highly developed before children are a year old. Thus our aural abilities are far broader than is required just for a language, and that in itself is a very important conclusion. Our aural abilities cannot have evolved 'for' language; in evolutionary terms they existed prior to spoken language and for other reasons. Thus it is an ability that was co-opted into use for language, and was possibly refined further. That it is already being used for communication is illustrated by the chimpanzees of Gombe that have more than 35 'sounds/words' that convey information (Goodall 1986).

The second general implication from this discussion is even more interesting, and is that the great apes also have quite a few symbolic mental abilities. In this case, the gorilla has, interpreted the spoken sounds as a question, decided that a sign is being asked for, and in particular the sign for 'good'. So in addition to the aural abilities, quite sophisticated mental abilities are required. It is not necessary that the great ape recognises and understands every word in the sentence, but in the present case the three features mentioned above seem minimal. However, it is unlikely that the abilities are so limited.

As mentioned earlier, it is fundamental to a Darwinian evolutionary understanding that we cannot 'evolve' something for a purpose that does not yet exist. In this case, we could not evolve spoken language in the expectation that it would be useful when we eventually invent the necessary aural processing powers. But already having this hearing ability means that it can readily be 'recruited' or 'co-opted' as the use of spoken language increases. The ability to process and understand sounds seems to be a necessary precursor to the origin of spoken language; indeed it may eventually turn out to be more difficult to process sounds than to make them.

Other mental abilities and categorisation

In this section I will give a little more interpretation of some of the other mental abilities that appear to be necessary for protolanguages. Given the known ability of communication systems in the great apes, we can infer many mental properties for them. They can recognise individuals (of their own, and other, species), including the recognition of faces (again, their own, and other, species). Probably this should not surprise us; recognition of individuals is both advantageous and necessary for most birds and mammals. I have already commented that some aspects of 'self-awareness' are present in the great apes (as well as in several other mammals, see de Waal *et al*. 2005), and this would aid any proto-language facilities being developed. Similarly, they show 'cultural dissonance', which is to devalue a choice after it is rejected. That is, just like humans, given two fairly equal choices, once one is selected, the other is then devalued for later choices (Egan *et al*. 2007).

The great apes recognise general categories, like 'birds', and can use standard Arabic numerals to represent numbers of objects (Matsuzawa 2009). In some cases, the ability of chimps to memorise numbers in a sequence exceeds that of most humans. Several great apes have mastered over 1000 Ameslan signs, and can invent both simple combinations of signs for new concepts, and spontaneously form simple sentences. In one case, with only two months of training for sign language, one great ape start combing signs into simple phrases or 'sentences'. This certainly implies that they can form a very wide range of concepts. In addition, simplifying observations into categories, both specific and general, is an important property for most mammals.

We still do not know how the great apes (in particular) form categories, and make decisions (about themselves and others). They must have a mental ability to form categories, and it would be relatively easy to assign 'names' to some of these (see Pinker 2000). We know that with humans we can learn to identify and 'name' increasingly complex concepts. We probably need more thought and experiments on this aspect generally. If we continue to some more abstract concepts, it appears the great apes recognise events that occurred in the past, or are occurring in the present and future. They can interpret intentions of individuals of both their own, and other, species (see Wood *et al*. 2007). Even similar parts of the brain can be used in great apes and humans (Xu *et al*. 2009).

Making decisions is equivalent to categorisation. Some animal behaviourists enjoy over-simplifying animal behaviour into the four 'f's of feed, flee, fornicate, or fight. Although said humorously, it emphasises that the ability to analyse situations, and come to decisions, is present in the great apes. These are all prerequisites for language to be effective.

Chimpanzee's studies have shown that they can use symbols on modified keyboards attached to voice synthesisers. But perhaps the main point just here is that the mental abilities for nearly all the components required by language are present in the great apes. Emphasis could arbitrarily be selected on 'recursion' within our human languages, but this ability is already present in some bird songs (Gentner *et al*. 2006). Similarly, we know that complex vocal apparatus evolved in the oscine song-birds, in particular – so there seems no reason to make a stand over that particular issue (that is, over vocal cords in humans). In addition, it is known that great apes have the concepts of 'good' and 'bad' (Lyn *et al*. 2008), and this is a basis that can be expanded in humans in moral decisions.

Conclusion

Each of the myriad pieces of evidence increases the support for there being continuity of mental states between a great ape ancestor and humans. That is, it is unlikely there was any change in 'kind' during human mental evolution, even though no single piece of evidence might be sufficient in itself. However, we can always invert this approach, and ask whether we know of anything that would make an 'unbridgeable' gap between the basic mental abilities of humans and the great apes. As I analyse each process, I cannot find any. Rather, I am amazed at the number and complexity of the simple mental abilities of the great apes in particular. If we really let go of Descartes, there is a fantastic number of things to learn.

However, there is probably an even stronger conclusion in a Popperian framework. If we considered the Darwinian and Descartian extremes of the range of ideas, we could ask which has led to the most new experiments and advances in knowledge. This is based on the Popperian idea that a hypothesis to be scientifically useful must lead to new tests. If we made the assumption that there was a major discontinuity between great apes and humans, it would scarcely have been worth investing years and years of study into something that was assumed not to exist! However, our null hypothesis of mental continuity between great apes and humans has led to an extraordinary amount of new knowledge – and why should it stop now? It should continue; for example, are similar regions of the brain in great apes activated when they are showing empathy (Zaki *et al*. 2009)?

To end on what is perhaps a defensive note for humans, and as emphasised in Figure 1, the recognition of the proto-language elements among the great apes in no way denigrates human achievements. Rather, it raises my appreciation of the great apes, whilst still knowing that they could NOT do any of the amazing human accomplishments shown in Figure 1. Certainly, human language is an amazing achievement, but it does not lower our appreciation of it to recognise the many elements/precursors/components of language displayed by the great apes. Yes, humans are unique, but so are all species (Foley 1987). We should enjoy the fundamental unity of the evolutionary processes.

Acknowledgements

I would like to thank Professor Michael Corballis for raising such an interesting and fundamental question. It clearly still needs more thought and discussion, and raising fundamental questions challenges all of us to better clarify our reasoning.

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