HUMAN AND ANIMAL COMMUNICATION: EVOLUTION AND SEMIOTIC CLASSIFICATION

PhD Alberto Maria LANGELLA
University of Salerno

Abstract: *This article is a quick examination of the differences between animal and human communication, from which some reflections on the evolution of language will be proposed. The theoretical framework of reference is represented on the one hand by the semantic classification of semiological codes elaborated by Tullio De Mauro in his book Minisemantics, and on the other by the most recent ethological studies on animal communication and the evolution of human language. In particular, it will be interesting to note how, from a common semiotic base consisting of limited and unambiguous communication codes with a finite number of elements, human communication will, in the course of its evolution, rely on increasingly complex codes, to arrive at codes with an infinite number of elements and a high degree of ambiguity.*

Introduction

The peculiar characteristic of natural-historical languages to be endowed with creativity will also be discussed, in the sense of the possibility not only to increase the lexical inventory in diachrony, but also to be able to modify the meaning of words according to context and co-text. Also dependent on creativity is the possibility that natural-historical languages have of changing the morphological and syntactic rules that govern the correct combination of elements.

The thesis argued in this article is that before the phonetic alphabet, human language had not yet expressed its considerable symbolic potential. The phonetic alphabet, invented by the Phoenicians and perfected by the Greeks, was the form of writing that gave full expression to the articulate character of language. Before its advent, we will see how the ability to count and the invention of words to refer to collections of objects greater than 3 were the crucial steps towards the acquisition of remarkable cognitive capacities.

1. **A semantic classification of communication codes**

In classifying animal communication codes, and distinguishing them from human ones, I will limit my analysis to intraspecific communication (between members of the same species). This is because it is in the sphere of relations between members of the same species that communication codes have evolved and increased their degree of complexity; communication between members of different species (interspecific communication) has not offered the same kind of semiotic growth, although it retains a certain interest for the ethologist and more generally for anyone with a curiosity for the biological sciences. I suggest reading Martin Lindauer's *Message Without Words* to anyone interested in interspecific communication. I try, in this paragraph, to classify the intraspecific codes according to an order ranging from the simplest to the most complex.

1.1 *Codes of certainty: unarticulated with a finite number of elements and no synonymy*

At the most basic level we find codes with unarticulated messages (not decomposable into parts) with a finite number of elements and no synonymy. In them we distinguish dyadic and triadic messages. Dyadics have the characteristic of being composed of signs without meaning. We could call them emotive messages, in the sense that they convey emotions or intentions of the sender towards the receiver: for example the gnashing of teeth among dogs and other mammals, the courtship rituals of birds, some words of our languages such as the Italian *ciao*, *scusa* and *buonasera* or the English equivalents *hello*, *sorry* and *goodevening*. There is no referent, only the co-presence of two specimens of the same species. The evolutionary linguist James Hurford gives the following definition:

> Human language use has both dyadic and triadic aspects. There are some purely dyadic speech acts, in which the only significance is what one speaker does to another in making an utterance, with no ingredient of referring to or describing anything. The conventional greeting *Hello* is meaningful, but doesn't describe anything. In saying *Hello*, a person greets another, and that's all. In saying *Sorry*, a person apologises to another. In saying *Goodbye*, a person takes conventional leave of another. These are all things we do to each other with words. The vocabulary for such bare non-referring speech acts in any language is only a tiny fraction of the total, but every language has them. They are reflections of a basic feature of all communication, namely the sender doing something to the receiver

> [...] And in this respect, human use of language is no different from communication of all sorts in the non-human world. Of course, the possibility of adding descriptive content to the message, with words that refer to things, gives human language a scope vastly exceeding anything in the communication of non-humans. (HURFORD 2014: 42-43)

They are probably the oldest animal communication codes, the first to have appeared in the evolution of life. At the next level of complexity we find the messages we have called triadic. In these, in addition to two specimens of the same species, we can have a referent: the messages refer to external reality while retaining the possibility of dyadic communication. In their simplest form, triadic codes refer to referents perceivable *in praesentia*. These triadic messages with proximate referents include, for example, the alarm cries of green guenons. These primates possess three different vocalisations for three different predators: pythons, eagles and leopards. Also among chimpanzees, as in other anthropomorphic apes, we find similar vocalisations to those of green monkeys. It is plausible to assume that such triadic messages must have represented the first words of our proto-language, at a stage when the articulate character and syntactic-combinatory potentialities that resulted were not yet within our reach in cognitive terms.

At a further level of cognitive complexity, but not combinatory, we have a form of triadic communication that makes use of the faculty that psychologists call object permanence: it is the capacity, shared by many animal species, to remember a referent even when it is no longer perceived externally. Think for example of a leopard hunting an antelope. If the antelope disappears behind a dense group of trees, the leopard continues to chase it, because it has a mental image of the antelope, an image that manages to motivate it in pursuit even when its prey is no longer visible.

All the messages counted so far have the characteristic of not being articulate, of having a finite number of elements and of not having synonymy. The non-articulateness determines that, for example, the vocalisations of green guenons cannot be broken down into parts; there is no part in these vocalisations that refers to a leopard and one that describes its distance or the direction from which it is approaching. The signifiers refer to meanings in a global way. Hence the finiteness of these codes in which the number of elements, however large, can always be counted. Since signifiers are in bi-univocal correspondence with referents, if these codes represented too many objects of the external world, their signs would grow out of all proportion, and each of them, being different from all the others, would have to be remembered in its entirety, not benefiting from the possibility, which articulated signs possess instead, of being able to be broken down into a circumscribed number of a few basic elements (like phonemes for example).

Such codes are by definition devoid of ambiguity and synonymy; two different signifiers cannot have the same meaning and the same signifier of the code cannot have multiple meanings. They are codes of certainty, the decoding of which is absolutely unproblematic.

Serial codes such as that of the signs of the Zodiac or the days of the week should also be counted in this same category. The latter add to those just discussed the property of possessing meanings that can be ordered according to a series, in which some signs come first and others come later. Tullio De Mauro gives a very eloquent description of them:

> In the case of the six signs of the Zodiac, the row and its order depend on the following of the apparent positions of the Sun on the celestial vault, in the midst of the constellations. And the positions change in the course of the year with the change of the Earth's position in its annual rotation around the Sun. In short, in the case of the Zodiac, the series of twelve signs is imposed on the observation of human beings, on their minds, by the unfolding of natural things. Perhaps it was precisely by observing phenomena of this kind, such as the turning of the constellations, the succession of lunar phases, and developing elementary techniques, such as planting the posts of a fence or threading the pierced stones into wire to make a necklace, that the minds of human beings became accustomed to the idea of the series in ancient times. (DE MAURO 1997a: 34)

Such codes must have represented a considerable cognitive step forward, insofar as they enabled our hunter-gatherer ancestors to compare the same things but of different numbers and different things but inserted in series of the same number of signs. We are at the very beginnings of the concept of number. We will return to this point in the next section. Serial codes, like the others discussed above, are not endowed with synonymy; they are codes of certainty with the virtue of possessing signs that can be arranged in sequence.

1.2 *Articulated codes with a finite number of elements and no synonymy*

Articulacy, i.e. the decomposability of signifiers into parts, opens up immense combinatory potential for animal communication codes. Before the phonetic alphabet, the ability to count and the invention of words for the expression of a cardinality greater than 4 pushed our cognitive potential for the first time beyond the boundaries of non-articulated codes. We will return to this later. For now, I will emphasise how such a cognitive leap was made by our species many years ago; probably, in accordance with the position of the great evolutionary psychiatrist Julian Jaynes, this must have occurred as early as 70,000 years ago, as evidenced by the significant technological evolution of the Sapiens of that period:

> Since language *must* introduce very conspicuous changes in the attention paid by humans to things and people, and since it enables a very large-scale transfer of information, it must have developed during a period in which archaeological remains document such changes. Such a period is the Upper Pleistocene, roughly between 70,000 and 8000 BC (JAYNES 2007: 164).

In this period we have evidence of significant advances in the production of artefacts and we are at the dawn of more advanced symbolic skills, such as those required by cave drawings and the practice of burial rites. My opinion is that for humans to fully benefit from the potential of the articulated character one had to wait for the advent of the phonetic alphabet first, and secondly its technological association with Gutenberg's typewriter. Before clarifying this point, it is necessary to dwell briefly on the semiotic characteristics of articulated codes.

At a first level of complexity, these codes, while having access to the infinite potential of combinatorial calculus, comprise a sub-family of codes with a finite number of elements. The articulated character alone is a necessary but not sufficient condition to guarantee an infinite number of elements. In combinatorial terms, in fact, redundancy is defined as the ratio between the number of elements in the code and the potential number of elements. For non-articulated certainty codes, it makes no sense to speak of redundancy, insofar as there is no combination of elements; the signifiers in their entirety refer to meanings in a two-way relationship: one signifier one signified. We were talking about redundancy. Finite articulated codes include many catalogues, lists and plates, as well as Morse and Braille codes. If, for example, we think of an elementary filing code consisting of two letters of the Latin alphabet (26 phonemes), one lowercase and one uppercase, arranged in groupings of two, the signifiers will be *aA*, *aB*, *aC,...*, *bA*, *bB*, *bC* etc. From combinatorial calculus[1] we know that we have 52 elements (26 lowercase + 26 uppercase) arranged in groupings of 2, for

[1] In combinatorial calculus, the arrangements of n elements in k places are k^n , where the order of the elements is distinctive. In fact given the two letters *a* and *b*, available in groupings of two elements, we have a vocabulary of only two elements: *ab* and *ba*, since *ab* ≠ *ba*.

a total of 52^2 elements: 2704 signs. In this case there is no redundancy since the filing code exploits all potential combinations. In the case of Morse code and Braille code, on the other hand, we have a certain degree of redundancy, albeit low:

> In the case of Morse, two units are grouped into arrangements of one to six places, which act as signifiers of the 26 letters of the alphabet and the ten Arabic numerals. The 36 signifiers are chosen from a set of groupings that can be calculated according to the well-known formula for computing possible arrangements: 2 ,2 , 2 , 2^{12345} , , 22^6 = 2 + 4 + 8 + 16 + 32 + 64 = 126. In Braille, the redundancy of meaning is less high: two units (raised and unrelief dots) can construct six-place arrangements, with a redundancy, therefore, of 36 used arrangements out of 64 possible ones. As we shall see, in languages the redundancy is immensely greater. (DE MAURO 1997b: 67-68)

The great advantage of articulated codes is that they exploit the immense potential of combinatorial calculus. If the Morse code, for example, allowed combinations of 3 elements instead of 2, it would increase the number of its elements substantially; we would then have 3 ,3 , 3 , 3^{12345} , , 33^6 = 3 +9 + 27 + 81 + 243 + 729 = 1092. The number of elements becomes about nine times higher simply by allowing for messages that allow for one more unit, 3 instead of two. This gives articulated codes the advantage of highly economical exploitation of their signs. Compared to certainty codes, they require the storage of a limited number of elements against the production of a large number of messages. Indeed, we have seen, in the case of Morse, a ratio of 2 to 126 and 3 to 1092. We will shortly discuss how the phonetic alphabet exploits this principle even more effectively.

This type of articulated code, while exploiting the potential of combinatory calculus, has a finite set of signs that lack synonymy. In the examples above, the syntactic rules governing the combination (arrangement) of elements have certain limitations. For a code to be synonymic and infinite, certain combinatorial requirements must be fulfilled. Let us see which ones.

1.3 *Articulated codes with an infinite number of elements and calculable synonymy*

We were talking about the combinatorial requirements for an articulated code to possess an infinite number of signs with synonymy. De Mauro enumerates them as follows:

a) groupings it is useful for them to be what is technically called 'dispositions': that is, they must be groupings in which, as in the usual Arabic numerals, Roman numerals, alphabetical spellings of words, sentences, etc., the order, the arrangement of combinable entities, is a factor of diversity [...], the order, the arrangement of the combinable entities, is a factor of diversity [...] *b)* in the groupings the repetition of an element, its iteration, must serve to distinguish different groupings... *c)* the number of places in the groupings must have no theoretical limit, in the sense that, given a grouping of one hundred entities [...] it must always be possible to have a grouping of one hundred and one units, and, in general, if the entities are *n*, it must always be possible to have a grouping of *n+1* entities. (DE MAURO 1997b: 41)

Condition (a) is a principle of economy, and in codes with a potentially infinite number of elements, this provides a considerable advantage. In the case of arithmetic codes, for example, this property applies in the case of certain operations. For subtraction and division we have in fact that the permutation of elements leads to different results. In fact *8:4* gives *2* but *4:8* gives *0.5*; *8 - 4 gives 4*, but *4 - 8* gives *- 4*. This allows a multiplication of signs/groupings using the same basic elements (words in the case of languages). In the case of natural-historical languages, this economic principle is used even more extensively. For we know that the phrase Mario *observes Mary has a* different meaning from the phrase *Mary observes Mario*, just as *Mario gives a book to Mary* has a different meaning from *Mary gives a book to Mario*. However, principle (a) can only multiply signs and groupings, but does not guarantee a potentially infinite number of elements. For a code to have this property, conditions b) and c) are the only ones, from a combinatorial point of view, necessary and sufficient.

Let us first reflect on property b). This property determines that the arithmetic expression *2 + 2* gives *4*, that the arithmetic expression 2 + *2* gives *6*, that the expression 2 + 2 + *2* gives *8,* and so on. In accordance with this property, the repetition of the operation of adding 2 gives rise to arithmetic arrangements with different values. This property is necessary but not sufficient on its own. In order for a code, in this case that of arithmetic, to possess infinitely many elements, property c) is also necessary: the number of iterations, and thus the possibility of increasing the number of expressions with distinctive effects between different arrangements, must have no theoretical limit: if *2 +2* is an expression accepted by arithmetic calculus then *2 + 2 + 2*, 2 + 2 + 2 + 2, *2 + 2 + 2 + 2* and so on to infinity.

It is necessary at this point to dwell on an important property that characterises these codes, a property that unites them with the code of natural language: synonymy. Arithmetic, like the other mathematical codes, is in fact synonymous. We know that *2 + 2*, *1 + 3*, *3 + 1*, *1 + 1 + 2, 8 : 2*, *2 X 2* , 1 + *1 + 1 +1* and a few others are all arithmetic expressions that give the same result: *4*. They are, to use an analogy with natural-historical languages, synonymous. Synonymy is a property that the arithmetic code, like other calculations, shares with natural language. Whereas, however, for codes we speak of calculable synonymy, for natural-historical languages we know that this is not possible: the number of synonymous sentences is incalculable. This incalculability and the property of being ambiguous codes differentiate languages from all other codes. These are the two properties that determine their extreme flexibility and the possibility of continuous change over time.

1.4 *Articulated codes with an infinite number of elements, with uncalculable synonymy, polysemous and ambiguous*

We have said that codes with an infinite number of elements possess properties (b) and (c), and in addition property (a), which is not necessary but very useful for the economic use of the code. Arithmetic and algebra, for example, possess all three of these properties. Furthermore, we have seen how they are also synonymous codes. Languages share properties a), b), c) and synonymy with calculus, and have two further properties that make them unique from a combinatorial and semiotic point of view: polysemy and ambiguity. Let us proceed in order and before discussing polysemy and ambiguity, let us briefly return to properties a), b), c) and synonymy of verbal codes.

As regards property a), we have seen how sentences such as *Mario observes Maria* and Mario gives a book to *Maria have a* different meaning from the sentences *Maria observes Mario* and *Maria gives a book to Mario* respectively: the permutation of the same elements is therefore significant. As regards property b), i.e. that repetition must serve to distinguish different groupings, we observe how the sentence *Mario helps to do the cleaning Maria has a different* meaning from Mario helps to do the cleaning *Maria helps to do the cleaning Giorgio*, and the latter has a different meaning from *Mario helps to do the cleaning Maria helps to do the cleaning Giorgio helps to do the cleaning Luisa*. Finally, in accordance with c), we could theoretically continue to infinity through the addition of relative sentences if this did not encounter the obstacle of our memory, of our inability to decode sentences that are too long. This shows that properties (b) and (c), for which the repetition of the same element must lead to groupings of elements or sentences differing in meaning and such repetition must theoretically be able to be performed ad libitum, apply to verbal codes. Finally, synonymy is also widely witnessed in natural-historical languages. For example, the synonymic sequence *languages*, *natural-historical languages*, *natural language*, *verbal codes* and *articulated codes with an infinite number of elements endowed with synonymy and ambiguous have been* used in this article. All these locutions can be used to a large extent in the same sentence contexts[2] . The phrases *Mario analyses the political framework*, Mario makes an analysis of the *political framework* and *Mario performs an analysis of the political framework* are also synonymous. The previous two synonymic sequences could be extended with other synonyms to the extent that languages represent an extremely ductile code, possessing a type of synonymy that cannot be calculated. A particularly creative speaker could always add a synonym to an already very long and apparently exhaustive list of words or phrases.

Let us now come to polysemy and ambiguity. As far as polysemy is concerned, let us think of the word *machines* in *I bought two used cars*, *Those football players are machines*, *The market today offers machines with great computing power*. In each of these sentences *machines* has different meanings. In the first it means 'cars', in the second 'footballers with perfect athletic condition', in the third 'computers'. Languages are full of polysemy, another property related to their extreme pliability and the principle of economy: a word in different co-texts can take on different meanings without the code requiring a new word each time. Languages increase their polysemy rate over time thanks to the metaphorical extension of signs. Metaphors are undoubtedly the linguistic mechanism of greatest semiotic value in terms of lexical growth of languages. Calculations rely much less on polysemy, but especially in these codes, the possibility of continuous extension of sign meanings is lacking. The arithmetic expression $\sqrt{25}$ can be interpreted as '+5' and as '-5', but the conditions under which it is interpreted in one way or another are always clear, and above all do not change over time as in the case of the words of languages. They do not, so to speak, have metaphorical variations.

[2] I adopt a distributionalist approach to the definition of synonymy in this article. Two or more words whose sum of the cotxts coincides are synonymous. For a closer look at this approach I recommend reading Leonard Bloomfield's *The Language, Methods in Structural Linguistics* by Zellig Sabbettai Harris and for the latest developments of this method of linguistic analysis *Méthodes en syntaxe* by Maurice Gross.

Entire phrases, moreover, can have multiple meanings depending on the context, as in the case of *Prendimi il giubbino quando salire*, which can mean 'Bring me the jacket that is at home' if pronounced in front of the front door of one's building, 'Bring me the jacket that is in the attic' if pronounced in the kitchen at home, or 'Bring me the jacket that is in the office' if pronounced towards a colleague at the entrance of the building where one works, and many other meanings depending on the contexts we can imagine; are pragmatic variations. This is completely absent in calculations: the expression *2 + (4 : 2)* does not vary its meaning when read or heard in the home, in the office or in any other situation.

Finally, let us consider the feature referred to in linguistics as structural ambiguity. Each of the following two sentences can be interpreted in two different ways. In *Mario saw his father in the square using binoculars* we have 'Mario saw his father in the square using binoculars', an interpretation according to which it is Mario who is using binoculars, and 'Mario saw his father in the square using binoculars', an interpretation according to which it is Mario's father who is using binoculars. For the sentence *The professor ran over the student with a motorbike* we have 'The professor ran over the student riding a motorbike' or 'The professor ran over the student who was on a motorbike'. Such cases are very common in natural-historical languages. The latter and the type of polysemy they possess give verbal codes the trait of vagueness. And they are the only communication codes to possess it. The communication codes of other animal species are not vague and neither are calculations. In arithmetic, *8 : 2* and *16 : 4* give only and always *4*.

2. **The evolution of human language: from the codes of certainty to the explosion of creativity**

In this paragraph, I would like to attempt to answer the following question: at what point in our evolution did language begin to manifest its full potential? We have seen that, according to Jaynes, this must have occurred very late (starting 70,000 years ago) in the course of our evolution from ape-like ancestors to sapient creatures equipped with complex symbolic codes. Our journey through a long series of anatomical transformations began between 7 and 6 million years ago. The oldest hominids of which we have fossil evidence are *Sahelantropus tchadensis* and *Orrorin tugenensis* (both dating back over 6 million years). Then between 5 and 4 million years ago, *Australopithecus africanus* appeared, also in Africa*, from which Australopithecus afarensis* originated. The latter was already endowed with the upright posture and, according to many palaeoanthropologists, would have originated the genus *Homo*.

These early ancestors of ours had ape-like brains and traits and did not yet possess any kind of technology. It is reasonable to assume that their language did not differ much from the kind of code still used today by our close relatives: chimpanzees and bonobos. It was a code still confined to the first type in the previous paragraph, which we called certainty codes. No articulation and a limited number of elements. A simple, non-vague language to convey a limited number of meanings.

Then, around 2.5 million years ago, we encounter *Homo habilis*: the first tool maker. These are rudimentary drop-shaped stone tools. Stones shaped by percussion of another stone into two edges, presumably used for hunting and slaughtering meat. This technology is called Olduvaian, as it was found in the Olduvai Valley in Tanzania. For a million years, we have no evidence of any significant innovation until the advent of a tool-making technology called Acheulean, the invention of which is attributed to *Homo erectus*. This technology first appeared around 1.5 million years ago and slowly perfected until it completely replaced the Olduvian technology around 500,000 years ago. Acheulean consists of so-called bifaces, standard-sized stones chipped on both sides and worked with remarkable symmetrical balance. The precision of the workmanship indicates a development of the capacity for coordination and concentration brought about by an increase in the visual and motor neocortex, but above all by better synaptic connections between these two important areas of the *Homo habilis* brain. Here again, I believe that no major linguistic-symbolic innovation originated the innovative Acheulean technology. The latter, like the Olduvian one, must be traced back to the potential of intuitive thinking. More complex and later technologies such as the Neanderthal are also likely to be traced back to this.

This hypothesis is surrogated by an experiment conducted a few years ago in Japan by a group of researchers, who explained to a first group of students how to produce a typical Neanderthal tool through practical examples and verbal explanations; a second group was shown only practical examples. The group that only received practical examples showed the same skills and or the same degree of understanding as the group whose practical examples had been accompanied by verbal instructions. It follows that the production of a technology as complex as that of the Neandhertal, a hominid coeval with Sapiens and extinct only 30,000 years ago, does not require any symbolic language but can be entirely realised through intuitive cognitive skills based on imitation. It follows that, in my opinion, until the advent of the cultural and technological innovations of the Sapiens from 70,000 years ago, all hominid species, as well as our own species, possessed a language ascribable to communication codes of the first type, the codes of certainty. We are therefore in a pre-articulatory phase, with communication codes that are not yet able to exploit the potential of combinatorial calculation.

The following question naturally arises at this point: How is it possible that anatomically already modern hominids, such as *Homo habilis* and *Homo heidelbergenis*, as well as the Sapiens before 70,000 years ago, were still confined to a form of verbal communication very similar to that of the other anthropomorphic apes and many other vertebrates?

To answer this question, it is necessary to call into question a concept that has become established among biologists in recent years: exaptation. Coming to the rescue is the great American palaeoanthropologist Ian Tattersall:

> [...] perhaps the most important lesson we can learn from what we know of our origins concerns the meaning of what has increasingly been referred to in recent years as exaptation. This term is useful to define traits that arise in one context and are then exploited in another [...] The classic example of exaptation becoming adaptation is provided by bird feathers. Today, these structures are essential for flight, but for millions of years before the ability to fly developed, they were simply used as thermal insulators. For a long time, therefore, feathers were a very useful adaptation for maintaining body temperature. As an aid to flight, on the other hand, they were simply exaptations [...] There are so many other similar examples that we cannot ignore the possibility that our vaunted cognitive abilities had the same origin as feathers. (TATTERSALL 2005: 100)

I propose to consider, for example, the lowering of the larynx as an exaptation. This anatomical transformation, which we know to be a fundamental prerequisite to the production of the wide range of sounds typical of our articulate language, began 2 million years ago with *Homo habilis* and can be considered to have ended around 600,000 years ago with *Homo heidelbergensis*. But if it is true, in accordance with the hypothesis I make in this article, that throughout that time our ancestors still only had an extremely elementary and unarticulated language, the lowering of the larynx should not be considered as an adaptation of our phonation organs to the demands of a complex and fully articulated language. It must probably have been the result of an overall anatomical restructuring triggered much earlier by the assumption of the upright posture by the

Australopithecines between 4 and 3 million years ago, only to be exaptated to phonation much later by the first Sapiens capable of mastering a more evolved symbolic language.

Articulate language must have introduced enormous changes in our cognitive capacities in accordance with a process based on continuous feedback, in which the one stimulated the other and vice versa: improved cognition brought about by the acquisition of an articulate communication code progressively stimulated the latter, which in turn continually stimulated a more complex cognitive manipulation of the symbols of our language. This process must have started, as Jaynes argues, 70,000 to 60,000 years ago, when *Homo sapiens* became the producer of real culture. This important innovation must have developed in Africa and must have been brought to Europe a few thousand years later by the first colonisers of our species on this continent:

> When the first Cro-Magnon men arrived in Europe some 40,000 years ago, they brought with them more or less the entire range of behaviour that distinguishes modern humans from every other species that has ever existed. Sculpture, carving, painting, body adornment, music, arithmetic notation, refined knowledge of different materials, elaborate burial rituals, minute decoration of utilitarian objects: all these were part and parcel of the everyday experience of early Homo sapiens, as documented by many European sites dating back to before 30,000 years ago. (TATTERSALL 2005: 100)

The spread of such complex symbolic behaviour probably occurred by cultural transmission until it became a common feature of all Sapiens inhabiting the Earth at that time. Such cultural diffusion exaptised, i.e. parasitised, a brain and phonatory apparatus that were already ready for it. Incidentally, this process points to an obvious analogy with the relationship between today's operating systems and computer hardware: the former find computers already engineered to accommodate them.

Among the many cultural behaviours brought by the Cro-Magnons to Europe was, as Tattersall argues, arithmetic. Our colonising ancestors on the European continent recorded many things through notches engraved on bones found in Palaeolithic caves. We have seen how the arithmetic code belongs to codes of the third type, codes articulated with an infinite number of elements and endowed with calculable synonymy. We are on the threshold of a fully articulated language that may have found its cognitive prerequisite in the ability to count and operate with numbers. Our own and other species have the biological ability to quickly discriminate sets of no more than three objects, and this must have been of undeniable value in terms of survival. Indeed, it must have been, and still is, of great practical use to be able to discern with a quick glance whether one, two or three predators were approaching us: the risk we run is directly proportional to the number of predators. Many languages testify to this ancient and widespread biological capacity insofar as they possess words to express numerosity up to 3. Above this numerical limit in many languages we find that for 4, for example, we use words meaning 'two two', i.e. 'two times two'. An elementary arithmetical operation that must, however, have opened up vast paths in the direction of increased symbolic activities in the minds of our Cro-Magnon ancestors.

For quantities greater than 4, we find words in many languages that refer to the fingers of the hands. The fact that many number systems have multiple bases of 5 (decimal, vigesimal, sexagesimal, etc.) is, according to linguist Caleb Everett, a consequence of bipedalism:

> Ultimately, the discovery of the existence of large precise quantities, and therefore the invention of most numbers, is an accidental by-product of our bipedalism, like many other distinctly human things. Bipedalism eventually yielded a greater manual fixation and the recognition of the symmetry of our fingers, and it also facilitated the occasional recognition of the one-to-one correspondence of fingers with other countable objects. As a result of such factors, our hands offered the path of least resistance in our trek towards numbers.

Everett hypothesises that the origin of our calculating abilities is to be interpreted as an *accidental by-product* of the acquisition of upright posture[3], a concept perfectly equivalent to that of exaptation just discussed.

The advent of the Neolithic with the invention and spread of agriculture starting 10,000 years ago, further stimulated our calculating capacities, to cope with the perimeter delimitation of the land allocated to each person, the quantification of food supplies as well as the needs of the first trade in goods. All this pushed forward our symbolic abilities, which

[3] The upright posture freed our hands from the constraint of quadrupedal locomotion, allowing us to be able to stare more intently. We have seen how the emergence of the concept of number and of words to express different numerical quantities can probably be traced back to this. This process, i.e. the acquisition of the concept of number from one of our physical features, the five fingers of our hands, is an example of what we now refer to as *embodied cognition.* This cognitive mechanism has presided and presides over the evolution of every language, through metaphorical extension from concrete meanings to increasingly abstract ones. See *Metaphors We Live By*

were further stimulated by the invention of writing around 3,500 B.C. in the Fertile Crescent. I believe that throughout the Neolithic and in the first phase of the development of writing, we continued to make use of a language that, although articulate, was not yet able to fully exploit the great potential that the phonetic alphabet would bring. De Mauro comments eloquently:

> Combinatorial calculus tells us that these groupings, which admit as distinctive the repetition of the same element (*caro* is different from *carro*) and which, moreover, are also distinguished by the different order of the same elements (*reco* is different from *creo*), are called 'dispositions with repetition'. Given the number of the *n* basic elements (the phonemes) and the number of places provided for a grouping (the length of the word signifiers), a fortunately very simple formula, namely n^k , allows us to calculate how many arrangements with repetition one can have. If *n* is given by the thirty Italian phonemes, we know that the one-place groupings (k = 1), such as the words *a* or *d',* number thirty, the two-place ones (k = 2), such as *tu* or *se*, number 900, the three-place ones jump to 27,000 [...] the theoretically possible four-place dispositions are 810,000: with these we are already beyond the number of words recorded by the major paper dictionaries [...] but words just longer than one place are extracted from a set of 24,300,000 possible dispositions. (DE MAURO 2002: 58-59)

If we add to these the words with 6, 7 and more phonemes, the combinatorial calculation pushes the number of combinations to astronomical figures. From this gigantic set of words we then extract, as speakers, the words that will combine to form sentences, the number of which, as we have seen from the considerations made in the previous paragraph, is theoretically infinite. The phonetic alphabet also freed our memory from the task of remembering the ideographic and logographic words of the previous writing systems, words that, not being decomposable into elementary parts, did not allow for a full application to language of those combinatory abilities with which our Sapiens ancestors had become familiar much earlier millennia through the invention of the concept of number.

The great advantage of phonetic writing thus lies in the possibility of generating from a small number of basic elements, the phonemes, an infinite number of sentences. This has conferred, since the establishment of this revolutionary writing system[4] in Greece starting around 700 B.C., immense symbolic and cognitive possibilities on those Sapiens who for tens of thousands of years were confined to what we have called the languages of certainty, the same ones that our ape cousins (chimpanzees and bonobos) still use today. The earliest writing systems, ideographic and then syllabic[5] , roughly from 3500 to 500 B.C., did not yet have this potential, insofar as they did not benefit from double articulation. Each word in these writing systems represented its meaning as a whole signifier that could not be broken down into parts. Each word, different from all the others, had to be memorised. This, in fact, was the prerogative of a priestly class endowed with special mnemonic talents, who dedicated their lives to learning a very large number of words. In the face of such a mnemonic feat, one thinks of the relative ease with which a child today can learn, in the first year of primary education, the phonetic alphabet and trace the many words learned back to a few dozen basic elements. The benefits, in terms of memory, are immeasurable. First arithmetic and later the invention of this revolutionary word technology, the effects of which were reinforced and amplified by the invention of Gutenberg's printing press, enabled our species to adopt a communication code unique in its symbolic potential, a code endowed with an infinite number of elements, whose greatest semiotic qualities are its vagueness and mutability. A code that continues its incessant lexical growth and transformation, a code that made us, just a few years ago, Sapiens different from all those who preceded us. Sapiens endowed with an infinite capacity to manipulate symbols.

Conclusions

We have seen how animal communication codes are confined to the first type of the classification proposed in this article: the codes of certainty, unarticulated with a finite number of elements. Our communication codes, on the other hand, are only partly assimilated to theirs, insofar as a part of

[4] For an in-depth study of the effects of phonetic writing on the Greek mind, consult *The Muse Learns to Write* by Eric A. Havelock. Walter Ong's contribution on the relationship between oral and written thought is also very interesting, particularly the reflections contained in *Orality and Writing*. I highly recommend reading *History of Communication* by Massimo Baldini, whose concise and rhetoric-free writing makes this small volume, in my opinion, the best introduction to the field of communication and thought studies.

[5] I recommend reading *General Theory and History of Writing* by Ignace J. Gelb to anyone interested in learning more about the history and differences between the main types of writing.

the linguistic expressions we use is without referent, and only expresses emotions or intentions: we have called them dyadic messages. Animals also produce triadic messages (green guenons for example), messages with a referent. They are always messages of the first type, messages that we have developed better than other species, through a remarkable evolution of that faculty that psycholinguists call object permanence. Up to this point, the difference between human beings and other species, although it is not only quantitative but also qualitative, is not sufficient to push us outside the perimeter of the rather elementary codes of the first type. The transition to articulated codes, first with a finite number of elements, and then to those with an infinite number of elements, has made our species make an immense cognitive leap. These are communication codes closely linked to our symbolic capacities, communication codes that exploit the great potential of combinatorial calculation. They are communication codes of the second, third and fourth kind, which distinguish us from the communication of other animal species.

As far as our evolution is concerned, we have seen how for millions of years, from 7 million years ago to 70,000/60,000 years ago, the communication of our ancestors was confined to the code of the first type, shared by a large number of other animal species. Distinguishing us from the latter, throughout this long evolutionary period, was the appearance of a marked sense of group collaboration, a consequence of the transition from an arboreal lifestyle to one based on hunting and gathering, and the appearance of a particular sensitivity to the production of certain elementary artefacts with the invention of Olduvian and Acheulean technology. If, as I have argued, these two characteristics are not to be traced back to and justified by the use of an evolved symbolic language, it is nonetheless true that they testify to an increased brain mass, and as far as lithic artefacts are concerned, an early improvement in the coordination between the motor and visual areas of the neocortex. We are at the advent of more evolved Sapiens, the Cro-Magnons, who colonised Europe from 40,000 years ago, bringing with them a vast repertoire of new symbolic skills and probably bringing about the extinction of the Neanderthals. Among these new skills of fundamental importance were the concept of number and the ability to calculate, as a result of which for the first time in evolution an animal species ventured beyond the semiotic limits of the codes of certainty. Homo sapiens became familiar with the symbolic potential that resulted from combining simple numbers into more complex ones.

We are on the threshold of the Neolithic and of new and more advanced technological capabilities linked to the domestication of livestock and the intensive exploitation of the land. This marks a transition of our species from a lifestyle based on hunting and gathering to a sedentary lifestyle. Shortly afterwards, with the advent of writing, our species gains access to new cognitive possibilities linked above all to the possibility of entrusting written signs with the memorisation of information that had previously been transmitted orally. However, it is only with the affirmation of a revolutionary type of writing, the phonetic one, that our species will make the great cognitive leap, accessing symbolic possibilities never known before, beginning to play a unique role on the stage of life, the role of a sapient species endowed with a communication code with unlimited expressive possibilities.

Bibliography

BALDINI M., 1995, *Storia della comunicazione*, Rome, Newton Compton Editori.

BLOOMFIELD L., 1996, *The Language*, Milan, Est Edizioni.

DE MAURO M., 1997a, *Guido all'uso delle parole*, Rome, Editori Riuniti.

DE MAURO M., 1997b, *Minisemantics,* Bari, Laterza.

DE MAURO M., 2002, *Prima lezione sul linguaggio*, Rome, Editori Laterza.

GELB I. J., 1993, *General Theory and History of Writing*, Milan, Egea.

GROSS M., 1975, *Méthodes en syntaxe*, Paris, Hermann.

HARRIS Z. S., 1952, *Methods in Structural Linguistics*, Chicago, University of Chicago Press.

HAVELOCK E. A., 2005, *The muse learns to write*, Rome, Editori Laterza.

HURFORD J. R., 2014, *The Origins of Language*, Oxford, Oxford University Press.

JAYNES J., 1996, *Il crollo della mente bicamerale e la nascita della coscienza*, Milan, Adelphi.

LINDAUER M., 1995, *Message without words*, Milan, Arnoldo Mondadori Editore.

ONG W., 2014, *Orality and Writing*, Bologna, Il Mulino.

TATTERSALL I., 2005, *How we became human*, 'Frontiers. The Best of Scientific American', p. 99-111.