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The Nature and Function of Languages

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Abstract: Several studies in philosophy, linguistics and neuroscience have tried to define the nature and functions of language. Cybernetics and the mathematical theory of communication have clarified the role and functions of signals, symbols and codes involved in the transmission of information. Linguistics has defined the main characteristics of verbal communication by analyzing the main tasks and levels of language. Paleoanthropology has explored the relationship between cognitive development and the origin of language in *Homo sapiens*. According to Daniel Dor, language represents the most important technological invention of human beings. Seemingly, the main function of language consists of its ability to allow the sharing of the mind's imaginative products. Following language's invention, human beings have developed multiple languages and cultures, which, on the one hand, have favored socialization within communities and, on the other hand, have led to an increase in aggression between different human groups.

Keywords: communication; symbols; neural recycling; cultural identities

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1. Introduction

For over two thousand years philosophers, theologians and poets have reflected on the nature of language (Heidegger 1959; Panikkar 2007). More recently, scientific disciplines, from linguistics to computer science, have also sought to clarify its characteristics and functions (Sapir 1921; Jakobson and Waugh 1979; Borden et al. 2006). Nevertheless, in spite of thousands of books and articles, both theoretical and experimental, the nature of language still remains rather enigmatic (Lieberman 2013; Scott-Phillips 2015; Corballis 2017a, 2017b).

In the *Encyclopedia Britannica*, language is defined as a symbolic system (composed of sounds, hand gestures or letters) created by a social group to facilitate human expression. According to this perspective, the functions of language include communication, cultural identity, play and imaginative and emotional expression (Britannica n.d.). The Italian encyclopedia *Treccani* also specifies that language is an exclusive faculty of human beings allowing for the expression of consciousness' contents through a conventional symbolic system (Treccani n.d.). These definitions, albeit general, highlight characteristic aspects of language: its communicative function, its symbolic nature and its ability to express and share consciousness' contents.

2. Language as a Communication System

Communication is a particular form of transport in which what is moved is neither matter nor energy but "information" (Escarpit 1976). Yet, information cannot exist without a material substrate, though it is not reducible to it (Longo 1998). For example, sending a telegram to New York saying "*all right*" would require the same amount of energy and matter as sending "*gar lilth*" instead. Both telegrams are composed of two words and the same eight letters arranged in a different order. Transmitting either message would require an equal amount of energy and matter; although, only the first would convey

understandable information. Thus, information is to be regarded as something altogether different from its material supports (Wiener 1948).

Every communication system, be it verbal expression, telephone lines, radio channels or the internet, consists of at least three elements: an *emitter* (source or transmitter), a *receiver* and the *channel* carrying information from the emitter to the receiver. The information source (emitter) selects the "message" and encodes it in a "code" that is a set of "signs" or "symbols" which are represented by "signals" compatible and specific to the channel in use (Pierce 1961; Singh 1966). For example, the channel of a telegraph can only transmit electric current impulses of two possible durations: a short impulse (dot) and a long impulse (line). Accordingly, all letters of the alphabet have to be codified as a series of symbols made up of sets of lines and dots before being transmitted (Singh 1999).

To date, information's nature remains rather elusive (Dodig-Crnkovic and Burgin 2019). Information plays an essential role in the functioning of living systems (cells, organisms and societies) and in the regulation of some man-made devices, in particular, in self-regulating systems such as thermostats and electronic processors. Norbert Weiner, in one of the earliest definitions of information, describes it as being neither matter nor energy (Wiener 1948, p. 132; Montagnini 2015). According to Gregory Bateson (1972), information has to do with the notion of "difference": for example, maps are representations of territorial differences (roads, hills, mountains, cities). If all land was alike and presented no discernible features, there would be no information. Giuseppe Longo has thus proposed to define information as a "difference that generates a difference to somebody" (Longo 1998; Longo and Vaccaro 2013). Such definition necessarily implies the existence of an observer (man or machine) able to detect and/or produce differences.

Transferring information through a channel while limiting the interference of "noise", which tends to distort and shatter messages, is considered a crucial aspect of communication by mathematicians and engineers alike. In the monograph entitled *The Mathematical Theory of Communication* (1949), Claude Shannon and Warren Weaver maintain that the fundamental engineering problem of communication is to reproduce in one point (A), in an exact, or more or less approximate way, a message originating in another point (B) (Shannon and Weaver 1949). Such two points can be separated in "space" or "time". In this sense, communication then not only concerns the spatial transfer of information, but also its storage on physical supports.

Shannon was concerned with the technical aspects of communication, and in order to make mathematical observations, he isolated information from its semantic contents (Longo 1998, p. 28; Longo and Vaccaro 2013, pp. 22–23). In such a manner it was possible to relate it to the concepts of uncertainty and entropy. The level of information depends on the number of possible messages: if only one message is possible, there is no uncertainty and therefore no information. Moreover, information is related to probability, therefore, to a certain element of surprise. The smaller a message's likelihood, the more informative it is. By elaborating on these concepts, Shannon established an equation to quantify the amount of information contained in a message, regardless of its meaning. This quantity was related to the average logarithm of the improbability of the message. It was basically a measure of its unpredictability (Gleick 2011).

Establishing that information was not a concept of the physical discipline, and could not be related to either matter or energy, called for the invention of a new unit of measurement in order to define it. Shannon had the brilliant intuition to think of information as something allowing to answer a question with either a "yes" or a "no". The answer of such question can take one of two possible values: "1" (yes) or "0" (no). Thus, each question corresponds to a *Binary Digit* or a bit. For example, it is possible to precisely define a number between one and one hundred by asking a series of questions that can be answered with "yes" or "no". "Is the number greater than 50?" (Yes). "Is the number lesser than 75?" (No), and so on. According to this perspective, any question with a possible answer can be codified in sequences of "1" and "0" and can thus be measured in bits. Since language is a set of symbols (phonemes or letters of the alphabet), it too can be rendered in a series of bits.

For example, as each letter of the English alphabet can be coded in five bits, an average book of about four hundred letters approximately contains two million bits of information.

Conceptualizing language as a communication system (*Code Model*) is a major model of linguistic analysis. However, as language is not only a system for the transmission of information but performs other functions, it can be examined through other analytical frameworks (Scott-Phillips 2015).

3. Signs, Symbols and Codes

Information sources emit message units. These units are exchanged by means of a code (such as the genetic code, the alphabetic code, the Morse code, etc.) between the emitter (encoder) and the receiver (decoder) (de Saussure 1922). The code is a list of units, called symbols, that constitute the message. Symbols are signs in which the relationship between what is being represented and its representation is arbitrary (Mazzone 2005; Deacon 1997). The word *sign* derives from the Latin "*signum*" and describes "something referring to something else" (Peirce 1931–1935), as claimed medieval philosophers: *alquid stat pro aliquo* (Bettetini 1963; Mazzone 2005). The word *symbol* derives from the Greek *symbolon* (σύμβολον) which means: "to cast together", "to connect", "make coincide". The symbol for the Greeks originally designated an object, a tile, a fragment of ceramic or metal that was divided in the stipulation of an economic, emotional or spiritual contract. Each party kept a piece in token of their agreement. Upon meeting, the fragments of the *symbolon* were brought together to honor the bond and commemorate the economic, emotional or spiritual ties uniting them (Mazzone 2005). Aristotle emphasized above all the conventional and relational aspect of language's symbols (words) (*De Interpretatione*, (Aristotle 1962)). Symbols are entities in relation with one another, and for this reason the meaning of a word opposes and differs from the words surrounding it.

Each symbol of language has two faces: the signifier and the signified. The mathematical theory of communication has been interested above all in the signifier and its characteristics: encoding and decoding, resistance to noise, speed of transmission. To return to our earlier example, sending a message via telegraph requires that the letters of the alphabet be encoded in the symbols of the Morse code. The individual letters transformed into Morse symbols are then sent through a series of short (dot) and long (line) pulses, minimizing the effects of noise along the telegraph line. Other areas of general communication theory, such as semantics and pragmatics, are more interested in aspects related to meaning and the communicative context (Longo 2001). A fundamental aspect, which is often forgotten, is that at the origin and at the end of most of the experiences of coding or decoding a message, we always find "language". It is a very particular form of communication that presupposes thinking and speaking individuals, who have tacitly agreed upon an interpretative code among themselves through an action of social coordination (Singh 1966; Escarpit 1976; Mazzone 2005).

In a series of reflections developed in the biophysical context, Howard Pattee analyzed the most significant characteristics present in cultural (such as language) and biological (such as the genetic code) symbolic systems (Pattee 2008, 2015; Pattee and Kull 2009; Pattee and Rączaszek-Leonardi 2012). According to Pattee, "symbols" are "formal entities that stand for something else" (representing something else).

The first defining characteristic of symbols is that they are constituted by physical structures. In fact, all codes, rules and even the most abstract descriptions related to the symbolic dimension have well-defined physical bases. For example, DNA is formed by nucleotides, phonemes are made up of sound signals and even the letters of the alphabet consist of signs drawn on paper. The second characteristic concerns the aspect of reproducibility. The symbolic structures can be transmitted through their replication, which is articulated first in a process of "reading" and then in a process of "copying". The third characteristic refers to arbitrariness. All the symbolic structures, aside from being informative (highly improbable), present a complete arbitrariness between the "signifier" (phonemes, letters, nucleotides) and the "signified". The arbitrary relationship between

symbols and their meaning depends on the history of that particular symbolic system (the history of languages or the history of the genetic code). Indeed, at the lowest level of organization, no symbol carries any meaning (i.e., no phoneme or no nucleotide refers to anything significant). The effects of the symbols are highlighted within a dynamic system capable of generating more or less complex structures. Symbolic systems are historically determined and represent "memories of possibility"; they are coordinated adaptations with biological, psychological or social reality.

4. The Symbolic Nature of Language

Compared to DNA and psyche, language is the symbolic domain that is most "external" (Fabbro 2021a, 2021b). It is a symbolic system constituted by several layers. At the most superficial level, sounds are symbols for phonemes. In turn, sequences of phonemes are symbols for words, while strings of words form symbols for sentences and, finally, ordered chains of sentences constitute symbols for narratives and stories.

All languages are made up of symbolic systems nested within one another and sharing some universal properties (Hockett 1960). The first is the *duality of structure*: all human languages use meaningless signs (phonemes), which combine into ordered sequences of sounds with meaning (words). The second characteristic refers to *arbitrariness*, which is one of the fundamental concepts of all symbolic systems. In language, this concept indicates that there is no physical similarity between a symbol (word) and the object that it represents. Within a linguistic community, phonemes, words and numerous grammatical aspects are passed on from one generation to the next (*transmission*) through usage and learning (de Saussure 1922; Thorpe 1972).

Like DNA, languages have a *linear code*. This implies that every verbal expression is made up at the most superficial level of a string of words that, at the deepest level, presents a hidden structure (syntax). Linearity manifests a fundamental aspect of spoken languages, namely the temporal arrangement of acoustic signals along a timeline (de Saussure 1922). An additional property of languages, which is also shared by DNA, is *discreteness*. The sound symbols of a language (phonemes) are represented by a discrete number of elements (in Italian = 30; in English = 44). The same can be said of words; there are no intermediate sentences between a sentence composed of "n" words and a sentence composed of "n + 1" words (Moro 2006).

Another important feature is *recursiveness*, which is the ability to infinitely repeat a process within the same structure. Since a sentence can consist of a nominal syntagm (SN) plus a verbal syntagm (VS) [S = NS + SV], and the verbal syntagm can consist of a verb plus a nominal syntagm or a verb plus another sentence [VS = V + NS or VS = V + S], it is possible to recursively expand a sentence by inserting another sentence at the level of the verbal syntagm. For example, "Marco is wearing a sweater" + "The sweater cost 100 euros" = "Marco is wearing a sweater that cost 100 euros". Recursiveness accounts for another property of languages: *openness*, that is, the possibility of producing sentences that are always new or have never been uttered before. As a result of recursiveness and openness, every speaker can generate an almost infinite number of sentences.

The rules that determine the organization of words within a sentence are called 'syntax'. Each language has specific syntactic rules. For some, such as Latin, word order has only rhetorical significance. In fact, in Latin there is little difference between the sentences: "*hominem videt femina*" or "*femina videt hominem*", while in English the order of the words is very important: the sentence "the child eats the chicken" means something very different from the sentence "the chicken eats the child" (Sapir 1921). Within human languages, there is an enormous variety of phonemes, words and grammatical rules. Nevertheless, there exist some restraints in their choice and implementation.

The repertoire of phonemes that humans can produce is limited. The phonoarticulatory organs and the nerve structures that coordinate them have structural and physiological constraints. Likewise, it is not possible to pronounce words that are too long (e.g., composed of 500 phonemes) because at a certain point the air emitted during exhalation runs out.

Based on these premises, many linguists, starting from Noam Chomsky, have argued that there are limits also in the possible syntactic rules. Therefore, the set of syntactic rules of all languages would be delimited by a system of categories, mechanisms and constraints called "universal grammar". Universal grammar seems to be related to the ways in which the brain develops, organizes and functions, which in turn are related to specific genetic information that has probably evolved over hundreds of thousands of years within a context of a musical nature (glossolalic singing) (Mithen 2005; Patel 2008; Fabbro 2018).

5. The Invention of Language

Humans belong to the class of *Mammals* and the order of *Primates*, which emerged about 80 million years ago and comprises about 400 species, including prosimians (tarsiers and lemurs), monkeys and anthropomorphic apes. The Hominid family, which includes our species, separated from the latter about 5–7 million years ago. The most significant characteristic that distinguishes hominids from other primates is the bipedal gait (Manzi 2017). Adapting to bipedal locomotion brought about a series of anatomical modifications, concerning the conformation of the lower limbs and feet, and important physiological transformations at the level of the respiratory system and central nervous system. The bipedal gait modified the respiratory rhythm allowing for an extended expiratory phase, a fundamental requirement to develop the ability to laugh, sing and speak (Provine 2000).

Homo sapiens, the only extant species of hominids, appeared in Africa about 300,000 years ago. Fossil remains attributed to *H. sapiens* have been found in Ethiopia (dated 195,000 years ago) and Morocco (dated about 300,000 years ago). The modern human presents a more gracile and slender structure than the Neanderthal man, with a brain volume of about 1400 cubic centimeters in *H. sapiens* and about 1600 cc in H. neanderthalensis. Paleoanthropologists believe that modern humans seem to have come from an eastern or southeastern region of Africa and then spread across the continent. They subsequently migrated, in several waves, to Eurasia and the rest of the world (Tattersall 2012).

For a long period of time, more than 200,000 years, H. sapiens did not produce any technological innovations: its lifestyle and style in manufacturing lithic tools was similar to that of other extant hominid species (*H. erectus*, *H. heildebergensis*, *H. neanderthalensis*, Denisova man). The only significant distinction consisted in a different organizational structure of human villages. In fact, modern humans present, in all hunter-gatherer cultures studied, a more numerous social structure than that of the other hominids. About 80–90 thousand years ago, *H. sapiens* began to manifest great creativity by producing ornaments, decorations and complex tools that involved the development of symbolic thinking. This was unprecedented. Numerous anthropologists, psychologists and linguists have wondered about the causes behind this qualitative leap in culture and technology. Some have concluded that what brought about this *cognitive revolution* was most probably the appearance of articulated language (Tattersall 2012; Lieberman 2013; Corballis 2015; Chomsky 2016).

Not much seems to have changed at the genetic, anatomical and physiological levels in *H. sapiens* since its appearance 80,000 years ago. For this reason, some neuroscientists and paleoanthropologists, including Israel Rosenfield and Ian Tattersall, have argued that a group of *H. sapiens* located in a southeastern region of Africa probably "invented" articulate language (Rosenfield 1992; Tattersall 2012; Fabbro 2018). Evidently this was not a "conscious invention", but rather a kind of social game probably developed by a sufficiently large group of children who lived together for a few generations. The hypothesis that articulate language was invented and did not evolve, as many biologists, linguists and psychologists have long argued (Pinker 1994; Dunbar 2014; Corballis 2002, 2017a), is supported by the recent discovery that at least two languages emerged from nowhere in a group of children in Nicaragua and in a community of Bedouins in the Negev desert (Senghas et al. 2004; Senghas 2005).

Nicaraguan sign language is the first language invented by a group of children to have been thoroughly studied (Tattersall 2012; Bausani 1974; Fabbro 1996). Towards the end of the 1970s, after the victory of the Sandinista revolution, a special school dedicated to the education of deaf and mute children was established in Managua, the capital of Nicaragua. Initially, 50 children were brought together, joined by more than 200 in 1981, a number that gradually grew in the years that followed. The school aimed to teach deaf–mute children to lip-read the Spanish language, a goal that was not achieved. Instead, just within the span of two generations, the children spontaneously invented Nicaraguan Sign Language.

The first generation shared a set of signs that they had developed in the domestic context of their families (*homesigns*). These signs did not represent an actual sign language yet, but rather a form of gestural communication. In contrast, the second generation of deaf children, younger in age, was able to develop a grammatically complete language on the basis of the signs shared by children of the previous generation. The younger children were able to categorize the gestures of the older students, generating a true grammar, i.e., a set of abstract categories capable of regulating the relationships between different symbolic units. Only younger children were able to transform "gestures" into "symbols". This confirms the hypothesis that a language can only be "acquired" in a complete form or "invented" by children who have not yet reached puberty (Senghas et al. 2004; Fabbro 2004).

The invention of articulated verbal communication (language) by (deaf–mute) children indicates that language has not evolved but has been invented (Rosenfield 1992). This means that some biological bases of language (concerning phonology and syntax) have evolved within vocal behaviors that are much more archaic than language, such as glossolalic singing. Spoken language is the most important technology serving the transmission of mental content. Other systems used for the transmission of mental contents are written language and mathematics. Overall, these all are technical and cognitive skills that, on the basis of pre-adaptation (*exaptation*) phenomena, have conquered brain territories that originally evolved to compensate for other functions (Dehaene and Cohen 2007; Dehaene 1997, 2009; Fabbro 2018, 2021a).

6. What Is Language's Purpose?

According to many authors, language is a form of communication (Miller 1975, 1987). However, it is possible to communicate effectively even without language: many animal species communicate very well even without speech. Recently, Daniel Dor argued that language is a technology aimed at sharing imagination (Dor 2014, 2015, 2016). According to this perspective, the task of the speaker is to provide clues about their own mental representations, while the addressee tries to reconstruct the mental representations of the speaker through a chain of interpretative processes (Scott-Phillips 2015). In fact, for every "literal meaning" of a word or a sentence, there are infinite possible modulations of meaning (also related to pragmatic aspects). This fact determines one of the most typical characteristics of language, namely the "pervasiveness of indeterminacy" (Scott-Phillips 2015). This is a limitation given that verbal expression does not allow a direct (literal) grasp of reality; at the same time, it allows a varied range of interpretative possibilities.

Like all technologies, language is a system for achieving a purpose, namely the construction of a network of psychic individualities that exchange the contents of their imaginations. It is an unconventional type of technology, similar to money, contracts and legal systems. Since human beings are social organisms, language's invention and its development were accomplished as collective processes. Individual minds can be viewed as the "nodes" of a metaphorical Web, in which language constitutes the software that each human being downloads into their own mind and uses to help achieve an imaginative community (Barabási 2002; Dor 2015).

Wilhelm von Humboldt (1836) was one of the first linguists to emphasize the central role that imagination plays within language. In his opinion, human languages are not tools for naming objects that have already been thought, but rather organs used for the formulation of thought. Similarly, Daniel Dor considers language as the "mother of all

inventions" (Dor 2015). According to this perspective, it was the invention of language that really gave rise to human beings. Thus, the first and most important technological product of human beings is language. At the same time, language has changed us radically.

The unintentional invention of language has occurred repeatedly throughout human history (Fabbro 2018). Deaf and mute children in Nicaragua who spontaneously invented a new sign language were able to experience the passage of the "magical frontier of language" and compare it to their previous lives. The experience was described as inconceivable, disconcerting and astounding; what struck these children most was the realization of the abysmal loneliness of their lives prior to entering the sphere of language (Schaller 1991; Senghas et al. 2004).

The relationships between language and technology are much closer than is commonly assumed. One aspect shared by both language and technology is recursiveness. In fact, all technological tools are constituted by components that are assembled according to a hierarchical structure. Technologies are comprised of technological components that contain smaller components within them, made up of even more elementary components (such as screws, vanes, bolts, etc.). Thus, modern technology is similar to a language that is open to the creation of new structures and functions (Arthur 2009). For these reasons, we believe that it is not a coincidence that the cultural and technological explosion that followed the cognitive revolution, some 80,000 years ago, is related to the most important invention made by humankind, namely the invention of language. Finally, some interesting evolutionary psychology studies, developed by Robin Dunbar (1996, 2014), have analyzed the possible role that vocal communication and language play in strengthening social bonds and reducing stress.

7. Languages as the Bedrock of Cultural Identities

It is likely that the first language split into several others just under a few hundred years after its invention. In fact, language can arise only from other human languages. The emergence of dialects is favored by a combination of geographic isolation and of linguistic variation (at phonological, syntactical and lexical levels) naturally occurring within generations (von Humboldt 1836; Locke and Bogin 2006). Languages facilitate relationships within the members of a group, yet they also contribute to the segregation of communities (Fabbro 1999; Pagel and Mace 2004; Pagel 2009). There is evidence suggesting that languages may act as biological barriers genetically isolating populations; indeed, the tendency to prefer partners speaking the same language still prevails among human beings (Spielman et al. 1974; Cavalli-Sforza 1996; Fabbro 1996, 1999; Lieberman 2013).

The acquisition of language, both in written and spoken form, sculpts the brain in specific ways and is affected by the existence of critical periods (or sensitive periods) (Fabbro 2004). Generally, it is possible to learn a second language well only before puberty and preferably before the age of seven. After the brain structures of the implicit memory system (particularly procedural memory) involved in the acquisition of language and syntax have matured, it is generally not possible to completely acquire a second language at the first language level (Paradis 1994, 2009; Cargnelutti et al. 2019). These observations suggest that the true "territory" of a language is not geographical, but rather neurological and mental (Fabbro 2018). Moreover, perfect language acquisition is only possible within early childhood.

The use of vocal signals, learned within specific critical periods, is a rather widespread biological phenomenon: it is present in many species of passerines (canaries, finches, etc.) and in some mammals, such as dolphins and killer whales (Riesch et al. 2012). In killer whales, the development of pod-specific cultural habits (related to singing and feeding) has mediated their speciation into numerous subspecies (Riesch 2016). Cultural and genetic isolation is one of the mechanisms for producing biological diversity, and diversity is the ground on which life originates and develops.

Language's advent determined the emergence of human cultures. Human beings within each culture have developed more or less different narratives, customs and tradi-

tions. The different tribes and populations of *H. sapiens* were rather technologically and traditionally homogenous before the invention of language. Its invention generated considerable diversity in ornaments, decorations and tattoos among different language groups. However, it is likely that linguistic and cultural diversity in hunter-gatherer societies also fostered an increase in violence (Fabbro et al. 2022).

Violence is a behavior of destructive and systematic aggression, aimed primarily at the elimination of isolated individuals or groups of the same species. In the second half of the last century, some ethologists have documented the presence of destructive behaviors between different groups of chimpanzees (Wrangham and Peterson 1996; Wrangham et al. 2006; Kelly 2005). These behaviors did not seem to be driven by food scarcity, but rather competition to access larger territories and greater food and sexual resources. In humans, language differences appear to have fueled the tendency for inter-group violence, as in almost all past human cultures those who spoke foreign languages were considered "subhuman beings" liable be subjugated or killed.

In fact, one of the most characteristic abilities of human beings, even of those who have not studied phonetics or phonology, consists of the ability to recognize from the pronunciation whether an individual belongs to their linguistic community or not. This ability, which seems to develop more during adolescence, is independent of the communication of information. According to this perspective, language plays a significant role as a marker of group identities (Locke and Bogin 2006; Ritt 2017). These aspects of human socialization and communication indicate that language, like many other aspects of cognition, has both strengths and limitations, which must be properly understood and regulated (Fabbro 2021a, 2021b; Fabbro et al. 2022).

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