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Human language in the light of evolution

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ABSTRACT

This paper explores a few consequences of the hypothesis that language evolved for the benefit of speakers. This hypothesis, supported by recent Darwinian scenarios of language emergence, explains why speech production organs were dramatically transformed through evolution, while auditory systems remained practically unchanged. It also explains the need for huge vocabularies and for large episodic memory, and it dismisses the possibility of gesture-first scenarios of language origins.

1. INTRODUCTION

The scientific study of characteristic features of animal species implies seeking for their biological function. Scientists who study the subtle coordination of the thousands of muscle in the trunk of proboscidians or the building behaviour of *Castor canadensis* have some idea of what kind of advantage these animals get from having these peculiarities. Quite surprisingly, the scientific study of language has been conducted for long in the absence of any questioning about the biological function of this human distinctive ability. Though, asking: "What's language good for?" may improve our understanding of this unique behaviour by bringing new answers to old puzzles and by raising new questions. This paper aims at demonstrating it with concrete examples.

For historical reasons due to the confusion with the origin of languages [29], and then because of the belief that the language faculty could emerge in the absence of any selection pressure ([9], p. 75), the *raison d'être* of the language behaviour remained excluded from scientific investigation. The renewal of interest in language origin can be dated from Steven Pinker and Paul Bloom's paper [33], in which these authors succeeded in putting the issue back on the Darwinian ground. Since then, a variety of books and papers addressed the issue, which proved to be unexpectedly rich.

In what follows, we first outline the theoretical framework that we use as reference, which is a Darwinian framework. It will allow us to conclude that, quite paradoxically, language benefits essentially the one who speaks. We will draw some consequences concerning the referential nature of language, the disproportionate size of the lexicon, which necessitated digital phonology, the existence of episodic memory and the universal oral character of human language, despite the potential superiority of gestures as means of conveying information.

THE BIOLOGICAL INTEREST OF SPEECH

A well-spread prescientific attitude consists in considering that language exists because the species that has it can share useful information about its environment. Such an explanation is irrelevant in a Darwinian framework. Present-day living beings are descended from past individuals that reproduced more, not than members of other species, but than other members of their own species. Natural selection is a competition within the species, not between species. In other words, the ecological success of a species has no predictive value for its evolution [43].

Game-theoretic calculus, when applied to Natural Selection theory [27], showed that any behaviour which is not directed toward kin must be beneficial to its author to become prevalent. In the case of language, the constraint is far from obvious. If language is used to convey potentially useful information, language acts seems to benefit listeners and not speakers, what poses a serious problem in a Darwinian context.

Several attempts have been made to solve this paradox on the theoretical ground. Some consist in putting language out of reach of natural selection, considering that it emerged from mere cultural habits ([30], p. 214; [39], pp. 94 & 208). Such a thesis is hard to defend when confronted with facts such as the 'abnormal' low position of our pharynx, which has no other plausible explanation than being an adaptation to language. Another phenomenon which is incompatible with a purely cultural origin of language is given by the existence of language universals. Let us mention in particular (see [16]) the existence of:

- digital phonology
- central recursion in syntax
- co-reference blocking when a pronoun binds a noun (e.g. *She says that Leïla's sister is sick*)
- narrative laws (sensitivity to closeness, to recency, to improbability…)

- laws of argumentation (the contradiction–abduction–negation mechanism)

These phenomena, and others, which are all specific to language, are too deeply rooted in human cognition for their universality to be attributable to any hypothetical cultural inheritance. And if language is biologically grounded, the question recurs with all its intensity: how can language acts benefit their authors?

Few hypotheses have been proposed to solve this problem. One consists in depicting language as a cooperative exchange of useful information, some kind of informational barter ([35], p. 28; [42] ; [5]). Language acts would benefit listeners initially, but then also first speakers when the role are reversed. Unfortunately, this description raises many difficulties [15]. Speaking, in a cooperative scenario, should always occur for utilitarian purposes. Moreover, individuals should be sparing with words, directing their speech to one listener at a time in order to avoid information theft which ruins the speaker's hope for return. Real language offers quite a different picture. Everyday utterances do not systematically content useful pieces of information; there are more talkative people around in quest for audience than information holders waiting for being prompted; and individuals most often talk to several people simultaneously, about two on average [20].

The only alternative hypothesis currently available is that language constitutes a display device, in accordance with the Honest Signalling theoretical framework (also called *Costly Signalling theory*) [23], which is a particular case of the handicap principle [44]. From this perspective, language has a fundamental function, which is to be involved in the establishment of social bonds [21]. Individuals would talk to display certain qualities, especially the *ability to know before the others*, which are much sought after among coalition partners [16]. The speaker's benefit, in that case, is immediate: it is to attract or to keep the best possible friends among the individuals who could be interested in that friendship [19].

The consequences of such a scenario are many and significant, as we will see in the remainder of this paper. The very first is that *selection pressure essentially acted on speech production*, since the speakers are the ones who seek to display certain qualities. To speak metaphorically, stallholders on a marketplace make every effort to set up a stall and to praise their goods, while customers stay with their normal behaviour, or just engage in haggling. We thus expect most physiological and behavioural transformations associated with language evolution to have occurred on the side of sound and utterance production.

THE PRODUCTION OF SOUNDS

Human language communication relies on a vocal production mechanism and on an acoustic analysis mechanism. From an evolutionary perspective, the dissymmetry between both is obvious. The sound production device has been considerably transformed if compared with what it is in other primates, whereas auditory capabilities have remained unchanged, in perfect conformity with the idea that language essentially benefits speakers.

The human vocal tract has evolved to significantly increase the resonant cavity formed by the pharynx, which has been lowered to the sixth vertebra, while its position in other mammals like the dog is at the level of the second vertebra [4]. This low position is not unproblematic, especially if one considers the high frequency of fatal food inhalation.[1] Another human specificity lies in the cortical control of the vocal apparatus, which offers a voluntary control over laryngeal muscles that other primates lack ([14], p. 250).

The contrast with acoustic abilities is patent. These abilities were not significantly changed during evolution, if we compare them with what they are in primates or even in mammals or birds. The ability to discriminate the phonemes of human languages has been demonstrated in species as different as macaques, chinchillas, budgerigars, pigeons, gerbils and rats [40]. The bonobo Kanzi can extract the words he knows from a continuous flow of speech [36]. If, as some utilitarian cooperative models of language evolution predict, language benefited listeners, natural selection would have endowed our species with overdeveloped acoustic capabilities, far and away from other primates, and we would carry swivel trumpet-like ears to steal information from others ([28], p.351). Human overdeveloped capabilities, in this matter, are located in the throat rather than in the ear.

The human phonological system is a digital combinatorial device through which, in each language, sounds are put together to build meaningful morphemes. It constitutes a rather efficient mechanism that enables us to emit, typically, some fifteen new signals per second. Again, it appears that the system has been optimized more on the side of the speaker than on the side of the listener.

> "In fact, the temporal resolution capacity of the ear would not be good enough at normal speaking rates to segregate different phonemes and to perceive their proper order, if phonemes were consecutive bits of sound (Liberman &

[1] For instance, about 270 deaths were caused by inhalation or aspiration of food items in 1987 in Canada [24]. The risk is high enough to justify the fact that the Heimlich manoeuvre be one of the few techniques taught for first aid certificate.

> Mattingly 1985). Nature circumvents this limit imposed by the auditory system by packing the phonemes in such a way that each segment of sound conveys information about several phonemes." [1]

Some modelling studies have shown that, under simple hypotheses of maximal acoustic contrast and minimal shape distortion, a simple tube with constriction points can evolve to produce vowels and consonants that are close to those observed in human languages [7]. This result is not obtained through a coevolution of the emitter and of the receiver devices, but only of the former, in conformity with the hypothesis that speech could evolve principally to the advantage of speakers.

AN OVERCROWDED LEXICON

The biological function of the phonological apparatus is undoubtedly to make the communication of numerous different lexical items possible. To achieve this, a digital combinatorial system constitutes an efficient solution [31]. One may wonder, however, how the lexical hypertrophy of human languages can be an advantage. Human adults understands dozens of thousands of words in their mother language, excluding the words they understand in other languages.[2] What is the reason for such profusion? For some authors, language has essentially an utilitarian function.

> "It is possible to imagine a superintelligent species whose isolated members cleverly negotiated their environment without communicating with one another, but what a waste! There is a fantastic payoff in trading hard-won knowledge with kin and friends, and language is obviously a major means of doing so" ([34], p. 367)

> "And, of course, the arrival of natural language would then have hugely facilitated both social co-operation and the acquisition knowledge. […] For its arrival would have made possible the detailed exchange of information, as well as the intricate but indefinitely flexible co-ordination of activity, which underlies much of the success of our species." ([8], p.231-232)

> "Language allowed our ancestors to share ideas and experiences, and to solve problems in parallel. The adaptive significance of human language is obvious. It pays to talk." [32]

Utilitarian communication, however, can hardly justify the use of overdeveloped lexicons. As Robin Dunbar observes:

> […] most people would, at least until very recently, have supposed that [was language conveys] was related to information about hunting or the manufacture of tools. 'There were bison down at the lake yesterday when I was passing there' or 'If you want to make an arrowhead, you need to hit the flint nodule right here to strike off a suitable flake'. What is unsatisfactory about such claims is that (a) these kinds of technological activities take up a relatively small proportion of our time and (b) when we do engage in them, we actually rarely use language when doing so. Hunting is often best done in silence, and tool-making is best done by demonstration rather than instruction. ([22], p. 220)

Indeed, most utilitarian communication and coordination systems (e.g. in air-traffic control or scuba diving) are limited to a few dozens of words or signs. Material aspects of the natural environment of *homo sapiens* were relatively repetitive; a few words and deictic gestures would have done the job of coordination if it were the purpose of human communication. The lexicon of any language includes plenty of words with almost redundant meanings, what imposes a considerable learning load and provides poor return, if efficiency is assessed by the usefulness of the conveyed information.

> Why do we bother to learn so many rare words that have practically the same meanings as common words, if language evolved to be practical? ([28], p. 370)

The inevitable conclusion one must draw from the existence of overdeveloped lexicons is that the prime function of language is not to contribute to a better fulfilment of human needs.

Geoffrey Miller [28] suggests that the richness of the lexicon results from a sexual competition which brings individuals to demonstrate their ability to master numerous concepts. This theory encounters many difficulties. Among the most important, let us mention the fact that both sexes are equally involved in language in our species, whereas Miller's theory necessarily predicts strong sexual dimorphism in language abilities. Another problem is that this theory does not account for the content of spontaneous utterances, which essentially consist in narratives and argumentation [16] in which both sexes take their parts, while natural selection should have confined this content to the expression of masculine qualities intended for feminine audience.

The theoretical framework we proposed [16] [19] confers a role to large lexicons. It results from the prime quality that language allows to display, which is that one is the first to know. Let us take an example. On July 6th 2005, at 14h00, some colleagues of mine went out of their office to announce the unexpected victory of London against Paris to be the host city for the 2012 Olympic Summer Games, while anyone thought that Paris would be chosen. My colleagues' behaviour would be incomprehensible if it were a reflex oriented toward utilitarian purposes: obviously, everyone would get the news before the evening. The reason why my colleagues were watching for the final decision on the Internet and did not lose one second to

[2] Bilingualism and trilingualism are frequent in hunter-gatherer societies, because of systematic exogamy and of the limited geographical range of languages.

announce it, was not to increase the collective wellbeing. The point was rather to put forward their capacity to know first. In this game, it is not so much the value of information itself that matters, but its originality.

If this is the prime function of language: to show that one holds original information, then the existence of very large lexicons makes sense. Original events, which allow those which announce them first to produce an effect on listeners, are unexpected events, which relate preferentially to rare facts [17]. And one cannot designate rare states of affairs with a vocabulary limited to a few dozens of words.

A DISPROPORTIONATE MEMORY

The lexicon is not the only disproportionate element of our cognition. Human beings hold in their memory numerous situations, all unique, after only one exposure. This astonishing capacity is also related to the production of language.

The observation of daily conversations shows that individuals devote half of their speaking time, about 10% of their awake time, to report past facts that they try to mention 'à propos' in conversation. The originality of such accounts lies in their *unexpected* character. Let us consider an example: as he is walking in a street of Paris with his friend, a speaker points to a school and explains that he witnessed a fire a few years earlier there: he could see the flames coming out of that window on the left. This narrative behaviour, which fills up human conversations, is made possible by a characteristics of our species, episodic memory [41]. Certain animals like squirrels or scrub jays (*Aphelocoma coerulescens*) have a specialized memory for remembering food caches [10]. Great apes seem to remember certain recent precise events [37], but the non-specialisation, the precision and the size of human episodic memory make it without known equivalent in the living world. Some authors tried to justify this capacity by its practical advantages [6], but as for the lexicon, the prohibitive cost of such an organ (the cerebral matter in which these memories are stored consumes twenty times more energy than muscles [2]) cannot be compensated by the memory of entirely instantiated episodes that contribute poorly to learning efficiency. The role of episodic memory, on the other hand, makes perfect sense if individuals use the episodes hold in memory to mention them in situations where they can appear unexpected.

An event is all the more unexpected if it is simpler to individualize than anticipated.[3] Hence the importance of storing perfectly instantiated episodes. Let us take two extreme cases: (1) the speaker who saw a school in flames when heading to his workplace found the situation highly unexpected at the time of the event, because it was easy to individualize within any class of situations that can be used as reference; (2) if he merely mentions to his friend that such school burnt in the past, she will not see what distinguishes that school from all other buildings the couple has been passing by when walking, nor what distinguishes that disaster from all the blazes that occur every year in Paris. The conversational effect will be weak, and is likely to cause a rejection like *So what?* [25]. If the speaker tells that he personally saw the flames which came out of that window on the left, the effect on his friend will be intermediate between (1) and (2): by using his instantiated testimony, she can more easily individualize the situation and appreciates its unexpected character.

The narrative behaviour, which represents about half of spontaneous utterances, requires being able to store and to describe unambiguously a large number of episodes. Here again, selection pressure acts on speakers. On the alliance marketplace, where social bonds form and break, individuals who can produce unexpectedness are appreciated. Evolution favoured those who held a large stock of episodes in memory and could use a large vocabulary to describe them unambiguously.

SPEECH AND GESTURE

Several authors suggest that human communication may have been gestural before having been oral, and that there is no continuity between the vocalizations of primates and the oral language of our species [11] [12] [3]. The manual-visual channel offers a variety of advantages compared with the vocal-auditory channel, what several authors consider as an argument in favour of the idea that its recruitment for referential communication was 'easier'. Leonard Talmy identifies a certain number of advantages of the manual-visual channel [38]. Let us mention:

- the existence of about thirty parameters that may vary independently, compared with only eight for the vocal-auditory channel
- a strong parallelism
- continuous parameters allowing strong iconicity

Talmy emphasises the strongly digital character of the vocal-auditory communication to explain the superiority that it eventually showed for the communication of abstract concepts. A similar argument is proposed by Corballis, who considers that the accumulation of meanings is incompatible with an analogical encoding:

[3] From a technical point of view, unexpectedness U is a difference in description complexity: $U = C_{exp} - C_{obs}$, where C_{exp} and C_{obs} designate the expected and the observed complexity, in the Kolmogorov sense [18].

> It would be difficult, for example, to make iconic signs that would distinguish ducks from drakes […] spoken words cannot be iconic representations of real-world objects or events. They can therefore be calibrated to minimize confusion between physically similar objects. ([12], p. 212).

The issue is debatable. The example of sign languages shows that the manual-visual channel can perfectly be used as support of a digital transmission. As it is not limited to strict iconicity, it can combine the advantages of both systems, while preserving its parallelism and the significant number of parameters that can vary independently. In that case, the fact that human communication is spontaneously oral and not gestural constitutes a mystery.

The solution of this enigma is again provided by the fact that our language evolved in the interest of speakers. The problem that any speaker must face, even before being in a situation of putting forward the quality of what she is about to say (in particular the unexpectedness of the reported situation in the case of narrative communication), is *to draw the attention of listeners*. The observation of daily conversations shows that they are the scene of a gentle rivalry in which speakers, not listeners, are in competition with each other.

> Watch any group of people conversing, and you will see the exact opposite of the behaviour predicted by the kinship and reciprocity theories of language. People compete to say things. They strive to be heard. ([28], p. 350)

In such a competitive context, drawing attention of others becomes crucial. In this function, the vocal-auditory channel has a decisive advantage on the manual-visual channel, because the auditory attention of individuals is much easier *to force* than their visual attention. Just observe a group of deaf people signing to get convinced. If this argument is correct, one must admit that language had an oral component from its very beginning, even at the stage of simple deictic gestures. The argument is not incompatible with a coevolution of oral speech and spontaneous gesturing, on the contrary. However, by conferring the primacy to the vocal modality, it excludes "scaffolding" scenarios in which human communication had to go through a purely gestural state in its evolution.

CONCLUSION

In what precedes, we evoked several consequences of the fact that language evolved for the benefit of speakers and not, contrary to a well-spread idea, for the benefit of listeners. Human language activity constitutes one of the *arenas* where the establishment and the maintenance of solidarity bonds are played out. Because of the particular social structure in which they live, characterized by coalitions of significant size, human beings use several criteria for choosing their allies. The informational abilities, through which individuals become aware of the state of their physical and social environment, are one of these criteria. The preference for well-informed individuals generates a competition in which speakers compete to advertise their informational competence, what they make in particular by reporting any fact which may appear unexpected.

The consequences of this competition are multiple and in conformity with what can be observed when one studies language as it is spontaneously used. We mentioned the non-utilitarian character of the majority of utterances, the fact that the vocal apparatus evolved way more than the auditory apparatus, the fact that lexicons reach a disproportionate size, the fact that human beings maintain in their memory a great quantity of instantiated episodes, and finally the fact that human communication goes through oral speech, whereas the gestural modality was predestined for this role if the prime criterion had been effectiveness.

This scenario, which present language as a means of displaying one's informational abilities, is rich of other predictions. For example, it explains how argumentation could emerge as a means for listeners to counter lies, as lying is a cheap way to produce unexpectedness when the reported facts are not verifiable [16].

The crucial point which remains to be cleared up lies in the social change of organization which occurred in the evolution of the human lineage. The hypothesis concerning the importance for human beings to advertise their informational abilities through language rests on the fact that a better knowledge of the physical and the social environment is essential for the collective decision-making within coalitions. This only makes sense if coalitions are of significant size, some five or ten individuals. Among male chimpanzees, coalitions rarely exceed three individuals [13]. The most praised quality is physical strength, and it is also the one which is preferentially advertised. For some reason which remains unknown, our lineage went through a point of bifurcation, characterised by the emergence of large coalitions. This change conferred its importance to the informational capacity, and we owe our language to it.

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