

Alessandra Falzone

Department of Cognitive Science – University of Messina
amfalzone@unime.it

Evolution of Language. Continuity and Discontinuity through Models and Empirical Data

Abstract. Over the last years, the debate about language evolution has been dominated by functionalist models looking for continuity among various animal species to understand language evolution and its nature. In this work, I analyze the theoretical mistakes of such approach, that ignoring structural body transformation does not allow the application of evolutionary methods to the study of functions. Here I propose a naturalistic approach, based on Evo-Devo perspective, which considers biological constraints as the necessary “mechanical trigger” upon which language function could have evolved. This framework, through the examination of the comparative study of the peripheral and central structures of vocal articulation, allows us to both avoid functional leap in language evolution and at the same time, guarantee species-specificity of language.

Keywords: language evolution; mechanical trigger; evo-devo; structural continuity.

Analyzing Language Evolution

Language is one of the human faculties that has been investigated the most. From the origins of philosophical thought until the most recent neuroscientific investigations, the faculty of language and its evolution have been at the center of the debate regarding the definition of human nature.

In the panorama of current cognitive science, the faculty of language, in fact, is considered to be the wrench of human cognition. Within this framework of investigation, Chomsky has repeatedly stated that the study

of language does not have necessarily to be tied both to evolutionary considerations and bodily-based accounts. His definition of “metaphorical use of language” (1968, p. 101) has pushed the cognitive sciences to understand the faculty of language as a property of the human mind and human cognition, as an object that can only be studied within the individual (Paolucci, 2011). This minimalist vision of language, which excluded from a definition of language the social and corporal dimension, has long deprived the cognitive sciences from the interest for the corporeity of linguistic processes – what in other circumstances we have defined as a type of “linguistic negationism” (Pennisi & Falzone, 2010, 2016). Today, this topic seems to be taken into account by the latest generation cognitive sciences (Lakoff & Johnson, 1999; Rowlands, 2010; Shapiro, 2011). Perhaps, this new tendency in recent cognitive science can be related to a reaction to the unchallenged hegemony of the “linguistic turn” in all of 20th century culture, the affirmation of the neuroscientific paradigm and more in general, the emergence of a new cognitive naturalism that has found its scientific fulcrum in evolutionist synthesis.

The attention to evolutionary explanations has become pervasive in the theories of language. Even Chomsky, one of the most strenuous advocates of the de-corporatization of language, is giving credit to this approach (Berwick & Chomsky, 2016). However, despite the fact that this may appear paradoxical, he continues to criticize the evolutionary paradigm on the basis of the idea that the functional hypotheses characterizing the evolutionary approach to language are purely speculative (Chomsky, 1988; Hauser et al., 2014).

The purpose of this paper is to describe the plausibility of the two approaches above described in order to recover the greater theoretical value in the broader and more naturalistically oriented framework of cognitive science. To this aim, we will present the specific case of vocal articulation considered in the light of the most recent empirical studies.

A Turning Point About the Structural Evolution in the Evo-Devo Perspective

An aspect that is common to the functionalist approaches to the evolution of language (Pinker & Bloom, 1990; Van Valin, 1991; Jackendoff, 1993) is a scientifically incorrect use of the term “evolution”, which is often adopted as a theoretical strategy to justify the presence of language in *Homo sapiens*. Indeed, the classical theory of evolution and even more the Modern Synthesis have a technical notion of evolution that is difficult to apply to

the exclusive explanation of cognitive functions. The functions, in fact, constitute a virtual projection of the possible behavioral applications of the structures themselves. That between functions and structures is always a chronologically causal relationship, although not of a deterministic nature: if the structures had not assumed a specific “body technology” (Pennisi, 2014, 2016), it would be impossible for the organisms to manifest certain functions, including formal or mental technologies. If there had been no previous structures, the functions would not be able to instantiate itself.

The epistemological reflection matured in the Evo-Devo has sought to clarify these problems by attempting to formalize a precise difference between variability, change and innovation in evolutionary or novelty processes (Newman & Müller, 2005; Wagner, 2011; Wagner, 2014; Love, 2015), which is based on purely morphological criteria. Müller and Wagner (1991), for example, highlighted how the functional approach, already when applied to the analysis of non-cognitive biological functions, is vitiated by a principle of circularity (“new structures arise from new functions and new functions from new structures” [1991, p. 231]). For this, it would be unable to explain all structures that are formed without a precise functional purpose (as in exaptation). In other words, functionalism does not provide any indication of the causes of structural change and does not explain how new structures may arise even without any change in function. In the view of contemporary Evo-Devo, on the contrary, it would be necessary to identify the level of the mechanical trigger in the flow of transformations of innovation (Pennisi & Falzone, 2016), that is, the level in which “the mechanistic causes that are responsible for a specific morphological solution for a new functionality and / or a structural problem” (Müller & Wagner, 1991, p. 231) become explicit.

According to this theoretical framework, novelty (morphological innovation) explains the generative mechanisms of change in relation to two fundamental bases: genetic and developmental ones. The first basis implies to clarify the type of genetic change that creates the heritable phenotypic variation, and to understand which population mechanisms are the foundations for this process. The second basis concerns the explanation of the timing of pro-genetic changes and the rapidity of ontogenetic changes; in other words, the heterochrony of evolutionary processes that detect the primary factors initiating changes.

For the Evo-devo approach, therefore, the problem of innovation is not classificatory but mechanistic (Minelli & Fusco, 2005). According to Wagner (2014, p. 19), structural changes require “a specific correction in the ontology of neo-Darwinian science”. The ontology of the neo-Darwinian

synthesis, in fact, tends to focus more on the differences between organisms but ignores their underlying variational tendencies. Instead, by introducing a stable distinction between variation and variability, we could grasp the need to build a theoretical bridge between what is actually achieved, what could be achieved and what could not be achieved: useful criterion, as we shall see, in the reconstruction of the faculty of language (Pennisi & Falzone, 2015).

A last topic introduced by Evo-Devo in the theory of innovation is the relationship between novelty and reuse. In fact, reuse is a key point of the innovation processes, because it can produce changes by reorganizing the same structures: this is not for certain, but it cannot be excluded as a possibility. If we apply the concept of reuse to the neural structure, the chances of this happening become very high. In fact, neural reuse is one of the most common physiological strategies adopted by the brain to control the organism. Many studies have pointed out that the support for neural reuse could shed some light on the evolutionary history of language (e.g. Anderson & Penner-Wilger, 2013). This is a common position among evolutionists who claim that the faculty of language does not come out of nowhere, but is the result of a re-functionalization of neural areas previously used for other skills: a kind of cognitive exaptation strictly bound by the nature of central and peripheral structures. Many cognitive functions can re-install only on nerve structures that have already been exploited in a functional way and selected from environmental needs, leaving “detectable traces both on the brain and on the behavior” (Anderson & Penner-Wilger, 2013). Neural reuse could, therefore, explain both the evolutionary innovation of the brain and the implementation of neural networks, mediating between the general form of the brain, functionality and individual variation.

The Mechanical Trigger and the Specificity of Language

In the light of what we have claimed so far, the response on the specific technicality of language that an evolutionist perspective cannot ignore begins to take on a central dimension.

As is well known, Chomsky has always held an internal position (Chomsky, 1995). Despite some concessions to the role of evolution in the positive selection of aspects in some way connected to the linguistic function (Broadwell, 1990; Catania, 1991; Fitch, 2010), he has always remained internal to the abstract and mentalistic perspective of the first cognitivism. In his last writings, in fact, it clearly emerges that the only specificity of language consists in the Universal Grammar (GU) and, in particular, in two

formal properties: “Merge” and “Move” (Chomsky, 1995). These two very general rules present in the human mind are, according to Chomsky, a unique feature of human beings that emerged suddenly during the evolution history that led to *Homo sapiens*. In Chomsky’s view, it is not important when this emergence has occurred, nor what specific change it involved: in a moment of evolution of hominids, a mental module must have appeared in the human brain allowing the management of the application of the central rules of the UG.

With Merge available, we immediately have an unlimited system of hierarchically structured expressions. The simplest hypothesis of the ‘great leap forward’ for the evolution of human beings may be that the brain has been rewired, perhaps by some slight mutation, to provide for the Merge operation, at once, marking the event fundamental to what happened in that dramatic ‘moment’ of human evolution (Chomsky, 2005, pp. 11–12).

Somehow completely unknown, our ancestors begin to develop human concepts. At a certain moment, in a very recent past, perhaps some 100,000 years ago, individuals of a small group of hominids in East Africa undergo a minor biological mutation that equips them with the Merge operation – an operation that treats the concepts human beings as computational atoms, and makes them structured expressions that are systematically interpreted by the conceptual system to provide a rich language of thought. These processes could be computationally perfect, or close to perfection, and therefore the result of physical laws independent of human beings. Innovation shows clear advantages, and is taken by the small group. At a later stage, the inner language of thought connects to the sensorimotor system, a complex task that can be solved in many different ways and at different times. (Chomsky, 2005, pp. 83–84)

Chomsky’s quotations are illustrative of the lack of importance attributed to evolutionary events and, above all, to the relationship between these and the possible consequences on cognition, especially for those functions that define human nature, such as language.

Despite theoretical efforts, therefore, Chomsky theory is still among the theories that support the uniqueness of human language as a result of a qualitative leap – an example of “recent reincarnation of ‘miracle theories’ of language as a divinely or otherwise suddenly endowed human ability” (Petkov & Marslen-Wilson, 2018, p. vi).

Such an epistemological position appears even more striking if we consider that within the framework of cognitive science several approaches

to the study of language have shown that the hypothesis of a species-cognitive specificity of human language is not at all incompatible with its evolutionary history (Rosas, 2013; Miyagawa et al., 2014; Balari & Lorenzo, 2015). All of Chomsky's biolinguistics arguments paving the way to a drastically emergent hypothesis are in fact due to the break they propose between the development of the two technologies, body and mind, the structure and the function, which are always occurring in the human linguistic machine. According to Chomsky, in fact, the sudden appearance of Merge presupposes that the sensorimotor and conceptual outsourcing apparatus pre-existed at that "dramatic moment" of human evolution. It would seem, that is, that the mysterious development of human concepts may have preceded the explosion of Merge. The main problem of this bold hypothesis is that it clearly separates the computational operations of the brain from the products of the outsourcing structures. A significant example comes from the metaphor used by Chomsky himself when he says that the sensorimotor and conceptual interfaces are simple outsourcing devices similar to "a printer attached to a computer rather than a computer CPU itself" (Berwick & Chomsky, 2016, p. 35), completely devaluing their species-specific contribution to the language faculty.

However, as has been properly observed, linguistic categorization is impossible without lexicon (Tallerman, 2014); in turn, without lexical categorization it is impossible to apply Merge: "the lexicon must be the critical starting point in the construction of the syntactic engine, since without lexical elements, there is nothing to unite" (2014, p. 208). To this extent, lexicon is a unitary and inescapable process. Chomsky solution seems impassable because it is based on an abstract mentalism. In fact, no explanation is given of the way in which the "internal" conceptual atoms could be transformed into words with the advent of Merge: "What kind of language could exist without externalization?" (2014, p. 209). It would be a language of conceptual atoms, an inner language of thought not expressed and / or not expressible. Therefore, it would not be connected to direct evolutionary advantages (i.e. connected to the possibilities of a more effective defense or a greater reproductive capacity), as hypothesized in ethological theories. These ethological theories question the lowering of the larynx and the consequent decrease in the dispersion of the formant, a characteristic of vocalic production that has direct consequences on the estimation of body size in the co-specifics (i.e. the body size exaggeration theory of Fitch, 2002).

It is evident from the above arguments that the species-specific technicality of the language faculty does not lie in the computational syntax of thought generated by a brain mutation that would have enabled us to apply

the Merge and Move concepts. The empirical data that will be examined in detail in the following paragraph further confirms this. The following hypothesized device could, in fact, explain the derived power of human language as an infinite multiplier of a recursive combinatorial, but it would not be the cause: if anything, it would be the result of a biological structure integrated with neural and musculoskeletal devices responsible for vocal articulation and synergy between hearing and voice (e.g. see the studies by Fitch, 2018 and De Boer & Zuidema, 2018).

A different answer by Chomsky must therefore take into account a specific technicality of language that is much more embodied than the computational syntax of thought and fully compatible with the monitoring of the naturalistically oriented components of the cognitive sciences (neuroscience, evolutionary biology, ethology, biolinguistics).

In Darwinian biolinguistics (Pennisi & Falzone, 2016) we proposed a synthetic model at 4 levels:

1. level of the “mechanical trigger” of innovation, that is, the level in which mechanistic causes responsible for a specific morphological solution are explained according to the model previously described by Müller and Wagner (1991);
2. level of performative compatibility of innovation in the context of the evolutionary development of the structure. Hence, the level in which the organisms experience the mental conditions and events necessary to transform innovation into a fully integrated structure in the global organism;
3. level of natural selection in the field of populational genetics. That is, the level in which the new integrated structures are confronted with functional experiments and the mapped returns of neuro-cerebral systems verifying the overall bio-cognitive rebalancing are able to affirm evolutionary advantages (also of a social nature);
4. level of adaptation and cultural selection. This is the level in which functional behaviors (no longer structures) rooted on now-established forms evolve rapidly, showing a high surface variability and a thorough capacity for environmental modification in a short or very short time-span.

In this theoretical context, the contrast between a gradually evolving vs. fast evolving hypothesis loses meaning. The first three levels may require very long time-spans (“mechanical trigger”) and certainly deal with gradual transitions through the genetic and physiological histories of different species and taxa, often without linear sequences. The fourth level, which certainly would not exist without the first three, describes

events that can develop very quickly: they are not structures but products of structures (e.g. syntaxes, vocabularies, writing of historical-natural languages, etc.). By placing at the center of the evolutionary process the structural aspects instead of the functional ones, the direction of the research is reversed. From this view, indeed, the current structural features represent the starting point to account for the evolution of language. Specifically, since human beings are “speakers” who communicate using mainly, if not exclusively, peripheral and central corporeal body structures suitable for modulating and decoding vowel sounds, in order to explain the phylogenetic process of language we must reconstruct the evolution of these structures. Even if in some circumstances the auditory-vocal structures are not used to communicate – such as for deaf people or in cerebral pathologies – and are substituted by other body structures (e.g. sign language or tactile codes, etc.), it is still possible to consider the vocal modality the core of language.

Furthermore, it is completely superfluous to pose reconstructive problems concerning the origin, in general, of the communicative function. This communication function may have used the gestural dimension or more generally the kinetic one, or, again, the emotional, imaginative, musical substratum, etc. However, from the moment in which the structures of the vocal articulation were made available in a stable manner, they no longer played any role or, at most, they were relegated to ancillary uses with respect to vocal articulation. In fact, it is the specific technicality of a clear structural nature that marks the evolution of human language; the entire community of cognitive sciences has begun to reflect upon this in a permanent way.

Articulated Language: Continuity, Innovation and Species-Cognitive Specificity

The centrality of the technology of human language both for the understanding of evolutionary steps and for the definition of its nature is evident in the most recent scientific literature: until a few years ago the work on this topic favored the functional perspective dedicated to speculative reconstruction on the cognitive antecedents of language (Bickerton, 1990; Corballis, 1992; Deacon, 1997). The recent debate dominates the research on the biological structures of language starting from the comparative study of the peripheral and central apparatus of vocal articulation and the relation between the latter and the phylogenetic and ontogenetic mechanisms

of learning and cognitive development (Zuidema & de Boer, 2018; Dichter et al., 2018; Litte et al., 2017; MacNeilage, 2008; Goldstein et al., 2006).

The pioneering studies of Lieberman (Lieberman et al., 1969; Lieberman & Crelin, 1971; Lieberman et al., 1972; Lieberman, 2008) which since the seventies of the last century have insisted on the species-specific role of the supra-arterial vocal tract, today are experiencing a period of enormous expansion. This is due to the decisive progress not so much of paleoanthropology, the reference discipline for the reconstruction of the specificity of human cognitive functions, but to evolutionary ethology and neuroscience. Many recent analyses have, in fact, proposed to re-examine the problem of the origin of language in the light of the “cognitive neuroscience of the voice” (Pisanski et al., 2016, p. 315). This is experimental research comparing the uses of vocal articulation in humans and other animals. According to this proposal, the problem in reconstructing the origins is mainly caused by the apparent absence of an “intermediate vocal communication system” (2016, p. 315) between human language and the less flexible vocal repertoires of other primates. If that existed, a better hypothesis could be reconstructed. The existence, however, of an uncommon ability to modulate the fundamental frequency (F0) and the basic formants in many primates, and also in several other species of living mammals – as well as in many species of birds – could constitute, according to these scholars, a “Living Relic” (2016, p. 304) of the original state. This would demonstrate that the evolution of the anatomical and cerebral structures of the articulated voice is characterized by a gradual and entirely repeatable process because it is instanced in the bodies of the current heirs of human and non-human primates.

The relationship between structural continuity and cognitive discontinuity seems to be of the utmost importance to us. Much progress in research on vocal communication in non-human primates and other animal species has been made in the last twenty years as compared to the twentieth century. The idea that chimpanzees, bonobos and other species express exclusively through visual-gestural, olfactory, tactile or other extra-vocal resources is beginning to be challenged by the most recent research. Precise empirical reconstruction of the vitality and frequency of the use of vocal behaviors in non-human primates in captivity (Lameira et al., 2015; Perlman & Clark, 2015) as well as in their natural social environment (Wilson, Hauser, & Wrangham, 2007; Crockford et al., 2012; Genty et al., 2014) has been put forth by recent research.

However, what does it mean to understand and use vocalizations at these evolutionary levels? In the specific context that we are facing now, it has

become essential to understand the relationship between these anatomical peculiarities, the physical principles of the voice and the possibilities of combining one and the other in view of social purposes that give us the idea of how we could configure a potential evolutionary advantage for the human species. From the point of view of modulation of the formants, we know today that not only humans, but also non-human primates and many other animal species are able to vary both the fundamental frequency (F0) and the other formants (Fitch, 2000). These variations are used to mark many biological and psychological dimensions, including sex and age, body size, hormonal condition, dominance, masculinity or femininity, and sexual and social attractiveness (Pisanski et al., 2016).

Fitch (2002) has shown, for example, that the variation of F0 is used by the red deer to simulate an increase in body size for reproductive purposes. The strategy of the red deer still remains within the so-called “honest signals” (Zahavi & Zahavi, 1997; Pisanski et al., 2014), a sort of probable exaggeration, the bearer of reliable information (Falzone, 2012). In some primates, however, the variation of the F0 for the low frequencies is so marked that it completely distorts the relationship with the body size. The little howler monkey (*Alouatta sara*), weighing about 7 kg, has a vocal structure able to emit low formants so intense as to project an image similar to that of the trumpeting of elephants or the roars of tigers. The use of vocalizations to exaggerate the size for reproductive or defense purposes is one of the most common vocal communicative traits in the entire animal world and also provides a first approximation of the importance of the vocal dimension for a given species (Dunn et al., 2015). According to Pisanski and colleagues (2016, p. 308), the vocal exaggeration of body size “may have paved the way for more intentional forms of source and filter modulation and may have been the main vehicle for the evolution of voice control”. In fact, what seems to be an abnormal use of modulation for social purposes in the screaming monkeys should be considered a typical example for the non-explicitly verbal uses of the articulated voice.

Many studies have shown that these uses are very common even among humans. The di-morphism in the modulation of formant frequencies, very marked in the human species, was, for example, shaped by sexual selection. All recent studies indicate that both males and females vary modulation, ranging from about 5% to 25% of F0, when they appeal to attractive members of the opposite sex. More specifically, it has been observed that many subjects of different sexes and ages, including children and adolescents looking for a vocal model, decrease the lower formants in response to male voices and increase them in response to the female ones (Cartei & Reby,

2013). Sexually typical patterns (low F0 for males, high frequencies for females) are unanimously considered as attractive by the opposite sex (O'Connor et al., 2014). Also from the point of view of self-perception, the sexual characterization of the formants is very strong. Male subjects who self-perceive as denoisers lower their F0 by turning to other males, while subordinate subjects raise it (Puts, Gaulin, & Verdolini, 2006). On the other hand, the lowering of the male voice is accompanied by a lower distinction of vowels to the advantage of females or gregarious males and in some cases the cost of the lower distinctiveness of sounds is accepted by subjects with low culturalization in order to feel their virility enhanced (Kempe, Puts, & Cárdenas, 2013).

Both men and women can also voluntarily vary the frequencies associated with a judgment of trust and intelligence by increasing F0 (Hughes et al., 2014). However, much production and understanding of social signals may sometimes appear to be contradictory – it seems certain that ignoring them is nevertheless too high of a social cost. One could, for example, fail a job interview (2014), choose a wrong partner (Leongómez et al., 2014), not be considered a good political leader (Klofstad, Anderson, & Nowicki, 2015), and so on. According to various scholars (Cheney & Seyfarth, 2005, 2018; Ackermann, Hage, & Ziegler, 2014; Pisanski et al., 2016), the social advantages related to the modulation of vocalization and the perception of its indexical senses, present well before the capacity for distinctiveness and a widening of the range of producible sounds were in use – certainly used by *Homo sapiens*, perhaps even more than the 50,000 years ago suggested by Lieberman – and may have played a fundamental role in the selection of articulated language.

On the other hand, the production of specific vocalizations and the ability to respond in a socially appropriate and cognitively relevant manner already require brain structures for motor speech control. Current neuroscientific evidence allows us to hypothesize a two-way model (“dual-pathway model”, Pisanski et al., 2016) including a first pathway related to cortical sensorimotor systems (including the cerebellum) that directly control learned vocations, such as speech and canine, and another pathway connected to the limbic system in the anterior cingulate cortex, to the basal ganglia circuit and responsible for the unreflected vocal motility and control of the injected vocalizations (e.g. laughter). These two pathways constitute a network system that connects, in a unitary structure, the most archaic parts of the brain and the cortical ones, reformulated by novelty and re-use, in which the most recent evolutionary changes related to articulatory skills have been manifested. These evolutionary innovations, which often appear

as producers of “uniquely human” behaviors, are rooted in a capacity for vocal modulation, already present in primates and socially functional: “the vocal flexibility in non-human primates suggests that the other species have greater neuroanatomical processing of the direct lateral cortical motor path than previously thought or, alternatively, they achieve flexibility with older neural structures” (Pisanski et al., 2016, p. 314).

The Evolution of Language and the Embodied Cognition of the Voice

If in a gradualistic perspective we can claim that the human vocal articulation undoubtedly derives from that of the other non-human primates, it is equally evident that some structures of vocalism in *Homo sapiens* are specific, as evidenced by data from several neurofunctional studies. In *Homo sapiens*, for example, the laryngeal nuclei are directly innervated in the motor cortex (Simonyan & Horwitz, 2011). In non-human rats and primates “there is an almost total lack of direct connections between the various pools of phonatory motor neurons” (Jürgens, 2009; Cunningham & Sawchenko, 2000; Owren, Amoss, & Rendall, 2011). Secondly, the control of the neuroanatomical system of the human voice is configured as a set of cortical and subcortical networks connected to each other and with the entire peripheral nervous system. The evolutionary innovation compared to a possible analogous system in non-human primates consists in a rewiring and migration to the dorsal layer of the upper cortex of areas dedicated to the fine articulation, range extension and the control of the discrete sounds in the laryngeal area, exclusively of *Homo sapiens*. In particular, studies by Brown, Ngan, Liotti (2008) investigated the existence of a specific cortical area responsible for the control of the intrinsic and extrinsic musculature of the larynx, demonstrating its specific somatotopic context through sophisticated brain imaging techniques. The results have enriched the original mapping of Penfield and Roberts (1959) demonstrating the existence of a specific, voluntary laryngeal control zone: a Larynx/Phonation Area with point control of the protrusion of the lips and vertical movements of the tongue: “this area is the main vocal center of the human motor cortex” and “its somatotopic location is extraordinarily different from that reported in the apes” (Brown et al., 2008, p. 837). It presides over and controls both the voice and singing, supporting its coordination with the respiratory system and constitutes, also from the evolutionary point of view, a point of synergy between vocal production and auditory perception.

Also from the point of view of perception, from Brown's experiments the specificity of the Phonation Area is evident both during passive perception and perceptive discrimination of vocal production, to such an extent that it constitutes an almost absolute automatism: a system of hearing integration – highly functional speech, even more than the manual system of mirror neurons. According to Brown “the most evolutionarily significant sensorimotor link for the human auditory system is undoubtedly the vocal system and not the manual one. This is particularly true if one looks, among the primates, at the unique capacity of human beings for vocal imitation and vocal learning” (2008, p. 842; see also Mueller et al., 2018 on auditory sequencing).

From further neuroanatomical comparisons, it has also emerged that in non-human primates, intrinsic and extrinsic laryngeal muscles have distinct representations within the topographic organization (Simonyan & Jurgens, 2002): compared to that of non-human primates, cortical mapping of *Homo sapiens* appears upside down, with the CT muscle – Cricothyroid Muscle – in a more medial position of the TA – Thyroarytenoid Muscle (Rödel et al., 2004).

These important studies, supported by more recent research (Brown et al., 2009; Belyk & Brown, 2014), have specified that somatotopia of laryngeal muscles follows an inverted pattern in human beings with respect to homologous somatotopic positions in non-human primates. This result reinforces “the hypothesis that Larynx/Phonation Area is an evolutionary novelty in human beings that can be migrated near the representation of lips and tongue to facilitate the coordination between phonation and articulation during the production of language” (Belyk & Brown, 2014, p. 371). In particular, this migration would have allowed the intentional emission of vocalization, vocal learning based on vocal imitation, co-articulation, and the rapidity of the oscillation between voiced and voiceless sounds specific of human language. According to Preuss (2004), it would be a species-specific evolutionary characteristic of the human brain.

In addition, according to Simonyan and Horwitz (2011, p. 202), the displacement of the laryngeal representation (from zone 6 to zone 4 of the premotor cortex) “can represent one of the major evolutionary developments in man towards the ability to speak and voluntarily vocalize”. In particular, “it could have allowed the creation of a unique direct connection between LMC and laryngeal motor neurons of the brainstem for a faster neuronal transmission and a direct control on the coordinated activity of laryngeal movements, orofacial and complex respirators for the production of speech” (2011, p. 202). This anatomical modification would have cut out non-human

primates from the “technical” ability to develop a complex and voluntarily controlled articulate vocal language.

The extensive data provided by the comparison of peripheral and central structures with other species, especially with non-human primates, and neurofunctional studies show the groundlessness of a functionalist approach in the debate on the evolution of language (Falzone, 2018; Petkov & Marslen-Wilson, 2018). It may be time to consider, on the contrary, structural continuity instead of cognitive continuity as the basis of the evolutionary process and to attribute the species-specific technicity of *Homo sapiens* language to the structures of the vocal articulation.

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