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Lenneberg's Views on Language Development and Evolution and Their Relevance for Modern Biolinguistics

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1. Introduction

Among the early pioneers of the biolinguistic enterprise (on which see Jenkins 2000, 2004, and Di Sciullo & Boeckx 2011), the names of Noam Chomsky and Eric Lenneberg stand out. Both did more than anyone else to make the study of language a biological topic. They did so in different, complementary ways (ways that we think are beginning to converge in a productive fashion for a variety of factors which we will not expand on here; cf. Boeckx 2010, Di Sciullo *et al*. 2010, Boeckx *et al*. 2011, Balari *et al*. 2011, and Di Sciullo & Boeckx 2011 for discussion). Chomsky stressed the importance of certain basic facts such as the creative aspect of language use and the poverty of the stimulus the child receives during language acquisition to call for the study of the innate factors underlying language growth and to bridge the gap between the tacit knowledge of language users and the primary linguistic data. Lenneberg provided arguments that were much closer to 'wet' biology.[1] In so doing, Lenneberg provided the first and to this day one of the clearest examples of what Boeckx & Grohmann (2007) dubbed "biolinguistics in the strong sense", a body of work of the highest interdisciplinary quality.

In fact, Lenneberg (1967: vii) started from the claim that, as regards language, "biology has been badly neglected". Like Chomsky, his intention was to "reinstate the concept of the biological basis of language capacities" (p. viii). He developed that aim by approaching language as a species-specific mental organ with non-trivial biological properties, which grows in the mind/brain of the

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[1] Lenneberg too was concerned with promoting nativism, as the following passage reveals: "There is, then, nothing unscientific about the claim that a species-specific behavior pattern, such as language, may well be determined by innate mechanisms" (Lenneberg 1967: 221).

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child in the same way that (other) biological organs grow, showing that the child's path to language displays the hallmark of biological growth.

Lenneberg's (1967) book *Biological Foundations of Language* is today regarded as a classic. Like all classics, it deserves to be re-read at regular intervals, not only to appreciate the success (and limitations) of previous attempts at a synthesis among fields, but also to learn things that we all too often forget. It is from this perspective that we decided to go back to Lenneberg's seminal work. Not to stress its importance, for this is already well established in the literature, but rather to make the point that Lenneberg's conception of the biology of language was much more modern than some more current conceptions, and in fact much more modern than one ought to have expected from a work written in the 1960s, in the heyday of Modern Synthesis in biology.

For such an objective to be fulfilled, we have chosen two topics which as far as we know, have remained unrecognized, or, at least, have not received the attention they deserve in the context of the assessment of Lenneberg's legacy. The first one is Lenneberg's treatment of development and related issues, especially the role he attributed to genes; the second is his treatment of the issue of domain specificity (or lack thereof) in the context of language. Our choice is not altogether innocent: These two areas are at the forefront of current biolinguistics, having been highlighted in the context of the *FOXP2* discovery and of the Hauser *et al*. (2002) Faculty of Language Narrow/Broad distinction.

Our aim is to show that Lenneberg's book has more merits than those usually attributed to it. He did not merely call for an explicitly biological approach to the study of human language at a crucial time in the development of cognitive science; he did so with really modern, indeed prescient, ideas and with 'biological' intuitions that the new biology is beginning to make standard.

2. Lenneberg on Genes, Development, and Maturation

Genes are undoubtedly an important piece of the organismal biological machinery, and they unquestionably play a role in developmental processes. These claims are near truisms. But how relevant are genes for such developmental processes to be fulfilled? Currently, a strong disagreement exists on that issue, and opposite answers are being offered. The "developmentalist challenge" (Weber & Depew 2001), which we are about to expand on, has criticized and undermined the Neo-Darwinian geno-centric stance that has defined modern biology for the past half-century.

Several decades ago, things were different. When Lenneberg wrote his book, biology was almost entirely dominated by the Neo-Darwinian postulates, which can be briefly summarized as the claim that genes are the only relevant materials for explaining development and evolution. Lenneberg's thoughts went beyond this 'orthodox' conception. Unfortunately, his views on this matter were never, as far as we know, acknowledged nor highlighted. Worse, we will see below that they have even been mischaracterized. By means of quotes from his 1967 book, we will try to show that Lenneberg considered genes to be a mere starting-point, which is to be complemented with and related to many biological elements and levels for making up non-trivial developmental paths.

2.1. Two (Ancient and Modern) Answers about the Generation and Development of Biological Form

To begin with, let us make clear certain very general positions about development. These will help us situate Lenneberg's vision better. How is biological form generated? Which are the sources for it? How does it develop? These questions, and their many ramifications, have been at the heart of biology for centuries. Accordingly, much ink has been spilt on them, and very disparate answers have been offered. Perhaps one of the clearer examples of the controversy surrounding those questions can be found in the 17th and 18th centuries. At that time, a heated debate arose about how generation and development of form should be considered (for a brief overview, see Maienschein 2005; for an in-depth analysis, see Pinto-Correia 1997 and especially Roe 1981). On the one hand, preformationists believed that the fetus preexisted in the form of an homunculus; although the homunculus was allegedly a being in miniature, it was conceived of as fully formed (i.e. preformed), with organs, limbs, traits, and so on. On the other hand, proponents of epigenesis assumed that the fetus did not preexist at all; instead, it developed step by step.

As biology advanced, it became clear that the preformationist position lacked any kind of empirical support, for the alleged homunculus was never found. However, there is a sense in which the Evolutionary Synthesis and the Neo-Darwinian movement which grew out from it, resurrected the preformationist position.[2] Such a resurrection was carried out by means of a much more subtle strategy, based on the notion of information, and it gave rise to the geno-centric stance, which endows genes with a "special directive, formative, or informative power" (Oyama 2001: 178). Accordingly, genes grew in importance to the point that they were taken to possess the essential information for the development of organisms (and traits) and claimed to be the only relevant elements for heredity, development, and evolution to take place. Hence the return of preformationism, which for example Mayr (1982: 106) explicitly adheres to: According to Mayr, the development of organisms "is controlled by something preformed, now recognized as the genetic program". For those reasons, a strict identification between form and genetic codification was a key premise of Neo-Darwinian thought. In the words of Maynard-Smith & Szathmáry (1999: 2): "[…] each egg contains, in its genes, a set of instructions for making the appropriate adult. […] [I]t is the information contained in the genes that specifies the adult form".

According to such a view, the sources of development lie in the information contained within the genes (nuclear DNA); thus, the conclusion is drawn that development merely consists of displaying something already contained within the genes, by means of a process also strictly directed by them. Hence the preformationism; in fact, Lewontin (2000a: xii) asks "what important difference is there except in mechanical details between a preformed individual and all the

[2] For justification of the preformationist nature of Neo-Darwinism, see Lewontin (2000a), Oyama (2000), Bateson (2001), or Longa (2008), among others. Griffiths & Stotz (2000: 34) coin the term of "neo-preformationism" ("This strategy is often described as 'neo-preformationism' because like the old preformation theory of the embryo it denies that the order manifested in the developed organism actually originates during development"), whereas Weber & Depew (2001: 241) prefer to name it "weak preformationism".

information necessary to specify that individual?". The result would in both cases essentially be the same: "[A]dult organisms are merely expanded versions of the fertilized egg" (Bateson 2001: 156).[3]

Quite the opposite characterizes the developmentalist position (cf. Johnston 1987, Oyama 2000, Gottlieb 2001, Moore 2001, Oyama *et al*. 2001, Johnston & Edwards 2002, Robert 2004, and Blumberg 2005, among many other works). This perspective considers that traits (whether physiological or cognitive) cannot be pre-specified in advance nor directly encoded in the genome. The notion of genetic program as the main (or unique) source of information for development is said to be misguided because it ignores the informational role of many non-DNA elements which are placed between genes and environment, and without which development would not take place. As already pointed out by Lehrman (1953), to assume that the genes have the information for traits, and consequently that traits are encoded or pre-specified in a genetic program, entails turning development into an irrelevant notion.[4]

In fact, development cannot be conceived of as a single function of the genotype, nor as an additive result of genetic and environmental influences alone. The reason is that development is a highly complex process defined by multiple interactions which arise from multiple biological states and stages. Hence the notion of epigenesis, the meaning of which is that "development emerges via cascades of interactions across multiple levels of causation" (Spencer *et al*. 2009: 79), only some of them being related to the genetic level. Accordingly, the traditional divide between genes and environment cannot capture the subtleties of developmental processes: In order to explain traits, much more is needed than genes and environment alone (cf. Johnston 1987, and section 2.3 below).

To sum up, the aforementioned positions are very different perspectives about form and development: According to preformationism, genes do have traits (or, equivalently, the information for them to be generated), whereas from an epigenesist perspective genes cannot contain traits at all; genes are simply a step (perhaps not even the first; cf. Newman 2010) towards a very complex sequence of events which, at the very end, produces the development of traits.[5]

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[3] It should be noted that the geno-centric perspective also pervades some versions of Evo-Devo (cf. Benítez-Burraco & Longa 2010, Linde Medina 2010, Pigliucci & Müller 2010). For example, according to Carroll (2005: 35), "[i]n the entire complement of DNA of a species (the genome) there exists the information for building that animal. The instructions for making five fingers, or two eyespots, or six legs, or black and white stripes are somehow encoded in the genomes of the species that bear those traits".

[4] This is not to say that developmentalism defends "a return to empiricism and notions of a 'blank slate'" (Spencer *et al*. 2009: 84); see Maclaurin (2002) for an even clearer position on that topic, and Lorenzo & Longa's (2009) developmentalist proposal within linguistic minimalism. It just means to say that developmental processes are much more complex than traditionally assumed.

[5] Both perspectives can be related to the sophisticated conceptual analysis of the 'gene' notion made by Moss (2003), who distinguishes two types of genes which he calls 'Gene-P' and 'Gene-D'. The 'Gene-P' notion corresponds to genes of the preformationist view, those entities being "determinants of organismic traits and phenotypes" (p. xvii), whereas the 'Gene-D', which can be ascribed to the epigenesist/developmentalist perspective, may be conceptualized as simply one of the developmental resources, among many others. Its role is to provide templates for RNA and protein synthesis, but it "has in itself no determinate relationship to organismal phenotypes" (p. xiv).

For the purposes of our paper, it is important to realize that Generative Grammar has traditionally embraced the preformationist perspective by means of its defense of the need for a genetic program for language (see Longa 2008 and Lorenzo & Longa 2009 for details). Modern nativists assumed that there exists a language-specific "genetically determined initial state" (Chomsky 1980: 233) for explaining language growth in the individual. That initial state, named Universal Grammar, contains the innate linguistic principles for language to develop. It is for that reason that Universal Grammar is fully conflated with the notion of linguistic genotype (Chomsky 1980: 65, Lightfoot 1982: 21, Lightfoot 1999: 52, Anderson & Lightfoot 2002: 22, Lightfoot 2006: 45–46), this notion being defined as "that part of our genetic endowment which is relevant for our linguistic development" (Anderson & Lightfoot 2002: 22).[6] Accordingly, many linguistic properties were considered to directly lie in the genes. Examples along these lines abound. Thus, when discussing the property of structure-dependence, Smith (1999: 173) argues that universal properties of language like such a property "have become encoded in the genes of the children". The same strategy has been defended by many generative scholars, who have ascribed many constraints, principles, etc., to the genotype.[7]

2.2. Lenneberg's Views on Genes

As just discussed, from its inception Generative Grammar considered the genotype to be the source of the linguistic form, in much the same way that Neo-Darwinism took the genotype to be the source of biological form. For this reason we find it remarkable that Lenneberg showed a very different conception from the view Chomsky and associates adhered to. A careful reading of Lenneberg (1967) shows that, undoubtedly, Lenneberg ascribes a significant role to genes. He considered them to make up a level of biological organization, of course, much like those developmentalist theorists who point out that genes have been vastly overestimated by 'orthodox' biology but who do not deny that those entities have a role (cf. Griffiths & Gray 2005: 420 as an answer to misunderstandings according to which in developmentalist thinking genes are thought to be unimportant or even irrelevant). But, crucially, for Lenneberg, this was not the only level, nor the unique level which contributes to development with information. As we will see in the quotes that follow, Lenneberg went beyond the simplistic view which linked genes and traits. Importantly, he did so in a period when the traditional geno-centric position was even reinforced by the notion of genetic

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[6] In this context, Jenkins' (1979: 106) characterization of Generative Grammar as belonging to the "traditional study of the genetics of organisms" does not come as a surprise.

[7] Here are some others:

> "If innate, language must be genetic." (Uriagereka 2007)
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> "It seems a miracle that young children easily learn the language of any environment into which they were born. The generative approach to grammar, pioneered by Chomsky, argues that this is only explicable if certain deep, universal features of this competence are innate characteristics of the human brain. Biologically speaking, this hypothesis of an inheritable capability to learn any language means that it must somehow be encoded in the DNA of our chromosomes. Should this hypothesis one day be verified, then linguistics would become a branch of biology." (Jerne 1993: 223)

program that molecular Neo-Darwinism brought to the fore in the beginning of the sixties.

Here is what we get when we turn to *Biological Foundations of Language*. According to Lenneberg, "genetic mechanisms definitely play a role in the development of an individual's behavior" (p. 22). However, Lenneberg's position on genes is characterized by two main aspects: The acknowledgement of a very indirect relationship between genes and traits, and the rejection of the existence of 'special' genes for language, that is, the rejection of the need for a specifically linguistic genotype. Consequently, he offered well taken ideas (with far-reaching ramifications) about what genes can or cannot do, and what their real function is. These aspects can be summarized, as we will show, in Lenneberg's lucid rejection of the following two assumptions: (i) genes contain traits, and (ii) genes directly determine traits.

Chapter 6 of Lenneberg (1967) is particularly enlightening in order to fully appreciate his views on those issues. There, Lenneberg discusses the role of the genes by analyzing "what is known about the specific action of genes" (p. 239). His answer is that "DNA molecules, the biochemical correlates of genes, probably do not more than control the protein synthesis within the cell". That is, according to Lenneberg, no kind of functional principle could be stored in the genes, a claim which prevents genes from specifying any kind of traits in advance. Let's note how similar that statement is to claims made by defenders of the developmentalist stance; for example, according to Bateson (2001: 157), "[g]enes store information coding for the amino acid sequences of proteins; that is all. They do not code for parts of the nervous system and certainly do not code for particular behavior patterns".

Lenneberg went even beyond this, and explicitly denied in several passages of his book the idea that there exist genes for specific traits (including language), or, put similarly, that genes can contain traits. An example illustrates this. Lenneberg points out that the synthesis and biochemical structure of the enzymes are controlled by the molecular structure of the genes, and small changes in that structure "may easily affect the catalyzing efficiency of the enzymes and thereby change the temporal proportions of many far reaching reactions" (p. 241). Those temporal irregularities may affect aspects like the speed of growth, therefore giving rise to altered temporo-spatial patterns. It is for that reason that "genes may be responsible for the inheritance of certain structural characteristics such as the famous Hapsburg lip,[8] or a shortening of the chin, or excessively long legs" (p. 241). In cases like those, the growth is abnormally scheduled: It continues for a longer time than the usual growth (or it may be inhibited before the usual growth).

Lenneberg goes on to argue, very relevantly, that "it is not strictly correct to speak of genes for long ears, for auditory acuity, *or for the capacity for language*" (p. 241) [italics ours]. The reason is that "[g]enes can only affect ontogenesis through varying the cells' repertoire of differentiation, but this, in turn, may have

[8] The 'Hapsburg lip' is a genetic disorder which consists of a thick and overdeveloped lower lip. That disorder is usually associated to the 'Hapsburg jaw' (mandibular prognathism), in which the lower jaw is projected forward.

secondary effects upon structure, function, and capacities" (p. 241).[9]

True, an anomalous sequence of DNA can cause an abnormal phenotype, but the crucial point is that the mirror image cannot be inferred: The correct version of that DNA sequence cannot be taken to be responsible for the trait. To put it in other words, the existence of a correlation between a given sequence of DNA and the presence of a trait does not entail at all a direct causation of the trait by that sequence of DNA. As Bateson (2001: 157) puts it, "[a] disconnected wire can cause a car to break down, but this does not mean that the wire by itself is responsible for making the car move".

As mentioned above, the assumption of a direct link between genes and traits has pervaded and still does not only society, but continues to populate academic writings, especially in the context of language. For example, the recent finding of the human version of the *FOXP2* gene in Neanderthals (Krause *et al*. 2007) has raised the widely extended inference that *Homo neanderthalensis* had a human-like (i.e. modern) language. This case illustrates pretty well that the assumption of a direct link between genes and traits is still accepted by many scientists, in the light of quotes like the following:

> […] Neanderthals must have had a communication system at least equivalent to the one we can infer for Aurignician moderns. […] This is consistent with recent genetic evidence (Krause *et al*. 2007) indicating that a critical gene known to underlie speech — namely *FOXP2* — was present in the Neanderthal genome. (d'Errico & Vanhaeren 2009: 38)

> Up to date behavioural and anatomical studies of neandertal fossils and the recent discovery of their possession of the *FOXP2* gene indicate Neandertals (and, very likely, their European ancestors) has linguistic capacities similar to living humans. (Frayer *et al*. 2010: 113)

However, the inference '*FOXP2* in Neanderthals, *ergo* (complex, sapiens-like) language' is very simplistic, and therefore, ill founded (cf. Benítez-Burraco & Longa, in press for discussion). Among many other reasons, a gene by itself is useless. As Dick Lewontin likes to stress, DNA is a dead molecule, among the most non-reactive, chemically inert of molecules in the living world. That is why it can be recovered from ancient plants and long-dead animals. It has no power to reproduce itself and, while it is promoted as producing proteins, in fact proteins (enzymes) produce DNA. As Fisher & Scharff (2009: 173) put it, "[i]t is worth emphasizing that because language is clearly underpinned by multifactorial influences, the status of a single gene in ancient DNA is insufficient to resolve long-standing debates over linguistic capacities of our extinct ancestors".

The widely extended assumption of a direct link between genes and traits derives from classical genetics (Mendelian–Morganian-like), which was conceived of as the analysis of discrete units acting upon specific phenotypic traits, and it basically entails considering a gene as a simple causal agent (Jablonka & Lamb 2005: 6). The (false) rationale underlying that reasoning has been nicely unraveled (and criticized) by Brian Goodwin:

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[9] In so doing, Lenneberg solves an apparent paradox that he himself raised (cf. p. 272): If the inherited genetic information has only to do with intracellular events, but at the same time language is a supracellular phenomenon, how could language have a genetic foundation?

> So a change in one gene can make a big difference to the shape of an organism, or indeed to any other inherited property. This is a very important observation, and a lot has been made of it. But the conclusion is often drawn that the genes themselves, through their products, contain the key to understanding how all the detailed properties and structures of organisms are made, so that all we need to know is what the genes are doing in order to explain how organisms get their shapes. […] The logic that leads to this very strong statement runs basically as follows. Because we know that a change in a single gene is enough to cause a change in the structure of an organism, genes must contain all the information for making that structure. If we can get that information, we'll understand how the structure is made. (Goodwin 1994: 16–17)

This conception of the genes as simple causal agents has led to the idea that a given gene is the direct and unique responsible for a given phenotype. That view, we insist, was not assumed by Lenneberg. In fact, he rejected that idea at least in two more passages of his book. Thus, Lenneberg points out that the way how genes influence the general patterns of structure and function is by means of their action upon ontogenesis. And, as he states, "it is possible to talk about language in connection with genetics without having to make shaky assumptions about 'genes for language'" (p. 244). Later, he goes on saying that although pedigrees and twin studies suggest that genetic transmission is relevant to language facilitation, "there is no need to assume 'genes for language'" (p. 265). To have firmly placed that conclusion on the agenda almost half a century ago is undeniably a great merit of Lenneberg's thought, one that too many (bio)linguists continue to ignore.

According to Lenneberg, "we do not know what the direct relationships are between man's complement of genes and his mode of communication; we merely wish to outline the theoretical possibilities for relating the two" (p. 244). As it can be appreciated, Lenneberg outlined those theoretical options (which are based on the existence of a very indirect relationship between genes and traits) very accurately. Lenneberg was perfectly aware that "[t]he idea that there is a gene for adventurousness, heart disease, obesity, religiosity, homosexuality, shyness, stupidity,[10] or any other aspect of mind or body has no place on the platform of genetic discourse" (Jablonka & Lamb 2005: 6).[11]

All the aspects raised so far naturally lead to discuss Lenneberg's view on development in general, and on language development in particular. Again, his treatment of these topics is both illuminating and remarkably modern-sounding.

2.3. Lenneberg on Development

In section 2.1, it was argued that the conception of development held by (ancient

[10] Or even voting behavior. Fowler & Dawes (2008: 587–588) state that "two extensively studied genes are significantly associated with voter turnout. Further, these are the first two genes ever directly associated with political behavior". It seems to us that this view would also be strongly rejected by Jablonka & Lamb (and by Lenneberg).

[11] Critics may argue against our interpretation of some passages of Lenneberg's book using quotes like "[a] direct and profound dependence of language capacity on genetic constitution" (p. 253). However, our discussion shows that "direct and profound" should not be understood as a direct causation at all.

or modern) preformationism can be said to imply that development is undervalued or even neglected, because the information for the traits is considered to pre-exist in the genes: The more relevant we consider the genetic program, the more trivialized development becomes. A key idea of such a preformationist perspective is to assume that genotype and environment are the only two relevant actors for development to take place. However, from a truly developmental view, it is obvious that this reductionist strategy is misguided, for it ignores the vast biological machinery which exists between genotype and environment. Without that machinery, both genotype and environment would be completely useless. This point is especially clear when we consider what is referred to as 'cascading events' in developmental biology (cf. Moore 2001: chap. 4): The development of any trait implies a very complex sequence of events, where "event A causes event B, which causes event C, and so on" (Moore 2001: 69). For sake of exposition, that phenomenon could be represented in a very simplified way with something like this:

$$A \Rightarrow B \Rightarrow C \Rightarrow D \Rightarrow E \Rightarrow F \Rightarrow G \ldots \Rightarrow Z$$

As Moore points out, cascading events resemble a typical 'domino effect', where a domino pushes over another domino, and so on. The relevant point is the following: "[I]t does not seem reasonable to call event A the cause of event Z, because many other events are involved in producing event Z as well" (p. 70). Therefore, cascading events entail that nor genotypes nor environment may have direct effects. However, those who argue for the preexistence of traits within the genes forget that aspect (cf. Johnston & Edwards 2002 for a proposal of a highly articulated developmental model, with many interactants).

Interestingly, Lenneberg did not fall into that trap. A feature pervading his book is the recognition of the enormously complex nature of development, in such a way that after the genes, "a very complex chain of event ensues, until a relatively steady state, called maturity, is reached" (Lenneberg 1967: 240). This implies that, according to Lenneberg, "organisms are not programmed for their behavior by an ex machina force, but they develop a program ontogenetically together with nervous and non-nervous tissues" (p. 4). Two more quotes make this point abundantly clear:

> The central nervous system and other tissues in the body develop simultaneously and influence one another continuously during morphogenesis.
> (Lenneberg 1967: 28)

> Animals develop as an integrated whole including structure, function and behavioral capacities. (Lenneberg 1967: 240)

Lenneberg clearly held an interactionist, dynamic view of development. That view involves the rejection of an encapsulated and self-sufficient conception of the genome.

Actually, Lenneberg's view can be related to a key feature of epigenesis, which is referred to as (complex) causal co-interactionism (cf. Lewontin 2000b, Oyama *et al*. 2001: 2, Robert *et al*. 2001: 955, Robert 2003: 96). In Robert's words:

> Constructive causal interactions in development involve inducing, facilitating, maintaining, and participating in time-sensitive feedback loops at multiple levels within and beyond the developing organism — only some of which might be characterized as gene activation. The interactions comprising organismal development are complex, and their effects are not simply additive. (Robert 2003: 96)

Complex co-interactionism thus means that development cannot be perceived as a linear series of stages, but as a continuous transformation across the overall process, where "biological products are built up, deformed, broken down, distributed or deformed" (Oyama 2000: 133), those changes being the very essence of development.

According to Lenneberg, there exists an immanent schedule of evolvement evolutionary program "in which apparently one set of events sets the stage for a subsequent set, and so on" (p. 313). This entails that both form and function do not pre-exist; rather, they "gradually develop through a process of differentiation" (p. 373), where "[t]he basic plan is based on information contained in the developing tissues" (p. 373); consequently, such a plan is not to be found in the genes themselves.

A brief discussion in the final passages of the book clearly shows the complete rejection of preformationism (cf. p. 380). There Lenneberg argues that sometimes the claim is made that to defend the species-specificity of behavior or to postulate innate factors determining that behavior implies to return to the preformationism of the 18th century. However, he rejects that idea by stating that "[n]othing could be farther from the truth" (p. 380); then he goes on to argue that "the epigenetic doctrine teaches that the adult form is the result of gradual formation of structure through a continuing process of reconstitution of molecules" (p. 380). Lenneberg's conclusion is as follows: "Clearly, our proposal of how language develops in the individual is in no way counter to an epigenetic view" (p. 380).

The aspects under discussion, and the discussion raised in section 2.2, point to Lenneberg's clear preference for a developmental model lacking any hints of preformationism, that is, an opposite model to the one which traditionally characterized Generative Grammar, based on linguistic principles with a content directly ascribed to the genes.

Lenneberg's view on nativism seems to us to fall within what Stich (1975) called the 'dispositional model' of nativism (as opposed to the 'input–output model'). This model defines an innate trait as a property which is determined to appear in a reliable way at a certain point of the developmental process of any member of the species (cf. Maclaurin 2002 as an updating treatment of that model). The dispositional model seems to fit in well with Lenneberg's conception of development. In fact, many references are made across the book to the "regularity in the sequence of appearance of given milestones" (p. 126) as a hallmark for "maturationally controlled emergence of behavior" (cf. pp. 126, 127, 133, 136, 142, 244, 326, 372, etc.). According to that model, innate traits are due to heterogeneous developmental resources, understood as any factor influencing development. Genetic factors are just one of them, but in no sense can they be regarded as the main or unique factors.

The discussion so far seems to us to provide enough evidence that Lenneberg's vision, encapsulated in his 1967 book, is quite different from the more popular representation of his views, as found, for example in the writings of Ken Wexler on "Lenneberg's dream" (Wexler 2003, in press).

Contra Wexler, we think that Lenneberg's dream cannot be characterized by the idea that development or maturation are pre-specified in the genes (cf. above) nor by the assumption that specific constraints are rooted in the genes. Certainly, Lenneberg stressed the importance of the process of internal maturation for language (cf. pp. 126, 139, 142, etc.), and he claimed that "the appearance of language is primarily dependent upon the maturational development of states of readiness within the child" (p. 142). However, for Lenneberg biological growth is not controlled by genes alone, something which is quite the opposite to Wexler's framework. According to Wexler (2003: 13), development "is in central cases taken to be genetically guided" in such a way that "many principles are genetically programmed" (Wexler 2003: 38). For example, his treatment of the UCC, the "Unique Checking Constraint" (Wexler 1998: 59)[12] clearly illustrates that assumption. According to Wexler (1998: 73), the UCC is "part of the genetic program"; therefore, "[t]he genetic system determines that at birth […] the UCC is in place" (Wexler 2003: 40). Wexler (in press: 38) goes on to argue that "[g]iven these results together with the results discussed in this paper, the field is beginning to hone in on which gene or genes control the development of UCC".

It is obvious from these quotes that, according to Wexler, there is a direct link between genes and a linguistic constraint. Wexler (2003: 45) points out that his framework resembles the way how Lenneberg expected language development to behave; hence, "Lenneberg's dream". However, as our discussion showed, the formulation of Lenneberg's dream cannot match the direction Wexler argues for. Lenneberg, we think, would not agree at all with that interpretation of his dream.

3. How Special Are the Language Mechanisms According to Lenneberg?

The second topic we have chosen from Lenneberg (1967) is his answer to the question whether or not language mechanisms are special. This issue especially matters because some parallels can be traced with the issue of the role provided by Lenneberg to genes and development. Let us clarify this point a bit more: Although he endorsed the innate nature of language, Lenneberg departed from the geno-centric perspective that has characterized Generative Grammar for decades. With regard to language specificity or unspecificity, his own thought also departed from the canonical position held by traditional Generative Grammar. In fact, it seems to us to fit in well with more recent approaches to the issue that soften the strongly system-specific stance that has dominated generative (bio)linguistics for so long.

As pointed out in Balari *et al*. (2010) and Di Sciullo *et al*. (2010), for many years, Generative Grammar was centered on the formal singularity and uniqueness of language as opposed to any other instance of cognition or behavior of

[12] The UCC states that "[t]he D feature of DP can only check against one functional category".

non-human animals. This meant that Generative Grammar highlighted the great specificity of the language faculty, which was conceived of as uniquely human (and functioning with uniquely linguistic mechanisms). Accordingly, Chomsky (1968) assumed that language was a capacity lacking true homologues in other organisms, therefore being a problem for Darwinian-based continuity theses.

However, with the beginning of the 21st century, that position has been somehow reformulated, especially since Hauser *et al*. (2002) and their case in favor of a comparative approach to the language faculty. According to that proposal, the faculty of language is not conceived of as a homogeneous whole (in an all-or-nothing style), but as a collection (or 'mosaic') of abilities and capabilities, some of them being shared with non-human animals and other being uniquely human. The divide between faculty of language in the broad sense (FLB) and in the narrow sense (FLN) represents the attempt to shed light on this issue: Many mechanisms related to the systems of thought, and especially, to the sensorimotor system are not uniquely human, but rather they are widely extended among non-human animals. That is not the case, though, of FLN, which is something like a residue of the uniquely human nature of the language faculty, which, by definition, cannot be compared to anything existing in the mind of other species (nor even in other domains of the human mind). A clear sign of the current interest on that topic is the fact that it is currently being much debated (cf. Hauser *et al*. 2002, Pinker & Jackendoff 2005, Fitch *et al*. 2005, and Jackendoff & Pinker 2005; see also Anderson 2004 and Samuels *et al*., in press).

Where does the interest of Lenneberg's approach to the issue lie? The answer is straightforward: In a moment when Generative Grammar, and Chomsky himself, stressed the differences between human language as a whole and animal systems, by stating that no linguistic mechanisms had anything to do with those found in animals, Lenneberg provided us with an incipient comparative method, which led him to the assertion that similarities between humans and non-humans can be found, even for those areas of the language faculty which in current terms would correspond to the FLN. That way, Lenneberg's view is that key mechanisms of language can be related to very ancient animal capacities.

A clarification is in order: What we have just said does not mean that according to Lenneberg language is not species-specific. It clearly is, and this is one of the most recurrent claims in his book. If that were not the case, animals could have access to language, but, as he repeatedly points out, that does not follow. What that claim implies is that the language specificity is based on the modification in humans of ancestral vertebrate mechanisms, a descent-with-modification view that would have pleased Darwin himself (who preferred the notion of descent to that of evolution). An example will help appreciate this. Consider MacNeilage's (1998) treatment of the evolutionary origins of the syllable (we hasten to add that we do not necessarily endorse this view on the syllable, but we think it nicely illustrates what we want to convey). According to MacNeilage (1998), syllabic cyclicity derives from repetitive movements associated to the mammal chewing. This does not involve to defend that the syllable is not a specifically linguistic unit; undoubtedly, it is. However, that unit is built upon ancestral mammal capacities. Something similar applies to Lenneberg's

view: Although some of the features that define the essence of language, like phrase-structure or transformations, are specifically linguistic features, they may nevertheless derive from very ancient capacities.

Lenneberg (1967: chap. 6) discusses some differences between animal communication and language, and he argues against the claim that "a straight-line of evolution" (p. 228) may be traced among them. In fact, he rejects two different versions of the continuity thesis: Straight-line evolution of language with only quantitative changes, and straight-line evolution of complexity by stepwise accretion, with missing links (cf. pp. 228–230). Instead, he defends the theory of discontinuity between animal communication and human language, by arguing that such a thesis "is not only biologically acceptable but, in fact, more in line with present theories in developmental biology than the former type theory" (p. 228). However, he clarifies that "[a] discontinuity theory is not the same as a special creation theory. No biological phenomenon is without antecedents" (p. 234). Although to his view those antecedents are not evident, he offers a highly interesting proposal in that regard, which combines shared nature and specificity.

The key of Lenneberg's proposal (p. 336) is that the cognitive mechanisms that underlie the components of language (syntax, semantics or phonology) are based on the processes of categorization, differentiation, and interrelation (differentiation and interrelation being just two aspects of the general process of categorization). What about the categorization process? Is it special to humans, or is it shared? Lenneberg's answer offers no doubts: Categorization is a universal phenomenon in the animal kingdom, although "the categorizations peculiar to language operate through the application of highly species-specific principles" (p. 336).[13] For that reason, Lenneberg states that the cognitive function which underlies language implies the adaptation in humans of an ubiquitous process among vertebrates of categorization and extraction of similarities: "The perception and production of language may be reduced on all levels to categorization processes" (p.374).

It is important to analyze what the process of categorization is for Lenneberg, for authors who would write much later, like Bickerton (1990), reached very similar conclusions. Bickerton states that categorization implies a process of segmentation of reality that in turn points to a process of abstraction of it. In fact, he showed that any category puts together actions, processes, or entities which cannot be taken as equivalent: For example, we can find very different tables, according to their size, raw materials, color, form, etc. However, when we categorize, we abstract away from those differences, and we keep only the constant features, which are mainly abstract (cf. Cohen & Lefebvre 2005 for an in-depth analysis of mechanisms of categorization).

Actually, intensive research with animals has unequivocally shown that they are also able to categorize, that capacity being at the basis of concept formation. As it happens with humans, animal's categorization involves to

[13] Incidentally, note also the modern character of Lenneberg's conception with regard to the recognition of complex processes in the animal mind. It should be kept in mind that in the 1960s the existence of animal minds was in general not recognized, given the predominance of behaviorism. Consequently, the possibility that animals could possess mental processes like categorization was in general not recognized either.

abstractly unify tokens of a concept which can greatly vary from each other, in such a way that an organism "somehow perceives relations of unity between objects that in superficial detail appear quite different" (Bickerton 1990: 92; cf. Harnad 1987). For such a task to be made, complex capacities such as induction, generalization and abstraction are required (cf. Hurford 2007: 27 ff.).[14]

As regards categorization, Lenneberg asserts that "[m]an is no different from other animal" (p. 298). In fact, language mechanisms are to his mind specific applications of mechanisms which are shared. All vertebrates, Lenneberg claims (p. 331), may superimpose categories of functional equivalence to configu-rations of stimuli, in order to give a single type of response to any member of a concrete stimulus category.[15] That way, animals organize the perceptual world through a process of categorization: "[T]here is no formal difference between man's concept-formation and animal's propensity for responding to categories of stimuli" (p. 332), although a substantive difference exist, which is that the overall possibilities of categorization are not the same among species.

As already mentioned above, from the basic process of categorization, two subsequent processes arise which are also shared by non-human animals: Differentiation or discrimination, and establishment of interrelations among categories, that is, to perceive transformations. And, importantly, Lenneberg uses those mechanisms in order to explain basic properties of language:[16] phrase-structure and grammatical transformations.

Phrase-structure arises, according to Lenneberg, by means of the progressive differentiation of categories which are very general in the initial stages of development. Accordingly, he considers that the progressive development of syntagmatic structure is a process of differentiation of grammatical categories (p. 294), in much a similar vein to the differentiation process that is the essence of the semantic component (by the way, it should be noted his impressive defense of a semantic naturalism) or the phonological one. With the differentiation procedure, he explains even main features of language, like recursion or nested dependencies.[17]

As regards transformations, Lenneberg acknowledges that they have played a pivotal role in the characterization of grammar (p. 296). Transformations operate by relating different phrase-markers, and they allow to perceive relationships and affinities between sentences with a very different surface structure, thus leading to the establishment of grammatical, semantic, and phonological connections (pp. 292, 299–300). But, again, far from considering them to be

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[14] Thus, "[p]ossession of words is not a necessary criterion for identifying possession of concepts" (Hurford 2007: 10).

[15] That capacity can be said to be an instance of MacPhail's (1987) level 2 of intelligence. This level goes beyond the connection between a stimulus and a response (level 1), in such a way that different stimuli can be connected, thus presupposing mental representations.

[16] This clearly goes beyond language, because "[t]his differentiation process is not confined to language. In fact, it is the hallmark of all development" (Lenneberg 1967: 295).

[17] "Both recursiveness and nested dependencies are simply consequences of differentiation or specification". He goes on to argue that "[o]rganization of phrase-structure with the resulting phenomenon of recursiveness and nested dependencies appears as a 'natural phenomenon' once we assume that a ubiquitous process is influencing a specific behavior", although to execute that behavior requires "specific cognitive and thus biological adaptations" (all from Lenneberg 1967: 296).

uniquely human and uniquely linguistic mechanisms, according to Lenneberg, transformations are a ubiquitous process, also derived from categorization itself.

If, as specified above, categorization implies to group configurations of stimuli that are different from each other, transformations imply to recognize the similarity, something which is not unknown for animals either, and which proceeds through the mechanism of interrelation:

> All animals have the ability to group together stimulus configurations which may be physically totally different from each other; however, the animal makes an identical response to certain ones and thus treats them as if they were similar in some respect; we cannot escape the conclusion that for the animal, some similarity exists among such stimuli. (Lenneberg 1967: 298)

Accordingly, the conclusion holds that "all similarities involve transformational processes" (p. 299). That is, where the grouping is made in terms of a categorization, a transformational process exists. To sum up, for Lenneberg, to perceive similarities must be a deeply entrenched process, in such a way that it points to the true nature of behavioral organization (p. 301).

According to Lenneberg, the common aspect of any transformation is an abstract schema (pp. 298–299); for example, the structural similarity between two strings of words transforms audible physical patterns into an abstract schema. That way, transformations operate by translating physical aspects into abstract schemas or representations, and they can be said to be simply the interrelation of categories (p. 335). For that reason, the transformational principle of language seems identical to the cognitive principle underlying the capacity of categorizing behavioral structures in a wide sense.

To sum up, according to Lenneberg, both phrase-structure and transformations are special applications of general models of organization because they "are common to the organization of the behavior of all higher animals" (p. 302). Therefore, according to Lenneberg, the cognitive function underlying language is the adaptation of a ubiquitous process of categorization and extraction of similarities among vertebrates (p. 374).

A final issue is in order: If language mechanisms are instances of mechanisms which pervade animal kingdom, "why is language species-specific?" (p. 302). The answer has to do with the fact that "cognitive processes must be highly adapted biologically" (p. 302). Although categorization is universal among animals, linguistic categorization operates according to principles which are specific of our species. That way, to perceive similarities and relations depends on the different capabilities of organisms for handling transformations (p. 325), those capabilities being biologically constrained.[18] The result is that the nature of categorization must be determined for each species.

Chapter 6 of *Biological Foundations of Language* offers some hints for the ultimate reasons lying behind the specificity of cognitive processes. In that chapter, Lenneberg discusses D'Arcy Thompson's (1917) famous method of transformations based on the superimposition of Cartesian coordinates on differ-

[18] In fact, Lenneberg (p. 371) argues that interspecific differences are not only related to differences in peripheral sensorial thresholds; as regards the cognitive organization, a function of upper, main processes, is also involved.

ent animal forms (or animal parts), the distortion of those coordinates generating several existing forms.

Lenneberg goes on to argue that those relationships among mature forms can be accounted for by "changes in growth gradients during ontogeny" (p. 245). Accordingly, those visible transformations derive from 'invisible' molecular transformations, which cause the developmental histories to differ. For that reason, the answer to the issue of language specificity should rest on developmental changes. That is a very nice result: Development as the source of evolution, much in the spirit of Evo-Devo.

4. Conclusions

Lenneberg's *Biological Foundations of Language* can be considered a key reference for the emergence of the Biolinguistic Program. Accordingly, it has exerted a central influence in placing the study of language in a biological context. However, in this paper we have tried to show that the book's merits by far exceed those which are usually given to it. In order to show that, we have looked at Lenneberg's treatment of the role attributed to genes and development, and his view on the issue of domain specificity for language. Lenneberg's answers to both issues are based on surprisingly modern conceptions, which went beyond the usual treatments on language and biology at the time when the book was written, but also strike us as far more modern than standard conceptions in current biolinguistics. Curiously, those conceptions are more in agreement with ideas brought to the fore by the Minimalist Program in linguistics (relativization of the role attributed to genes, and a new look at the issue of language specificity), and by the calls for an extended synthesis in biology (Pigliucci & Müller 2010). In many ways, Lenneberg's book was clearly ahead of its time.

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