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Introduction

Life is a state of mind

Sam Mendes, *Empire of Light* (2022)

Over the years, research in the different domains of human knowledge and technology has evolved an increasingly fascinating activity, resulting in an exponential advance in our understanding of the world, but also of ourselves, as well as the resolution of long-lasting problems and human needs. More than ever, the stimulating horizon of innovation and application reliability is drawn as a real promise. Also, in linguistics. The multidisciplinary marriage, the advancement in techniques of observation and documentation of verbal activity, and the urgent need for comprehensive prisms have promoted significant turns in linguistic research and have favored the anchoring and extension of spheres such as biolinguistics. Some more general theoretical and methodological shifts in the field of linguistics have also favored such turns. Currently, exhausted modes of description are being relieved both to avoid routine research, and above all to amend the prejudiced cultivation of a linguistics centered on the verbally foreseen. In some way, investigations limited to a language-product model have reached their limit, and, as a result of the rise of corpus linguistics, the relevance of diversity has been focused on even in grammatical works. The panorama of the variable in data repertoires has also required new theoretical frameworks to channel analysis, so that there are emerging needs for consideration and labeling that do not allow to be limited to a single school/theory. On the other hand, the explanatory evaluation of the data requires interpretation beyond the statistical results, even if they are gradients, so the presence of cognitive factors to establish hierarchies and priorities becomes necessary in corpus research that does not limit to the quantitative (Gries and Wulff 2009; Arppe et al. 2010).

The so-called “convergent evidence” is a clear proof of how corpus-based investigations complement their results in cognitive horizons (Schönefeld 2011; Blumenthal-Dramé 2012). This is certainly a first step towards a non-prejudiced linguistic research, without limitations due to confirmation biases due to adjustments to the foreseen verbal model, or forced commitments of a theoretical school. Without a

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doubt, it has been corpus linguistics, with the seasoning of the atmosphere sprayed by new technologies, but also, and in a stellar role, advances in observation and documentation techniques on verbal processing, that have led to a strong turn in the approach to communicative dynamics in the strict sense: in its emergence-in-the-user (Diessel 2019). No longer considering the emissions as analyzable products, but in their procedural course, how they are constructed from the user, the very act of communicating has become the object of interest of the most recent linguistics. A linguistics of cognitive-communicative root inevitably centered on verbal processing (Schmid 2020). The notion of *entrenchment* has gained prominence. Naturally, there are prominent antecedents in the history of linguistics regarding the focus on ongoing verbal activity linked to users. The contributions of Roman Jakobson (1956, 1969, 1980) and his research work in multidisciplinary collaboration with, among others, Alexander Luria (cfr. 1977), are beacons of open approaches regarding how cognitive orientation is key to communicating:

La propriété privée, dans le domaine du langage, ça n'existe pas: tout est socialisé. L'échange verbal, comme toute forme de relation humaine, requiert au moins deux interlocuteurs: l'idiote n'est donc, en fin de compte, qu'une fiction quelque peu pervers (Jakobson 1956: 54–55).

The chief target of international linguistic thought in its endeavors to overcome the Saussurian model of langue as a static, uniform system of mandatory rules and to supplant this oversimplified and artificial construct by the dynamic view of a diversified, convertible code with regard to the different functions of language and to the time and space factors, both of which were excluded from the Saussurian conception of the linguistic system (Jakobson 1969: 38).

Edward Sapir, as early as 1921, also acknowledged the need to combine the active mental base to organize what is communicated into semiotic representations:

Language is primarily an auditory system of symbols (. . .) In normal individuals the impulse to speech first takes effect in the sphere of auditory imagery and is then transmitted to the motor nerves that control the organs of speech (. . .) Communication, which is the very object of speech, is successfully effected only when the hearer's auditory perceptions are translated into the appropriate and intended flow of imagery or thought or both combined (Sapir 1921: 11).

But it has been primarily the Chomskyan proposals (Chomsky 1965, 1986, 2000) that have emphasized focusing on both processing and representations to develop a generative model of knowledge and language faculty:

Any interesting generative grammar will be dealing, for the most part, with mental processes that are far beyond the level of actual or even potential consciousness (1965: 8).

A generative grammar is not a model for a speaker or a hearer. It attempts to characterize in the most neutral possible terms the knowledge of the language that provides the basis for

actual use of language by a speaker hearer. When we speak of a grammar as generating a sentence with a certain structural description, we mean simply that the grammar assigns this structural description to the sentence (1965: 9).

Generative grammar (. . .) is concerned with those aspects of form and meaning that are determined by the “language faculty”, which is understood to be a particular component of the human mind. The nature of this faculty is the subject matter of a general theory of linguistic structure (. . .) called “universal grammar” (UG). UG may be regarded as a characterization of the genetically determined language faculty (1986: 3).

The language faculty has at least two different components: a “cognitive system” that stores information in some manner, and performance systems that make use of this information for articulation, perception, talking about the world, asking questions (2000: 117).

There are also previous research programs that have developed theories based on attributing language, in its origin and nature, to a biological root and character. Evolutionary proposals applied to the history of languages and encoded in “laws” in nineteenth-century historical-comparative linguistics, and more forcefully in the so-called naturalistic linguistics of August Schleicher (1821–1868), were rooted in such convictions (Ennis 2014). Assumptions that, while at least partially defensible from the standpoint of ontological modeling, would still need to be nuanced in their methodological equivalence with the categorical laws of nature. Already in his *Prinzipien der Sprachgeschichte* (1880; cfr. Auer and Murray 2015), Hermann Paul refined its strong and imperative character, which Antoine Meillet summarized as follows:

the formulae of the general evolutionary phonetics express a possibility, not a necessity. One can find out how a consonant would change if placed between two vowels, but this alone does not mean that the consonant will actually change (Meillet 1925: 78).

Such pioneering glimpses in theme, approach, or method have had their continuity over time, and have solidified in recent years into what is decidedly built as biolinguistics (Section I of this book: The biolinguistic enterprise). With certain conditions and tweaks, and above all, with an intentional expansion and definition of the field. The narrow views—by being excessively focused only on issues of “language origin” and “language acquisition”—of biolinguistics have become solid concepts that define the area for its unequivocally essential character for the comprehensive understanding of linguistic activity. The thematic expansion (communicative disorders, bilingualism, multilingualism, verbal dynamics processing . . .) has simultaneously entailed considerations both of a conceptual nature about the biological, as well as of a methodological nature about how to focus on language-in-process, and of a technical nature around powerful and rigorous tools in observation and documentation. Precisely, in today’s linguistics, an ideal research context is drawn to orient the axis towards language-in-processing inherent to usage dynamics, and

this necessarily involves appreciating its consubstantial neuro-cognitive dimension. Examining verbal uses, communication-in-action, requires a comprehensive approach that combines the neurocognitive with the social and the semiotic, so that the biolinguistic perspective is a key ingredient in research, no longer subject to the so-called language-product components. The cognitive prism (which is nothing but biolinguistic) irrigates all verbal investigations.

The field of biolinguistics is firmly established in its intensive definition by its object of study, the bio-human nature of language (Boeckx and Grohmann 2007; Fitch 2009; Boeckx 2013; Di Sciullo and Jenkins 2016; Martins and Boeckx 2016), and by its expanded thematic scope. The challenge of theorizing in this sphere is a real aspiration today (Section III of this book: Theorizing biolinguistics). Certain variables of the general scientific climate have acted as catalysts: among others, proposals about the brain as a functional organ, as a network of neurons (S. Seung's *connectomics* 2012), neuroimaging observation instruments, and neurophysiological eye-tracking experimentation, gradually assessed for their suitability for activity (Godfroid 2020), or the artificial modeling of processing (Bolognesi 2020) (Section II of this book: The quest for interdisciplinarity and the challenges of technification). But what is certainly crucial in the research coordinates of today's linguistics is the urgent need to fill gaps in documented research in data repertoires to contrast their empirical strength, either through cognitive explanations or through convergent evidence from the neuromental sphere. This is what Blumenthal-Dramé (2012: 205) catalogs as the corpus-to-cognition principle: "If a whole range of caveats is heeded, certain corpus-extracted variables may, to some extent, be used as a yardstick for entrenchment in the brain or fan average language user".

The robust and innovative methodological and focus catalysts have certainly uncovered central epistemological issues in linguistic research in which, in one way or another, biolinguistics plays the lead role. Not only have some topics of crucial importance been revived, such as empiricism and causality in linguistic research, but also ontological components in the complex nature of language have been illuminated that are scarcely ignited. The reliability of the data and the guarantees of the results do not derive exclusively from an objective source (the intersubjective norms found in actions, in terms of Itkonen 1979, 1983), but must also be taken into account the so-called indirect evidence provided by sophisticated instruments to observe neuroconnective activity and by artificial models that simulate those processes: different sources of evidence are contemplated ("as pluralist as the approach is, as pluralist is the type of linguistic evidence that can be used", Penke and Rosenbach 2004: 17). The challenge of multidisciplinary (Benítez-Burraco 2011a, 2011b, 2013; Boeckx and Benítez-Burraco 2014; Benítez-Burraco 2016) attributed to biolinguistics necessarily involves the introduction of *empiricism* (even if classified as *empiricism2* by Itkonen 1979, and linked to fac-

tual-normative data), even in grammar, and therefore extends the character of linguistic research beyond the repeatedly advocated hermeneutic procedure for the so-called “autonomous linguistics” (Itkonen 1978, 2005). As for *causality*, appreciating the bio-human activity of language promotes questions about its origin, its changes, and its presence as a species-specific capacity: open, fruitful, and relevant debates about “universals”, about “innatism” (Elman et al. 1998), or about the central and delicate issue of the “psychological reality” of linguistic representations, which fertilizes considerations such as the following:

Although mental and cerebral phenomena are qualitatively different, we will proceed from the assumption that they are intrinsically related in that there is no mental activity without brain activity (Blumenthal-Dramé 2012: 69).

Cerebral functions (such as vision, consciousness, or feelings) are emergent properties of the brain (. . .) They emerge from the activation of particular neural circuits. Thinking is to the brain what walking is to the legs or rotation to the wheel—an abstraction (Paradis 2009: xii, cfr. Bunge 2007).

We examine what kind of neural processes actually *explain* the fundamental properties of consciousness, rather than merely correlate with them. Many neuroscientists have emphasized particular neural structures whose activity correlates with conscious experience. It is not surprising that different neuroscientists end up favoring different structures (. . .) it is a mistake to expect that pinpointing particular locations in the brain or understanding intrinsic properties of particular neurons will, in itself, explain why their activity does or does not contribute to conscious experience. Such an expectation is a prime example of a category error, in the specific sense of ascribing to things properties they cannot have (Edelman and Tononi 2000: 19).

The most notable contribution of the advances in biolinguistics may lie in having refined the notion, overly strong and oriented, of *causality*, which is actually *correlation* in complex dynamics of processes conducted under the principle of uncertainty. But if there is an epistemological sphere in which biolinguistics has introduced a vital impulse, it has been the ontological one, with the unquestionable foundation of the biohuman/biocognitive/neuromental nature of language, which must necessarily be considered regardless of the specific inquiry intended. The biolinguistic prism entails the integral vision of language-in-process activity, which occurs in contexts and with semiotic support. In summary, the stellar contribution of the biocognitive program lies in the dissolution of the language-product-foreseen as an object of study, and the consequent ascension of the dynamics and processes associated with communicative activity as a prominent subject of research. Variation and evolution versus invariability. Integral conception versus atomized vision. Considerations such as those of Givón (2002: xvi) outline this panorama.

When language is viewed as a biological phenomenon, then the study of diversity—both within the individual speaker or speech community and across languages— becomes enormously relevant. Variation is aptly treated by empirically-inclined linguists as a vital methodological issue.

The contents of this volume are glimpses into the previously outlined context. But they are also advancements toward a promising horizon in linguistic research that, inevitably, must participate in the biolinguistic program. The institutionalization and visibility of the field are undoubtedly remarkable in areas that verify the challenge of applicability. The so-called social machines, designed in the laboratory The MIT Center for Constructive Communication under the direction of Deb Roy, are an artificial reflection of emotions/decisions processed electronically based on cognitive-communicative verbal data: the so-called *stance*, so popular in pragmatic corpus research, is nothing but a biocognitive correlate of the users' mental disposition, of how they process the environment to decide and communicate. In the same line, the designs of the 'headband' *Emotiv* created by Tan Le, or the means of sensory substitution ("a vest that listens") by David Eagleman, require biolinguistic substrates in their elaboration and for their operation (Eagleman 2020). Also, the recent design of semantic decoders that transfer verbal brain activity to words, created by a team at the University of Austin, entails biolinguistic bases. Finally, the learning programs (of mathematics/reading) organized at the *Collège de France* around the team of Stanislas Dehaene are grounded in Dehaene's own neuromental research on early verbal and cognitive development.

In the last part of this foreword section, we provide an overview of the contributions to this volume. The seed of this book is a conference on clinical linguistics celebrated in Santiago de Compostela (Spain) in 2022. The subtitle of the conference was "From biolinguistics to speech therapy", highlighting the prominent role of biolinguistics in present and future work on clinical linguistics. The conference included two round tables about the interface between clinical linguistics and biolinguistics chaired by two of the contributors to the book. While these origins are reflected in the contents of the book (particularly, the high number of authors from Spain), the volume contains chapters by some other international experts on the topics to be discussed.

Section I is aimed, as noted, as an introductory part to the volume. Its main objective is presenting biolinguistics as an emergent investigation program within linguistics. More specifically, this section tries to offer a comprehensive theoretical contextualization of this research program and to provide readers with an outline of its most defining notions, concepts, and scope. As discussed enough above, biolinguistics, which deals with the biological aspects of language, was at its beginnings mostly a shorthand for Chomskyan approaches to

the problem of language acquisition and evolution. Later, it diversified and expanded, and it is now mostly a shorthand for any approach to language aimed to understand the biological underpinnings of our ability to learn and use languages. This expansion has greatly paralleled the noteworthy advances experienced by its allied disciplines, like molecular biology, genetics, neurobiology, or neurosciences. In this light, biolinguistics has raised high expectations about the contribution it could make to the resolution of the utmost questions of modern linguistics: namely (and formulated in Chomsky's own terms), what kind of knowledge language is, how it is acquired and used, how it is implemented in the brain and how it has evolved in the species.

Chapter 1, by José Luis Mendivil Giró, presents a detailed historical account of the origins of biolinguistics. A main concern for the chapter is the distinction, mentioned above, between biolinguistics in a broad sense and biolinguistics in a narrow sense. As discussed by the author, in a broad sense, biolinguistics boils down to any way of meaningfully connecting natural language to its specific underlying (neurophysiological, (epi-)genetic, bio-physical, mathematical, and other) bases. In a narrower sense, however, it is felt by some that the advanced study of syntax is a prerequisite for the success of this project. This is under the assumption that, although obviously everything biological is highly interconnected in this planet and possibly elsewhere if life is as widespread as one hopes, there is something uniquely curious about such human linguistic traits as recursion, reference, metaphor, etc. This is broadly consistent with Chomsky's postulation of some uniquely human Language Acquisition Device and Lenneberg's Critical Period Hypothesis, which some still hope may be substantiated by our current understanding of grammar. The chapter provides a historical reconstruction of these proposals and their challenges, together with a dispassionate look at the current results in the Minimalist Program that may (not) take us closer to that still unfulfilled hope for a successful theory of biolinguistics.

Chapter 2, authored by Milagros Fernández-Pérez and Miguel González-Pereira, analyzes the place of biolinguistics within the general framework of linguistics. With this aim, the chapter takes as its starting point the role of biolinguistics in promoting a conceptual turn in linguistics and in expanding the research interests of the discipline. The chapter then focuses on the key role played by biolinguistics in the quest for a truly methodological interdisciplinarity in linguistics. In this way, biolinguistics is contextualized within both internal and external dimensions in the progress of our knowledge about language facts. Regarding the conceptual turn, the chapter examines the indisputable role of cognitivism and the integral brain-mind-language model (this including neurocognitive approaches, the 'connectome' model, or theory of mind, among others) in helping to disentangle some of the utmost (and, to some

extent, obscured) questions in linguistics, like language origin or language acquisition, which are issues more amenable to be examined through a multidisciplinary approach. As for this interdisciplinary methodology of biolinguistics, the chapter overviews how the combination of innovative experimental tools (like event-related potentials (ERPs), eye-tracking or metabolic scanning) and documentation protocols, as well as corpus-based sample assessments has resulted in more empirical support and more data convergence in biolinguistic research. As a result, this biolinguistics research is progressively becoming cross-cutting to linguistic research, and its presence is undeniable in such fields of language study as grammar, pragmatics, or linguistic typology.

The bulk of the book is devoted to the four key challenges biolinguistics needs to confront. Summarizing our discussion above, the first challenge is integrating into a coherent view of language an increasing body of data about language, as generated not only by linguistics, or even by biology, but also by other allied disciplines, like archaeology, ethology, genetics, or neuroscience. We called this *the challenge of multidisciplinaryity*. But at the same time, biolinguistics is expected to design and conduct its own experiments, which can be very demanding from a methodological perspective, since they might involve the use of increasingly sophisticated techniques. We called this *the challenge of technification*. These two related challenges are examined in Section II of the book. Overall, the chapters within this section discuss in detail the theoretical and methodological relations of biolinguistics with other areas of research (specifically, child development, psychology, neuroscience, and genetics), with two ultimate aims: outlining the contribution of findings in these areas to our understanding of language acquisition and use, and determining which experimental paradigms in these allied sciences may be particularly useful for doing biolinguistics research.

Chapter 3, by Eliseo Diez-Itza, examines the biolinguistic approach to language acquisition, more specifically, to child phonology. Although the biolinguistic enterprise has traditionally focused on other aspects of language, most notably syntax and semantics, the changes in the articulatory abilities and the phonological knowledge of the child as he grows emerge as a privileged window to the more general changes in our perceptive and cognitive mechanisms as we acquire our first language(s), and ultimately, in our biology. By this reason, child phonology is also an optimal testing ground for hypotheses about language development and evolution. As discussed by the chapter, this relevance of child phonology for understanding the nature of language was already highlighted by Eric Lenneberg, but it is indeed part of a broader naturalistic tradition in linguistics, which can be traced back to Aristotle himself and which crystallized in the cognitive revolution in the sixties, which nourished present-day biolinguistics. In accordance with this naturalistic tradition, the chapter describes the changes in child speech and phonology during de-

velopment, with a focus on some hotly discussed topics (like recursion in phonology, or the perceptual biases that channel the acquisition of phonology), and advances some (biolinguistic) explanations for these changes, mostly in terms of neurocognitive models, such as the embodied cognition approach to phonology or the hypothesis of the phonological mind.

Chapter 4, by José Manuel Igoa, presents an overview of the principal contributions of psycholinguistics, as a merger discipline of linguistics and psychology, to the biolinguistic enterprise. After briefly comparing the two disciplines, the chapter focuses on different ways in which psycholinguistic theories and methodologies may contribute to a better understanding of the biological underpinnings of linguistic knowledge and use. The bulk of the chapter is devoted to the examination of some prominent examples of current research on the computational processes underlying language comprehension and production at different processing levels, such as phonology, the lexicon, parsing and sentential semantics. The emphasis is put on the experimental behavioral methods that have been devised for that purpose. This psycholinguistic perspective complements the behavioral and neurolinguistic perspectives adopted by chapters 3 and 5 within this section. A main conclusion of this chapter will be that biolinguistics would greatly benefit from taking into account the methods and findings by psycholinguistic research.

Chapter 5, by Silvia Martínez-Ferreiro, is accordingly aimed to deepen on the evolution and changes that have shaped neurolinguistic research during the last decades, in coincidence with the advent of biolinguistics. The focus is put on a wide range of methodological and experimental aspects, including the use in biolinguistics research of (new) techniques from other disciplines such as neuroscience, neuropsychology, cognitive science, linguistics, or communication disorders. As noted by the author, this proliferation of interdisciplinary data and approaches has contributed to a better understanding of the neurophysiological mechanisms underlying linguistic processing across the board: from healthy mono- or multilingual individuals across developmental stages to people with conditions affecting any aspect of their linguistic behavior. The chapter thus includes specific sections devoted to brain imaging and electrophysiology, experimental design in neurolinguistics, computer modeling, and clinical linguistics from a neurobiological perspective. The chapter ends with a provoking discussion about future directions and challenges in neurobiolinguistic research.

Finally, chapter 6, by Ron Nudel, examines the contribution of genetic studies to our understanding of the biological basis of language. The chapter puts the focus on language disorders, which have traditionally been the main source of candidate genes for language development. Recent decades have witnessed great methodological and technological advances in genetics and molecular biology, and in the genetic study of human diseases specifically. These advances are ex-

pected to contribute very significantly to efforts aimed to disentangle the etiologies of neurodevelopmental disorders impacting on language, and ultimately, the genetic underpinnings of our capacity for acquiring and using languages. The chapter introduces, in relatively non-technical language, the basic concepts and methodologies of human genetics and genetic studies of diseases. Examples from major studies of developmental language disorders are presented, although other neurodevelopmental conditions linked with developmental language disorders are also evaluated. One important conclusion by the chapter will be that one of the reasons why the gap between molecular etiology and language disorders is still wide (and this is also valid for language as a cognitive faculty) is that researchers from the main disciplines that are involved in the endeavor to understand these conditions (genetics, linguistics, language pathology, neurobiology, and developmental psychology) do not necessarily speak the same language. This reinforces the view, discussed by other chapter of this section, that a truly interdisciplinary approach to language facts is still a pending issue in the current biolinguistics enterprise.

Section III in the book is devoted to the third challenge biolinguistics needs to confront: generating (and properly testing the plausibility of) own hypotheses about the nature of language on the basis of data provided by other disciplines, but also from its own experimentation, as discussed in section II. Such hypotheses are expected to transcend (and improve) the models of language based on linguistic theory only. We have called this *the challenge of theorizing*. The two chapters within this section put forward how a biolinguistic lens can achieve a better understanding of, specifically, the nature of language in the human brain and the origin of language in the species.

Chapter 7, by Elliot Murphy, addresses the crucial issue of the true biological nature of language, but with a focus on syntax. Natural language syntax affords humans with the ability to construct an unbounded array of hierarchically structured expressions. Syntax involves forming binary-branching sets via the operation MERGE, taking objects from the lexicon or objects already part of the syntactic workspace. However, it has not been until relatively recently that concerns for how this ability is realized within an organic computational system have been explored. Early periods of generative grammar gave little concern for the fact that the human brain must ultimately take full responsibility for executing the postulated operations of syntax. Overall, the chapter reviews some recent moves to migrate concerns of linguists over to domains of cognitive science that take full consideration of the nature of human mental capacities, imposing a number of apparent constraints on computational feasibility. These mostly pertain to search procedures and workspace memory, but also object complexity and notions grounded in algorithmic compressibility. By attempting to inject models of syntax

with concerns relating to organic (and neural) computability constraints, it can be expected to achieve something that traditional psycholinguistics and neuroimaging of language processing have been unable to – unveil a means to reconcile properties of human language syntax with endogenous properties of the brain.

Chapter 8, by Víctor M. Longa, examines the origins and evolution of human language. In sharp contrast to the generative enterprise in the past century, this has been a major topic in current biolinguistics. This is largely due to the advent of the minimalist program, an attempt to minimize the language-specific innate, biological endowment of the human species (what was traditionally termed Universal Grammar). Specifically, the Merge-only view (also examined by chapter 7) has rendered the topic of language evolution far more accessible than before, and as such the evolution of this recursive combinatorial operation should be one central issue to be considered first. Unfortunately, as also discussed by the author, such an endeavor has not been fully made in mainstream biolinguistics, at least in a way that conforms with our understanding of biological evolution in general. Particularly problematic is the idea of a saltational emergence of Merge, that is, of a combinatorial operation with no evolutionary precursor and abruptly appeared in a full-fledged form only very recent. This minimalist view of language evolution thus poses a challenge to the Darwinian idea of descent-with-modification. To solve this tension and bring biolinguistics in closer contact with other areas of evolutionary studies, a gradualist scenario of the evolution of Merge has been proposed, according to which Merge or its varieties are neither language-specific nor species-specific in evolution, and that its apparent domain-specificity can be understood as an instance of specialization during development. Nonetheless, this view raises in turn the question of what else is evolutionarily needed for having human language. An obvious candidate is the lexicon, whose evolution remains almost untouched in the biolinguistics literature. Still, it has been suggested that the human lexical conceptual atoms evolved from more primitive ones with the help of Merge. Thus, Merge is at work beyond narrow syntax or even beyond language and is at the core of many other aspects of human cognition or the human nature itself. Against this (mostly) theoretical background, chapter 8 adopts a more interdisciplinary perspective. Specifically, it examines the archaeological register with the aim of finding confident proxies of both the lexicon and the grammar in the remains of extinct species, with the ultimate objective of covering the gap between comparative studies of animal cognition and animal communication, on the one side, and research on the language abilities of modern humans, on the other side. In this sense, one common proxy has undoubtedly been symbolic evidence. As a result, the inference “if there is symbolism, then there must be (modern) language” is widely assumed in paleoanthropology and linguistics and, by extension, the presence of alleged symbolic remains is taken to automatically reveal the existence of complex language in the hominin species who produced them. Against this

line of argument, the chapter raises doubts on the aforementioned inference by arguing that it is not possible to ascertain whether or not the vast majority of artifacts considered to be symbolic in nature were in fact symbolic. Instead, a complementary approach is proposed: to analyze archaeological remains according to the computational processes and capabilities required for their production. This approach looks at purely formal features susceptible of revealing a language-like computational complexity and is more in line with the claims by chapter 7 about the biology of language.

Overall, the approaches and findings by biolinguistics, as presented in sections II and III of the book, suggest that diverse social problems could benefit from the biolinguistic enterprise. Nonetheless, such a transfer of biolinguistics research to society, even if desirable, is still pending, though some promising instances are already underway. We called this *the challenge of applicability*, which is the object of interest of Section IV. The chapters encompassing this last part of the book focus, specifically, on the applicability of biolinguistic research to language phenomena such as language disorders, language change during aging, language learning, and language variation resulting from biosocial factors. In this way, the proposed chapters not only illustrate the value of adopting a biolinguistics lens for better addressing social problems in which language is somehow involved, but reinforce the significant contribution of biolinguistics to the explanation of diverse aspects of language proficiency and use.

Chapter 9, by Antonio Benítez-Burraco, examines language disorders from a biolinguistics perspective. Traditionally, a main concern for clinical linguistics has been establishing exact typologies of developmental language disorders (e.g., dyslexia, childhood apraxia of speech, or developmental language disorder). Ideally, each disorder presents with a distinctive, disorder-specific set of abnormal features at different language levels, from phonology to morphology to syntax, but also with regards to how language is put into use. What is more, each disorder is expected to result from the dysfunction of different, disorder-specific perceptual or processing abilities, brain areas, and brain-expressed genes. Nonetheless, it usually happens that patients can be seldom ascribed to one of such categories unambiguously, because of the widespread problem of comorbidity. Additionally, symptoms appear in a variable fashion in different patients suffering from the same condition. It is also very difficult to propose a single psycholinguistic, neurobiological, or even genetic cause of most of these disorders, as different perceptual and/or processing abilities can be impaired, diverse brain areas can show structural or functional anomalies in the affected people, and many different genes can be found mutated in patients suffering from the same condition. At the same time, disorders that result from a known underlying anomaly (mutations in specific genes, damages in selected brain areas, or alteration of certain processing

or perceptual abilities) rarely present a uniform linguistic phenotype. All these circumstances impact negatively on language therapies aimed to assist the affected people. The main message of the chapter will be that better typologies of language disorders can be achieved if we improve our bridging theories between biology and language, that is, if we adopt a truly biolinguistic perspective, and specifically, if we consider intermediate-level biological components of language, like brain oscillations. As a final concern, the chapter argues for using disorders as a major source of data for the biolinguistic enterprise, since the impact on language structure and use of specific damages in the language infrastructure facilitates to a great extent the understanding of the roles played by the intact components of such infrastructure.

Chapter 10, by Olga Ivanova, focuses on language changes during aging from a biolinguistic perspective. The chapter argues for a construal of these changes in terms of changes in specific cognitive functions supported by specific neuroanatomical areas. One main concern by the chapter is the finding that healthy older people, while showing deficits and problems in some language domains, can also exhibit improved, and even outperforming skills in some others when compared to younger speakers. This is due not only to their accumulative bent, but also to their capacity to recruit auxiliary neurocognitive networks and non-dominant language areas for fulfilling specific functions. The chapter also discusses what these patterns of language change, preservation, and even improvement in healthy aging can reveal about the human neural and cognitive specialization for language, and ultimately, about the robust emergence of language during development.

Chapter 11, by Pablo Cano López and Isabel Fernández López, also examines language development from a biolinguistics perspective. Nonetheless, in this chapter the focus is put on language learning. A historical overview will be offered, with the main purpose of highlighting those key notions that can act—and have acted indeed—as a kind of area of intersection between the two fields. Special emphasis will be made upon the Chomskyan concept of linguistic competence, and also, albeit in a lesser degree, upon the usual taxonomy of language skills. In the second part of the chapter, the focus will move on to current state and the foreseeable future of the linkage, with a keen interest on ascertaining such lines of research as seem more promising in that regard. Attention will be paid to the bearings of biolinguistic research on one of the main provinces of the theory and practice of language teaching: reading instruction. The ultimate goal is to rise awareness of the influence that biolinguistics has already exerted on language teaching, and also to persuade of the need to enlarge the bridges that link those fields.

Finally, chapter 12, by Chris Sinha, provides a reflection on the complex interactions between biology and culture in shaping (and evolving) human language(s). Current research suggests that most biological components of language are shared with other species. Likewise, cultural variation and cultural transmission are not unique to human. At the same time, theoretical biology has changed from gene-centric theories of evolution (as in the Neo-Darwinian modern synthesis from the mid-twentieth century) to theories advocating for a central role of culture and niche construction in evolutionary processes (as in the Extended Evolutionary Synthesis). Overall, these comparative findings and this recasting of evolutionary theory cannot fail to impact the foundations of biolinguistics. Specifically, biology and culture cannot be seen, as they largely were in the last century, as competing ‘causes’ of language and human cognition. Accordingly, the chapter will advocate for the advent of a *biocultural linguistics*, understood as an improved biolinguistics that is fundamentally interdisciplinary and is adequately situated in contemporary accounts of both human evolution and linguistic diversity. The chapter will thus outline the main features of such a biocultural science of language, by addressing the complex and dynamical relationship between what all human languages have in common, in what ways they display variation, and how language variation is (and is not) situated in differences between cultures and societies.

Altogether, the chapters of the book examine the present status of biolinguistics among cognitive sciences, looking back to its history, but also looking forward to the new challenges it faces, as well as potential ways of improving the biolinguistic approach, with the ultimate aim of providing the reader with a state-of-the-art of the biolinguistic quest broadly construed.

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