Introduction

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1. The study of complexity in phonology and phonetics

What is complex? What is *not* complex, or simple? Is there a gap between simple and complex? Or is complexity gradient? While universal answers to these questions are probably of limited relevance, their resolution in specific fields of research may be crucial, especially in biology or social sciences, where complexity factors may play a highly significant role in the emergence and the evolution of systems, whatever they are (Edmonds, 1999).

In phonetics and phonology, these questions have been present for more than a century. For example, according to Zipf (1935:49), "there exists an equilibrium between the magnitude or degree of complexity of a phoneme and the relative frequency of its occurrence". In this controversial work, he thus tried to evaluate the *magnitude of complexity* of phonemes from articulatory effort (Zipf, 1935:66; but see also Joos, 1936) under the assumption that it plays a major role in phonetic changes as well as in the structure of phonological systems. Soon afterwards, Trubetzkoy reanalysed this interaction in terms of markedness (1938:282), leading the way to a long-lasting tradition of intricate relationships between the notions of markedness, frequency, complexity and functional load, well exemplified by this quotation from Greenberg, forty years later:

> "Are there any properties which distinguish favored articulations as a group from their alternatives? There do, as a matter of fact, appear to be several principles at work. [There is one] which accounts for a considerable number of clusters of phonological universals (…) This is the principle that of two sounds that one is favored which is the less complex. The nature of this complexity can be stated in quite precise terms. The more complex sound involves an additional articulatory feature and, correspondingly, an additional acoustic feature which is not present in the less complex sound. This additional feature is often called a "mark" and hence the more complex, less favored alternative is called marked and the less complex, more favored alternative the unmarked. (…) It may be noted that the approach outlined here avoids the circularity for which earlier formulations, such as those of Zipf,

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> were attacked. (…) In the present instance, panhuman preferences were investigated by formulating universals based in the occurrence or non-occurrence of certain types, by text frequency and other evidence, none of which referred to the physical or acoustic nature of the sounds. Afterward, a common physical and acoustic property of the favored alternatives was noted employing evidence independent of that used to establish the universals" (Greenberg, 1969:476-477).

Indeed, the notion of phonological complexity is implicitly present in numerous works dealing with linguistic typology and universals (as in Greenberg's quotation), language acquisition (e.g. Demuth, 1995) and historical linguistics. Articulatory cost, perceptual distinctiveness and systemic constraints have thus been proposed as driving forces for explaining sound changes (Lindblom & Maddieson, 1988; Lindblom, 1998:245), beside an undisputed social dimension. The role of such mechanisms has also been extended to the structure of language systems, leading some linguists to postulate a balance of complexity within language grammar, a lack of complexity in one component being compensated by another more complex component (e.g. Hockett, 1958:180-181). However, this assumption is highly debated and still unsolved (Fenck-Oczlon & Fenk, 1999, 2005; Shosted, 2006).

However, one must acknowledge that the word *complexity* itself has not been often explicitly referred to, even if it underlies several salient advances in phonetics and phonology.

For example, when Ohala pointed out that an 'exotic consonant inventory' such as { ɗ k' ts ɬ m r | } is not observed in languages with few consonants, he suggested that a principle of economy is at work at the systemic level (Ohala, 1980; but see also, Ohala, this volume). Consequently, one can infer that the above system is too complex to be viable; but too complex with respect to what? And how to measure this complexity; is it a matter of global number of articulatory features, of intrinsic phonemic complexity, of the overall size of the phonetic space used in this language? Contrary to what Greenberg said, measuring complexity is not straightforward, even when the problem is narrowed, for instance to articulatory complexity (e.g. Ohala, 1990:260) and we still lack relevant tools. Lindblom and Maddieson (1988) began to address this question and proposed to divide consonants into three sets (simple, elaborated and complex) according to their articulatory complexity. They analysed the distribution of these segments among the UPSID database (Maddieson, 1984) and they suggested that languages have a tendency to use consonants and vowels picked

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from an adaptive phonetic space according to the number of elements in their inventories. This influential paper combined a typological survey and a theoretical attempt to decipher the mechanisms responsible for the observed patterns (see also, Lindblom, 1998; Lindblom, 1999). In this sense, it threw a bridge between the bare issue of complexity measurement and the use of methods fostered by physics and cybernetics to account for the general behaviour of languages, viewed as dynamical systems. In a late work, Jakobson judged that:

> "Like any other social modelling system tending to maintain its dynamic equilibrium, language ostensively displays its self-regulating and self-steering properties. Those implicational laws which build the bulk of phonological and grammatical universals and underlie the typology of languages are embedded to a great extent in the internal logic of linguistic structures, and do not necessarily presuppose special 'genetic' instructions" (Jakobson, 1973:48).

Phenomena such as *self-organisation*, evoked above, and *emergence*, which also comes to mind in this view, are commonly found in the study of complex adaptive systems, a subfield of the science of complexity. These approaches connect the microscopic level (the components and their interactions) to the macroscopic level (the system and its dynamic behaviour), and they aim at explaining complex patterns with general mechanisms without any teleological considerations[1]. As far as phonetics and phonology are concerned, these perspectives have already generated a noteworthy literature (e.g. Kelso, Saltzman & Tuller, 1986; Lindblom, 1999) and several recent developments are described in this book (mostly in Part 3). The next paragraph provides some landmarks necessary to grasp the aims and content of this book.

2. Complex adaptive systems and the science of complexity

Since the middle of the twentieth century, scientists from numerous fields of research, ranging from physics to graph theory, and from biology to economics and linguistics, have built a web of theories, models and notions, known today as the Science of Complexity. This paradigm pertains to our everyday experience, and has provided us with insights in phenomena as distinct – at first glance – as properties of ferromagnetic materials with respect to temperature, motion patterns of persons on crowded sidewalks or of fish schools, social behaviour of ants or termites, fluctuations of finan-

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cial markets, etc (e.g. Markose, 2005; Theraulaz et al., 2002; Gazi and Passino, 2004). The strength of this approach probably dwells in its protean capacity, an adaptability that has been described by Lass (1997:294) as "a syntax without a semantics" preventing any "ontological commitment". The exact scope of disciplines and methodologies which can potentially benefit from this new science is therefore not restricted, and a reanalysis of long-lasting open issues in the light of complexity leads to exciting connections to most areas of research, and linguistics is not an exception.

The main focus of the Science of Complexity is the study of complex systems. A system is said to be complex when its overall behaviour exhibits properties that are not easily predicted from the individual description of the parts of the system. Hence, a car is not really complex but just complicated: it consists of many interacting parts, but the behaviour of the car is predictable from its components (and that is why we can safely drive it). On the contrary, when the same car is caught in a traffic jam, it becomes very difficult to predict the evolution of the blockage and even the individual trajectory of this particular car: the interaction of the cars (and of their respective drivers) generates a complex collective pattern.

An essential element of complex systems lies in the interaction between each component and its environment. Systems may differ in terms of the reactivity of their components – an ant cannot match a human being when it comes to analyzing and reacting to the environmental input – but a minimal threshold has to be exceeded for complex behaviours to appear. Besides, complex systems are generally explained by recourse to the notions of nonlinearity and emergence.

Nonlinearity refers to phenomena for which the effect of a perturbation is not proportional to its initial cause, due to the complex network of interactions in which it is entangled. The famous butterfly effect, popularized in chaos theory, illustrates the sensitivity to the initial conditions that derives from this condition. *Emergence* refers to the appearance of structures at the overall level, from the interactions of the components of a *dynamic* complex system. Such structures can apply to relevant dimensions of the system – like its spatial organization – but also unroll in time with the consistent occurrences of transient or stable states. These emergent properties often result from trade-off between conflicting constraints and from self-organizing processes that can stabilize the system enough for such regularities to appear.

Most complex systems do not follow deterministic paths because of the existence of degrees of freedom leading to a wide range of possible states

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in answer to internal and external constraints. Thus, various evolutionary trajectories may be observed, and from a given initial state, these systems may reach various final configurations, whose likelihood is a function of the self-organizing forces at hand. In other words, it is impossible to predict the evolution of a single system, but it is possible to draw reliable conclusions for a large enough set of them: a collection of complex systems may indeed exhibit a diversity of states, with some more frequent than others, and some very unlikely but still explainable in terms of probability laws for "rare events", etc[2].

The human language faculty is a complex system, both as an outcome of interacting linguistic components *within* each individual and as a collective set of conventions resulting from the interactions *among* individuals.

On the one hand, linguistic products themselves – words, sentences, sets of sentences – are the outputs of a cognitive system composed of linguistic components, as well as a set of complex relationships between them. Competing pressures over lexicon and grammar (such as articulatory/auditory constraints mentioned above) widely influence language production and understanding by human beings, and dynamical processes (e.g. activation propagation and decay in the mental lexicon, or interactive meaning construction of sentence from lexicon and grammar). On the other hand, language seen as a dynamical distributed system of conventions in a community can also be analysed as a complex system, given the intricacy of the linguistic interactions taking place between the speakers.

Indeed, the science of complexity has successfully addressed tremendous challenges in our understanding of the human language faculty. Theoretical approaches that integrate self-organization, emergence, nonlinearity, adaptive systems, information theory, etc., have already shed new light on the duality between the observed linguistic diversity and the human cognitive faculty of language. Most of the recent literature written in this framework focuses either on the syntactic level addressed through computational complexity (Barton et al., 1987; Ristad, 1993; among others) or performance optimization (e.g. Hawkins, 2004), or explicitly on the emergence and evolution of language as a communication convention (e.g. Galantucci, 2005; Steels, 2005, 2006; Ke, Gong and Wang, 2008). Other linguistic components have been less thoroughly investigated, Dahl (2004) and Oudeyer (2006) providing noteworthy exceptions offering stimulating approaches to long-lasting questions. However, no unified framework has yet come into sight, and the field is characterized by a wide variety of approaches.

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3. Goal and contribution of the present volume

This book is the first one to propose an outline of this multi-faceted field of research in the general framework of phonetics and phonology. It is organized in four parts and covers a large spectrum of issues addressed by the community of specialists in two directions shaped by the concepts of complexity and complex systems. The first branch ranges from the measurement of complexity itself to the assessment of its relevance as an explanation to typological phonology and to phylogenetic or ontogenetic trajectories. The second branch ranges from the quest for phonetic/phonological primitives to the dynamical modelling of speech communication (perception and/or production) as a complex system in an emergent and self-organized attempt to explain phonetic and phonological processes.

Beyond this diversity, all the contributors of this book consider that the notions of complexity and complex adaptive systems offer today a huge potential for developing groundbreaking research on language and languages, to the extent that they may partially reveal the "invisible hand" for the organization and evolution of speech communication – a metaphor borrowed from Adam Smith's work in economics and already developed in Keller (1994) in a diachronic perspective. As said above however, no unified framework exists yet, and the contributions gathered here bring together different pieces of the puzzle investigated from several points of view and methodologies. Consequently, a reflection on phonological complexity is present in all chapters to some degree, and the analyses are always based on experimental data or cross-linguistic comparison.

In Part I, the questions of the nature of the relevant primitives in sound systems is addressed in the light of complexity at the phonetics/phonology interface. In chapter 1, Ioana Chitoran and Abigail C. Cohn bring together a number of different notions that correspond to interpretations of phonological complexity (e.g., markedness, naturalness), building on them a clear and comprehensive overview of the main points of debate in phonetics and phonology. These debates revolve around: (i) the interaction between phonetics and phonology; (ii) their gradient vs. categorical nature; (iii) the role of phonetic naturalness in phonology; (iv) the nature of units of representation. Ioana Chitoran and Abigail C. Cohn argue that a clear and complete understanding of what complexity is in phonetics and phonology must necessarily engage these four points, and must take into account phenomena that have generally been interpreted as lying at the interface between pho-

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netics and phonology. As such, it must crucially take into account variability.

Chapters 2 (John J. Ohala) and 3 (René Carré) in this section both address the issue of variability and challenge traditional representations of phonetic primitives. Ohala further develops the idea that the degree of complexity of a sound system should not be limited to the number and combination of distinctive features. Rather, one has to consider the balance between symmetry and economy as described in phonology, and asymmetry and absence of categorical boundaries, as found in phonetics. Starting from the idea that distinctive phonetic features in language X can be present non-distinctively in language Y, Ohala argues that phonetic variation must be included in a measure of phonological complexity, because it is part of a speaker's knowledge of the language. The concept of coarticulation, for example, is not entirely relevant for a phonological system, but the systematic variation it introduces in the speech signal can, over time, affect the composition of segmental inventories.

Carré (chapter 3) presents results from production and perception experiments suggesting that the identification of vowels in V1V2 sequences is possible based exclusively on dynamic stimuli, in the absence of static targets. Carré proposes that reliable information on vowel identities in V1V2 sequences lies in the direction and rate of transitions. He connects this finding to the known importance of transition rate in the identification of consonants. The implication of this connection is a possible unified theory of consonant and vowel representation, based on the parameter of transition rate: consonants are characterized by fast transitions and vowels by slow transitions. Carré's dynamic approach thus presents an intriguing challenge to more traditional views of phonetic specification, based primarily on static primitives.

Part II starts with a contribution by Ian Maddieson where he proposes several factors contributing to phonological complexity, departing from the traditional counts of consonant and vowel inventories, tone systems or syllable canons. The approach benefits from tests on a large representative sample of the world's languages and from a thorough analysis of the literature. The first factor deals with "inherent phonetic complexity". The author proposes various ways of establishing a scale of complexity for the segments, on which we can then base the measure of the system complexity by summing the complexity of its particular components. The second factor assesses the combinatorial possibilities of the elements (segments, tones,

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stress) present in a given phonological system, and one possibility suggested by the author is to calculate the number of possible distinct syllables per language. The third factor focuses on the frequency of types of the different phonological elements of a system. The idea put forward by the author is that the complexity of a language regarding a particular element is the inherent complexity of that element weighted by its frequency of occurrence in the lexicon. In other words, the more a language uses a complex element, the more complex it is. The major concern then lies in the way one calculates the type frequencies for a large sample of languages: shall it be based on lexicons or texts? The last potential complexity factor is called "variability and transparency". It has to do with phonological processes and no more with inventories. The author suggests evaluating the motivations behind phonological alternations; these variations can be ranked from more conditioned ones, (highly motivated, thus less complex) to free variations (no motivations, thus more complex). This complexity value can be weighted against the number of resulting variants in the alternation, giving a combined score of variability and transparency. The author concludes by reckoning that even if all the proposed complexity factors are proved to be relevant, the main problem will remain how to combine all of them in one overall measure of complexity.

The second contribution of part II is by Nathalie Vallée, Solange Rossato and Isabelle Rousset. It echoes the second factor proposed by Ian Maddieson regarding combinatorial possibilities of segments. The authors analyze some languages' preferred sound sequences (syllabic or not) using a 17-language syllabified lexicon database (ULSID) in the light of the frame/content theory (MacNeilage, 1998). They focus on the alternations of consonants and vowels looking at their place of articulation. They confirm previous findings stating preferred associations like coronal consonants with front vowels, bilabial consonants with central vowels, and velar consonants with back vowels. They also examine the so-called "labial-coronal effect" according to which CV.CV words are predominantly composed of a labial first consonant and a coronal second one. Their data extend this result by showing the existence of the labial-coronal effect in other syllabic patterns as well. Finally, they look at sequences of plosive and nasal consonants, revealing that preferred associations question the validity of the sonority scale. To account for all their typological findings, the authors put forward convincing arguments from articulatory, acoustic and perceptual domains; they conclude that the patterns of sound associations encountered

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in the world's languages find their source partly outside of phonology in the sensorimotor capacities that underlie them.

The third contribution by Christophe Coupé, Egidio Marsico and François Pellegrino departs from the two previous papers, as it does not aim at proposing any measure or scale of phonological complexity for phonological segments or sound patterns. The contributors rather consider phonological systems as complex adaptive systems per se and consequently, they propose to characterize their structure in the light of several approaches borrowed from this framework. The main rationale is that, by applying models designed outside phonology and linguistics to a typological database of phonological systems (namely UPSID), the influence of theoretical a priori is limited and consequently allows the emergence of data-driven patterns of organisation for the phonological systems. They propose two different approaches. The first one, inspired from graph theory, consists in analysing the structure of phonological systems by constituting graphs in which phonemes are nodes and connections receive weights according to the phonetic distance between these phonemes. Using a topological measure of complexity, this approach is used to compare the distribution of the structural complexities among broad areal groups of languages. In the second approach, they model the content of phonological inventories by considering the distribution of co-occurrences of phonemes in order to define attraction and repulsion relations between them. These relations are then used to propose a synchronic measure of coherence for the phonological systems, and then diachronically extended to a measure of stability. Emergent patterns of stability among phonological systems are demonstrated, supporting that this approach is efficient in extracting a part of the intrinsic information present in the UPSID database and avoiding as much as possible the use of any linguistic a priori.

The last contribution of this second part is by Christopher T. Kello and Brandon C. Beltz who propose an exciting hypothesis on the dynamical equilibrium leading to a relationship between phonological systems and phonotactics on the one hand, and the process of word formation in the lexicon on the other. Their approach, like the one by Coupé, Marsico and Pellegrino, imports the mathematical theory of graph into linguistics. Phenomena that exhibit behaviour described by power-laws are widespread in physics, biology and social systems. When observed, these laws generally signify that a principle of least-effort is operating, and that a dynamical equilibrium results from the interaction between several competing constraints. Christopher T. Kello and Brandon C. Beltz observe power-law

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behaviours in word forms and phonological networks of American English, built according to inclusion relation between the lexical items (in contrast with semantic or purely morphological rules). As endorsed by the contributors, this result may stem from a trade-off between distinctiveness and efficiency pressures. In other words, a ”valid” language deals both with the need to maintain a sufficient distance between the words of its lexicon and with a constraint of parsimony leading to the reuse of existing phonotactic or orthographic sequences. Their assumption is extended to the lexical networks of four other languages, and then assessed by comparison with artificial networks. While power-laws were first shown in lexical networks in Zipf's seminal work a half-century ago (Zipf, 1949), Kello and Beltz' work goes further by demonstrating that several kinds of constraints interact and generate the same type of behaviour in word formation mechanisms. In a sense, this study fills a part of the gap between the lexicon and the phonology of a language, and provides a convincing link that will be essential for developing a systemic view of languages able to take all linguistic components into account.

Part III is specifically dedicated to approaches that aim at revealing the nature and organisation of human phonological representations in a multidisciplinary framework and in the light of complexity.

Noël Nguyen, Sophie Wauquier and Betty Tuller's contribution develops a dynamical approach to explore the nature of the representations activated during speech perception. In the first section, they set the debate between abstractionist and exemplar-based models of speech perception. Since arguments exist in favour of these two antagonistic hypotheses, they argue that these statements result from the dual nature of speech perception. In this view, phonetic details are retained, not as exemplars but as a dynamical tuning of a complex and continuous “shape”, and an abstractionist-like behaviour is also possible, based on the existence of several stable attractors. A dynamical model is developed and a review of several tasks of speech categorization is proposed. The existence of a hysteresis cycle in the behavioural performances observed during the task indicates that perception does not operate in a basic deterministic manner since it is sensitive to the previous state of the system in a way typical of nonlinear dynamical systems. These results strongly support the proposal of a hybrid and dynamical model of speech perception bringing together the properties of both exemplar and abstractionist models.

in Approaches to Phonological Complexity (2009), Phonology & Phonetics Series, 16, Mouton de Gruyter: Berlin, ISBN 978-3-11-022394-1

In connection with John Ohala's contribution in the first part of this book, and with the dynamical model of speech perception detailed in the previous chapter (Nguyen, Wauquier and Tuller), Adamantios Gafos and Christo Kirov implemented a nonlinear dynamical model of phonetic change illustrated with the case of lenition. They assume that phonological representations consist of feature-like components that could be theoretically modelled using activation fields borrowed from the dynamic field theory, and ruled by differential equations. In their view, production/perception loops self-generate the well-known word frequency effect reported for lenition. More specifically, the interaction between field activation (biased toward the inputs of the perception stage) and memory decay is the backbone that enables gradual phonetic change. Production/perception loops are thus responsible for both the potential shift of the phonetic realization and the positive feedback that lead to the emergence of a new stable variant of the phonetic parameters.

The third contribution of this part, from Willy Serniclaes and Christian Geng, investigates the bases of categorical boundaries in the perception of the place of articulation of stop consonants. It compares the perceptual boundaries of Hungarian and French, using artificial stimuli differing in terms of formant transitions and generated with the DRM model (see René Carré's contribution in the first part of this volume). Four places of articulation are distinctive in Hungarian, while only three are phonologically relevant in French. Consequently, comparing the positions of their boundaries is informative on the influence of universal phonetic predispositions on the organisation of phonological categories. Results show that the perceptual boundaries are similar for the two languages, dividing the formant transition space into three salient areas. It happens that the palatal-alveolar boundary is not as salient as the other boundaries and that an additional feature (besides burst and formant transition) probably plays a role. These results are discussed in the perspective of the emergence of distinctive boundaries from coupling between natural phonetic boundaries; they also echo John Ohala' contribution on the importance of so-called secondary features in language evolution (see the first part of this book).

Nathalie Bedoin & Sonia Krifi's contribution deals with the fundamental issue of the organisation of phonetic features, as revealed in the context of reading tasks. They provide a thorough review of this literature, and a series of visual priming and metalinguistic experiments. These experiments explore the temporal course of reading by manipulating not only phonetic feature similarity between primes and targets, but also the nature of these

in Approaches to Phonological Complexity (2009), Phonology & Phonetics Series, 16, Mouton de Gruyter: Berlin, ISBN 978-3-11-022394-1

features. Taken as a whole, their results suggest that voicing, manner and place are processed at different rates and that a complex pattern of activation propagation and lateral inhibition is involved. More specifically, voicing seems to be processed first but, depending on the experimental conditions, a prominent impact of manner over place and voicing may also be evidenced when processing time is no more a relevant factor. Nathalie Bedoin & Sonia Krifi's contribution thus highlights the complexity of the organisation of phonetic features both in the temporal and the hierarchical dimensions. Additional information is provided by the replication of these experiments with second and third grade children, revealing a gradient setting of the underlying processes during language acquisition and development.

The relevance of the approaches to phonology borrowed from the science of complexity can only be assessed by evaluating whether such models succeed in tackling some of the challenges that limit our knowledge and understanding of human language capacity and linguistic diversity. If granting a significant role to complexity is correct, one of the most salient fields in which it will radically change our comprehension is the domain of language acquisition, and especially along two directions. First, computational dynamical models of emergence of linguistic patterns may assess hypotheses related to the mechanisms of linguistic bootstrapping (e.g. Morgan & Demuth, 1996; Pierrehumbert, 2003). Second, cross-linguistic comparison of courses of language acquisition may reveal universal tendencies, not necessarily in terms of phonological units (gestures, features, segments or syllables) but in terms of their intrinsic complexity and of their interactions in the communication system. In the longer run, these two approaches will probably give rise to unified models of phonological acquisition, and they already have reached significant results on the balance between universal and language specific constraints in acquisition, as shown in Part IV.

In the first paper, Hosung Nam, Louis Goldstein and Elliot Saltzman promote a dynamical model of the acquisition of syllable structures, compatible with what is attested in the world's languages. More specifically, the emergence of asymmetries between the frequencies of syllables with onsets (CV structure) versus syllables with codas (VC structure) is observed with their model which avoids the partially circular notion of the unmarkedness of the CV structure. These effects emerge as a consequence of the interaction between the ambient language and the intrinsic characteristics of the oscillators that control the phasing of the articulatory gestures

in Approaches to Phonological Complexity (2009), Phonology & Phonetics Series, 16, Mouton de Gruyter: Berlin, ISBN 978-3-11-022394-1

in the "child model". By implementing a nonlinear coupling between these oscillators, multiple stable modes can emerge as attractors, given the generic assumption that in-phase and anti-phase coordination of gestures are preferred. Without additional hypotheses, differences between the duration in the acquisition processes of CV and VC structures also emerge, regardless of the target ambient distribution. Next, the computational model is proved to efficiently model the faster acquisition of VCC over CCV. Hence, the model successfully manages to reproduce two seemingly contradictory phenomena regarding the course of acquisition of CV vs. VC structures on the one hand and of CCV vs. VCC on the other. In this framework, the contributors demonstrate that data from linguistic typology and from longitudinal studies of language acquisition can foster methodologies inspired from complex adaptive systems in an extraordinarily fruitful approach.

The two last chapters of this book (contributed by Yvan, and Sophie Kern & Barbara L. Davis) do not implement any computational models. However they thoroughly explore the driving forces underlying phonological acquisition in a multi-language framework. Yvan Rose argues for the necessary synthesis between diverging approaches and he urges development of a multi-faceted approach in order to overcome some failures of current approaches in accounting for patterns observed during early phonological acquisition. Reanalysing several papers from the literature on early acquisition, he suggests that the role of the statistical patterns of the ambient language has been overestimated and an alternative explanation based on structural complexity is introduced. In the rest of the chapter, the contributor discusses a series of phonological patterns taken from data published on early acquisition in terms of interactions of driving forces grounded in several potentially relevant "facets" (articulation, perception, statistics of the ambient language, child grammar as a cognitive system). Yvan Rose's contribution thus offers a strong argumentation in favour of the multi-faceted approach and a rich and stimulating interpretation of existing data built upon factors of phonological complexity.

Sophie Kern & Barbara L. Davis's contribution tackles the issue of cross-linguistic variability in canonical babbling, thanks to an unprecedented amount of empirical data from five languages. The contributors take advantage from this unique material to investigate the universality and/or language-specificity of canonical babbling. The theoretical bases supporting the existence of universal driving forces are introduced and developed in the vein of the Frame/Content perspective, and the impact of the ambient

in Approaches to Phonological Complexity (2009), Phonology & Phonetics Series, 16, Mouton de Gruyter: Berlin, ISBN 978-3-11-022394-1

language is discussed from a review of the literature. More specifically, Sophie Kern and Barbara L. Davis highlight that the lack of common ground strongly limits the cross-linguistic relevance of these studies (because of the different procedures applied in different languages). Then, they analyse the similarities and differences observed in their data, at the segmental level and in terms of subphonemic and phonemic co-occurrences in the babbling structures. The discussion of these results draws a coherent scheme that emphasizes the role of speech-like prelinguistic babbling as a first step into language complexity, but predominated by universal characteristics of the production system.

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Notes

1. It may be more correct to state that these approaches imply a *limited* teleology, in the sense that they are often based on the optimization of a given criterion and thus can be seen as 'targeted' to this optimization. See Blevins, (2004:71-78) for a thorough discussion about the nature of teleological and functional explanations in sound change.
2. This statement can obviously be put in perspective with considerations on language universals and the distribution of patterns among languages, e.g. see Greenberg (1968): "In general one may expect that certain phenomena are widespread in language because the ways they can arise are frequent and their stability, once they occur, is high. A rare or non-existent phenomenon arises only by infrequently occurring changes and is unstable once it comes into existence. The two factors of probability of

in Approaches to Phonological Complexity (2009), Phonology & Phonetics Series, 16, Mouton de Gruyter: Berlin, ISBN 978-3-11-022394-1

origin from other states and stability can be considered separately" (Greenberg, 1978:75-76).

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