linguistics and child language development, in paleontology, and in artificial intelligence to assess the state of art, focusing on ontogeny and phylogeny, without necessarily overlooking synchrony. The invitation stated the following goals:

> For the "Complexity" workshop, our aim is to sort out things about the most useful way(s) to conceive of complexity in language. Need there be only one way or can there be several ways specific to particular research objectives? For instance, should the interpretation in relation to the phylogenetic emergence of language be the same as in comparisons of structures of modern languages? Indeed, can one claim that one language is more complex than another? If the answer is affirmative, how does he/she go about demonstrating it? If the answer is negative, what are the arguments in support of the position? Does the scholarship on language complexity measure up to the current scholarship on complexity theory? Can one discuss complexity without discussing emergence as understood in complexity theory? We would like to address some of these questions and/or any others that you may think of.

To be sure, some authors such as Östen Dahl and Talmy Givón discuss some of these aspects of complexity briefly, the former especially in relation to emergentism and the latter in relation to the phylogenetic evolution of language. Nonetheless, we think that modern linguistics may benefit from more exchanges of ideas, especially those also engaging colleagues from other disciplines who are modeling various dynamical (systemic and social) aspects of language. We want to emphasize that our goal is not to downplay the relevance of those approaches that focus on different aspects of structural complexity. Rather, it is to shed more light on the other, interactional/dynamical and emergentist aspects of complexity that deserve just as much attention and provide us a better sense of how linguistic communicative systems differ from their nonlinguistic counterparts both systemically and socially.

The contributors to this book address COMPLEXITY from the perspectives of both the evolution and the ontogenetic development of language. They focus on social dynamics involving decisions that speakers or signers make (not necessarily consciously) during their

interactions with others and on the dynamics that produce systems out of the different units or constructions they use frequently in their utterances. This approach helps us address the question of whether, say, pidgins (leaving creoles alone) still exhibit some complexity and remain generative, in the sense that they can generate new structures and thus be adapted to the expanding communication needs of their speakers, as is evidenced by expanded pidgins such as Cameroon and Nigerian Pidgin Englishes, Tok Pisin, and Bislama.

3. The chapters

The body of the book starts with the chapter by Luc Steels and Katrien Beuls. Focusing on the origins and evolution of grammatical agreement as a case study, they use multi-agent modeling to explore how various aspects of complexity (especially in the system and in forms, among others) emerge in language. Their working assumption is that complexity arises gradually from innovations produced by interactants largely to meet their new communication needs. It arises also from the competing variants (phonetic, lexical, syntactic, and semantic) they introduce during the process, owing largely to imperfect copying. On the other hand, this communal form of complexity decreases as the speakers' emergent idiolects convergence toward some norm (which maintains less variation), the outcome of their repeated successful interactions. According to Mufwene (2001), mutual accommodations that speakers/signers make to each other are indeed among the mechanisms that drive selection in language evolution, in particular the emergence of new language varieties such as creoles.

Steels and Beuls illustrate another fold of complexity by discussing, with some examples, the way in which ambiguity (in simpler forms or structures) increases complexity in processing. This arises from the fact that the hearer has to eliminate references that may be associated with particular constructions and/or interdependences between constituents

that are not relevant in a multi-word utterance. They show what a critical role agreement markers play in disambiguating utterances. This suggests that, although they have typically been interpreted as adding complexity to the structure of a language, agreement markers actually decrease complexity in processing. If complexity is assessed in terms of processing time (Newmeyer & Preston 2014), morphological complexity does not appear to be particularly costly when it enables speakers to express more information compacted in a short form, as with fusional markers such the Latin *–arum* inflected on a noun to indicate that it is PLURAL, FEMININE, and in the GENITIVE/POSSESSIVE. This appears to corroborate Hawkins' (2009: 259) position that "complexity in form processing is matched by simplicity with respect to the processing functions performed by rich case marking and definite articles."

Likewise, the cooption of some current forms for new grammatical functions, such as in grammaticalization, is said to be a case of "damping complexity," as the strategy reduces guess work in figuring out the new meaning or function. So is the erosion of forms or constructions that follows for ease of production, supporting their hypothesis that speakers tolerate just the necessary amount of complexity they need to communicate efficiently in their language; otherwise they dampen it. Steels and Beuls' discussion highlights the fact that the architecture of a language is multi-modular (though it is not evident how many modules one must posit) and that complexity can be assessed differently, depending of the work that the module is assumed to do. Though we need not subscribe to the traditional position that all languages are of equal level of complexity, we may need a multi-dimensional metric for assessing the extent to which a language is more, or less, complex than another.

Chapter 3 focuses on the following question: When a language can function with just a dozen contrasting sounds (e.g., Hawaian), why does the average phonetic inventory of the

world's languages amount to 29 sounds? This leads Bart de Boer to start with the observation that "Languages are more complex than is strictly necessary for their communicative function." Assuming that this makes it possible to tell which language is more complex than another phonetically, he focuses on determining "which aspects of linguistic complexity are due to cultural processes, and which aspects are due to cognitive biases."

One may want to entertain the question of whether the emergence of languages can really be attributed to cultural processes? If culture is understood roughly as the particular ways in which members of a particular population behave and do things, is this question well-formulated? Is a linguistic system not a cultural system enabled by the particular evolutionary trajectory of its practitioners and shapers? Not only is cultural evolution not mutually exclusive with biological evolution, it also presupposes it. Only animals endowed with uniquely generative and highly adaptive mental/cognitive capacities (viz., the hominine species) have produced human cultures, aspects of which include culture-specific languages (Mufwene, in press).

We want to clarify that De Boer does not want to exclude the role of biological evolution in language evolution cum cultural evolution. What he means by "cultural processes" appear to be related to the fact that nobody really builds a language with foresight and based on a masterplan. If we can borrow from William Croft (this volume), a linguistic system emerges in the same way as other "emergent phenomena" (the way systems are seen in the science of complexity), through the addition and/or disuse of the strategies that the interactants develop in the here and now of their communicative acts, as they integrate gradually into a system. De Boer concludes tentatively that the "complexity of phonological systems is due to cognitive mechanisms that re-use and generalize building

blocks." This appears to be the consequence of transmission through learning by inference, which replicates unfaithfully and introduces (more) variation, as well as of the nonlinear way in which linguistic systems evolve.

In Chapter 4, Thomas Schoenemann argues, in ways consistent with Bart de Boer, that "the complexity of language is the result of the evolution of complexity in brain circuits underlying our conceptual awareness." According to him, modern languages have evolved from the complex interactions of biological evolution, cultural evolution, and successions of ontogenetic development in several generations of individuals in particular populations. Linguistic systems, with their patterns, have been facilitated by humans' "socially-interactive existence," which is reminiscent of Steels and Beuls' discussion of how communal norms emerge. From this perspective, Schoenemann argues that language complexity can best be understood when it is grounded in an evolutionary perspective, focused on interactions of the biological evolution with the changes in the ecologies in which the interacting agents evolve.

Highlighting differences and similarities between humans and chimpanzees in particular, notably in the ways they conceptualize about the world, Schoenemann also concludes that the differences can be correlated with differences in the anatomies of their brains. However, some of the similarities also suggest that humans' ability to conceptualize is pre-linguistic, suggesting that the emergence of Language and the complexification of its architecture are the consequence of the further complexification of the human mind, beyond the chimpanzee under the conditions of "social-interaction existence." He observes that ontogenetically "the development of expressive grammatical complexity appears to be an exponential function of the size of the lexicon."

Assuming that phylogenetic language evolution proceeded gradually, William Croft argues in Chapter 5 that "at least some elements of the structural complexity of modern human languages are the consequence of the cognitive complexity of the conceptual structures being communicated." He also argues that "It is only in its social interactional context that the evolution of linguistic complexity can be understood," thus, that "the evolution of social-cognitive complexity (in terms of joint action) is a prerequisite for the evolution of structural complexity of linguistic signals." Language as a communal phenomenon is the product of joint action; it is more than the sum of the actions and systems of its practitioners. Thus it satisfies the characterization of a complex system according to practitioners of the science of complexity, especially since it can work only if every member of the community cooperates towards its successful behavior/practice.

From an ecological perspective (Mufwene 2001, 2013), Croft also highlights the role played by the material in determining the shape of the emergent semasiographic system ("encod[ing] information in a lasting, visual medium"), for instance, the role of clay in reducing the number of iconic signs. If this hypothesis is correct, one may assume that the shapes of the Chinese logographic characters were largely influenced by the use of papyrus and ink. Overall, Croft's general observation is that writing systems, which have evolved from simpler non-linguistic and more iconic semasiographic conventions, emerged gradually, becoming more arbitrary as they were increasingly being used to represent speech. It is, of course, debatable whether the Chinese system has evolved to serve speech, as the same graphic representation can be read equally in any Chinese variety (e.g., Mandarin or Cantonese).

Croft also argues that "Writing did not express grammatical elements until centuries after its first emergence. In other words, substantial common ground between author and

reader was required to interpret just the linguistic form encoded by early writing." Illustrating how exaptation works in cultural evolution, Croft shows through his discussion of musical notations how elements of the current system are recruited for new functions, to help expand it (to the satisfaction of the performers/practitioners). This is indeed reminiscent of the exaptation that takes place during grammaticalization.

Based on how semasiographic systems have evolved, gradually and from restricted to a wider range of functions, Croft hypothesizes that "language began in highly restricted functional domains, and its extension to become a general-purpose communication system was a long and gradual process in human prehistory." He further concludes that, like the semasiographic systems, "language initially functioned simply as a coordination device for joint action," conveying minimal information.[12] It is only later that it became more explicit, conveying richer information, and developed more complexity in its architecture, especially as it developed "displacement" (Hockett 1959), the capacity to convey information about entities and states of affairs that are not present.

In Chapter 6, Christophe Coupé, Egidio Marsico, and François Pellegrino start with a historical synopsis of the interest of linguists in complexity since Ferdinand de Sausure's (1916) characterization of a language as a system consisting of interacting parts. Then they consider the particular ways in which scholarship in complexity theory, as practiced in especially physics, mathematics, and cybernetics, has inspired some of the current research in phonology. They also underscore the fact that "A language is an aggregate of individual idiolects" (comparable to Mufwene's 2001 idea that it is "extrapolation from idiolects"). As spoken of in linguistics, individual languages are reductions of convenience, which overlook

[12] Croft uses *coordination* in a way related to *cooperation* in theories of human and cultural evolution, in reference to members of a population engaging in joint actions.

inter-idiolectal variation, which is more closely matched by Michel Breal's (1897) idea that every idiolect is somewhat a separate language. Both inter-idiolectal variation and the breakdown of sounds into (articulatory and acoustic) features add complexity in the ways phonological systems can be thought of.

Coupé, Marsico, and Pellegrino also highlight the difference between acknowledging that a system is complex and assessing the extent or level of complexity, while citing some studies that have proposed particular metrics. They warn against importing uncritically hypotheses developed by physicists and mathematicians, which are typically based on simplified models of reality, although they are useful research tools. This is consistent with their basic position that any research field (including linguistics) can contribute to the science of complexity.

Applying the statistical method to 451 phonetic inventories, the authors address the question of whether phonological systems world-wide present evidence of preferred interactions among segments that may be based on manner or point of articulation, nasality and orality for vowels, or any other phonetic features. That is, are there any particular features that are more significant than others in the emergence of phonological systems? Their conclusions include the observation that, from an evolutionary perspective, "it [is] (…) difficult to conclude in favor of strongly non-linear interactions between either features or segments." They also note that it is difficult to assess the overall complexity of a language using tools developed for physics and biology, as they do not transfer faithfully to language. While it is evident that traditional, typologically-oriented discussions of linguistic complexity do not capture the full picture, linguists should consider a more informative metric for addressing the question of whether or not different languages display the same level of global complexity.

Barbara Davis focuses, in Chapter 7, on the ontogenetic development of the phonological component of language to explore the kind of light the analysis may shed on the phylogenetic evolution of language. Like Schoenemann, she grounds her discussion in the interpretation of COMPLEXITY in the science of complexity. According to her, "Within the tenets of complexity science, phonological knowledge and behavioral patterns can be seen as emerging from connections enabled by *general-purpose* child capacities such as learning and cognition as opposed to language-dedicated modular mechanisms." The emergence of a complex phonological system in the child is driven by both their cognitive-neural capacities and the production system capacities which work in cooperation. She refers to the complex interaction between the environment and the child's brain in the gradual emergence of his phonological system, which appears to call for an approach similar to the analysis of emergent phenomena in the science of complexity, which may presuppose only the disposition of a mind sensitive to complex interactions and ready for complex systems rather than specifically for language.

Davis' observations are similar to those of Schoenemann. She terms this approach "biological-functional approach to phonological acquisition," according to which "outcomes of phonological acquisition result from multiple interactions between heterogeneous aspects of a complex system." She moves on to explain the significance of change in both the ontogenetic development and the phylogenetic emergence and evolution of language, especially in introducing complexity throughout the adaptations that the emergent system undergoes to satisfy current communicative pressures. The ACQUISITION of phonology is thus characterized as "'change' in infant output capacities." Thus, the "progressive diversification in the inventory of sound types and how they are produced in sequences relative to ambient

language patterns is usually considered a critical index of increasing complexity toward mature phonological capacities."

In Chapter 8, Lucía Loureiro-Porto and Maxi San Miguel approach complexity in language practice from the point of view of language choice in a multilingual setting, especially those that may result in language loss. That is, they focus on complexity that arises not from interactions between the different components and/or modules of language as a system but from various factors external to the system that influence speakers' choices in their discourses, especially when they have to alternate between languages in a bilingual setting. Their study involves modeling as a simplified tool for addressing certain specific questions regarding linguistic behavior in this particular case.

From the outset, the authors articulate a distinction they make between a COMPLEX SYSTEM from a COMPLICATED SYSTEM (such as an airplane), which is "composed of many parts, each [of which] has a clear, identifiable function which makes prediction possible." Complexity has to do largely with the unpredictability of the properties of the whole from those of the parts. From the point of view of language practice, the whole regards the vitality of a language, as it depends on language choices speakers make when they interact with each other, without foresight of the ultimate consequences of these decisions regarding the languages in competition. It is the whole ecosystem in which the language belongs, in coexistence with other languages, that is of concern. What are the factors that individually or in combinations determine the choice of one or another language (variety) on specific occasions of social interactions? Things are made more unpredictable by the fact that speakers are not necessarily coordinated about their decisions in the typically dyadic or triadic interactions they are most often engaged in.

Loureiro-Porto and San Miguel's modeling reveals the significance of local interactions in bilingual settings, regarding how they reduce the chances of sustaining the vitality of both of the languages in competition. Other interesting questions arise too, as language evolution is not uniform from one bilingual setting to another. One of them regards when multilingualism spells the endangerment of the less prestigious language(s) and when it does not. In the real world, the explanation can be found in differences between the population structures of the multilingual settings: for instance, those fostering assimilation also favor endangerment, whereas those that are socially segregated according to language groups do not.

Because it simplifies reality, of necessity, modeling helps us become more aware of the complexity of factors that influence the linguistic behavior of (members of) a population and thus bear on language vitality. Underscoring the complexity of actuating factors is the fact that even those population structures that are assimilationist do not endanger the disadvantageous languages at the same speed either. Loureiro-Porto and San Miguel's modeling reveals differences between small-world networks, regular lattices, and networks with community structure. As the authors conclude, "the kind of network in which interactions take place is a strong influencing factor on language dynamics, as it plays a central role in the potential survival or disappearance of one of the languages in competition."

Closing the book, Albert Bastardas-Boada approaches linguistic complexity both from the parts to the whole and from the whole to the parts. The aspect of complexity he focuses on is that which arises from the interaction of the system with its ecology, including the socio-conceptual matrix of the speakers' interactions, economic pressures, the distribution of political power, and the effects and language policies. Complexity increases as a

consequence of the fact that populations are not uniform and foster variation, which obtains not only inter-individually and between groups, but also inter-generationally. According to the author, a language must be conceived of "as a historical and, therefore, temporal phenomenon, with earlier events playing a major role in how the phenomenon evolves." History shapes and may provide some explanation for the present, including current linguistic behavior.

There are indeed other aspects of complexity that this book, like the dominant literature in linguistics, still does not tackle, despite our focus on developmental and evolutionary perspectives. One of these is the extent to which increase in population size affects complexity in the communal language, perhaps more in the pragmatic and social aspects of its usage than in its structures. Another is whether contact with (an)other language(s) reduces or increases structural complexity, and under what specific conditions. Is contact the only explanation for why major world languages such as Modern English and Modern French have lost most of the inflections of Old English and Old French, respectively? On the other hand, hasn't contact also increased complexity in their systems in other ways, such as in introducing alternative grammatical rules and/or changing some of the rules while preserving some exceptions? These are all interesting topics for future studies.

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