13 The Emergence of Complexity in Language: An Evolutionary Perspective

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Abstract. Like an increasing number of linguists and other scholars especially interested in the evolution and/or the ontogenetic development of language, the author claims that languages are complex adaptive systems (CAS). These have been characterized as reflecting complex dynamics of interactive agents, experiencing constant instability, and in search for equilibrium in response to changes in the ecologies of their usage. Putatively, thanks to self-organization, transitional moments of apparent stability obtain during which patterns and systems emerge, and evolutions obtain from the alternations of periods of instability and stability in seemingly unpredictable ways. The author addresses the issues of the many interpretations of 'complexity' applying to language(s), of the description of the interactive agents that produce the above characteristics, of the emergence of complexity in language(s) from the point of view of language evolution, of the kind(s) of evidence that support(s) the various interpretations of 'complexity' that are conceivable, of the way in which complexity in language compares with complexity in other non-linguistic phenomena, and of the causes of the "chaos" which prompts languages to reorganize themselves into new systems.

1 Introduction

The scholarship on the evolution of language has come a long way since the earliest speculations in Antiquity and even since those of the 18^{th} and 19^{th} centuries. While it was commonly assumed that speech had evolved from natural cries similar to animal vocalizations (which is not totally groundless), it was also assumed incorrectly that the transition from the "cries" to modern languages involved no intermediate transition(s). Today, influenced by Darwinian theory of gradual and ecologically-driven evolution of species, including hominins, modern students of the evolution of language assume gradualism. It matters little that there is still a great deal that we do not know, and certainly no consensus, on the specifics of the evolutionary trajectory.[1] The present essay is in line with this Darwinian approach, focusing on the emergence of linguistic complexity, which has itself become an elusive notion over the past few years. As I show below, it can be interpreted in diverse ways which are not mutually exclusive.

Most of the recent publications in linguistics have focused on what Dahl (2004) calls "constitutional complexity" and DeGraff (2009) characterizes as "bit complexity," having to do with how many units (e.g., the size of the phonetic inventory) and rules/constraints a language possesses.[2] The rules/constraints specify what combinations of units are allowed and under what specific conditions some of the combinations are not permitted. (See also Nichols 2009, though she hesitates about the inclusion of constraints.) Adding to the complexity, which must be considered more dynamically than statically, are also pragmatic conventions specifying when particular forms or constructions can be used and when they may not.

The "bit complexity" approach, which may also be claimed to be structural, has generally been comparative, leading to the conclusion that a language with a larger inventory of units and rules/constraints is more complex than one with a smaller one. Like Dahl (2004), Nichols (2009) adds that this can be measured by the length of the description that can account for the language, assuming of course that the same framework of analysis has been applied to languages being compared. In reality, the comparisons have focused on subsystems, making it easier to claim that a language has a more complex phonetic inventory or phonological system than another, though it has also been observed that most languages fall within

[1] In Mufwene (in press-a), I argue against monogenetic phylogeny, which is still assumed by many, if not most, of recent publications. The current paleontological evidence does not support monogenesis, especially with the fossil evidence dispersed all over in East Africa. It is not even necessary to assume it in order to account for the common features of human languages. By homology, these may be considered as natural consequences of the particular mind which co-opted the same anatomical structures in all hominin populations for the local production of various languages. This position makes typological linguistic diversity more natural and easier to account for, without having to invoke unmotivated systemic changes. Because no particular population ever selected the full range of sounds they could produce (Maddieson 2006) and because there are alternative ways of handling linearity that followed from the adoption of the phonetic technology (see below), there is plenty of room for cross-systemic variation, which is evident already at the level of dialectal variation within the same language. *Mutatis mutandis*, the same is true of signed languages, where the primary technology is manual. In this essay, my alternating between the singular and plural in speaking of the emergence of language(s) simply reflects alternative emphases on either the common features or the variable peculiarities of languages.

[2] As noted by Givón (2009), it is the fact that units and rules maintain, respectively, space and functional relations to each other which justifies interpreting this aspect of language as complexity. This feeds into the dynamical interpretation of complexity that I develop below.

the average range of complexity (Maddieson 2005a, 20085, 2005c). It has been difficult to show that overall one language is more complex than another, though some students of the evolution of language are exploring this possibility (e.g., Nichols 2009, Wang 2011, Hombert 2011). Because, as noted by Nichols (2009), no comprehensive comparisons of all modules have been undertaken yet, the question remains open.[3] Besides, even if there are comprehensive studies of some languages, the comparison can be difficult to undertake fruitfully if they are not written in the same framework of analysis and are not equally informative about details of the (sub)systems.

Overall, the "bit complexity" approach has been at variance with discussions of complexity in studies of emergence outside linguistics. "Complexity theory," as the scholarship on emergence is often referred to, has focused on interactions between agents, which keep the ever-emergent "system" in constant search for equilibrium (e.g., Dooley 1997, Heyligen 2009). Complexity arises from the adjustments the "agents" (i.e., interacting units) make to each other, how the adjustments modify the overall properties of the emergent system, and how the properties of the latter fail to amount to the sum of the properties of its components.[4] There is thus a lot of emphasis on self-organization, which generates structures that have been planned by nobody. We may term this "interactional," "dynamical," or "systemic complexity" (Mufwene 2009), which, in the case of language, does not deny the value of "bit complexity" but simply shows another aspect of language that is equally worth (better) understanding.

Interactional complexity is given more attention in this essay, because it helps us best understand how human languages differ from animals' means of communication, to which the term *system* can apply only loosely. Human languages, both spoken and signed, are multi-modular. The interactions of their modules, which run concurrently during the production and processing of utterances, generate complexity, just as do intra-modular units in their paradigmatic interrelations and

[3] To me, this line of research is like comparing the architectures of two or more computers doing basically the same kinds of jobs, or can be adapted to do each other's jobs, but are using different (combinations of) algorithms. I think that, from the perspective of the phylogenetic emergence of language, it is less informative regarding the aspects of human languages that distinguish them from animal means of communication, as I show below.

[4] An issue arises from the interpretation of the term *agent*. According to complexity theory, the agents can be nothing but the units/components which self-organize into an emergent system. These are the counterparts of units and rules/constraints in languages. On the other hand, languages are like viral species, whose characteristics emerge from the communicative activities/behaviors of the communicators, who shape them in the process. Is one therefore justified in assuming, as do Lee *et al.* (2009) and Beckner *et al.* (2009) that the agents are speakers/signers? Or should one assume, consistent with emergentism, that self-organization applies the same way in languages as in other "systems," especially since speakers/signers have no foresight of how things fall in place in the emergent linguistic systems? This is a question that practitioners of usage-based grammar cannot dodge.

syntagmatic interactions.[5] In this respect, even those linguistic systems claimed by some linguists to be the very simple, such as child language and incipient pidgins (e.g., Bickerton 2010, McWhorter 2001, but see below), exhibit a level of complexity that is not evident in, say, primates' vocalizations.

I argue below that the main reason for this difference between human languages and animal means of communication lies in the fact that nonhuman primates' vocalizations are holistic signs; they do not have discrete/digital structures and do not lend themselves to compositionality. Though long vocalizations are modulated prosodically, they simply cannot be segmented into constitutive units. This fundamental difference alone has exponential consequences, including the fact that, as far as we know, sequences of apes' vocalizations do not display syntagmatic relations (unlike long utterances in human languages), let alone the kinds of inter-utterance relations identifiable in conversations or other forms of discourse. Yet, it is possible to identify syntagmatic relations in child language and pidgins (though these lack complex syntactic structures). As explained in Mufwene (2010), it's not evident that Bickerton was justified in characterizing them as "protolinguistic," though they are transitions to full-fledged linguistic systems (communal rather than individual in the case of pidgins).

Another fold of linguistic complexity emerges from the communal aspects of languages, as their norms represent the convergence of idiolectal systems towards structures that are more similar to each other. It may be characterizes as "social" or "socio-interactional complexity," associated with the various accommodations that speakers make to each other in order to streamline mutual intelligibility, by reducing idiosyncrasies among them.

There is a whole lot we can learn about interactional and social complexities that can be revealing about the phylogenetic emergence of languages and the particular ways they differ from other animals' means of communication. I approach languages as hybrid and modular technologies (see below), which emerged through the co-option of human anatomies, and whose primary function has been to facilitate communication (Mufwene, in press-b). As is evident from other

[5] Sadock (2012) captures this adequately in explaining that the modules are separate subsystems, each dedicated to its own job, such as the syntactic organization of smaller units into constituents of various sizes in sentences (syntax), the combination of small meaning-bearing units into words (morphology), or the basic arrangement of sounds into acceptable words (phonology). The relations between the different modules are not isomorphic, as each of them has categories that are independently suitable to itself. Mismatches arise during the interfacing of the modules, for instance, semantics, morphology, and syntax, because clashes arise from their respective combinatorics. There are also exceptions to rules ("patterns" in emergentism); and all these add to complexity, as the modules keep up with each other during the production or processing of utterances. The mind processes concurrently, in the different modules, complementary aspects of the production of utterances, making sure that they all converge toward a meaningful and well-formed utterance, in accordance with norms which are partly culture-specific (as suggested by typological diversity) and partly universal. Universal principles may be consequences of the particular anatomical technology used and of the mind that has produced this.

animals, communication is anterior to language, which only made it richer and more explicit, as I explain in the next sections.[6]

2 Languages as Technologies

In this essay, as in Arthur (2009), technology need not be understood as a tool or machinery planned and designed by a group of experts (in a laboratory) to solve a particular set of problems. Languages are unplanned tools of communication that emerged incrementally, with different interactants innovating and contributing different pieces at different times (not without particular constraints!) when necessary, under specific social pressures to express and share their thoughts or feelings. They are outcomes of successive responses of the human mind to social-ecological pressures to communicate; their norms have been shaped by particular social interactive dynamics driven by speakers'/signers' disposition to cooperate.[7]

In a nutshell, as social life exerted ecological pressures for hominins to communicate, the mind co-opted what it could use in the their anatomy, especially the buccopharyngeal structure or the hands, to produce phonetic or manual symbols, which function as the hardware of the technology. The software of the linguistic technology consists of the principles regulating how to combine the phonetic and manual signs to form meaningful utterances: words, phrases, sentences, etc. In the case of speech, on which this paper is focused, the basic materials to work with are sounds, prosody, and silence/pause, the expected or perceived position of the latter being used to mark boundaries of words and larger utterances, which facilitates the processing of the strings produced by the speaker. Diamond (1992) is correct in observing that we do not always perceive it, as is made more obvious when we listen to utterances in languages we are not familiar with. I submit that part of developing competence in a language is identifying those positions where silence, or a pause, can occur to mark word or other, larger constituent boundaries.

Linguists have usually explained the structure of utterances as hierarchical (barring a few languages that are said to have flat structures), which means that sounds combine into morphemes or words, while the latter combine into larger constituents associated with predicate, argument, and adjunct functions, as they

[6] There are indeed several publications in the past decade that have been devoted to linguistic complexity, including the following books: Dahl (2004), Hawkins (2005), Miestamo *et al.* (2008), Sampson *et al.* (2009), Givón (2009), Givón & Shibatani (2009), Pellegrino *et al*. (2009), and Faraclas & Klein (2009). Because they typically focus on bit complexity, I will not refer to them in the present essay. Besides, most of them do not even define complexity, let alone problematize it. Studies such as Givón (2009) and Nichols (2009) are still limited to bit complexity only. Dahl (2004) is perhaps the only one that has adopted an emergentist approach, akin to that developed here.

[7] The role of cooperation, like that of joint attention, in the phylogenetic emergence of language is well explained by Tomasello (2008) and Corballis (2011), among others. I submit that it is the driver of communal conventions in linguistic communities, through the mutual accommodations that speakers/signers make to each other, reducing, if not eliminating, the variation that can impede mutual intelligibility (Mufwene 2001).

collectively form sentences. It is thus tempting to assume that language emerged likewise phylogenetically, even though we should know from naturalistic language development that words are acquired first and their morphological structures emerge at a later stage, just in the reverse order of morphosyntactic analyses. (See also Givón 2009 for a similar discussion.) One can imagine, incorrectly of course, that Homo erectus abandoned the original ape-like vocalizations to produce individual sounds and then combined them at a later stage into words, while Homo sapiens would combine them much later into sentences. Such a scenario would suggest that there would have been no (vocal) communication for a while, a contradiction and undoubtedly frustrating evolution during a protracted period in which hominins (from Homo erectus to modern Homo sapiens) were developing the phonetic phonology just to respond to current social pressures for more explicit and richer communication than just kinesically, with gestures, and with holistic vocalizations.

An alternative scenario, inspired indeed by how a child develops language seems to be more plausible, which probably also answers partially the question of the passage from vocalizations to speech.[8] Once the hominin mind became more complex and Homo erectus or early Homo sapiens could organize more complex social structures, the pressure to do more than naming entities and events must have increased. Attempts to modulate the vocalizations would have led to the production of vowels as discrete segments separated perhaps initially by the glottal stop and later by consonants for easier distinction of syllables. Larger inventories of both vowels and consonants would permit what MacNeillage (2008) calls "syllabic variegation."

Though I believe that the emergence of modern phonetic inventories must have been protracted, I will not explore here the question of which sounds emerged first and which ones later. It is safe, however, to speculate that social and cognitive pressures to increase the vocabularies must have called for larger inventories of sounds. On the other hand, phonotactic combinatorics would have made it unnecessary to keep inventing new sounds past a particular threshold, since the vocabulary could be increased by modifying sound combinations and/or the number of syllables per word. Thus, for instance, although Hawaiian has a small phonetic

[8] Although ontogeny does not recapitulate phylogeny, it can provide plausible hints about the latter, as also argued by Givón (2009). Tomasello & Call's (2007) and Corballis' (2011) observation that apes' gestural communication is closer to human language than their vocalizations is not *ipso facto* an argument against the position that human speech evolved from ape-like vocalizations. As indeed observed by Corballis (2011: 67-70), vocalizations are controlled by the same mirror-neurons and the same parts of the brain (F5 among the apes and the Broca's area among humans) that control gestures. Vocalizations appear to have been the transition from gestural communication to speech (though they did not displace gestures), an evolution that occurred after the buccopharyngeal structure had undergone some changes (Corballis, *ibid.*), including the sinking of the root of the tongue (Lieberman *et al.* 1972, Fitch 2010). The question is whether we can explain how the transition from the ape-like non-digital vocalizations to the digital structure of speech took place. I attempt an explanation below.

inventory, it can produce a large vocabulary by having long sequences of syllables in which two or more vowels can alternate as syllabic peaks.[9]

There's been controversy in the literature (on the one hand, Carstairs-McCarthy 1999, Wray 1998, 2002 and, on the other, Tallerman 2005, 2007; Bickerton 2007) over how specifically the transition from the non-digital vocalizations to discrete speech took place. The transition is an issue if one assumes that there was a sudden shift from no phonetic inventory to full-fledged phonetic inventories (Mufwene 2010). It is not if one assumes gradual evolution by slight modifications of vocalization patterns that would produce just a couple of distinct vowels in the beginning and enable enough distinctions for a vocabulary that grew only gradually and in a protracted way. It seems even more plausible to assume syllabic variegation first, with the number of segments needed for this state of affairs increasing only as pressure for more lexical oppositions also increased. The rest of the evolution would only be consistent with emergence, as communicators would capitalize on what they could do already in order to produce new elements. It would not be difficult to innovate a new vowel or a couple of additional ones after two or three vowels were already in place, combining with a couple of consonants, to produce some words. This is when the question of the order in which the segments may have emerged arises, a question that phoneticians are better placed to address.

So, the phonetic inventories of the world's languages appear to have emerged as a consequence of the gradual emergence of larger vocabularies as human social structures, material cultures, belief systems, and knowledge of the surrounding physical ecologies became more complex. Note that phonotactics is a consequence of linearity, which is itself a consequence of the phonic materials used in the speech technology. No two sounds can be produced concurrently, bearing in mind that coarticulated sounds are special cases of mixed single units involving two concurrent points of articulation. In other words, there was no other choice but to domesticate the ensuing linearity of the speech technology and to adopt constraints, some of them probably arising from the hominin anatomy itself (Maddieson 2006), on how to combine sounds into words, and then words into larger constituents. As noted above, pauses (and prosody in some languages) do the job of marking boundaries between words and between larger units. Syntax too is thus the consequence of the domestication of linearity, with some of its principles (such as word order) being culturally determined and therefore variable from one language community to another, while some constraints assumed to be universal may have a cognitive basis.

[9] As pointed out by Maddieson (2006), variation in the size of the phonetic inventories has no bearing on the size of the vocabularies that different populations can produce. Different populations did not have to settle on the same norms for combining the sounds either, though there are sounds and combinations thereof that appear to be favored as opposed to those that populations tend to avoid because they require more energy or are found too difficult. Otherwise, the culture a particular population has developed determines the size of the vocabulary they need to talk about various aspects of it. The size of the vocabulary reflects the communicative needs of the relevant population of speakers/signers, not only regarding what they find useful to name but also what degrees of distinctions they think necessary to keep between some related concepts, such as between ARM and HAND, LEG and FOOT, between different kinds of hair (*cheveux* vs. *poil* in French) or between HOLE and SINKHOLE.

As the knowledge required to communicate became more and more diverse and the mind had to handle many operations concurrently, language self-organized into modules, at least from the emergentist perspective assumed in this essay.[10] Since languages do not really have agency of their own, what this means is that the minds producing them organized the structures of the emergent technologies modularly, in ways that would facilitate, for instance, the selection of concepts, the production of sounds, and, hierarchical structure of an utterance concurrently. While the production and processing of utterances became multilateral, the overall architecture of languages also became more robust, as the whole system need not collapse if a module malfunctions. This reality is evident from the various cases of aphasia, which involve only partial loss of the patient's linguistic ability. This evolution into modular architecture also fostered the emergence of systemic complexity, regardless of the size of the phonetic inventory in a language.[11] I discuss this topic in the next section.

3 The Phylogenetic Emergence of Complexity

3.1 The Nature of Linguistic Complexity

With regard to system emergence, interactional complexity seems to have arisen in two fundamental ways in language.[12] First, as the inventory of phonetic units

[10] Givón (2009) is right in observing that the process was probably facilitated by a mind that was already handling various cognitive processes modularly. After all, there is no part or network of particular parts of the brain that is specialized for language only. The same parts of the brain and modules of the mind appear to have been exapted for language. For instance, the same Broca's area and mirror-neurons that were already controlling mastication, gestures, and other sensorimotor activities were coopted for speech production.

[11] Modularity is what also led Hockett (1958) to assert that the total grammatical complexity of any language is about as complex of any other. There would be inter-modular compensation especially between the computational and the formal aspects of the linguistic technology. Like the speculation that some languages (not counting transitional stages such as incipient pidgins) are more, or less, complex than others, Hockett's claim too needs to be verified by more comprehensive comparative studies.

[12] I speak of *arise* because, as suggested above, the hominins who developed language were more interested in establishing explicit and rich communication than in devising a system with some foresight of how the different components would be integrated together. All adjustments have been ad-hoc, taking place in the *hic-et-nunc* of communication without any anticipation of what the overall system would look like at some point. Every innovator must have striven for easy recognition of his/her innovation and, in the case of units other than sounds, for their adequate interpretation through inference. What makes languages so interesting from the point of view of emergence and brings up the question of interactional complexity is that systems have emerged nonetheless, as if the different units and principles had some agency in negotiating their distinct(ive) positions and functions within the emergent systems. This led Dahl (2004) to analogize coexistent linguistic units, which continually calibrate their spaces and functions relative to each other, to agents in the "emergent systems" of complexity theory.

and symbols (individual meaning-bearing units) increased, it became necessary for the perceptual and semantic spaces of neighboring sounds and symbols respectively to be calibrated next to each other. Sounds had to be kept distinct from each other, to ease perception and processing. In some cases, their production had to vary according to the phonetic environment, such as with the voiceless stops in English (where they must be aspirated vs. where they should not or cannot) or the voiced stops in German (when they are devoiced and where they cannot). The negotiation of phonetic space and the stipulation of principles regulating allophonic variation produced paradigmatic complexity. This is a kind of interactional complexity that may be considered structural and is closely related to bit complexity. It helps the meanings of related words (e.g., body parts, kin relations, color hues, or motions) to remain differentiated as clearly as possible, though these relations can change over time when the ecologies of language practice change. Adjustments are constantly being made regarding the paradigmatic position and function of every unit and principle relative to others with which they cannot alternate freely, i.e., without changing the meaning and/or pragmatic effect.

Second, complexity arose from all the principles/constraints (really the outcomes of habit formation) on what units can combine together and what rules can apply concurrently, but what particular combinations are disallowed (i.e., not considered normal). This may be termed "syntagmatic complexity," which compels the speaker to be aware of the complementarity of several units and principles within subsystems or modules. If the structures of languages could be reduced to these paradigmatic and syntagmatic relations alone, human languages would still be more complex than the vocalizations of our primate cousins, which can be interpreted just as limited vocabularies (i.e., inventories of labels) for a closed list of situations and emotions but have no internal structures (unlike spoken words, which consist of concatenated sounds and sometimes morphemes) and no syntagmatic relations, and certainly no (hierarchical) constituent structure in the sequencing, generally repetitions, of the vocalizations. Except at the earliest developmental/evolutionary stage, even child language and incipient pidgins show (some degree of) this hierarchical constituent structure in utterances.

As linguists have always assumed, units are not of the same kind, nor are the principles (rules and constraints) that apply when we speak. Moreover, while units of the same kind are paradigmatically mutually exclusive (a consequence of the linearity of the phonetic technology) principles of different kinds typically apply concurrently. This is made possible by the modular architecture of the system. As the vocabulary expanded and communication involved more than just naming entities and events, the emergent systems became more and more crowded and harder to manage without any kind of integrative structure. Units and principles that worked jointly towards the same goal, like producing words or sentences, were thus allocated to different modules, not because speakers thought deliberately that they should organize their languages this way but probably because the mind was capable of carrying out the necessary tasks concurrently and found it useful to adopt a division of labor. As noted above, this modular structure fostered speed and efficiency in processing language. For instance, while the semantics module is busy with the selection of the correct word-meaning pairs and relevant combinations into larger meaningful utterances, the phonetics module deals with how the segments that the words consist of must be pronounced. At the same time, the syntax module handles the particular ways that words are combined together, regarding the order of constituents and their dependency relations (expressed hierarchically in a language such as English). The modules interact inevitably with each other during the process, with the interfacing generating interactional complexity.

The Complexity arises especially from the synchronization of the complementary activities of the modules at every significant step of the linearized production of utterances. The reverse takes place during the perception and processing of utterances, though a certain amount of delays and backtracking is often necessary for accurate interpretations.[13] What is particularly significant about this interactional complexity is that even the most rudimentary utterances produced by a child or the speaker of an incipient pidgin involves it. This characteristic makes more evident how the architecture of human languages differs from that of animal means of communication, though, as several experts have been pointing out, there may be nuances in how these differences must be specifically articulated.

Note again that my focusing almost exclusively on interactional complexity is not a denial of bit complexity. The latter, which has typically received exclusive attention from linguists, has its place too in discussions of the emergence of complexity in the phylogeny of human languages. One may in fact argue that interactional complexity as explained above is a consequence of the emergence of bit complexity and the ensuing modular structure of languages. Typological variation among different languages also highlights the fact that languages are cultural artifacts after all, reflecting particular options chosen by those who speak and fashion them. Although the basic principle in having different vowels with their own respective articulatory and acoustic properties is to maintain segmental distinctiveness in ways that vocalizations cannot, languages vary regarding the specific (numbers of) vowels included in their inventories and how the perceptual distances between the segments are articulated. As noted by Maddieson (2006), whether a language has five vowels, seven, or more has little bearing of the size of the vocabulary that the relevant language can develop or the syntactic principles that underlie the production of sentences. Likewise, as long as a language permits predication, it does not matter whether or not the head of the predicate must always be a verb or whether the verb is phrase-initial or phrase-final. Languages also vary regarding the specific categories into which particular semantic domains such as kinship and furniture are organized, just as they vary regarding both the particular syntactic conventions that have been adopted to form larger utterances from words and how words can break non-arbitrarily into morphemes.

[13] This sets languages as "complex adaptive systems" (Mufwene 2001, Beckner *et al.* 2009, Cornish *et al.* 2009, Lee *et al.*, 2009) apart from complex manufacturing enterprises (like the computer and automobile industries), in which the components that will go into a machine need not all be produced all at the same time, nor even in the same factory. There is no room for such asynchrony in language, although the processing of utterances can be revised in mid-course, just as utterances themselves can be repaired, thanks to a feedback mechanism within the speaker/hearer, which adds another fold to the interactional complexity.

On the other hand, while it is obvious that one particular module in a language may exhibit more, or less, bit complexity than its counterpart in another language, it is not evident yet that the architecture of a particular language can be claimed to be generally more complex than that of another. Only comprehensive comparisons will answer this question that, as noted above, seems to have preoccupied some linguists of late (Nichols 2009, Hombert 2011, Wang 2011). What claims regarding the simplicity of child language and incipient pidgins seem to show is that the architectural complexity of a language reflects the extent of its communicative functions. Social interactions in which a limited, if not simply a closed, repertoire of information is exchanged do not generate complex means of communication. Rather than being protolinguistic fossils (Bickerton 1990, 2010), child language and incipient pidgins represent that transition to full-fledged systems capable of expressing, through various adjustments, an infinite array of information. They represent the onset of modular architecture and interactional complexity.

The linguistics literature that has focused on comparing bit complexity across languages has simply contributed to our understanding of typological diversity. It's like comparing computer programs in terms of the details they include to do fundamentally the same kinds of jobs. Consistent with the Darwinian evolutionary position that I have assumed since the outset of this essay, I will soon speculate on how both bit and interactional complexities emerged in language.

However, because languages are discussed in linguistics as communal phenomena, we cannot ignore an important communal, also interactional and equally dynamical, aspect of complexity, which plays an important role in how norms emerge and how languages change. Let's identify it as "socio-interactional complexity." It is the consequence of the fact that linguistic knowledge is born in individual speakers' minds and is fundamentally variable from one idiolect to another. The variation among idiolects is a consequence of the fact that languages are learned by inference in social environments where every individual (perhaps twins excluded!) has a different interactional history (Mufwene 2008) and is anatomically different, which affects their perception and reproduction of sounds, for instance. Besides, as with other sociocultural skills, speakers are not equally gifted for language. It is thus amazing how in the same network or the same community of practice idiolects are more similar to each other than they may be expected to be. The reason is that speakers are cooperative and constantly calibrate themselves to each other, which reduces differences between them (Mufwene 2001). The socio-interactional complexity lies in the mutual accommodations they make to each other in order to facilitate mutual intelligibility, as noted above. It has to do with the fact that interactions are typically dyadic or triadic and the sets of interactants change frequently. How does every speaker keep track of the variation and how do members of a community of practice ultimately converge toward common norms on individual variables?

How speakers decide whom to accommodate or not and how their respective accommodations lead to the emergence of communal norms, thus reducing the presence or significance of idiosyncratic features, involves complex dynamics that practitioners of complexity theory are perhaps better equipped to explain than linguists can. It is not clear that nonhuman primates do not do this too, as social convergence is a fundamental feature of social interactions. Aside from the fact that there is not much to accommodate in communicative practices that are innate (rather than learned), the difference must lie first in the extent of complexity that follows both from the extent of systemic complexity in human languages, starting with idiolectal systems. It also lies the larger sizes of communities of practice among humans, more broadly, in the sizes of language communities, in which individuals are likely to interact with more other members, depending on the extent of mobility and population structure. Modeling may help better understand the dynamics involved in the emergence of communal norms.

3.2 How Did Complexity Emerge Phylogenetically in Language?

According to the current scholarship in paleontology, hominins did not acquire the requisite anatomical structure for speech until late Homo erectus or early Homo sapiens (500,000 – 200,000 years ago). Modern language itself did not apparently emerge until modern Homo sapiens about 50,000 years ago (Corballis 2010, 2011; Lieberman 2010), around the time of the dispersal out of Africa. The period coincides with the appearance of rupestrian paintings, which suggests that modern Homo sapiens had developed the mental capacity to represent (complex) concepts, which is part of what is involved in syntax, which allows the composition of (more) complex concepts from those associated with individual words. This capacity involves not only combining denoting terms together but also showing the respective roles of the different participants in situations or events described or queried about in utterances, as indeed in pictorial representations.

The emergence of syntax this late in the human phylogeny means that even if Homo erectus had had a buccopharyngeal structure similar to that of modern humans, they could not have done much without a mind capable of co-opting and domesticating this particular structure for complex communication. They may have developed a (limited?) phonetic inventory which enabled them to name entities and events vocally but were apparently not able to take the next step of combining them into more complex utterances. This accomplishment means what Hockett (1959) identified as “displacement,” the ability to talk not only about the *hic et nunc* of the interaction but also to reminisce about the past and to plan the future together. Such discourse entailed situating events and states in time, expressing one’s attitude toward what is depicted verbally, and specifying reference, viz., indicating the number or quantity of participants in the different thematic roles, showing whether they have been previously identified, are assumed known already, or are being introduced for the first time, etc. These semantic specifications entailed being able to modify nouns and verbs morphosyntactically with other materials. It appears that there must have been an explosion of strategies, about 50,000 years ago, for expressing complex thought, with of course quite a bit of variation from one culture to another. After all, our hominin ancestors did not all live in one village in East Africa, and their fossils have been found in places quite distant and isolated from each other.

Whether the explosion meant sudden, non-gradual evolution is an open question. However, it is hard to imagine that any aspect of the above manifold evolution would have started without the basic idea of predicating about particular individuals, about other entities, and, later, about states of affairs.[14] As the mind of modern Homo sapiens made him increasingly capable of domesticating his physical ecology and it became more and more necessary for members of communities to be better organized and cooperate toward common goals, pressure also mounted to develop richer, more sophisticated, and more explicit communication systems. It was no longer enough for the communicator to name individuals, entities, and perhaps situations and to have the addressee guess what was intended. Communicators had to express the contents of their thoughts and the nature of their sensations and feelings as explicitly as they could. While hominins had always been able to express their emotions nonverbally (a property we continue to share with other animals), they now also had to share their thoughts or what they wanted their kin or associates to do and how. This included commenting about individuals and entities around them. Therefore speech had to evolve from mere ability to name individuals, entities, and states of affairs to predicating about them.

Although child language and incipient pidgins have made it obvious that elementary verbal communication can take place by just combining undelimited nouns and verbs or other predicative items into sentences (with a minimal set of function words), we also know that no full-fledged human language has remained stuck at that level. Every language has developed strategies for situating in time the states affairs being reported or queried about, although the specific morphosyntactic strategies used and the distinctions made within this domain of grammar vary from one population/culture to another. Likewise, every language has developed strategies for specifying reference and quantifying, although the specific morphosyntactic strategies used are not identical, just like the relevant distinctions within this domain, which vary crosslinguistically. These are important aspects of linguistic communication that had to evolve as a consequence of the ability to predicate. Some populations have also found it necessary to be explicit about thematic functions with such devices as case markers or postpositions. The emergence of all such strategies in linguistic communication already increased bit and structural complexities.[15]

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[14] Predicating about states or events entails embedding a clause within another. This strategy was enabled by by recursiveness, which, according to Lieberman (2006, 2010) is a general cognitive property not specific to language.

[15] I still maintain that ontogeny does not recapitulate phylogeny, largely because the human infant and child are already endowed with modern Homo sapiens' mind, though this still needs to mature to adult stage before it can command all the strategies available in the language of their social environment. However, I submit that the order in which the child "acquires" these linguistic strategies is suggestive of that in which they and their typological variants developed phylogenetically in language. Those emerging the earliest in child language are phylogenetically the most deeply entrenched and resilient, the ones most likely to survive the reductions observed in motherese. Some of them are those that correspond to cognitive priorities in hominin communication, the kinds of strategies that our species would have found essential to explicit communication, though the modern child only has to learn them.

It must not have been long before the relevant hominins found it necessary to modify and delimit nouns and verbs or predicate phrases. It is more informative to be able to discriminate otherwise similar individuals, entities, and events/states of affairs from each other and, more fundamentally, to specify how nouns used in an utterance single out individuals, entities, or states of affairs in the universe of reference, and also to situate the activities or states being described or queried about in time. It was thus necessary to introduce the relevant grammatical strategies, which also vary typologically, according to whether they are affixes or free morphemes and whether they precede or follow the noun or the verb. The morphosyntax of adjectives and adverbs also varies crosslinguistically, as does the modification of nouns with clauses, for instance whether or not they precede the head of the phrase and whether or not there is a dedicated connector between the head and the modifier.

This evolution to more structural complexity was in the interest of systemic economy and productivity, making it unnecessary to invent new terms and phrases for any individual, entity, or state of affairs that is slightly different from another to which it is fundamentally similar. It may have called for more interpretive rules, as a matter of fact, which produces computational complexity. Pidgins such as Tok Pisin do not lose in interactional complexity by making maximal use of modification to keep a great deal of their vocabulary transparent, such as by using the cognate of the English word *grass* not only literally but also for what grows on the human scalp, body, and chin, as well on animal body and for birds' feathers and then showing the semantic differences by modification. The online dictionary of Tok Pisin (October 2011) lists the following oppositions among others: *gras* 'grass' or 'fur', *gras bilong ai* 'eyebrow, eyelash', *gras bilong pisin* 'feather' (*pisin* [< *pigeon*] 'bird'), *gras bilong sipsip* 'wool' (*sipsip* 'sheep'), *gras nogut* 'weed(s)', *maus gras* 'beard', and *gras bilong het* 'hair'.

It is very likely that systemic complexity evolved in language to meet the kinds of semantic distinctions that communicators wanted to make during their interactions. Grammatical morphemes, which have been the focus of "theories of grammaticization" over the past few decades, evolved to further satisfy the need for explicit communication, making clear which specific roles are assumed by the individuals and/or entities being talked about and what constituent modifies what (for instance, in a combination of nouns), and even what clause functions as a complement or modifier of something else. Overall, grammar in any language increased in complexity in response to pressures to package more explicit pieces of information in utterances. The strategies used to achieve this increased the computational aspect of language, while reducing the burden on the capacity to memorize more different signs.

The alternative of modification would have been to invent a new noun or verb for every new nominal or verbal concept that is somewhat different from another to which it is related or similar. The consequence would have been an increase in bit complexity and a greater demand on memory. Human populations have generally opted for a few rules/principles that rely on the speaker's/hearer's capacity to compute the new meaning working with a smaller inventory of symbols with less specific meanings. To be sure, languages probably vary on a continuum regarding the seemingly complementary distribution between bit and systemic complexities; but this is speculation on which future research can rule. Languages such as Tok Pisin seem to instantiate the culmination of the modification strategy, working with a limited basic vocabulary and exploiting compositionality to the max in order to produce apparently more specific concepts or express richer meaning chunks.

If child language development gives us any reliable hint about the phylogenetic emergence of language, it appears that structural complexity emerged incrementally, starting with basic predication. Whether the evolutionary trajectory followed the order suggested here or that discussed by Heine & Kuteva (2007) and largely supported by Givón (2009) is another issue.[16] What is certain is that none of all this systemic complexity could have happened outside a social mode of existence that exerted pressure for humans to socialize and cooperate toward joint goals (Tomasello et al. 2005, Tomasello & Call 2007, Corballis 2011) and to be more explicit in the information exchanges, notwithstanding the emergence of a mind that made such social life possible in the first place. The same mind was thus also capable of developing the right strategies for meeting the social demands for sometimes quite detailed communication. Much of all this phylogenetic evolution appears to have occurred over the past 200,000 years or so (maybe just 100,000 years), during the transition from Homo erectus to modern Homo sapiens. Based on Lieberman (2010) and Corballis (2010, 2011), the greatest part of it started with the ability to predicate, no sooner than 50,000 years ago.

I'd like to emphasize that it is only for reasons of expository clarity that this discussion has been oversimplified and developed as if languages were organs, allowing no internal variation within their structures, i.e., as if all idiolects that they are extrapolated from (Mufwene 2001) were identical. As has been made quite obvious by the variationist sociolinguistics literature (well summed up by Labov 2001, 2004), even idiolects display internal variability, which is governed by structural and/or sociological principles, depending on the case.

An important reason for this state of affairs is that the development of an idiolect instantiates what is known in biology as polyploidy, as the learner receives inputs from different sources and the variants thus absorbed usually wind up coexisting, some in a latent state, with each other. The learner ranks them, according to which is dominant in the population, which is more transparent, which is more

[16] These are the evolutionary stages proposed by Heine & Kuteva (2007: 310): 1) One-word utterances; 2) Mono-clausal propositions; 3) Head-dependent structures; 4) Elaboration of phrase structures; 5) Temporal and spatial displacement, the beginning of clause subordination; 6) Obligatory expressions, elaboration of clause subordination. Givón (2009: 10) proposes: a) Words before clauses, b) One-word clauses before multi-word clauses, c) Single-clause discourse before multi-clause discourse, d) Chained clauses before subordinate/embedded clauses, e) Nominal objects before clausal complements, f) Single-word restrictive modifiers before clause-size modifiers, g) Pre-grammatical (pidgin) communication before grammar, h) Manipulative speech-acts before declaratives and interrogatives, i) Deontic modality before epistemic modality, j) Non-displaced spatio-temporal reference before displaced reference.

regular, etc. in their community of practice. He/She selects the variant that will prevail in his/her system. The fact that speakers develop idiolects that are different from each other produces and sustains natural variation in the community of practice, as their communal language is truly nothing but a set-theory union of idiolects that are similar on the family resemblance model. Although speakers understand each other most of the time, there are nonetheless cases when communication between two individuals fails for no other reason but the variation between their idiolects.

Independent of polyploidy and from a phylogenetic or historical perspective, it is noteworthy that, as noted above, speakers are physiologically and mentally not identical, which entails that they do not perceive and reproduce identically the signs and structures which they learn by inference. This state of unfaithful replication (Lass 1997), which is heightened by the noise factor, generates or sustains variation. It is evident that innovations are not copied and propagated faithfully, which makes allowance for more variation to be generated. I speak of "more variation" because the innovations themselves are not necessarily identical from one innovator to another. Two or more individuals expressing the same new idea in different speech events and communicative settings may not exapt exactly the same current materials; thus, they may produce alternative expressions or structures for the same thing (Mufwene 2001, 2008). As these alternatives become available to other speakers with similar communicative needs, competition arises: one of them is preferred by a particular copier because it is easier to pronounce, or because it is more consistent with other expressions that he/she is already familiar with, or because its meaning is transparent, or because it is more impressive/fashionable, etc.

It is noteworthy that the copiers may not converge in their preferences, though eventually some convergence will arise in a community of practice, which still leaves room for variation within the overall language community. A variety of regional and sociological factors (age, gender, ethnicity, profession, etc.) may also influence the selection, so that patterned variation may arise within the population, though there are often also cases where just one alternative is dispreferred. These outcomes arise from multiple, temporally overlapping dyadic or triadic interactions in which speakers learn from and accommodate each other. In the language of Complexity Theory, the outcomes are "emergent patterns" produced by self-organization, though this term belies the complexity of the interactional histories that produce both distinct idiolects and communal norms.

So, from the point of view of variation, language communities or communities of practice constitute feature pools in which the variants are subjected to competition and selection through the accommodations speakers make to each other as they seek to establish common norms in the production of units and structures (Mufwene 2001, 2008). Because interactions usually take place in usually changing dyads or triads, the tacit negotiations that speakers are engaged in produce socio-interactional complexity.

4 Conclusions

Languages display more than one form of complexity. Bit complexity, consisting of units and rules that populate a(n emergent) system, is only one of them. It is evolutionary interesting in that, in the first place, it shows the extent to which human languages exhibit richer inventories of signs and principles (rules and constraints) than animal means of communication. It is also typologically interesting, as it shows how different languages have managed to serve their communicative needs adequately with smaller or larger inventories of sounds, with smaller or larger vocabularies (ignoring Tok-Pisin modification style), and with sets of combinatorial principles that are not identical. Traditional cross-linguistic comparisons, which have typically been partial, cannot show whether a language is phylogenetically more, or less, evolved or complex than another. It is not evident either that a comprehensive comparative study can be undertaken that covers all the communicative needs that the language may be adapted to.

To date, all languages reflect their capacity to satisfy the communicative needs of those who shaped and use them. It is undeniable that child language and incipient pidgins display some simplicity compared to adult and full-fledged languages, but they are transitional stages whose simplicity reflects the kinds of communication they are used for. Nonetheless, they exhibit more complexity than animal means of communication. They are also true to their characterization as complex adaptive systems (Mufwene 2001, Cornish *et al.* 2009, Beckner et al. 2009), because they can adapt to new communicative needs by increasing their vocabularies and innovating new structures by exaptations of current ones (Heine & Kuteva 2007). Typologically, they are not interesting, because they represent transitions to full-fledged vernaculars. They are more interesting from a phylogenetic perspective, because they give us hints about the gradual evolution of language in mankind, having started with less rich communication and less elaborate systems. Just from the point of view of vocabulary, we can assume that, evolutionarily, the systems became more crowded as the speakers' cognitive capacity increased and it became more and more necessary to discriminate among denotata with different labels. This progression is likely to have been gradual, because the evolution of the hominin line has been gradual and the communicative needs to satisfy were not equally important quantitatively at the different stages.

Another form of complexity is interactional, which emerged from the modular architecture of languages. It arose both from the coexistence relations between the different units and rules, as they determine their respective spaces or functions, and from the interfacing of the modules as they operate concurrently during the production and processing of utterances. It can be characterized as dynamical or systemic complexity. It is the kind that makes human languages significantly different from animal means of communication, even at their rudimentary stages such as child language and incipient pidgins. It reflects more of the evolutionary stage of the minds that produced human languages.

These aspects of complexity can mostly be surmised and modeled now; we still lack the necessary theoretical tools to describe the patterns of the interactions that generate them.[17] As illustrated with the Tok Pisin example, with regard to populating the lexicon, a community of speakers may opt for an opaque system where different symbols that may be unrelated morphologically are used to designate items that are conceptually related. Another population may alternatively choose to be very transparent and exploit either morphology or compositionality, combining basic lexical items with each other or other morphemes into composite words or phrases that express the same concepts. It is hard to determine whether combinatorial strategy, which entails more computing at the conceptual level, is less complex than a system that opts for distinct lexical items that are morphologically opaque or less transparent.

How this system complexity emerged phylogenetically is another story, which must explain how hominins evolved from having no phonetic language to having one with modern structures. It is unlikely that phylogenetically it all evolved wholesale and "overnight." As explained above, syntax must have started with simple predication. Then pressure arose to specify reference and situate the states of affairs being described in time. After that, anything could have been added to further complexify the emergent systems by way of modifying nouns (with adjectives, other nouns, or clauses) and verbs (with adverbs or adverbials). The question is whether we may conjecture that recursion and adpositions emerged concurrently. Or could adpositions have emerged separately, as an alternatives to case marking, to specify semantic-syntactic roles, e.g., AGENT/SUBJECT, PATIENT/OBJECT, BENEFICIARY/DATIVE, POSSESSOR, LOCATIVE, and ADJUNCTS? Their emergence earlier may have paved the way for modifying a noun with another noun (thus making it possible to distinguish the modifier from the head noun) or with a clause. However, could the latter strategy have happened without the prior emergence of clause embedding, which enabled the subordinate clause to function as the object of the higher/main clause? Unlike Givón (2009), it is not evident to me that predicate serialization is not just an alternative to subordination (Mufwene 1990).

I have succeeded more in showing how structural complexity emerged than in proving the specific order in which it did, except perhaps in showing how the emergence of some strategies must have presupposed that of others, in ways not fully consistent with what Heine & Kuteva (2007) and Givón (2009) suggest but not completely different either. Though Heine & Kuteva show that grammaticization undoubtedly played an important role in the emergence of structural complexity, a notion that I am having a hard time articulating clearly as different from both systemic and bit complexities, they do not show convincingly that the order they suggest is fully plausible, largely because they do not articulate structural interdependences between these grammatical strategies.

Be that as it may, we cannot overlook the other form of complexity that arises from the communal aspect of language. Languages as discussed in historical, genetic, and evolutionary linguistics are collective productions, with various

[17] Note that invocations of self-organization by complexity theorists to account for emergent patterns just shift the focus to the outcome, providing no explanation about the workings of the mechanisms that generate them.

speakers contributing their innovations on different occasions to their communities' feature pools and other speakers selecting among competing variants and thereby spreading their preferences. As explained above, these selections are not so simple processes; they involve numerous multilateral tacit negotiations that produce communal norms. Such considerations have led to the conclusion that languages are complex adaptive systems (Mufwene 2001, Beckner *et al*. 2009, Cornish *et al*. 2009, Lee *et al*, 2009), raising the issue of what the agents producing the complexity are: materials within the systems themselves, speakers, or both. Modeling and complexity theory give us some hope here, especially as they are combined in Steels (2011). A time may come soon when we can articulate these complex dynamics explicitly, but so far the relevant scholars working with "language games" have been using oversimplified abstract systems that are far from approximating real linguistic systems.

In any case, it is evident that linguistic complexity is manifold. One must clarify which particular fold they focus on and for what purpose. This is one particular reason some of us have been reluctant to accept that some languages, especially creoles and pidgins, are, according to McWhorter (2001), the world's simplest languages. DeGraff (2001, 2009) has made a convincing case about creoles, which in fact applies also to expanded pidgins. Incipient pidgins are transitional phases in the history of a language, just like child language is a phase in the development of a native speaker's competence. Both reflect the kinds of interactions in which the variety is used, meeting the communicative needs of its users fairly adequately. Their systems expand as the communicative needs also increase in complexity and variety.

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