Language Acquisition, Change and Emergence: Essays in Evolutionary Linguistics

Edited by
James W. Minett
William S-Y. Wang

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Introduction: Essays in Evolutionary Linguistics

James W. Minett
Chinese University of Hong Kong

The human language faculty has evolved at multiple levels: from changes in the cognitive processes by which language is acquired in the individual, to language change by diffusion of acquired linguistic features across populations of individuals, to the emergence of linguistic features over phylogenetic time scales. Evolution of language at each of these levels interacts with that at each other level. Furthermore, the language faculty has developed as a product of the complex interactions among the genetic codes that determine our physical and cognitive capabilities, and the environments — both physical and cultural — within which we live and interact. In order to better understand how human language has come to be the way it is, a holistic approach to studying language evolution is essential. The essays that follow provide a broad coverage of current efforts to better understand how language evolves.

Part I concentrates on the phylogenetic emergence of language. Chow opens this part by reviewing the literature on the discovery and subsequent mapping of the *FOXP2* gene, which has been implicated as having a role in the emergence of the human language faculty. The gene was discovered primarily as a result of studies of the so-called "KE" family, some of whose members have impaired language abilities. The affected individuals were found to have grammar-specific difficulties, particularly with suffixation. For

some, this has been considered evidence that *FOXP2* provides a genetic basis for grammar. However, the affected individuals were also found to have other deficits, such as poor motor control of the musculature of the vocal tract and impaired speech production and perception, suggesting that the gene supports a broader inventory of functions than just grammar.

Chow goes on to explain that the human *FOXP2* gene has undergone strong positive selection since the human lineage split from that of the other primates. In that time, the human *FOXP2* amino acid has undergone two mutations, becoming fixed sometime in the last 120,00 years, whereas the corresponding amino acids of other primates have undergone no change (except in the case of orangutans). What drove the evolution and fixing of this gene? Chow suggests that the driving force might have been language. The time depth of the fixing of *FOXP2* coincides quite well with both the estimated time depth of between 154,000 and 160,000 years for the earliest known remains of anatomically modern humans, found at Herto, Ethiopia in 1997, and the appearance of novel human behaviors, such as art and long-distance trade, some 50,000 years ago.

One should be careful, however, not to infer that language necessarily emerged anew at that time. As Chow notes, only a few cases of language impairment have been accounted for by mutation of *FOXP2*. The emergence of language has probably been influenced over an extended period of time by numerous genetic factors, *FOXP2* simply being the first such gene identified. The search is on for further genes that impact upon language function and proficiency. The mapping of these genes, the estimation of the time depth of their fixing, and the identification of their interactions with other genes are essential next steps in the study of the genetic basis for language.

Schoenemann discusses the origin of grammar in human language. He begins by explaining that evolution tends to favor small, incremental changes to pre-existing functions, rather than the creation of novel, domain-specific functions, which would most often lead to a decrease in fitness of an organism and so be selected

against. He proposes that speech production and perception, semantics and syntax each evolved continuously in this way. Pointing also to the lack of clinical syndromes that affect only language, Schoenemann argues that grammar is not hard-wired into a language-specific cognitive module, but rather evolved as a result of incremental changes to pre-existing cognitive mechanisms that allowed for progressively complex conceptualization. He notes that the syntactic universals that exist in modern languages are just emergent properties of underlying semantics constraints, rather than encoded within a built-in Universal Grammar. For instance, the distinction of nouns from verbs is considered to follow directly from our general ability to conceptualize objects as distinct from actions.

Schoenemann then relates the growth of cranial capacity — an indicator of brain size — in the hominid lineage to an increasing capability for complex conceptualization. He argues that the increasing capabilities of hominids in cognizing their environment led to the emergence of increasingly complex language. In other words, Schoenemann holds that semantics drove the emergence of syntax. Reporting his own previous work with computer simulations using populations of interacting artificial neural networks, Schoenemann has found that populations comprising larger networks evolve more complicated languages faster and with less error than those comprising smaller networks. This result demonstrates that an increase in the size of a neural net does lead to an increase in the ability to process information, and further supports his hypothesis that language emerged through a process of evolutionary continuity.

Like Schoenemann, MacWhinney believes that language emerged as a result of a series of gradual evolutionary adaptations. However, he goes further to suggest that grammar arose to support switching between different perspectives. He reviews a broad range of the literature on perspective taking, in terms of both cognitive processes and grammar, to argue that perspective taking underlies language structure and much of higher-level cognition. After highlighting the frames of reference (egocentric, allocentric, geocentric and temporal) by which individuals cognize their

environments, MacWhinney explains how various linguistic constructions are influenced by the underlying perspective. For example, he presents a perspective shifting account for constraints on the co-reference of pronouns that complement and, in some cases, obviate the need for the more complex hypothesized innate principles of theories such as Government and Binding. He also offers an explanation for the relative ease with which restrictive relative clauses of different types are comprehended in terms of the number of perspective shifts that must be undertaken: for example, in English, which has SVO word order, subject-subject relative clauses, which require no shift in perspective, are generally easier to comprehend than subject-object relative clauses, which require two shifts in perspective.

MacWhinney outlines a set of tasks that should be undertaken in future research to understand better the role of perspective as a force shaping cognition and language processing. If its role can be well established, this would be an example of a simple cognitive factor leading to complex emergent structure in the surface form of language.

In the next chapter, Coupé and Hombert discuss arguments for and against the polygenesis of language and linguistic diversity. Rather than consider whether the human language faculty as a whole emerged at a single site or at multiple sites, they consider the relative likelihood of monogenetic and polygenetic emergence of distinct linguistic strategies akin to Hockett's 'design features'. They follow the approach adopted in a model by Freedman and Wang of using probabilistic arguments to investigate the likelihood of polygenetic emergence under various conditions, modeling a wide range of plausible demographic states of pre-historic hominid groups. However, they go beyond Freedman and Wang's work by using simulation techniques to model the cultural transmission of linguistic strategies as a result of contact between groups.

The authors consider the role of a number of parameters, including population density, the rate at which groups traverse a designated hunting zone, and the threshold distance that should separate two groups before they can come into contact with each

other. They observe strong relationships between the time taken for a strategy to diffuse across a population and both the threshold distance for contact and population density, as intuition would lead us to expect. For plausible estimates of the population density of hominid groups and other relevant parameters, the authors infer that the probability of complete diffusion of a strategy across a population, and so of monogenesis, is typically significantly lower than the probability of polygenesis. However, they do not rule out the possibility that some key strategies emerged monogenetically which were then transmitted culturally from group to group across the entire hominid population.

Part II treats language acquisition, with three papers describing approaches for modeling aspects of the acquisition process. In each essay, learning is seen to be achieved by distinguishing and encoding patterns of regularity. Christiansen, Conway and Curtin describe a connectionist model to suggest how children acquire language, in part, by integrating the information provided by multiple probabilistic cues present in caregiver speech. Their view is that not all linguistic structures can be acquired based on evidence from a single source; some structures require that evidence from multiple sources be integrated in order that acquisition take place. Even when certain cues have low validity, the use of multiple cues in combination can act to increase the robustness of the acquisition process.

The authors focus on word segmentation, a necessary skill that a child must acquire in order to build up a compositional understanding of spoken utterances. They argue that word boundaries are discovered by the child from probabilistic sub-lexical cues of three types: phonology, lexical stress and utterance boundary information. They present simulation results, training simple recurrent networks to segment utterances from the CHILDES corpus of child-directed speech, to demonstrate how multiple-cue integration in a connectionist network can perform robust speech segmentation. The comparison of their simulation results with empirical evidence for the word segmentation performance of both infants and adults supports their claim that humans do indeed

follow a probabilistic learning mechanism to integrate cues from multiple sources to learn to segment words.

Christiansen et al. go on to reiterate their main thesis that multiple-cue integration facilitates language acquisition in general, and briefly review evidence supporting the existence of salient probabilistic cues for the learning of word meaning, grammatical class and syntactic structure.

Next, Kit examines the extent to which an unsupervised learning procedure can learn to perform word segmentation, adopting an alternative statistical learning procedure based on compression. This approach draws heavily upon concepts of complexity, a brief introduction to which is given by Gell-Mann in Part IV. In Kit's model, regularities that are detected in the speech data allow the data to be compressed — the more the speech data is compressed, he argues, the closer this reflects the mechanism by which the speech data was produced. Kit therefore assumes that the language learner seeks the representation for the input speech data that compresses the data the most. The learner is assumed to have no prior knowledge of the morphotactic constraints of the target language. Invoking the principle of least cost, measuring cost in terms of the number of bits required to represent the compressed data, he shows that an unsupervised learning procedure can perform accurate word segmentation on a corpus of child-directed speech, derived from the CHILDES corpus. In doing so, Kit's work suggests that prior knowledge encoded within a built-in language acquisition device is not required in order for a child to learn to segment words from fluent speech.

Yang then looks at a different issue in the acquisition of language: the acquisition of irregular morphology. He derives a rule-based model to explain the widespread existence of irregularity in the lexicon, focusing on irregularity in verbs in the past tense of English: for example *hold-held*, which a child might say as *hold-holded*. He argues against Pinker's Words and Rule (WR) model, in which the past tense of all regular verbs is derived by applying the single rule 'add -d', whereas the past tense of each irregular verb is stored as an associated stem-past pair. Instead, he

favors a Rule over Words (RW) model, in which irregularities are encoded by over-riding default rules by more specific exception rules that operate on verbs classes, e.g. *throw-threw*, *know-knew*. In particular, Yang points out that if Pinker's WR model were correct, irregular verbs heard more frequently than others would be remembered and used correctly more often — he illustrates by example that this is not the case. In the RW framework, although specific verbs belonging to a particular class might be rare, instances of verbs belonging to that class might be sufficiently frequent for the class to be learned — Yang calls this the Free-rider Effect. Irregular verbs are recovered by applying the most specific rule when multiple competing rules are present, a principle he refers to as the Elsewhere Condition. This framework resembles the default hierarchy of a classifier system, discussed by Holland in Part IV.

Yang presents a detailed procedure for the induction of phonological rules. In his model, a word is represented as a sequence of phonemes that are themselves represented distinctly in terms of a set of articulatory features. The rules encode context-specific phonological changes that are applied to verb stems in order to generate the corresponding past tense forms. For example, a default rule might specify that the past tense is formed by adding '-d' to the stem, while an exception rule might specify that verbs ending '-ɪŋ' form the past tense by changing 'ɪ' to 'æ', such as *sing-sang*. Rules are induced as a result of observing recurrent patterns among the articulatory features of strings of phonemes heard during acquisition. Rule competition gives rise to the empirical phenomena of analogical leveling and extension. By applying the model over successive generations of language learners, Yang is able to show how evolution of the stem-past system is influenced by such a rule-based learning procedure, inferring that irregularity is all but inevitable.

The three essays in Part III deal with language change. Van Driem begins by summarizing the Leiden theory of language evolution which holds language to be a symbiotic organism. In this account, language change is driven by the self-replicating components of language: *memes*. He goes against Dawkins's

account of the meme as a unit of cultural transmission or imitation, which van Driem calls a *mime*, reserving the term *meme* for a unit of linguistic meaning, whether lexical or grammatical. He goes on to discuss the nature of linguistic meaning, explaining that meanings do not behave according to the principles of conventional logic but as non-constructible sets. In his view, meanings evolve as a result of the applications to which they are put, constrained by the underlying structure of the neural circuitry of the brain. Van Driem also briefly summarizes the Leiden view of the emergence of syntax from meaning by splitting of holistic utterances. His views on the emergence of language coincide, in part, with those of Schoenemann: particularly that the emergence of syntax was driven by semantics.

Ruhlen discusses language change from the perspective of historical linguistics, his aim being to clarify the different goals and methodologies of three distinct disciplines — taxonomy, typology and historical linguistics — which he argues have come to be confused by linguists during the last century. He begins by distinguishing taxonomy from historical linguistics, specifically reconstruction. He defines linguistic taxonomy as the identification of the hierarchical structure of languages and their families. This, he writes, should precede historical linguistics, which comprises tasks such as reconstruction of the proto-language, the identification of sound correspondences, and the like. He stresses that reconstruction is the task of inferring the proto-language of a family that has *already* been identified by taxonomy. Ruhlen equates taxonomy with classification and, controversially, multilateral comparison. While he admits that the existence of language families such as Indo-European, Algonquian and Austronesian can be verified rigorously by establishing regular sound correspondences among sibling languages, he maintains that these families were first recognized by linguists who observed the grammatical and lexical morphemes that characterize each essentially by the method of multilateral comparison that both he and Greenberg have advocated. Ruhlen suggests that the recent failure to distinguish these disciplines has led to a stagnation in the discovery of new

genetic relationships among languages and language families.

Ruhlen then turns to the issue of using word lists to identify genetic relationship. He discusses in particular the pattern *tVnV*, having meanings such as 'child', 'son' or 'daughter', which he finds to be widespread among the Amerind languages of the Americas. Accepting that systematic sound correspondences for these putative cognates might be hard to come by, he maintains that the most parsimonious explanation for the pattern is genetic affiliation.

Ruhlen distinguishes typological classification and genetic classification: the former, he comments, is based on "historically-independent structural traits" and should have no place in the identification of genetic relationships, while the latter is based on "historically-related genetic traits". He also discusses in some detail the controversy regarding the use of 2nd and 3rd person pronouns alone to detect genetic relationship, focusing on the Eurasian M/T pattern and the Amerind N/M pattern.

Cucker, Smale and Zhou close Part III with a presentation of a formal mathematical model for language evolution. For a population of speakers sharing a common language, the idiolect of each speaker is treated as a matrix whose elements indicate the probability of association between a particular meaning and a particular signal. They further define a *communication matrix* that models the influence of each speaker on the acquisition of language by other speakers. Speakers are assumed to interact iteratively by exchanging meaning-signal pairs with each other and updating their languages so as to improve the probability of successful communication.

Their main result is to prove formally that a common language will emerge within a finite number of iterations with non-zero probability provided that speakers exchange sufficiently many meaning–signal pairs and that the communication matrix exhibits the mathematical property of *weak irreducibility*. They also prove that once a common language has emerged, a population will continue to maintain a common language — although language change might temporarily introduce a degree of heterogeneity among the idiolects of a population of agents, a globally

homogeneous language will eventually re-emerge. The authors also show how the model can be applied to the modeling of both language emergence and acquisition. Studying the behavior of this model as the number of exchanges between speaker and learner are reduced, so introducing a learning bottleneck, would be a useful next step that might allow new insights into language acquisition and change to be obtained.

The final part of the book is concerned with the complexity of language. Gell-Mann opens this part with a discussion of the fundamental concepts of complexity, both in theory and as they pertain to language. He begins by summarizing several notions of complexity from a theoretical perspective. He then discusses *arrows of time*, or unidirectional processes, by which is meant the tendency of complex systems to evolve in certain directions or manners. In particular, Gell-Mann considers whether there are arrows of time in human language that might allow some of the features of a hypothesized universally shared ancestral language to be deduced. After reviewing the proposed language families of the world, including a discussion of the super-families that have been hypothesized by "lumpers" such as Greenberg and Ruhlen (see the chapter by Ruhlen in Part III for a discussion of evidence supporting the existence of the Amerind language family), Gell-Mann discusses the possibility that word order is just such a feature, believing the word order of early human language to be SOV, the most prevalent word order of extant languages.

Gell-Mann then considers the relative complexity and simplicity of extant languages in terms of their typological features. For example, he questions whether there might be a general tendency towards reduced phonological complexity: reduction in the size of the phonological inventory, delaryngealization, and the loss of clicks, for example. On the other hand, he notes, processes such as palatalization give rise to increased complexity. With a number of unidirectional changes already known, for example the sound change /p/ to /f/ to /h/ to nothing, Gell-Mann suggests that there might be many more such unidirectional processes that are less obvious. Finding such arrows of time and determining the relative

rates of simplification and complexification may tell us a great deal about how modern language first arose, whether by monogenesis or by polygenesis, and how language subsequently evolved. Computational models, such as that proposed by Coupé and Hombert in Part I, may help us to better assess how the numerous processes of simplification and complexification fit together into a coherent whole.

Holland then describes an agent-based model for investigating the acquisition of language by individuals possessing domain-general cognitive mechanisms but no language-specific learning strategies. Holland makes use of the *classifier system*, a rule-based learning framework that he himself developed for investigating complex adaptive systems in general.

After giving a conceptual introduction to complex adaptive systems, Holland describes a classifier system that he proposes be used to model processes of social interaction and language acquisition by individuals in a community. In the model, agents representing the language users move about a shared two-dimensional environment in which are distributed the resources, such as food and shelter, that enable the agents to "survive". The agents interact with this environment and each other by transmitting, receiving and acting upon messages. The messages comprise the sensory information received from the environment, the internal "cognition" of the agent, and the commands output to effectors by which agents interact with the environment. The survival of an agent is determined by its ability to acquire resources through appropriate action sequences.

The agents are initialized with very general, default rules that provide general functionality, such as movement and resting, but which sometimes lead to inappropriate action. When a default rule has a tendency not to fulfill an agent's designated needs and goals, an exception to it may occasionally be triggered. The resulting pair of rules, in which the initial, default rules are sometimes over-ridden by novel, exception rules, gives rise to behavior that is more efficient than either rule alone. As more and more exception rules are generated, forming a *default hierarchy*, increasingly complex

behavior is encoded that allows the agent to behave efficiently over a wider range situations — Yang makes use of much the same concept in his modeling of the memorization of irregular verbs as exceptions to a default rule. In this framework, language is seen as an emergent behavior that results from the association of auditory input and output with fitness-enhancing behavior. As such, language is treated no differently from any other phenomenon — its emergence relies on efficient marshalling of domain-general capabilities. By adopting the classifier system as a framework for simulating language emergence and acquisition, we should be able to better understand how various cultural processes impact upon the robust acquisition of language, and the extent to which domain-general cognitive capabilities can generate artificial languages that incorporate some of the complexities of natural languages.

The next chapter, by Lin and Ahrens, focuses on lexical ambiguity, one aspect of complexity in natural language. The authors seek a definition for word meaning that is psychologically sound. They contrast three methods for defining word meaning: meanings listed in dictionaries, meanings provided by human subjects, and meanings constrained by a linguistic theory. Dictionary meanings are often used because they are easy to obtain. However, differences in the meanings that are presented in different dictionaries makes it difficult for researchers to agree upon a particular set of meanings for a word. Furthermore, dictionary meanings do not keep close track of the productive language usage of current speakers, including obsolete or rarely used meanings and lacking novel meanings. An alternative approach is to use semantic intuition, by sampling the accessible polysemy — the number of different meanings that subjects are able to think of for a word — of many people. This method, however, can fail to reveal some meanings of a word, and obscures the criteria by which word meanings are distinguished. A third approach, advocated here by Lin and Ahrens, makes the criteria explicit by identifying and distinguishing *senses* of meanings from *facets* of meanings. As the authors write, "two meanings are distinct senses, when they involve

different conceptual domains, and when they occur primarily in distinct linguistic contexts." This definition of word sense can be applied to both dictionary meanings and to the semantic intuition of subjects.

Conducting experiments for both Chinese and English, they find significant correlation between the numbers of meanings found by each method. Drawing upon their previous research into the ambiguity advantage, in which they found that words having many linguistics senses were recognized more quickly than words having fewer senses, they conclude that the sense-based definition of word meaning is psychologically sound.

LaPolla discusses the complexification of linguistic systems, arguing that the complexity of a language must be considered in terms of its sub-systems, a view shared by Gell-Mann and Comrie. Complexification of one system may lead, through extension, to simplification of another system. As an example, he cites the Qiang language of Northern Sichuan Province, China, in which a conventionalized set of orientation marking prefixes related to geophysical environment have been extended metaphorically to mark perfectives and imperatives. The increased complexity in the system for orientation marking has brought about increased simplicity for the marking of perfectives and imperatives because no separate set of markers need be developed.

One important issue that LaPolla stresses is "complex for whom?" For example, Chinese orthography may be read from left to right, from right to left, from top to bottom, and even from left to right *and* from right to left — in other words, in just about any direction. Although this causes no added complexity for the writer, the reader's task is made more complicated because there is no standard direction of reading. On the other hand, with a standardized word order, the job of the writer is more complex, but the task of the reader is simplified by the constraint to the inferential process.

While some linguists argue that "languages differ in terms of what you *can* say," LaPolla prefers the position that "languages differ in terms of what you *have* to say." For example, English

requires explicit mention of the subject of a sentence due to grammaticalization of a set of obligatory constraints on referent identification that have come to be associated with 'subject'. Chinese, however, has not conventionalized these same constraints on referent identification, so the identification of the referent is not obligatory. Such conventions force particular interpretations of sentences, constraining what a language must say.

Comrie closes the volume by considering whether creoles tend to be less complex than other languages, as is widely held to be true by linguists. He begins by discussing the difficulty that linguists have encountered in defining exactly what is a creole. Like pidgins, creoles arise as a result of contact between speakers having insufficient exposure to each others' languages to acquire them perfectly. However, creoles are distinguished from pidgins, which are the first language of no one. Historically, for creoles that have formed due to contact between speakers of a European language and one or more non-European language, the European language has typically provided the majority of the lexicon. The creole grammar is typically very different from that of the lexifier language. However, the longer the period of contact between them, the greater the number of complexities of the lexifier language that tend to be found in the creole.

Comrie agrees with LaPolla that it is not meaningful to consider the complexity of a language as a whole; rather, one should consider the complexity of a particular subsystem. Here, Comrie focuses on the complexity of the morphology of creoles. He distinguishes three types of morphological complexity. First, a language may exhibit agglutination, in which multiple affixes are attached to a single root, as in Turkish. Although there is evidence that such complexity poses no problem for first language learners, borrowing of this feature does not occur. Second, a language may exhibit fusional morphology, in which multiple semantic oppositions are fused into a single morpheme. This can be observed in Italian, for example, where no separate suffices to adjectives can be identified that encode number and gender. Such fusional morphology is very rare in creole languages. Third, a language may exhibit morphological irregularity.

For example, German specifies several mechanisms for formation of the plural. Creole languages often lack such inflectional irregularity. Nevertheless, Comrie reminds us that creoles are "sufficiently complex to carry the full range of functions that are required of human language."

Comrie also reviews three particular accounts of the genesis of creole grammars: McWhorter's view that creole grammars emerge as a result of universal principles, with little input from either the lexifier or substrate language; Bickerton's Bioprogram Hypothesis, in which an innately specified, unmarked grammar tends to be acquired in the absence of consistent evidence for any particular marked target grammar; and Lefebvre's analysis of Haitian Creole, which emphasizes the role of relexification.

The essays included in this book represent a mosaic of current research into the evolution of language. The essays by Schoenemann and MacWhinney on language emergence, by Christiansen et al., Kit and Yang on language acquisition, and by Gell-Mann, Holland and Comrie on language complexity, for example, all present arguments for the shaping of language by relatively simple, cognitive processes, such as perspective taking, cue integration and the learning of default hierarchies. Some of these hypotheses make apparently contradictory claims about the underlying processes of language evolution. This is most evident in Part II, where compression-based processing, connectionism and rule-based processing are all invoked to explain features of language acquisition. But this diversity of approaches is a necessary step in expanding our understanding of the processes by which language evolves — without comparing the explanatory power of the various competing hypotheses, how is one to evaluate the extent to which they are each valid? As research into the structure of the brain advances, it is to be hoped that the biophysical correlates of the cognitive capabilities adduced in such hypotheses can be either verified or disproved. A further challenge for a holistic account of language evolution is that the various theories should meld into a consistent whole. Thus, the theories of the phylogenetic emergence of language should reflect established patterns of ontogenetic development (a case of ontogeny

recapitulating phylogeny) and historical change or else be explained in terms of advances in genetic, cognitive and social adaptations in the human lineage.