The Emergence of Language as a

Complex Adaptive System

Author: Nick C. Ellis

1. History: The Mysterious Process

Saussure (1916) characterized the units of language as linguistic signs, the signifiers of linguistic form and their associated signified functions, concepts or meanings. In Saussure's view linguistic signs arise from the dynamic interactions of thought and sound – from patterns of usage: 'what happens is neither a transformation of thought into matter, nor a transformation of sound into ideas. What takes place is a somewhat mysterious process by which "thought-sound" evolves divisions, and a language takes place with its linguistic units in between these two amorphous masses' (p. 110-111). Thus began Structuralist linguistics, the study of language as a relational structure, whose elemental constructions derive their forms and functions from their distributions in texts and discourse. This approach had significant impact upon applied linguistics too. Fries, the founder of the English Language Institute at the University of Michigan, distinguished between lexical and structural meaning, with structural meaning concerning the patterns relating a particular arrangement of form classes to particular structural meanings. In this view, language acquisition is the learning of an inventory of patterns, as arrangements of words, with their associated structural meanings. Fries' (1952) *Structure of English* presented an analysis of these patterns, and Roberts' (1956) *Patterns of English* was a textbook presentation of this system for classroom use. Harris (1955), founder of the first US linguistics department at the University of Pennsylvania, developed rigorous discovery procedures for phonemes and morphemes based on the distributional properties of these units. For Harris, form and information (grammar and semantics) were inseparable. He proposed that each human language is a self-organizing

system in which both the syntactic and semantic properties of a word are established

purely in relation to other words, and that the patterns of a language are learned through

exposure to usage in social participation (Harris 1982, 1991). Structuralism, the dominant

approach in linguistics for the earlier part of the twentieth century, was overtaken in the

1960s in the US by Generative approaches. Harris' student, Chomsky (1965, 1981)

abandoned structure-specific rules and developed the Principles-and-Parameters

approach, the general grammatical rules and principles of an assumed-to-be innate

Universal Grammar. Grammar became top-down and rule-governed, rather than bottom-

up and emergent. It was modularized, encapsulated, and divorced from performance,

lexis, social usage, and the rest of cognition. The analysis of linguistic structures as

functional patterns and their 'somewhat mysterious' emergence from usage was no

longer pursued within generative linguistics.

  Language and cognition, however, are mutually inextricable; they determine each

other. Language has come to represent the world as we know it; it is grounded in our

perceptual experience. Language is used to organize, process, and communicate

information, from one person to another, from one embodied mind to another. Learning

language involves determining linguistic structures from usage and this, like learning

about all other aspects of the world, involves the full scope of cognition: the

remembering of utterances and episodes, the categorization of experience, the

determination of patterns among and between stimuli, the generalization of conceptual

schema and prototypes from exemplars, and the use of cognitive models, metaphors,

analogies, and images in thinking. Language is used to focus the listener's attention to the

world; it can foreground different elements in the theatre of consciousness to potentially

relate many different stories and perspectives about the same scene. What is attended is learned, and so attention affects the acquisition of language itself. The functions of language in discourse determine its usage and learning. Language usage, language change, language acquisition, and language structure are similarly inseparable. There is nothing that so well characterizes human social action as language. Cognition, consciousness, experience, embodiment, brain, self, and human interaction, society, culture, and history are all inextricably intertwined in rich, complex, and dynamic ways.

Despite this complexity and despite its lack of overt government, instead of anarchy and chaos, patterning pervades the complex system of language. The patterns are not pre-ordained by god, by genes, by school curriculum, or by other human policy, but instead they are emergent from the interactions of the agents involved – synchronic patterns of linguistic organization at different scales (phonology, lexis, syntax, semantics, pragmatics, discourse genre, ...), dynamic patterns of usage, diachronic patterns of language change (linguistic cycles of grammaticization, pidginization, creolization, ...), ontogenetic developmental patterns in child language acquisition, global geopolitical patterns of language growth and decline, dominance and loss, need and education, etc.

Various disciplines within cognitive science (including Cognitive Psychology, Child Language Studies, Cognitive Linguistics, Corpus Linguistics, and Connectionism) focus upon their own local patterns of interest to try to understand the processes by which they come about. But above and beyond these particular investigations, other approaches (under banners such as Emergentism, Complex Adaptive Systems, and Dynamic Systems Theory) recognise that there are general principles which characterise the emergence of patterns in complex systems whatever their content or scale. In what follows in this

chapter I will first consider some of the specific disciplines focussing upon the patterning of information and its creation in human mind, brain, culture and society, before I then introduce the study of emergence itself. The chapter concludes with a view of language as a complex adaptive system (CAS).

Local perspectives upon the mysterious process

An overview of the ways in which relevant disciplines are studying the origins of patterns in language can be conveniently organized by first focusing upon Saussure's linguistic sign. However convenient, this does not imply that the structure of language is primary; far from it – we should look to meaning and social communication for that.

Usage-based theories of language acquisition hold that we learn language incidentally while engaging in communication (Barlow and Kemmer 2000; Hopper 1998), the 'interpersonal communicative and cognitive processes that everywhere and always shape language' (Slobin 1997). Within these approaches, the modern parallel to the sign as a basic unit of language representation is the *construction*. Constructions are the fundamental units of language acquisition and reflect the most direct embodiment of learners' communicative intentions. Some of the basic tenets of usage-based approaches to language and its acquisition, many of them explicitly addressed by Saussure (1916), are:

- Language is intrinsically linked to human cognition and processes of perception, attention, learning, categorization, schematization, and memory.

- Language is intrinsically symbolic, constituted by a structured inventory of constructions as conventionalized form-meaning pairings used for communicative purposes.

- Adult language knowledge consists of a continuum of linguistic constructions of different levels of complexity and abstraction. Constructions can comprise concrete and particular items (as in words and idioms), more abstract classes of items (as in word classes and abstract constructions), or complex combinations of concrete and abstract pieces of language (as mixed constructions). Consequently, no rigid separation is postulated to exist between lexis and grammar.

- Constructions may be simultaneously represented and stored in multiple forms, at various levels of abstraction (e.g., concrete item: table+s = tables and [Noun] + (morpheme +s) = plural things).

- Linguistic constructions can thus be meaningful linguistic symbols in their own right, existing independently of particular lexical items. Nevertheless, constructions and the particular lexical tokens that occupy them attract each other, and grammar and lexis are inseparable.

- Language structure emerges ontogenetically from usage in particular contexts. Development is slow and gradual, moving from an initial heavy reliance on concrete items to more abstract linguistic schemata. This process is crucially dependent on the type and token frequencies with which particular constructions appear in the input. Storage of wholes depends on token frequency, the development of abstract linguistic schema depends on type frequency.

Particular approaches to language and cognition within the language sciences, psychology, and cognitive science concentrate upon different facets of patterning. The linguistic approaches analyze the units of language, the psychological approaches their learning and usage:

Functional analyses of language catalogue the inventory of constructions, investigating the ways in which constructions are symbolic, their defining properties of morphological, syntactic, and lexical form being associated with particular semantic, pragmatic, and discourse functions (Croft 2001; Croft and Cruise 2004; Halliday 1994; Taylor 2002).

Corpus Linguistic analyses of large collections of language show how there are recurrent patterns of words, collocations, phrases, and constructions, that syntax and semantics are inextricably linked, and that grammar cannot be described without lexis, nor lexis without grammar (Biber et al. 1998; Biber et al. 1999; Hoey 2005; McEnery and Wilson 1996; Sinclair 1991, 2004).

Construction Grammar and Phraseological analyses of language show that much of communication makes use of fixed expressions memorized as formulaic chunks, that language is rich in collocational and colligational restrictions and semantic prosodies, and that the phrase is the basic level of language representation where form and meaning come together with greatest reliability (Ellis 1996, 2008b; Fillmore 1988; Goldberg 1995, 2003; Granger and Meunier 2008; Pawley and Syder 1983; Sinclair 1991, 2004; Wray 2002).

Child language acquisition researchers gather dense longitudinal corpora in order to chart the emergence of creative linguistic competence in children's analyses of the

utterances in their usage history and their abstraction of regularities within them (Goldberg 2006; Tomasello 1998, 2003).

Psycholinguistic theories of the mental representation of language show that fluent language users are sensitive to the relative probabilities of occurrence of different constructions in the language input and to the contingencies of their mappings to meaning (Ellis 2002a; Gaskell 2007; Gernsbacher 1994).

Psychological analyses of Perception and Attention investigate the ways in which human embodiment and our perceptuo-motor systems govern our representation of the world and the ways that language can guide our attention to these representations (Barsalou 1999, 2008; Mandler 2004; Talmy 1988, 2000a, b).

Associative learning theory analyzes how the learning of stimulus-outcome contingencies is affected by: factors relating to the form such as frequency and salience; factors relating to the interpretation such as significance in the comprehension of the overall utterance, prototypicality, generality, redundancy, and surprise value; factors relating to the contingency of form and function; and factors relating to learner attention, such as automaticity, transfer, overshadowing, and blocking. Selective attention, salience, expectation, and surprise are key elements in the analysis of all learning, animal and human alike (Shanks 1995). These principles pervade language acquisition too (Ellis 2002a, 2003, 2006, 2008c).

Learning theory recognizes three major experiential factors that affect cognition: frequency, recency, and context (e.g., Anderson 2000; Bartlett [1932] 1967; Ebbinghaus 1885). Learning, memory and perception are all affected by frequency of usage: the more times we experience something, the stronger our memory for it, and the more fluently it

is accessed. The more recently we have experienced something, the stronger our memory for it, and the more fluently it is accessed. The more times we experience conjunctions of features, the more they become associated in our minds and the more these subsequently affect perception and categorization; so a stimulus becomes associated to a context and we become more likely to perceive it in that context. The power law of learning (Anderson 1982; Ellis and Schmidt 1998; Newell 1990) describes the relationships between practice and performance in the acquisition of a wide range of cognitive skills – the greater the practice, the greater the performance, although effects of practice are largest at early stages of leaning, thereafter diminishing and eventually reaching asymptote. The power function relating probability of recall (or recall latency) and recency is known as the forgetting curve (Baddeley 1997; Ebbinghaus 1885). These three factors pervade the acquisition, form, access, and processing of constructions (Ellis and Cadierno 2009).

Cognitive theories of categorization and generalization analyze how schematic constructions are inferred inductively by the learner in acquisition (Barsalou 2008; Harnad 1987; Lakoff 1987; Schank and Abelson 1977; Taylor 1998). Prototypes, exemplars which are most typical of a category, are those which are similar to many members of that category and not similar to members of other categories. The operationalization of this criterion predicts human categorization performance -- people more quickly classify as birds sparrows (or other average sized, average colored, average beaked, average featured specimens) than they do birds with less common features or feature combinations like geese or albatrosses (Rosch and Mervis 1975; Rosch et al. 1976). Prototypes are judged faster and more accurately, even if they themselves have

never been seen before -- someone who has never seen a sparrow, yet who has

experienced the rest of birds, will still be fast and accurate in judging it to be a bird

(Posner and Keele 1970). Such effects make it very clear that although people don't go

around consciously counting features, they nevertheless have very accurate knowledge of

the underlying frequency distributions and their central tendencies. The prototype

emerges from the conspiracy of memorized exemplars (Rogers and McClelland 2008).

Connectionist, *Competition Model*, and *Rational* analyses of language demonstrate

the ways in which generalizations emerge from the conspiracy of memorized instances,

the ways in which different cues and their cue reliabilities compete for activation, and the

ways in which these representations provide the best model of language that is available

from the learner's sample of experience, one that is optimized in its organization for

usage (Anderson 1989; Anderson and Schooler 2000; Bates and MacWhinney 1987;

Chater and Manning 2006; Christiansen and Chater 2001; Ellis 2006; Elman et al. 1996;

MacWhinney 1987, 1997)

Probabilistic and frequency-based theories of language analyze how frequency and

repetition affect and ultimately bring about form in language and how probabilistic

knowledge drives language comprehension and production (Bod et al. 2003; Bybee and

Hopper 2001; Ellis 2002a, b; Jurafsky 2002; Jurafsky and Martin 2000). Distributional

analyses of language also show the importance of Zipf's law at all levels in determining

the structure and network characteristics of linguistic systems and the effects of these

properties on learning (Ferrer i Cancho and Solé 2001).

Sociocultural theory analyses how language learning takes place in a social context,

involving action, reaction, collaborative interaction, intersubjectivity, and mutually

assisted performance, and how individual language learning is an emergent, holistic

property of a dynamic system comprising many dialectic influences, both social,

individual, and contextual, involving the learner in a conscious tension between the

conflicting forces of their current interlanguage productions and the evidence of

feedback, either linguistic, pragmatic, or metalinguistic, that allows socially scaffolded

development (Ellis 2008b; Kramsch 2002; Lantolf and Pavlenko 1995; Lantolf and

Thorne 2006; Vygotsky 1980, 1986). Current child language acquisition research

emphasizes how language learning is 'socially gated' (Kuhl 2007) in the same way that

the Interaction Approach (Gass 1997) to second language acquisition shows how

interaction is not simply language usage, but negotiation, with participants' attention

being focused on resolving a communication problem and thus 'connecting input, internal

learner capacities, particularly selective attention, and output in productive ways' (Long

1996)

 The Scientific Study of Consciousness, its neural correlates, and its involvement in

learning and memory (Baars 1997; Koch 2004) show there are different forms of

language learning, broadly, the implicit tallying and chunking that take place during

usage (Ellis 2002a, b) and explicit learning in the classroom, sometimes a consequence of

communication breakdown (Ellis 1994; 2005, sections 3-4). Implicit learning from usage

occurs largely within modality and involves the priming or chunking of representations or

routines within a module, with abstract schema and constructions emerging from the

conspiracy of memorized instances. It is the means of tuning our zombie agents, the

menagerie of specialized sensori-motor processors that carry out routine operations in the

absence of direct conscious sensation or control. It is largely automatized. It operates in

parallel. In contrast, conscious processing is spread wide over the brain and unifies otherwise disparate areas in a synchronized focus of activity. Conscious activity affords much more scope for focused long-range association and influence than does implicit learning. It brings about a whole new level of potential associations. It operates serially.

Consciousness too is dynamic; it is perhaps the prototype example of an emergent phenomenon: the stream of consciousness is one of every-changing states, each cued by prior state and perceptual context, the units of consciousness being identifiable as patterns of brain synchrony in time. The dynamics of language learning are inextricably linked to the dynamics of consciousness, in neural activity and in the social world as well.

As these diverse research efforts illustrate, language usage involves agents and their processes at many levels, and we need to try to understand language emergence as a function of interactions within and between them. This is a tall order. Hence Saussure's 'mysterious process' and his observations that 'to speak of a "linguistic law" in general is like trying to lay hands on a ghost ... Synchronic laws are general, but not imperative.. [they] are imposed upon speakers by the constraints of common usage... In short, when one speaks of a synchronic law, one is speaking of an arrangement, or a principle of regularity' (pp. 90-91). Nevertheless, 100 years of subsequent work within the disciplines introduced above has put substantial flesh on the bone, as you will see if you follow up on the readings. And more recently, work within Emergentism, CAS , and Dynamic Systems Theory (DST) has started to describe a number of scale-free, domain-general

processes which characterize the emergence of pattern across the physical, natural, and social world. Next, I consider language in this light.

3. Common Mysteries of Emergence

Emergentism and Complexity Theory (Ellis 1998; Ellis and Larsen Freeman 2006a; Elman et al. 1996; Larsen-Freeman 1997; Larsen-Freeman and Cameron 2008; MacWhinney 1999) analyse how complex patterns emerge from the interactions of many agents, how each emergent level cannot come into being except by involving the levels that lie below it, and how at each higher level there are new and emergent kinds of relatedness not found below: 'More is different' (Anderson 1972). Emergentism and Complexity Theory align well with DST which considers how cognitive, social and environmental factors are in continuous interactions, where flux and individual variation abound, and where cause-effect relationships are non-linear, multivariate and interactive in time (de Bot et al. 2007; Ellis 2008a; Ellis and Larsen Freeman 2006a, b; Port and Van Gelder 1995; Spencer et al. 2009; Spivey 2006; van Geert 1991).

'Emergentists believe that simple learning mechanisms, operating in and across the human systems for perception, motor-action and cognition as they are exposed to language data as part of a communicatively-rich human social environment by an organism eager to exploit the functionality of language, suffice to drive the emergence of complex language representations.' (Ellis 1998: 657). Language cannot be understood in neurological or physical terms alone, nevertheless, neurobiology and physics play essential roles in the complex interrelations; equally from the top down, though language

cannot be understood purely in experiential terms, nevertheless, conscious experience is an essential part too.

Language considered as a CAS of dynamic usage and its experience involves the following key features:

- The system consists of multiple agents (the speakers in the speech community) interacting with one another.

- The system is adaptive, that is, speakers' behavior is based on their past interactions, and current and past interactions together feed forward into future behavior.

- A speaker's behavior is the consequence of competing factors ranging from perceptual mechanics to social motivations.

- The structures of language emerge from interrelated patterns of experience, social interaction, and cognitive processes.

The advantage of viewing language in these ways is that it provides a unified account of seemingly unrelated linguistic phenomena (Holland 1995, 1998; Beckner et al., 2009). These phenomena include: variation at all levels of linguistic organization; the probabilistic nature of linguistic behavior; continuous change within agents and across speech communities; the emergence of grammatical regularities from the interaction of agents in language use; and stage-like transitions due to underlying nonlinear processes.

4. Characteristics of Language as a CAS

The following are seven major characteristics of language as a CAS, which are consistent with studies in language change, language use, language acquisition, and with the computer modeling of these aspects which is a core component of CAS research (Beckner et al., 2009).

Distributed control, and collective emergence Language exists both in individuals (as idiolect) as well as in the community of users (as communal language). Language is emergent at these two distinctive but inter-dependent levels: an idiolect is emergent from an individual's language use through social interactions with other individuals in the communal language, while a communal language is emergent as the result of the interaction of the idiolects. Distinction and connection between these two levels is a common feature in CASs. Patterns at the collective level (such as bird flocks, fish schools, or economies) cannot be attributed to global coordination among individuals; the global pattern is emergent, resulting from long-term local interactions between individuals.

Intrinsic diversity In a CAS, there is no ideal representing agent for the system. Just as in an economy, there is no ideal representative consumer, similarly, there is no ideal speaker-hearer for language use, language representation, or language development. Each idiolect is the product of the individual's unique exposure and experiences of language use (Bybee 2006). Sociolinguistics studies have revealed the large degree of orderly heterogeneity among idiolects (Weinreich et al. 1968), not only in their language

use, but also in their internal organization and representation (Dąbrowska 1997).

Mindfulness of intrinsic diversity is helpful for theory construction.

Perpetual dynamics   Both communal language and idiolects are in constant

change and reorganization. Languages are in constant flux, and language change is

ubiquitous (Hopper 1987). At the individual level, every instance of language use

changes an idiolect's internal organization (Bybee 2006). As we define language

primarily through dynamical rules, rather than by forces designed to pull it to a static

equilibrium, it shares, along with almost all complex systems, a fundamentally far-from-

equilibrium nature (Holland 1995).

Adaptation through amplification and competition of factors   CASs generally

consist of multiple interacting elements, which may amplify and/or compete with one

another's effects. Structure in complex systems tends to arise via positive feedback, in

which certain factors perpetuate themselves, in conjunction with negative feedback, in

which some constraint is imposed (for instance, due to limited space or resources)

(Camazine et al. 2001; Steels 2006). Likewise in language, all factors interact and feed

into one another.

Nonlinearity and phase transitions   In complex systems, small quantitative

changes in certain parameters often lead to phase transitions, i.e. qualitative differences.

Elman (2005) points out that multiple small phenotypic differences between humans and

other primates (such as in degree of sociability, shared attention, memory capacity, rapid

sequencing ability, vocal tract control, etc.) may in combination result in profound

consequences, allowing means of communication of a totally different nature. Also, in a

dynamic system, even when there is no parametric change, at a certain point in a continuous dynamic, system behavior can change dramatically and go through a phase transition. For example, constant heating of water leads to a transition from liquid to gas, without having any parametric change. In language development, such phase transitions are often observed, for example developmental 'lexical spurts' which often lead to rapid grammatical development (Bates and Goodman 1997).

Sensitivity to and dependence on network structure Network studies of complex systems have shown that real world networks are not random, as was initially assumed (Barabási 2002; Barabási and Albert 1999; Watts and Strogatz 1998), and that the internal structure and connectivity of the system can have a profound impact upon system dynamics (Newman et al. 2006). Similarly, linguistic interactions are not via random contacts; they are constrained by social networks. The social structure of language use and interaction has a crucial effect in the process of language change (Milroy 1980) and language variation (Eckert 2000), and the social structure of early humans must also have played important roles in language origin and evolution.

Change is local Complexity arises in systems via incremental changes, based on locally-available resources, rather than via top-down direction or deliberate movement toward some goal (see, e.g., Dawkins 1985).   Similarly, in a complex systems framework, language is viewed as an extension of numerous domain-general cognitive capacities such as shared attention, imitation, sequential learning, chunking, and categorization (Bybee 1998; Ellis 1996). Language is emergent from ongoing human social interactions, and its structure is fundamentally moulded by the pre-existing cognitive abilities, processing idiosyncrasies and limitations, and general and specific

conceptual circuitry of the human brain. Because this has been true in every generation

of language users from its very origin, in some formulations language is said to be a form

of cultural adaptation to the human mind, rather than the result of the brain adapting to

process natural language grammar (Christiansen and Chater 2008; Deacon 1997;

Schoenemann 2005). These perspectives have consequences for an understanding of how

language is processed in the brain. Specifically, language will depend heavily on brain

areas fundamentally linked to various types of conceptual understanding, the processing

of social interactions, and pattern recognition and memory. It also predicts that so-called

'language areas' should have more general, pre-linguistic processing functions even in

modern humans, and further, that the homologous areas of our closest primate relatives

should also process information in ways that makes them predictable substrates for

incipient language. Further, it predicts that the complexity of communication is to some

important extent a function of social complexity. Given that social complexity is in turn

correlated with brain size across primates, brain size evolution in early humans should

give us some general clues about the evolution of language (Schoenemann 2006).

Recognizing language as a CAS allows us to understand change at all levels.

5. Future Directions: Dynamic Structure

As the diverse research cited in this chapter illustrates, understanding the

emergence of language requires the full range of techniques of cognitive, social and

natural science. But more than that, it requires the overarching frameworks of Emergentism, CAS, and DST.

A common counterpoint within linguistics is the contrast between Saussure and Vygotsky, between structuralist approaches to language and those that emphasise the processes of language use in social interaction, between thin and thick descriptions (Geertz 1973). Vygotsky's ([1935] 1986) *Thinking and Speaking* addresses that same mystery as Saussure's, and makes equal resort to metaphor, for example, 'A thought may be compared to a cloud shedding a shower of words' (p. 150), and 'Consciousness is reflected in the word like the sun is reflected in a droplet of water. The word is a microcosm of consciousness, related to consciousness like a living cell is related to an organism, like an atom is related to the cosmos. The meaningful word is a microcosm of human consciousness.' (p. 285). While we remember Saussure more for his analysis of linguistic signs, we remember Vygotsky more for his emphasis on process and context:

'A word acquires its sense from the context in which it appears; in different contexts, it changes its sense. Meaning remains stable throughout the changes of sense. The dictionary meaning of a word is no more than a stone in the edifice of sense, no more than a potentiality that finds diversified realisation in speech.' (p. 245). 'The relation of thought to word is not a thing but a process, a continual movement back and forth from thought to word and from word to thought. In that process the relation of thought to word undergoes changes which themselves may be regarded as development in the functional sense. Thought is not merely expressed in words; it comes into existence through them. Every thought tends to connect something with something else, to establish a relationship between things. Every thought moves, grows and develops, fulfils a function, solves a

problem. This flow of thought occurs as an inner movement through a series of planes.' (p. 218). 'The relation between thought and word is a living process; thought is born through words. A word devoid of thought is a dead thing, and a thought unembodied in words remains a shadow. The connection between them, however, is not a preformed and constant one. It emerges in the course of development, and itself evolves.' (p. 255).

Language emerges in both the Saussurian sign and the Vygotskian process.

Related chapters

Language learning and language education

Psycholinguistics

Cognitive Linguistics

Corpus Linguistics

SLA

Suggestions for Further Reading

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Biographical Note

Nick Ellis is Professor of Psychology, Research Scientist in the English Language Institute, Professor of Linguistics, and Associate of the Centre of the Study of Complex Systems at the University of Michigan. He serves as the General Editor of *Language Learning*.

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