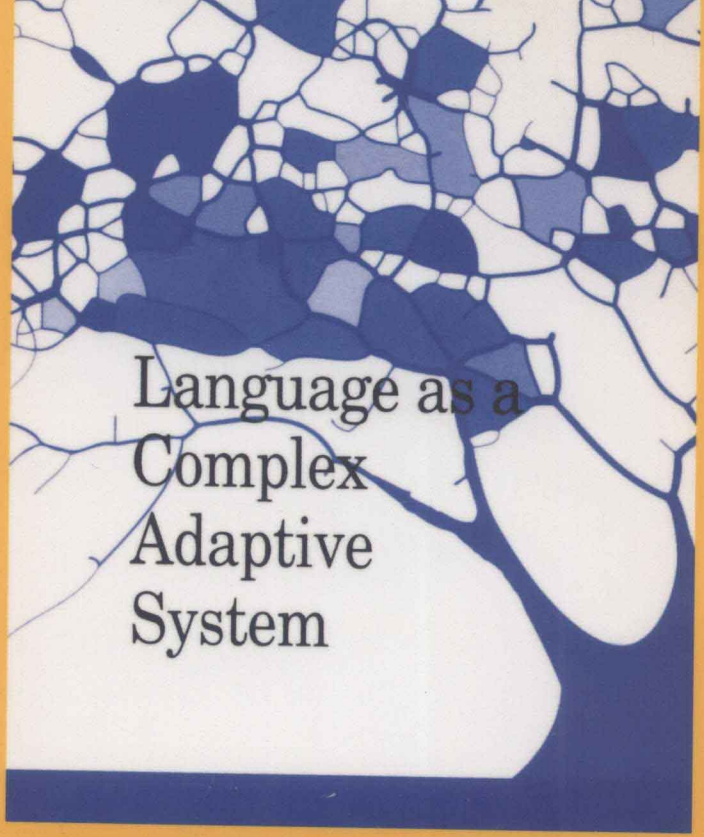

Language as a Complex Adaptive System

Editors Nick C. Ellis and
Diane Larsen-Freeman

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LANGUAGE AS A COMPLEX ADAPTIVE SYSTEM

Nick C. Ellis and Diane Larsen-Freeman, Editors

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Editorial and Dedications

Our 60th Anniversary

Language Learning was first published from the University of Michigan in 1948. Its subtitle then was "A Quarterly Journal of Applied Linguistics"; indeed the beginnings of "Applied Linguistics" have been attributed to this usage. In the 60 years since, our subtitle has evolved to become "A Journal of Research in Language Studies," reflecting our mission:

> *Language Learning* is a scientific journal dedicated to the understanding of language learning broadly defined. It publishes research articles that systematically apply methods of inquiry from disciplines including psychology, linguistics, cognitive science, educational inquiry, neuroscience, ethnography, sociolinguistics, sociology, and semiotics. It is concerned with fundamental theoretical issues in language learning such as child, second, and foreign language acquisition, language education, bilingualism, literacy, language representation in mind and brain, culture, cognition, pragmatics, and intergroup relations.

This supplement celebrates our 60th anniversary, our remarkable success toward these ends, and our realization that an understanding of language learning can only come from such integrated interdisciplinary inquiry.

The value of a journal lies in the quality of the articles it publishes. First and foremost, this comes from our submitting authors and from the scholars who voluntarily give many hours of their time and their expertise reviewing these submissions, thus to shape our discipline. There is a considerable investment from our Editors, our Board, and our Publishers too. Finally, there are you, our readers, who appreciate this work, cite it, and build upon it. Our first dedication, then, is to all who have made this journal what it is over the last 60 years.

Language as a Complex Adaptive System

To celebrate our anniversary, members of the Board, past Editors, our associates at Wiley-Blackwell, and friends and confederates in this enterprise, held a conference at the University of Michigan from November 7 to 9, 2008. The

subject of the event was "Language as a Complex Adaptive System." Leading researchers in linguistics, psychology, anthropology, and complex systems discussed the path-breaking significance of this perspective for their understanding of language learning.

This theme built upon foundations laid by colleagues at a meeting at the Santa Fe Institute in March 2007. As a result of that workshop, the "Five Graces Group" (named after their rather special accommodations there) authored a position paper, *Language as a Complex Adaptive System*, which was circulated to 10 invited speakers who were asked to focus upon the issues presented here when considering their particular areas of language in the 60th anniversary conference and in their papers in this special issue of *Language Learning*.

The authors of these 10 papers are active in their recognition of complexity in their respective areas, ranging from language usage, structure, and change, to sociolinguistics, cognitive linguistics, anthropology, language evolution, first language acquisition, second language acquisition, psycholinguistics and language processing, language education, individual differences, and language testing. After their presentations at the conference, the discussion of these papers was led by members of the Board of *Language Learning* in order to contextualize these influences within Applied Linguistics and the Language Sciences more generally.

The conference was recorded. The podcast records of the main presentations from the conference are free to download at http://www.wiley.com/bw/podcast/lang.asp. We thank our publishers Wiley-Blackwell, for sponsoring this.

After the conference, the speakers submitted written versions of their papers, revised in the light of the discussions there. All of these underwent the standard review process. The results are gathered here as a special issue of *Language Learning* (Vol. 59, Supplement 1, December 2009), beginning with the Five Graces position paper.

The study of Complex Adaptive Systems, Emergentism, and Dynamic System Theory is a relatively recent phenomenon, yet it is revolutionizing our understanding of the natural, physical, and social worlds. Our beginnings here in considering *Language as a Complex Adaptive System* rest on the foundational research in this area, much of it from the Santa Fe Institute (SFI). One of the founding fathers at SFI was John Holland. His work on CAS and genetic algorithms, including his two key books *Hidden Order: How Adaptation Builds Complexity* (1995) and *Emergence: From Chaos to Order* (1998), pioneered the study of complex systems and nonlinear science. We are lucky to have him

at the University of Michigan and as a member of the Five Graces group. John is 80 years old this year. Our second dedication, therefore, is to him.

Nick C. Ellis, General Editor, *Language Learning*
Diane Larsen-Freeman, Member, Board of Directors
Editors of this 60th Anniversary Issue
University of Michigan July 9, 2009

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Language Is a Complex Adaptive System: Position Paper

The "Five Graces Group"

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Language has a fundamentally social function. Processes of human interaction along with domain-general cognitive processes shape the structure and knowledge of language. Recent research in the cognitive sciences has demonstrated that patterns of use strongly affect how language is acquired, is used, and changes. These processes are not independent of one another but are facets of the same *complex adaptive system* (CAS). Language as a CAS involves the following key features: The system consists of multiple agents (the speakers in the speech community) interacting with one another.

This paper, our agreed position statement, was circulated to invited participants before a conference celebrating the 60th Anniversary of *Language Learning*, held at the University of Michigan, on the theme *Language is a Complex Adaptive System*. Presenters were asked to focus on the issues presented here when considering their particular areas of language in the conference and in their articles in this special issue of *Language Learning*. The evolution of this piece was made possible by the Sante Fe Institute (SFI) though its sponsorship of the "Continued Study of Language Acquisition and Evolution" workgroup meeting, Santa Fe Institute, 1–3 March 2007.

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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 constraints to social motivations. The structures of language emerge from interrelated patterns of experience, social interaction, and cognitive mechanisms. The CAS approach reveals commonalities in many areas of language research, including first and second language acquisition, historical linguistics, psycholinguistics, language evolution, and computational modeling.

Introduction: Shared Assumptions

Language has a fundamentally social function. Processes of human interaction along with domain-general cognitive processes shape the structure and knowledge of language. Recent research across a variety of disciplines in the cognitive sciences has demonstrated that patterns of use strongly affect how language is acquired, is structured, is organized in cognition, and changes over time. However, there is mounting evidence that processes of language acquisition, use, and change are not independent of one another but are facets of the same system. We argue that this system is best construed as a *complex adaptive system* (CAS). This system is radically different from the static system of grammatical principles characteristic of the widely held generativist approach. Instead, language as a CAS of dynamic usage and its experience involves the following key features: (a) The system consists of multiple agents (the speakers in the speech community) interacting with one another. (b) 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. (c) A speaker's behavior is the consequence of competing factors ranging from perceptual mechanics to social motivations. (d) The structures of language emerge from interrelated patterns of experience, social interaction, and cognitive processes.

The advantage of viewing language as a CAS is that it allows us to provide a unified account of seemingly unrelated linguistic phenomena (Holland, 1995, 1998; Holland, Gong, Minett, Ke, & Wang, 2005). These phenomena include the following: 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 stagelike transitions due to underlying nonlinear processes. We outline how the CAS approach reveals commonalities in many areas of language research, including cognitive linguistics, sociolinguistics, first and second language acquisition, psycholinguistics, historical linguistics, and language evolution. Finally, we indicate how the CAS approach

provides new directions for future research involving converging evidence from multiple methods, including corpus analysis, crosslinguistic comparisons, anthropological and historical studies of grammaticalization, psychological and neuroscience experimentation, and computational modeling.

Language and Social Interaction

Language is shaped by human cognitive abilities such as categorization, sequential processing, and planning. However, it is more than their simple product. Such cognitive abilities do not require language; if we had only those abilities, we would not need to talk. Language is used for human social interaction, and so its origins and capacities are dependent on its role in our social life (Croft, 2009; Tomasello, 2008). To understand how language has evolved in the human lineage and why it has the properties we can observe today, we need to look at the combined effect of many interacting constraints, including the structure of thought processes, perceptual and motor biases, cognitive limitations, and socio-pragmatic factors (Christiansen & Chater, 2008; Clark, 1996).

Primate species are particularly socially interactive mammals, but humans appear to have emphasized this type of social interaction to an even greater extent. This means that language evolved in the context of an already highly interactive social existence. This intensive interaction suggests that the evolution of language cannot be understood outside of a social context. Language plays a fundamental role in human society and culture, providing the central means by which cultural knowledge is transmitted, elaborated, and reformed over time. Culture itself is at least partly to be understood as a reflection of what humans find interesting and important, which in turn reflects a complex interplay of both evolved biological biases (e.g., we find pleasure in satiating biological desires) as well as cultural biases (e.g., styles of clothing, etc.). Thus, both language and culture are emergent phenomena of an increasingly complex social existence.

The nature of language follows from its role in social interaction. Although social interactions can sometimes be uncooperative and characterized by conflict, they are often characterized by what philosophers of action call shared cooperative activity (Bratman, 1992, 1993, 1997) or joint actions (Clark, 1996). Joint actions are dependent on what might be broadly called *shared cognition*, a human being's recognition that she can share beliefs and intentions with other humans. Joint action involves (among other things) individuals performing individual actions that are intended to carry out a jointly intended shared action, such as moving a piano or performing in a string quartet. Bratman enumerated

several mental attitudes for shared cooperative activity, including meshing of subplans to carry out the joint action, a commitment to help out the other, and shared belief of all of the above.

Finally, Bratman also pointed out that the individual actions that form the joint action must be coordinated for the joint action to be carried out successfully (imagine what would happen if the movers of the piano or the performers in the string quartet did not coordinate their actions). This is where language ultimately comes in. Joint actions pose coordination problems (Lewis, 1969) between the participants. There are various coordination devices that solve the coordination problems of joint actions, of which the simplest is joint attention to jointly salient properties of the environment (Lewis, 1969; Tomasello, 1999). However, by far the most effective coordination device is, of course, for the participants to communicate with each other. However, communication is a joint action: The speaker and hearer must converge on a recognition of the speaker's intention by the hearer (Grice, 1948/1989). Humans have developed a powerful coordination device for communication—that is, convention or, more precisely, a conventional signaling system (Clark, 1996, 1999; Lewis, 1969). Convention is a regularity of behavior (producing an utterance of a particular linguistic form) that is partly arbitrary and entrenched in the speech community. As a coordination device, it solves a recurring coordination problem, namely the joint action of communication. Additionally, communication is in turn a coordination device for any joint action (or other type of interaction) that human beings wish to perform or have happen. On this basis, human culture is built.

Language is a two-level system embedded in the two higher levels of communication (i.e., meaning in the Gricean sense) and joint action (which illocutionary acts are really a simplified example of; see Austin, 1962; Searle, 1969). Language involves the production of signals in a medium such as speech, sign, or writing. This is the regularity of behavior to which the interlocutors jointly attend, called an *utterance act* by Austin. However, these signals are formulated into what Searle called propositional acts and what linguists call words and grammatical constructions. Thus, there are finally four levels in which language operates: producing and attending to the utterance; formulating and identifying the proposition; signaling and recognizing the communicative intention; and proposing and taking up the joint action (Clark, 1992, 1996).

This complex model is in fact fragile, as everyone who has misunderstood someone or has been misunderstood knows. However, there are fundamental reasons why the communicative process is fragile and, therefore, introduces

variation, the substrate for change in language. First, of course, is that we cannot read each other's minds. Equally important is that convention is not airtight as a coordination device (Croft, 2000, 2009). A speaker chooses the words and constructions—the linguistic conventions—to communicate a situation based on the prior use of these conventions in similar situations. The hearer does the same—but the hearer's knowledge of prior uses of the conventions is not the same as the speaker's. Finally, the new situation being communicated is unique and subject to different construals. Although we must not overstate the impossibility of communication—after all, vast civilizations have been constructed on its basis—we cannot deny the indeterminacy of communication, whose product is the ubiquity of language change.

Usage-Based Grammar

We adopt here a usage-based theory of grammar in which the cognitive organization of language is based directly on experience with language. Rather than being an abstract set of rules or structures that are only indirectly related to experience with language, we see grammar as a network built up from the categorized instances of language use (Bybee, 2006; Hopper, 1987). The basic units of grammar are constructions, which are direct form-meaning pairings that range from the very specific (words or idioms) to the more general (passive construction, ditransitive construction), and from very small units (words with affixes, *walked*) to clause-level or even discourse-level units (Croft, 2001; Goldberg, 2003, 2006).

Because grammar is based on usage, it contains many details of co-occurrence as well as a record of the probabilities of occurrence and co-occurrence. The evidence for the impact of usage on cognitive organization includes the fact that language users are aware of specific instances of constructions that are conventionalized and the multiple ways in which frequency of use has an impact on structure. The latter include speed of access related to token frequency and resistance to regularization of high-frequency forms (Bybee, 1995, 2001, 2007); it also includes the role of probability in syntactic and lexical processing (Ellis, 2002; Jurafsky, 2003; MacDonald & Christiansen, 2002) and the strong role played by frequency of use in grammaticalization (Bybee, 2003).

A number of recent experimental studies (Saffran, Aslin, & Newport, 1996; Saffran, Johnson, Aslin, & Newport, 1999; Saffran & Wilson, 2003) show that both infants and adults track co-occurrence patterns and statistical regularities in artificial grammars. Such studies indicate that subjects learn

patterns even when the utterance corresponds to no meaning or communicative intentions. Thus, it is not surprising that in actual communicative settings, the co-occurrence of words has an impact on cognitive representation. Evidence from multiple sources demonstrates that cognitive changes occur in response to usage and contribute to the shape of grammar. Consider the following three phenomena:

1. Speakers do not choose randomly from among all conceivable combinatorial possibilities when producing utterances. Rather there are conventional ways of expressing certain ideas (Sinclair, 1991). Pawley and Syder (1983) observed that "nativelike selection" in a language requires knowledge of expected speech patterns, rather than mere generative rules. A native English speaker might say *I want to marry you*, but would not say *I want marriage with you* or *I desire you to become married to me*, although these latter utterances do get the point across. Corpus analyses in fact verify that communication largely consists of prefabricated sequences, rather than an "open choice" among all available words (Erman & Warren, 2000). Such patterns could only exist if speakers were registering instances of co-occurring words, and tracking the contexts in which certain patterns are used.
2. Articulatory patterns in speech indicate that as words co-occur in speech, they gradually come to be retrieved as chunks. As one example, Gregory, Raymond, Bell, Fossler-Lussier, & Jurafsky (1999) find that the degree of reduction in speech sounds, such as word-final "flapping" of English [t], correlates with the "mutual information" between successive words (i.e., the probability that two words will occur together in contrast with a chance distribution) (see also Bush, 2001; Jurafsky, Bell, Gregory, & Raymond, 2001). A similar phenomenon happens at the syntactic level, where frequent word combinations become encoded as chunks that influence how we process sentences on-line (Ellis, 2008b; Ellis, Simpson-Vlach, & Maynard, 2008; Kapatsinski & Radicke, 2009; Reali & Christiansen, 2007a, 2007b).
3. Historical changes in language point toward a model in which patterns of co-occurrence must be taken into account. In sum, "items that are used together fuse together" (Bybee, 2002). For example, the English contracted forms (*I'm*, *they'll*) originate from the fusion of co-occurring forms (Krug, 1998). Auxiliaries become bound to their more frequent collocate, namely the preceding pronoun, even though such developments run counter to a traditional, syntactic constituent analysis.

Such detailed knowledge of the interactions of grammar and lexicon in usage, which includes knowledge of which words commonly go into which constructions, leads to a conception of lexicon and grammar as highly intertwined rather than separate (Bybee, 1998a; Ellis, 2008b; Goldberg, 2006; Halliday, 1994; Langacker, 1987). The cognitive representations underlying language use are built up by the categorization of utterances into exemplars and exemplar clusters based on their linguistic form as well as their meaning and the context in which they have been experienced (Pierrehumbert, 2001). Because this categorization is ongoing during language use, even adult grammars are not fixed and static but have the potential to change as experience changes (e.g., MacDonald & Christiansen, 2002; Sankoff & Blondeau, 2007; Wells, Christiansen, Race, Acheson, & MacDonald, 2009).

Language change proceeds gradually via localized interactions, but this is not to say that there are no generalizations within or across languages. General properties of language that are both formal and substantive come about in language as in any CAS—through the repeated application of general processes of change. Because the same processes apply in all languages, general resemblances develop; however, the trajectories of change (such as paths of grammaticalization) are much more similar than the resulting states (Bybee, Perkins, & Pagliuca, 1994; Greenberg, 1978).

In the usage-based framework, we are interested in emergent generalizations across languages, specific patterns of use as contributors to change and as indicators of linguistic representations, and the cognitive underpinnings of language processing and change. Given these perspectives, the sources of data for usage-based grammar are greatly expanded over that of structuralist or generative grammar: Corpus-based studies of either synchrony or diachrony as well as experimental and modeling studies are considered to produce valid data for our understanding of the cognitive representation of language.

The Development of Grammar out of Language Use

The mechanisms that create grammar over time in languages have been identified as the result of intense study over the last 20 years (Bybee et al., 1994; Heine, Claudi, & Hünnemeyer, 1991; Hopper & Traugott, 2003). In the history of well-documented languages it can be seen that lexical items within constructions can become grammatical items and loosely organized elements within and across clauses come to be more tightly joined. Designated "grammaticalization," this process is the result of repetition across many speech events, during which sequences of elements come to be automatized as neuromotor

routines, which leads to their phonetic reduction and certain changes in meaning (Bybee, 2003; Haiman, 1994). Meaning changes result from the habituation that follows from repetition, as well as from the effects of context. The major contextual effect comes from co-occurring elements and from frequently made inferences that become part of the meaning of the construction.

For example, the recently grammaticalized future expression in English *be going to* started out as an ordinary expression indicating that the subject is going somewhere to do something. In Shakespeare's English, the construction had no special properties and occurred in all of the plays of the Bard (850,000 words) only six times. In current English, it is quite frequent, occurring in one small corpus of British English (350,000 words) 744 times. The frequency increase is made possible by changes in function, but repetition is also a factor in the changes that occur. For instance, it loses its sense of movement in space and takes on the meaning of "intention to do something," which was earlier only inferred. With repetition also comes phonetic fusion and reduction, as the most usual present-day pronunciation of this phrase is (*be*) *gonna*. The component parts are no longer easily accessible.

The evidence that the process is essentially the same in all languages comes from a crosslinguistic survey of verbal markers and their diachronic sources in 76 unrelated languages (Bybee et al., 1994). This study demonstrated that markers of tense, aspect, and modality derive from very similar semantic sources crosslinguistically. For instance, of the 76 languages, 10 were found to have a future that developed from a verb meaning "go," 10 languages develop a similar meaning from a verb meaning "come," and some languages use a verb meaning "want" (an example is English *will*, which formerly meant "want").

Thus, grammatical categories develop in all languages in this way, but not all of the categories turn out the same. Categories from different lexical sources may have different nuances of meaning; categories that are more or less grammaticalized have different meanings and range of usage. Some rare lexical sources also exist. As odd as it may seem, using a temporal adverb such as "soon" or "by and by" to form a future is rare but does occur.

Given that grammaticalization can be detected as ongoing in all languages at all times, it is reasonable to assume that the original source of grammar in human language was precisely this process: As soon as humans were able to string two words together, the potential for the development of grammar exists, with no further mechanisms other than sequential processing, categorization, conventionalization, and inference-making (Bybee, 1998b; Heine & Kuteva, 2007).

Language change is a cultural evolutionary process (Christiansen & Chater, 2008; Croft, 2000). According to the General Analysis of Selection (Hull, 1988, 2001), evolutionary processes take place at two linked levels: replication and selection. Replicators are units such as a gene, a word, or the practice of marriage that are replicated with some chance for innovation and variation. Selection is a process by which individuals—organisms, or humans as speakers or cultural beings—interacting with their environment cause replication of the replicators to be differential; that is, some replicators are replicated more than others, which in the extreme case leads to fixation of the former and extinction of the latter. In language, linguistic structures—sounds, words, and constructions—are replicated in utterances every time we open our mouths; that is, replication, and variation, occurs when we use language in the service of joint actions between human beings in a community. Due in part to the indeterminacy of communication described earlier, this replication process produces variation. Speakers differentially replicate certain structures through interaction with their environment, namely the situations being communicated and their interlocutors. In the former case, changes in lifestyles lead to the rise and fall of words and constructions associated with those lifestyles (e.g., the rise of *cell* [*phone*] and the fall of *harquebus*). In the latter case, the social identity and the social contexts of interaction lead to the rise and fall of linguistic forms that are associated with various social values by speakers.

First and Second Language Acquisition

Usage-based theories of language acquisition (Barlow & Kemmer, 2000) hold that we learn constructions while engaging in communication, through the "interpersonal communicative and cognitive processes that everywhere and always shape language" (Slobin, 1997). They have become increasingly influential in the study of child language acquisition (Goldberg, 2006; Tomasello, 2003). They have turned upside down the traditional generative assumptions of innate language acquisition devices, the continuity hypothesis, and top-down, rule-governed processing, replacing these with data-driven, emergent accounts of linguistic systematicities. Constructionist analyses chart the ways in which children's creative linguistic ability—their language system—emerges from their analyses of the utterances in their usage history using general cognitive abilities and from their abstraction of regularities within them. In this view, language acquisition is a sampling problem, involving the estimation of the population norms from the learner's limited sample of experience as perceived through the constraints and affordances of their cognitive apparatus, their