牛津应用语言学丛书

Complex Systems and Applied Linguistics

复合系统与应用语言学

Diane Larsen-Freeman

Lynne Cameron

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出 版 说 明

本世纪初，外教社先后引进“牛津应用语言学丛书”（19种）和“牛津应用语言学丛书（续编）”（10种）。这些图书由于内容权威、选择精当而受到了外语界的好评，在科研论文中被广泛引用，对推动我国外语教学和研究的发展起到了重大作用。

近年来，随着研究的不断扩展和深入，国内学界对研究资料有了新的需求，像“任务型教学法”、“英语作为国际通用语”、“二语习得的跨学科研究”等逐渐成为了热门的话题。有鉴于此，我们又从牛津大学出版社出版的应用语言学图书中精选了10本，以更好地满足广大教师和科研人员的需求。希望这次出版的这10本图书，能够和以前的29本一起，反映出国际应用语言学重要领域研究的前沿，为全面、深入推动我国外语科研起到新的作用，做出新的贡献。

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Preface

Many of the ideas in this book—'complexity' and 'chaos,' for example—excite the imagination. Such terms are certainly evocative. Nevertheless, the terms, and importantly, the concepts underlying them, do not mean the same within the theory we present here as they do in everyday language. 'Chaos' does not mean complete disorder, and 'complexity' does not mean complicated. The complex systems approach we adopt in this book originated in the physical and biological sciences, and these terms have precise meanings within these disciplines. As the complexity approach has moved out from physics and biology to the human sciences, and even to the humanities, these terms and associated concepts have been used in an extended way that springs from analogical and more general applications. Indeed, here, we do not use the approach to calculate equations or to model systems; instead, we use the approach for a complexity description of topics of concern to applied linguistics. However, even when describing, we think it is essential to stay as true as possible to the original meaning of the terms. For this reason, following the introductory chapter in which we attempt to situate a complexity approach both within its originating fields and within fields closer to applied linguistics, we have included two chapters that introduce the terms as they are used in their source disciplines in order to create understandings that we extend and apply more descriptively in subsequent chapters.

Complexity theory is a perspective that we encountered independently—one that we both concluded helped us make sense out of, and bring coherence to, our experience in applied linguistics and to ask questions we might not have otherwise asked. It is a way that we have found both challenging and exhilarating. The challenges have come, first of all, in grappling with literature from outside of our field—research reports and theoretical discussions in mathematics, physics, and biology. One of us has some knowledge of mathematics, and that has helped a little, but our reading of the complexity theory literature has, out of necessity, been selective. A second challenge has been in 'translating' our understanding into applied linguistics. This has been somewhat easier to do, as we are both applied linguists, and although we have different areas of primary interest, we are well steeped in the issues in our focal areas. Often, attributes of complex systems in one field, such as ecology, have much in common with characteristics of other fields such as immunology or economics. As a result, the complex systems approach is inherently interdisciplinary; insights and results can be translated across fields. Nevertheless, a challenge remains, and that is to avoid making superficial comparisons across disciplines.

As complexity theory originated in the physical sciences, we are also sensitive to accusations of being overly enamored with the physical sciences. Applied linguistics research investigates language—its learning and its use—and thus it is an endeavor that seeks to understand fundamentally human phenomena. Nevertheless, science, at its best, in its openness to exploration and discovery and in its commitment to empirical rigor, has qualities that we value. As educators, the 'attitude of inquiry' of science (Larsen-Freeman 2000a) is one that we find laudable and worthy of emulation. Further, since the present century has been characterized as the century of biology, it should not be surprising, being alive at this point in time, that we should find attractive and illuminating a theory whose roots lie in biology.

However, we admit to a more nettlesome problem. In writing this book, we have faced the dilemma of how to talk about matters of complexity theory. This is because our ways of knowing are so bound up with the language we use to discuss them. For this reason, developing a new perspective is also a language challenge—one that we have not always found straightforward ourselves. It is easy to fall back into old ways of thinking, and requires continual monitoring to ensure that ways of talking (or writing) reflect complex dynamic ways of thinking.

We are also fully aware of the risks of importing theories from outside our discipline. It is quite natural to analogize; indeed, that is precisely one way new meaning is made, a theme on which we elaborate in the chapter that follows. However, there is a risk in analogizing if it does not come from a deep understanding, and that is why the following chapters contain the detail they do. Clearly, from the fact that we have chosen to write this book, we believe that the benefits promise to outweigh the risks. The final challenge, then, and perhaps the most demanding one of all, is the need to address the question that any applied scholar must—the 'so what?' question.

So what does this promised new way of looking at issues deliver? How has our understanding and practice as researchers and teachers been altered? Are we, as a result, closer to solutions to real-world problems involving language, its learning, and its use? Are we better practitioners? These have proven to be daunting questions, around which we will have much to say in subsequent chapters. Given the nascent research in complex systems and applied linguistics, the tentative nature of our claims is quite natural, and we hope easily understood. In any case, it seemed sufficiently important to share the insights that this new view has afforded us at this point in time, in order that we might encourage others to join in the quest for making sense out of the 'new science' of complexity, as it is often referred to.

The science we make use of has been called the 'new science' even within its source disciplines. It is certainly new to applied linguistics, although there are signs to suggest that interest is growing within our field. Some indication of this growing interest is provided by the colloquia organized by Ellis and Larsen-Freeman on emergentism at AILA 2005 in Madison, Wisconsin; de Bot on methodology of dynamic systems theory at the joint American and

Canadian Associations for Applied Linguistics Conference in Montreal, 2006; and by Schumann and his students on the interactional instinct and Atkinson on sociocognitive dimensions of second language acquisition at the American Association for Applied Linguistics Conference 2007 in Costa Mesa, California. We are certainly not the only ones to be exploring a complexity approach to see what it has to offer applied linguistics, and we will be drawing on the work of colleagues as well as our own here. Nevertheless, it is still very early on in the development of the approach and certainly in its application to topics of concern in applied linguistics. For this reason, there will be questions that readers will have that will remain unanswered, and no doubt some of our ideas are inchoate. This book opens a conversation and invites collaboration with others. It is not the last word.

1

Complexity theory: what's it all about?

In our daily lives, complexity and constant change can be difficult to live with. One way we cope is to seek the comfort of routines. Another way is to downplay the continual change that we experience by turning the living, dynamic world into named objects and thinking about them as fixed entities, as river, tree, city, or person. We turn our life experiences into stories, and our continually changing selves into sets of more or less fixed attributes, attitudes, and identities.

The same preference for an artifice of simplicity and synchronicity appears in our scholarly work. Change is inherent to most of our concerns as applied linguists, and yet in our theories we everywhere find processes converted into objects. A post-modern response to over-simplification of the world through a focus on entities is to fragment and disperse, to deny wholeness by making it multiple, hybrid, and difficult to grasp. Complexity theory, in contrast, embraces complexity, interconnectedness, and dynamism, and makes change central to theory and method.

Complexity theory aims to account for how the interacting parts of a complex system give rise to the system's collective behavior and how such a system simultaneously interacts with its environment. The field of complex systems intersects traditional disciplines of physical, biological and social sciences, as well as engineering, management, economics, medicine, education, literature, and others. Its power comes not only from its application to many different disciplines, but also from the fact that it can be applied to many different levels. It can, for example, be applied to neurons in the human brain, cells and microbes in the human body, and flora and fauna in an ecosystem as well as to more social activities such as the way information flows over a social or computer network, the dynamics of infectious disease transmission, and the behavior of consumers and firms in an economy. Each of these phenomena works as a 'complex system'.

It is important to note from the outset that the word 'complex' has a special meaning as used here. It does not merely mean complicated. Although the agents or components in a complex system are usually numerous, diverse, and dynamic, a defining characteristic of a complex system is that its behavior emerges from the interactions of its components.[1] The emergent behavior is often non-linear, meaning disproportionate to its causal factors. In other words, sometimes a great deal of energy may be expended with nothing to show for it; on other occasions, the slightest pressure on the system can have dramatic effects, such as the dire consequences for our ecological system from even a slight temperature rise. The agents or elements in a complex system change and adapt in response to feedback. They interact in structured ways, with interaction sometimes leading to self-organization and the emergence of new behavior. They operate in a dynamic world that is rarely in equilibrium and sometimes in chaos.

Complex systems have been referred to by a number of names depending on which dimension of their behavior is being emphasized. To emphasize the fact that they change over time, they are often referred to as 'dynamic(al) systems' and to emphasize the fact that adaptation and learning occur in these systems, they are sometimes called 'complex adaptive systems'. The complex systems in which we are interested have no distinct permanent boundaries; they are not a 'thing' themselves. They exist only through the fluxes that feed them, and they disappear or become moribund in the absence of such fluxes. For example, a tropical cyclone comes into being due to certain sea and air current conditions, and it is sustained by them. When these change, such as when a tropical cyclone hits land, it weakens and eventually dies out. Of course the overall weather system remains, and if the conditions that caused the first cyclone prevail, then a new cyclone might be spawned further up the coast; however, the particular perturbation caused by the original cyclone disappears in the absence of the fluxes that fed it.

Some antecedents of complexity theory

Complexity theory has many disciplinary progenitors; therefore we can only be selective in tracing its genealogy here.[2] In this section we point to particular key influences on the development of complexity theory; the next two chapters elaborate on them. We begin our treatment in 1940 with the work of biologist Conrad Waddington. Waddington challenged the assumption of the day, which was that genes carried the full description of an organism's form. Instead, he showed that genes are only the starting point for embryogenesis. Once embryogenesis is underway, each step in the process of development creates the conditions for the next one. In other words, 'the form of the body is literally constructed by the construction process itself—and is not specified in some pre-existing full instruction set, design or building plan ...' (van Geert 2003: 648–9).

Biologist von Bertalanffy (1950) followed in proposing 'general systems theory' to account for how complex order arises.[3] Von Bertalanffy opposed reductionism in explaining an entity as the sum of the properties of its parts, advocating instead a systems approach—understanding the relationships among the parts which connect them to the whole.

In the 1970s, chemist Ilya Prigogine (Prigogine and Stengers 1984) would contribute to this line of thinking through the study of systems that he called 'dissipative'. A dissipative system is open to energy from outside of itself, which, once taken in, leads to reactions out of which complex patterns self-organize. Self-organization is the creation of more complex order spontaneously; the resulting more complex structure is not planned or managed by an outside source. Thus, the study of dissipative systems focuses on the close interplay between structure, on the one hand, and change (or dissipation) on the other.

Also, in the 1970s, Chilean biologists Humberto Maturana and Francisco Varela (1972) came to an important awareness from their study of vision, which contributed to the evolution of complexity theory. They came to realize that vision was not received by the nervous system as a camera lens receives an image, but rather it is from light and color that our eyes construct images. Based on this insight, they proposed that living organisms are characterized by what they termed 'autopoiesis'. Autopoietic systems continually change and build new structures while maintaining their identity.

Developments in the 1980s shifted to the search to understand the increasing order and structure in open systems. Haken (1983) and Kelso (1995) worked on the relationship between components of a system which give rise to a new macroscopic order not present in any of the components, an interdisciplinary study called 'synergetics'. In 1984, the Santa Fe Institute was founded and became an important independent research center for a multidisciplinary understanding of complex adaptive systems. Many researchers were involved in this effort; here we can but cite a few of the major figures.[4] We do so along with the books they wrote for a lay audience because the titles of such works are telling: biologist Stuart Kauffman's (1993) *The Origins of Order: Self-organization and Selection in Evolution* and (1995) *At Home in the Universe: The Search for the Laws of Self-organization and Complexity*, physicist Murray Gell-Mann's (1994) *The Quark and the Jaguar: Adventures in the Simple and the Complex*, and computer scientist/psychologist John Holland's (1995) *Hidden Order: How Adaptation Builds Complexity* and (1998) *Emergence: From Chaos to Order*.

Overlapping a great deal with complexity theory is 'dynamic systems theory', whose lineage is more mathematical than biological. At the turn of the century, the French mathematician Henri Poincaré developed the study of non-linear dynamics as a mathematical discipline in its own right. However, it especially took off when the digital computer was developed after World War II. Even the early models allowed for the study of complexity and dynamism unheard of in the history of science up until that point in time. The development of the computer also led to some fundamental ideas about systems represented in new systems approaches such as 'cybernetics' (Wiener 1948; von Neumann 1958).

In the 1960s, the French mathematician René Thom (1972, 1983) began to study the properties of general systems that exhibit sudden changes, more particularly of discontinuities, which he called 'catastrophes'. 'Catastrophe theory' involves the description of the (sudden, abrupt) discontinuities induced by the continuous local perturbations of a system. The catastrophes, sometimes triggered by small changes, result in sudden and unpredictable shifts in the behavior of the entire system.[5] About this same time, using the computer to model weather systems, meteorologist Edward Lorenz also observed the sudden switches in behavior that Thom had identified. Lorenz further pointed to the fact that simulated dynamic weather systems settle into regular, but never identical patterns, called 'strange attractors'. Lorenz also found that some of these patterns are highly sensitive to initial conditions, an observation that became known as 'the butterfly effect' from the title of a paper given by him in 1972 to the American Association for the Advancement of Science in Washington, D.C. entitled 'Predictability: does the flap of a butterfly's wings in Brazil set off a tornado in Texas?'. The flapping wings of the butterfly represent a small change in the initial condition of the system, which affects a chain of events leading to a large-scale phenomenon like a tornado. Had the butterfly not flapped its wings, the path of the system might have been vastly different. These observations are more likely these days to be associated with 'chaos theory'.

Chaos theory is the study of non-linear dynamical systems, i.e. systems that do not unfold over time in a linearly predictable manner. Such study has 'revealed the chaotic nature of a wide variety of physical systems' including certain classes of neural networks (van Gelder and Port 1995: 35–6). It is important to note, however, that in this context, chaos is not complete disorder, but is rather behavior that arises unpredictably in a non-linear system. Because of their complexity and because the trajectories of chaotic systems are susceptible to even minor perturbations, at no point in time in the evolution of such systems can chaos be predicted.

Applying complexity theory

Despite their diverse origins, this research and these theories have left their mark on what we will refer to as 'complexity theory'. Complexity theory deals with the study of complex, dynamic, non-linear, self-organizing, open, emergent, sometimes chaotic, and adaptive systems (Larsen-Freeman 1997). In the last twenty or so years, complexity theory has been taken from its originating fields of biology, mathematics, and physics, and applied in other disciplines. Business management was early on the scene, adopting ideas and terms from complexity theory to understand organizations as complex systems (Battram 1998) and dynamic processes such as supply and demand chains. Economists working at the Santa Fe Institute and elsewhere developed models of economic systems as complex adaptive systems, and epidemiologists have modeled the spread of disease as a complex system.

Closer to our own field, developmental psychologists have seen the potential in applying dynamical systems theory to child motor development and other human systems (Thelen and Smith 1994; Port and van Gelder 1995) and have suggested enticing possibilities for other areas of psychology:

> A dynamics systems approach to cognition and action provides a biological ground for cultural and contextual accounts of human cognition ... mental life as emergent from the activities of everyday life. (Thelen and Smith 1994: 329)

More recently, in psychology, Spivey has developed a complex dynamic view of mind that he calls 'continuity psychology' (Spivey 2007). He aims to convince cognitive psychologists of the inadequacies of a computer metaphor of mind and of the viability of a replacement view that sees the mind in continual flux and mental processes as continuously dynamic. According to Spivey this entails dropping 'the assumption of stable symbolic internal representations ... continuing on to a fully ecological dynamical account of perception, cognition, and action' (ibid.: 332) that connects brain, body, and world.

In our own field of applied linguistics, Larsen-Freeman (1997) wrote explicitly about the value of seeing second language acquisition from a chaos/complexity theory perspective, following up in 2002 (2002a) by showing how such a perspective can help to overcome the dualism that often besets our field. Meara (1997, 2004, 2006) used dynamic modeling to describe vocabulary development or loss. More recently, de Bot, Lowie, and Verspoor (2005, 2007) have applied dynamic systems theory to second language acquisition, and Herdina and Jessner (2002) have used it to discuss changes in multilingual proficiency on an individual level and to provide a more dynamic description of multilingualism. Lee and Schumann (2003) have used the lens of complex adaptive systems to view the evolution of language. Cameron (2003a) has applied complexity theory to the dynamics of metaphor in discourse showing how language and conceptual development interact. Most recently, contributors to a special issue of the journal *Applied Linguistics* (December 2006), co-edited by Ellis and Larsen-Freeman (2006), have addressed a number of issues of concern to applied linguists, using complexity theory in an emergentist approach.

It seems that the tide of complexity is lapping at our feet as applied linguists, making it timely to consider how the assumptions and perspectives of our own field may be challenged by complexity. In the pages that follow, we suggest that complex systems can be found throughout applied linguistics. The language used by a discourse community can be described as such a system, as can the interactions of learners and their teacher in a classroom, as can the functioning of the human mind. We aim to show that reconceptualizing these and other phenomena in terms of complexity opens up the possibility for new understandings and actions.

Is anything ever new?

Again, it is right that we pause to pay homage to our forebears. Certainly, some of the propositions that we entertain in this book are not new. For instance, the ancient Greek philosopher Heraclitus viewed the world as constituted of a constant flux, a ceaseless river, an endless play of forms and figures. The Renaissance, as Widdowson (personal communication) has pointed out to us, was obsessed with 'mutabilité' and how to cope with it—religious belief was one way of imposing order on perpetual change. The Enlightenment sought rational alternatives through the philosophy of science, but there was never any denial of variation and change, nor any pretence that the underlying general laws proposed accounted for every particular.

Nevertheless, resolving the tension between the two poles of stasis and dynamism has been elusive. In more modern times, the tension has been characterized by what Bernstein (1983) called 'the Cartesian anxiety'. Varela *et al.* elaborate:

> This feeling of anxiety arises from the craving for an absolute ground. When this craving cannot be satisfied, the only possibility seems to be nihilism or anarchy. The search for a ground can take many forms, but given the basic logic of representationism, the tendency is to search either for an outer ground in the world or an inner ground in the mind. By treating mind and world as opposed subjective and objective poles, the Cartesian anxiety oscillates endlessly between the two in search of a ground.
> (Varela *et al.* 1991: 141)

The search for groundedness in the mind led linguist Chomsky (1965) to investigate mental competence rather than performance, while sociolinguists, such as Weinreich, Labov, and Herzog (1968: 99) sought to find order in the social world by creating 'a model of language which accommodates the facts of variable usage ... and leads to a more adequate description of linguistic competence'. Applied linguists have followed suit, preferring to explain the facts of language acquisition either through an appeal to a mental competence (for example, Gregg 1990), or by taking language use factors into account, showing patterns in variability (which have led them to coin and use the hybrid term 'variable competence') (R. Ellis 1985; Tarone 1990). But mental competence, when it is seen to be 'irreducibly self-contained, cannot meaningfully relate to the world "outside"' (Leather and van Dam 2003: 6)—which applied linguists must do—and the hybridity of more socially-oriented approaches have tended to treat the world (context) as an independent variable that influences linguistic form, not as a dynamic system itself. Here, perhaps, complexity theory may contribute to a resolution.

From a complexity theory perspective, there is nothing static about language. There is no need to distinguish performance from competence. Humans 'soft assemble' (Thelen and Smith 1994) their language resources in order to respond in an intentional way to the communicative pressures at hand. As they do so, patterns emerge, such as those language-using patterns that manifest in linguistic corpora. However, performance stabilities arising from the dynamics of language use are transformed with further usage (Bybee 2006). Since the patterns are variegated in form (Tomasello 2000), even the very categories of language itself are negotiable and subject to change. Moreover, the context of language use is no more pre-existing and external to the language user than are language resources. In other words, context is not a stable background variable outside the individual that affects linguistic choice. Instead, a complexity theory view sees the individual and context as coupled. Because of the coupling, the context itself can change in a process of co-adaptation between the individual and the environment.

This shift in perspective

> reflects the necessity of understanding cognitive systems not on the basis of their input and output relationships, but by their *operational closure*. A system that has operational closure is one in which the results of its processes are those processes themselves.
> (Varela *et al.* 1991: 139–40)

The advantage of this type of explanation is its 'reciprocal causality' (Thompson and Varela 2001), in which there is 'upwards' emergence of the patterns from individuals interacting, which is none the less 'downwardly' constrained due to both the historic trajectory of the system and by its present-day sociocultural norms. Thus, a complexity theory-informed view—one shared by Varela *et al.* and ourselves—rejects classical Darwinism which, like the behaviorism it spawned, viewed the environment as external to and independent of the organism (Juarrero 1999: 108).

Complexity theory goes one step further. Not only is there ongoing interaction between the sociocognitive (our preferred term) and the environment, it is also the case that humans shape their own context. As such, seeking an explanation for individual differences in cause-effect patterns and generalizable findings does not fit a complexity theory perspective either. It 'is no longer sufficient to talk about individual differences in SLA against a backdrop of a universal learner ... variation becomes the primary given; categorization becomes an artificial construct of institutionalization and scientific inquiry' (Kramsch 2002: 4; Larsen-Freeman 2006b); as Kramsch says, paraphrasing Yeats: it may not be possible 'to tell the dancer from the dance'. More recently Ushioda (2007) puts it this way: 'The unique local particularities of the person as self-reflective intentional agent, inherently part of and shaping his or her own context, seem to have no place in [the earlier] kind of research'.

Although we will return to these ideas throughout this book, for now, we submit that complexity theory offers us new ways of conceptualizing and perceiving, changing our 'objects of concern' into processes, change, and continuities. While complexity-informed research is new to applied linguistics, it is growing. Not surprisingly, many of the details we discuss here