Preview Article

Complex Systems and Applied Linguistics

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This book introduces complexity theory as a metaphor or supra-theory for systems in applied linguistics. Change and heterogeneity are central to complexity theory and to the resonances that we find with applied linguistics systems. Principles of complexity theory are explained, drawing on work in the biological, psychological and social sciences. These principles include descriptions of change over time (system dynamics) that work for all levels and scales: movement from temporary and relative stability through adaptive behaviours to the emergence of new patterns not amenable to reductive explanations. Seeing applied systems as complex, adaptive and dynamic opens up new conceptualisations of properties and activities, enables new questions about how people use, learn and teach languages, and demands new ways of investigating behaviour and development.

Keywords: complex systems, dynamics, change, language

Dieses Buch stellt eine Einführung komplexer Systeme als Metapher oder Supratheorie für Systeme in der Angewandten Sprachwissenschaft dar. Veränderung und Heterogenität sind zentrale Grössen in der komplexen Systemtheorie und in den Resonanzen in Systemen in der Angewandten Sprachwissenschaft. Die Prinzipien der komplexen Systemtheorie werden in Bezugnahme auf biologische, psychologische und soziale Wissenschaften erklärt. Diese Prinzipien beinhalten Beschreibungen von Veränderung im Laufe der Zeit (Systemdynamik), die sich auf alle Niveaus und Skalen beziehen kann: Veränderung von temporärer und relativer Stabilität durch

angeglichenes Verhalten hin zur Emergenz von neuen Mustern, die nicht durch reduktive Erklärungen nachvollziehbar ist. Die Sichtweise von angewandten Systemen als komplex, adaptiv und dynamisch eröffnet neue Konzeptualiserungen von Eigenschaften und Aktivitäten, ermöglicht neue Fragestellungen zu Sprachgebrauch, -erwerb und – unterricht, und erfordert neue Arten der Untersuchung von Verhalten und Entwicklung.

Schlüsselwörter: komplexe Systeme, Dynamik, Veränderung, Sprache

In our daily lives we seem to find it difficult to live with constant change and to need the comfort of routines. We deny 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 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. The 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. Complex systems theory, in contrast, embraces change, focuses on change and makes change central to theory and method.

As a scientific theory, complex systems theory is fairly new (although it has roots in earlier general systems theory) and has seen its major development in the biological sciences, where it has supported a growing focus on the dynamics of whole systems. From its early days, complex systems theory (also then talked about as complexity or chaos theory, see Larsen-Freeman 1997) offered a compelling approach to describing and explaining real-world phenomena, even though the techniques of partial differential equations underpinning theory development were inaccessible to non-mathematicians. The descriptions of systems with many different elements in continuous flux and how they change over time seem to resonate with the problem spaces of applied linguistics. A language learning community can be thought of as a complex system, as can the brain/mind of an individual language user, and conventional ways of thinking of language as a system can be extended to seeing language as a complex system. Complex systems theory seems to make better sense of our experience as applied linguists and to offer fascinating new tools for thinking and for research.

What are complex systems?

Complex systems are composed of elements or agents that are of many different types and that interact in different ways. Complex systems are dynamic: the elements and agents change over time, but crucially so also do the ways in which they influence each other, the relations among them. Complex systems are open rather than closed; energy and matter can come into the system. The dynamic nature of element interactions and the openness of a system to the outside lead to non-linearity, which in complex systems theory signifies that the effect is disproportionate to the cause.

A city can be seen as a complex system, composed of people, places, routes and activities. These elements and agents of the system interact in multiple and changing ways. For example, people live, shop and work in certain places as a result of family history, transport systems, economic and many other factors. Over time, patterns of living change as these factors evolve. Seen as a system, the city self-organises and adapts in response to changes. The city system has non-linear dynamics and may display relatively sudden shifts in patterns of living. For example, global changes in economic activity may lead to empty warehouses and factories which, combined with rising house prices, may lead to regeneration of the city centre as the empty warehouses are converted into apartments for young single people; this new city centre population supports new entertainment and leisure facilities and requires changed public transport. The dynamics of the city as complex system produce the emergence of a new phenomenon which is called "city centre living".

Other examples of complex systems include economic and financial systems, transport systems, population systems, ecological systems such as a forest or an atoll, and neural systems. Similar processes of self-organisation, adaptation and emergence can be seen in each of the very different systems, leading to the suggestion that complex systems theory can work as a 'supra-theory' (Baake 2002) with the same principles of system behaviour and similar types of system change applicable to all systems, including those of concern to applied linguists. It remains for us as authors a live issue as to whether, in adopting complexity as a supra-theory, we claim that real-world systems are actually complex systems with the mathematical constraints and requirements that entails, or whether we are invoking something more akin to metaphor or analogy: we do not claim that the systems under consideration can be categorised definitively as complex but rather than they can be "seen as" complex systems.

A complex dynamic system moves through a sequence of states, or modes of behaviour; some of these may be quite stable states where the system maintains the same kind of behaviour over some time; others may be highly unstable, with the system changing rapidly from one state to another. A stable state is called an 'attractor', since it seems as if the system is attracted into this state. A helpful example to illustrate the idea of a system moving through a succession of more or less stable states is that of a horse and its rider moving together in a field or arena (Thelen and Smith 1994: 62–3). Because of its shape and structure, a horse has four different ways of moving, or 'gaits'. The English language has specific verbs to describe these different types of movement, from the slowest to the fastest: *walk, trot, canter, gallop*. What is more, there is a conventional collocation used to describe a change to a faster type of movement: *the horse broke into a trot/canter/gallop*. The movements are not just faster versions of the same gait, but distinctly different, with a change in how the pairs of back and front legs move relative to each other. As a walking horse increases speed, there comes a point where it shifts into a new gait: *trotting*. There is usually some factor external to the horse that leads to the increase in speed, often a rider. The horse is one element in a larger system that includes the rider and aspects of the context, such as the surface and weather conditions. The horse-and-rider system displays both types of change that can occur in complex systems. On the one hand, the state of the system can change continuously within a gait, as when the horse trots faster or more slowly. On the other hand, the system changes discontinuously when the horse reaches particular speeds that prompt a shift to a new gait. Discontinuous changes like this in a complex system are called phase shifts or bifurcations**.** The states of the system before and after a phase shift are very different.

Phase shifts in applied linguistic systems might include shifts in pronunciation in the history of a language (Bybee 2006), restructuring in the learnt grammar of a language (McLaughlin 1992), sudden increases in vocabulary size in early first language acquisition (Meara 1997), or the appearance of a new genre in the language use of a speech community.

Before leaving the horse-and-rider example, we should note two other key features of complex systems highly relevant to our discipline. The environment or context is not external to the complex system but is part of the system, just as the moving horse is part of a complex dynamic system that includes aspects of context or environment. The stable attractors of a system, e.g. the horse in trotting mode, do not represent totally fixed behaviour but rather stability with some degree of variability: a horse can trot faster or more slowly. The relation between stability and variability becomes an important aspect of system dynamics, reflecting potential for more dramatic change or for long-term stability.

Visualisation of a complex system invokes the powerful image of a landscape with hills and valleys over which the system roams, leaving behind its trajectory. The landscape (or phase space) represents the probabilities of various modes or phases of system behaviour, and a path is carved out by a particular system as it moves from one mode to another. The size and shape of hills and valleys represent the probability that a system will enter a particular mode and, having once entered it, the probability that it will remain there. A valley with steep sides shows a stable mode of behaviour that will be difficult to move out of. A hill shows an unstable mode of behaviour that will require effort to maintain for any length of time. The valleys are attractors in the system, preferred modes of behaviour that the system tends to return to. A system can move along calmly, avoiding deep valleys and steep hills, but may suddenly move into one of the attractors in a more dramatic phase shift. The system is changed by its move into the attractor – new patterns emerge. Around the edge of some attractors is an area of phase space that represents highly variable modes of behaviour – Kauffman's "edge of chaos" (1995). Here, the system is highly unpredictable as it adapts rapidly, or self-organises, in response to a changing landscape.

In the book, two chapters explaining the nature of complex systems and their dynamics are followed by chapters applying these ideas to four areas of applied linguistics. We suggest the types of systems that can be found, their agents and elements, and their patterns of change over time. We re-interpret earlier work in the four areas through the complexity lens and outline what is opened up by this new perspective. A synopsis of each follows below.

Complex systems in language and its evolution

A complexity view of language dissolves dichotomies that have been axiomatic in linguistics, such as the ones between synchonicity and diachronicity or *langue* and *parole*, and reveals insights into the nature of language and its learning that these dichotomies have obscured. Dichotomising has contributed to static conceptualisations of language. Instead, we take language as a dynamic system that is being continually transformed by use. A language at any point in time is the way it is because of the way it has been used, and any use of language changes it. Thus, if language is viewed as an open, continually evolving, system rather than a closed one, then concepts such as "end-state" grammars become anomalous since open systems are constantly undergoing change, sometimes rather rapidly.

Forms in language are therefore to be seen as epiphenomena of interaction. They are emergent stabilities or attractor states in the dynamic system, where the state of a complex system refers to current patterns of behaviour, not to stasis. As emergent forms are taken up as adaptations by members of a speech community, some become more privileged than others and endure or, at least, change at slower rates than others. Privilege might be bestowed because certain structures have greater semantic or pragmatic utility or because they are associated with certain prestigious dialects or because of their specialized register or function. Even though language is open to all sorts of influences and is continually changing, it still somehow maintains an identity as the "same" language. Within a given timescale, social forces and motivation around national or community identity play a role in "maintaining" a language in the same way that the cells of the human body are constantly being created and sloughed off while the person from all appearances perseveres.

At the level and scale of the individual user, language in use is "soft-assembled" (Thelen and Smith 1994); it is a make-do extemporaneous response to the communicative pressures at hand. When two individuals' systems interact and adapt to each other, the state space of the systems changes as a result of co-adaptation. On a longer time-scale, at another level, across a speech community, these local interactions can transform the state space of the language system. The self-organizing property of complex systems, when applied to language, suggests that we do not need to view the emergence of complex rules as the unfolding of some prearranged or innate plan (Tucker and Hirsh-Pasek 1993: 364) because all that is required to account for complexification is a sensitive dependence on initial conditions and a context in which the system can adapt and change. Any structure arises in a bottom-up fashion from frequently occurring patterns of language use rather than as *a priori* components of fixed, autonomous, closed, and synchronic systems. In this way complexity theory provides an explanation for the emergence of macroscopic order (indeed even that which has sufficiently stabilized to be labelled French or English) and complexity from microscopic behaviour of language speakers (Port and van Gelder 1995: 29).

Such an explanation extends to the phylogenetic evolution of language. Linguistic structure emerges as a complex, adaptive system from the verbal interaction of hominids attempting to communicate with each other. Individuals organize lexical items into constructions, and if the constructions are learnable and frequent, then their use will spread throughout the community and become grammaticized (Bybee 2006). The interaction modifies the grammatical structures to fit the brain rather than requiring the

brain to evolve a genetically based mechanism designed to specify the form of the language (Lee and Schumann 2005).

Complex systems in language development

In elaborating a complex systems perspective on first and second language development, we take issue with nativist views, suggesting that a complex systems supra-theory offers more convincing explanations. We deliberately differentiate the terms 'acquisition' and 'development'. While the former is commonly used in the research literature, from a complexity perspective, 'development' is preferred. A complex systems view of language rejects the notion of language as something that is taken in – a static commodity that one acquires and therefore possesses (Larsen-Freeman 2002). Instead, we see language as much a process as a product, something in which one participates (Sfard 1998). Because language is a dynamic system, continuously changing, its potential too is always being developed, and it is never fully realised. Further, the use of the term 'development' is meant to recognize the fact that language learners have the capacity to create their own forms with meanings and uses (morphogenesis) and to expand the meaning potential of a given language. Finally, a language is not a single homogeneous construct to be acquired; rather, in the complex systems view that sees language as resulting from use, the centrality of variation and speakers' choice of lexicogrammatical constructions within a social context is foregrounded.

Complex systems approaches have much in common with emergentism (Ellis and Larsen-Freeman 2006). Both call for some genetic prerequisite to first language development but differ hugely from nativist stances. The genetic contribution is not seen as a matter of transmitting the principles of universal grammar through an organ in the brain. Rather it is seen as consisting of more domain-general capacities (e.g. the ability to imitate, to detect patterns, to notice novelty) and perhaps even the social drive to interact with conspecific caregivers, which may exist in other social animals, but be less powerful than that which drives humans (Lee and Schumann 2005).

Nativists believe that the flow of language from adult to the child underdetermines the structure that is required for a child to produce it; they thus conclude that the only viable explanation for the shift from a child to an adult mental system is to assume that the complexity is genetically pre-specified. From the perspective of complexity theory, language development can be seen to stem from the emergence of new forms in a complex system.

What is striking from a complex systems view is that the language learning child produces language that is richer or more complex than the language addressed to her or him (van Geert 2003: 659). This is a commonly observed property of all complex systems, in which complexity emerges not from input to the system nor from an innate blueprint, but rather from the creation of order, as happens when a creole develops from a pidgin. Viewing language development as self-organisation or structure formation in a dynamical system means that different learners may develop different language resources even when the ambient language is similar (Mohanan 1992).

With complexity as a supra-theory not only do we get a more variegated portrayal of language, we also get a different, more emic, account of its development. Learning is not the taking in of linguistic forms by learners but the constant adaptation of their language resources in the service of meaning-making in response to the affordances that emerge in the communicative situation.

The assumption of monolinguals speaking the same language acquiring an equally homogeneous target language is another convenient reduction that has to be discarded in a complex systems approach. From a complex systems perspective, language in use in the multilingual situation, which has been common in the past and likely will become almost universal in the future, is not a matter of translation between totally discrete and distinct language systems. For example, Meara's (2006) bilingual lexicon modelling, which allows for some interaction of two lexicons (at even a low level of "entanglement"), shows how general properties of lexical networks can emerge such that even relatively small amounts of input in one language can effectively suppress the other language without building in some special "language switch". It is a misconception to see a bilingual speaker as two monolinguals joined together, a point made clear in Herdina and Jessner's (2002) dynamic model of multilingualism.

Neither is it the case that the two systems converge. Although progress in SLA has traditionally been viewed as the degree to which a language learner's interlanguage aligns with the target language, it should be acknowledged from a complex systems view that there will never be complete convergence between the two systems. For one thing, there may be little reason for a learner to attempt to emulate native-speaker norms (Cook 2002; Seidlhofer 2004), and for another, there is no fixed, homogeneous target end state to language evolution or development (Larsen-Freeman 2005). That does not mean, of course, that forms cannot become entrenched (MacWhinney 2005), whereby with repeated use they become more fixed. This is particularly true when the L2 develops at first as parasitic or dependent on the L1.

In any event, what is psycholinguistically real language for learners is not identical to what is descriptively real for linguists. It may, instead of being governed by rules, be "pastiches of various kinds of item-based constructions" (Tomasello 2000: 76). What we see in second language acquisition is the waxing and waning of such constructions or patterns. Language learning is not a linear, additive process, but an iterative one (de Bot, Lowie and Verspoor 2007), which is context-dependent and variable. There is no single context; individual agents find their own environments and reconstruct them through their activities. Every organism is changing and determining what is important in its world – creating and remaking the world in which it lives (Lewontin 2000). For this reason, what generalizations exist at the group level often fail at the individual level. Different learners are following different routes to SLA, although even these are patterned (Larsen-Freeman 2006). This view of development might be better served by conceiving of it as a web rather than a developmental ladder (Fischer, Yan and Stewart 2003), development being seen as a complex process of dynamic construction within multiple ranges in multiple directions. While it is possible, of course, to separate context and person for the purpose of analysis, such separation requires the untenable assumption that the two are independent (van Geert and Steenbeck 2005).

Complex systems in discourse

While the language system can be considered as a complex dynamic system, we can also conceptualise discourse more broadly as a complex system in which several individuals interact over time in language-using processes. Face-to-face conversation is taken as the primary type of language use from which all others spring (Clark 1996; Schegloff 2001). In developing a complex systems view of discourse, we work from Clark's premise that face-to-face conversation must be characterised first and that characterisation used to build descriptions of other discourse settings, that require specialised skills and some process of learning beyond face-to-face conversation, including literacy events that involve writing and reading, and learning settings such as the language classroom.

Each person engaged in face-to-face conversation can be seen as a complex system of interacting sub-systems of continuous ideational, emotional and physical activity, from the cellular and neural levels upwards to the physical being encountered in the conversation. This individual comes to the conversation from, and with, his or her ontogenetic history and will move on from the conversation, changed in some way by participating in it. In conversation, speakers soft-assemble their contribution, through the

adaptation of these sub-systems in the moment and "on the fly" (Thelen and Smith 1994). What we see and hear happening in a conversation are the observable traces of interior physical, emotional and cognitive sub-systems continually adapting in soft-assembly to the discourse environment, which includes the topic, oneself and 'the other'. For example, the movement of tongue, mouth and jaw in a person's speech production system "can compensate adaptively for disturbances or perturbations encountered by one part of the system by spontaneously readjusting the activity of other parts of the system" (Saltzman 1995: 157). At a cognitive level, there is two-way feedback and adaptation between the grammar of the language being used and the idea being talked about (Slobin 1996), and between the ideational/conceptual or pragmatic and lexical choices that speakers exercise.

Speakers often sub-consciously adjust their physical posture and position in response to what they observe about their interlocutor's posture and position; if one person in a group places their hands behind his or her head, the likelihood is that other members of the group will follow this action. This kinaesthetic mirroring reminds us that the systems at work in conversation include physical systems as well as systems of language.

Each person is also a social being and comes to a conversation as a member of various socio-cultural groups (collectives and aggregates) and having played a range of roles within groups: families, school classes, political groups, peer and friendship groups, speech communities, etc. A person's history of interactions in these various groups builds up collections of experiences through other conversations and through other events that contribute to the language, cognitive and affective resources available to be drawn on in future talk. Each of the collectives or groups that people belong to can be seen as complex systems (Sealey and Carter 2004), in which individuals or smaller groups function as agents, and from which emerge 'discourses' of various types (Gee 1999), and which have trajectories or histories as groups.

Important and far-reaching implications follow from seeing speakers within a conversation not as autonomous systems but as part of a larger coupled system, i.e. a dialogic view of discourse. The first implication is that language used in dialogue is a property of the coupled system of the conversation and not a property of the individual speakers. While an individual has 'a latent potential' to use language, it is only in a suitable discourse environment that this potential is actually expressed through the talk, in that environment (Beer 1995). People have a latent potential to engage in discourse or what we also call their language (and other) 'resources'. The second implication, which follows from the first, is that language resources are virtual and do not exist independently from their

manifestation in use. All we have – as researchers collecting data, as testers or as teachers – is language-using behaviour in particular contexts or discourse environments. Each occasion of language-using behaviour is dependent on the specific discourse environment, and conversely each discourse event is unique.

Taking a complexity perspective motivates a search for changing patterns of stability and variability in the systems under scrutiny. Several emergent discourse phenomena arise from face-to-face talk. The trajectory of a face-to-face conversation across its phase space landscape will feature gentle attractors in the shape of routinised sequences and pre-sequences of the sort described in conversation analysis. Local routines help reduce the complexity of the system by narrowing down choices for participants. These kinds of joint action do not just happen "out of the blue" but take the form they do partly because people come to talk with expectations derived from previous experiences as members of socio-cultural groups. These socio-cultural forces have pre-shaped the landscape on which conversation takes place and so work 'downwards' on to the microgenetic timescale. The IRF pattern characteristic of talk in classrooms, with its three parts of teacher Initiation – student Response – teacher Feedback (Sinclair and Coulthard 1975; Mehan 1979), can be seen as an attractor on the classroom discourse landscape that shows variability around a very stable form and that has arisen through adaptation in response to particular classroom contingencies. The discourse system will tend to return to the IRF attractor because it is a pattern that works; it is a preferred behaviour of the system.

In addition to patterns of classroom talk, that stabilise in particular classrooms and across classrooms, other stabilities in the dynamics of discourse include lexical-conceptual pacts (Brennan and Clark 1996) and metaphors that stabilise over the timescale of a discourse event (Cameron and Deignan 2006). Further discourse phenomena emerge upwards in level and in timescale from face-to-face talk and belong to discourse understood as "a broader range of social practice" (Schiffrin et al. 2001: 1) as speech genres (Bakhtin 1981, 1986). Genres are themselves dynamic and continue changing through use. Their stability combines with variability, and it is this variability that provides the potential for growth and change. Genres that are changing and adapting fast and frequently may indicate that the discourse system is "at the edge of chaos", about to move into a new attractor or to dissolve and reform in some other shape altogether. Such is the case, for instance, with text messaging. First people tried to text the way they wrote, then adapted, and for a short time people were abbreviating to things like "C U 2morro". However, then the technology changed to include predictive spelling, and now texts come with full words, spelled even more accurately than the texters might have written them. Who knows where

technology will drive the dynamics of the system next? Complex systems theory reminds us that understanding variability is crucial to understanding dynamics, and that understanding genres must include understanding their flexibility as well as their stability.

Complex systems in the language classroom

A description of language that naturally flows from a complex systems perspective is one that sees a dynamic and evolving system with meaning and use as central. It emerges out of a socio-cultural–cognitive–historical context. It is discourse- or text-based; this is where its in-time dynamism is most apparent. Its descriptive units are constructions, form–meaning–use composites, emergent stabilities of varying sorts and sizes. What then of the learning and teaching of such a system in instructed contexts?

A complex dynamic systems perspective on the language classroom highlights interaction across interconnected levels of organisation – from individual minds up to the socio-political context of language learning – and interconnected timescales – from the minute-by-minute of classroom activity to teaching and learning lifetimes.

The dynamic systems that pervade and envelop the language classroom are continuously changing and adapting, sometimes shifting dramatically from one mode of behaviour to another, sometimes hovering flexibly "on the edge of chaos". We describe the language classroom as a complex system, not reducible to its component parts, but in which the parts contribute to the whole while also being formed by the whole. A systems perspective can help understand language classroom problems and issues and suggest how to intervene to improve learning.

Having argued that language is a complex dynamic system, always changing, always adapting and evolving as it is used, second or foreign language learning presents us with an intriguing question. How is a dynamic, constantly changing language to be taught and learned? It seems inevitable that the complexity of the dynamic system that is a living language will need to be managed for the purposes of learning and teaching. The language that is the aim and content of instruction is a moving target for learners. Moving targets are difficult to hit, so students must be assisted in several ways so that they can cope with the dynamism and complexity of the target language. First, though, educators need to start with a suitable description of the target. This has always been the case, of course: an education system that wishes to teach a foreign language uses or constructs a description of the foreign language to serve as the target or goal of language learning in schools and colleges. However, the description (and

samples drawn up according to it) needs to be of a particular kind from a complex systems perspective. Then, although thoughtful descriptions are extremely useful as a starting point, they are not in and of themselves, sufficient. They need to, firstly, inform the selection or construction of language samples with which to engage learners. Secondly, students need to become aware of change and variation in the living language, in a manner that is commensurate with their level of development. Thirdly, all the awareness-raising in the world remains inadequate if students do not have the experience of soft-assembling their language resources, a process that Larsen-Freeman (2003) has referred to as "grammaring".

A complex systems position holds that input cannot be enough for learners to produce the target language. Students need to experience the second language as a dynamic system, shaping their complex dynamic systems of the new language through working with it, soft-assembling what they can from their resources for different tasks and purposes. Each experience of soft-assembly leaves a trace or changes the latent potential of the learner. To see how a complex systems perspective describes language learning, we take the example of language learning tasks. The process of completing the task is described by the complex dynamic system of language use moving across a task-based landscape, where the hills and valleys are constructed by the nature of the task. In a view of task as static frame, the unfolding task action is reflected in the trajectory of the system across a stationary landscape. However, while such a representation might work with a very rigid task, such as colouring in a picture through dictation or reciting a poem learnt by heart, language tasks designed to engage and involve learners by giving them some degree of choice are better described with an evolving landscape that represents coupled, co-adaptive systems. In these tasks, the group talk changes the task as they begin to do it, and the task is constructed through the doing of it. As the task proceeds, so the landscape of potential shifts and changes. For example, a pair of learners engaged in a "spot the difference" task may adapt to each other and to the pictures they are using, and evolve efficient ways of establishing differences. The idea of the evolving task landscape allows us to describe how learners may reduce the demands of a task – flattening the landscape – as an alternative to pushing across the landscape by stretching their language resources to meet those demands (Cameron 2003).

If we focus on what happens when language is used in the classroom, i.e. the systems in focus are classroom language-using systems, then once again all is dynamic: the learning, the discourse, the activity, the language and the interlanguage. At this point, an essential dimension of teaching is the provision of feedback – implicitly or explicitly, through teacher-initiated, peer-initiated or self-initiated means, in a manner that is affectively and

socially supportive while being judiciously targeted. Teaching does not cause learning but rather becomes the management of learning (Larsen-Freeman 2000) – corralling the development of the learners' ongoing system, continually nudging it into a trajectory towards an acceptable attractor.

Describing classroom activity in terms of interacting complex systems helps see how teachers and students can co-adapt to stable patterns of teaching behaviour, motivation and participation that may not always be supportive to learning. Intervention to increase learning is a perturbation to a system stuck in an unhelpful attractor, attempting to move it into new paths on its landscape of potential.

Taking a complex systems perspective involves some major changes in how we see aspects of the language classroom: we find that there can be no replication, no static independent and measurable "things" to measure, test, evaluate or codify, no limits to what might be relevant in understanding classroom activity and behaviour. This expansion is somewhat compensated for by the powerful apparatus for description and explanation of complex systems that is described in the final chapter of the book.

Researching complex systems in applied linguistics

Analysis or investigation of discourse from a complex systems perspective does not require us to throw away other approaches and their techniques. Indeed, multiple types of analysis are needed to work with information from systems at different scales, and new ways of blending methods are needed to explore simultaneous activity on several scales.

In the final chapter of the book, we describe and discuss research techniques compatible with complex systems approaches, including computer simulation and modelling. We examine the possible contributions to blended research methods of corpus linguistics, conversation analysis, microgenetic techniques and adaptations of SLA methods. A set of methodological principles for researching language and language development is drawn up, and we debate the issue of validity in this new perspective.

The book aims to pass on our conviction that complex systems theory offers a potentially rich and fertile supra-theory for applied linguistics, and to provide a stepping stone to further development and a larger frame for understanding.

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