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CHAOS / COMPLEXITY THEORY IN SECOND LANGUAGE ACQUISITION

Nasrin HADIDI TAMJID*

Abstract: System theory explores items in terms of their internal connectivities (interactions) and external relationships with their surroundings. It is argued that EFL research should be built on recent advances in scientific thinking and adopt systems theory for the purposes of investigating the English language classroom so that a more comprehensive picture of the factors involved in learning can be drawn. Unlike some traditional scientific approaches that analyze systems in isolation, chaos / complexity theory (C / CT) considers the synthesis of emerging wholes of their individual components. From unpredictable interactions larger structures emerge, taking on new forms. In this article, a brief look at chaos / complexity theory and its application on second language acquisition as a dynamic and complex process is evaluated. While doing that, Larsen-Freeman's (1997) work is used as the main text for discussion.

Keywords: chaos, complexity, theory, second language, acquisition

Özet: Sistem kuramı, ögeleri hem kendi içinde hem de etrafında bulunan diğer ögeler ile olan ilişkisi bağlamında inceler ve açıklar. Alanda yapılan son çalışmalar, yabancı dil öğretiminin bilimsel gelişmeler ışığında şekillendirilmesinin ve sistemler kuramının da alana uyarlanmasının gerekliliğine işaret etmektedir. Ancak böyle bir yol izlendiği takdirde öğrenme ile ilgili olan tüm ögelerin daha kapsamlı bir görüntüsü elde edilebilir. Sistem analizini değişkenleri göz ardı ederek yapan geleneksel yöntemlerin aksine, Kaos / Karmaşa Kuramı farklı bileşenlerden oluşan bütünselliği çalışır. Tahmini mümkün olmayan ögelerin bileşeninden daha büyük oluşumlar, farklı yapılar ortaya çıkar. Bu çalışmada kaos / karmaşa kuramı ve bu kuramın ikinci dil öğretimine uyarlanması ele alınmaktadır. Makalede, Larsen-Freeman'ın (1997) çalışması temel alınmıştır.

Anahtar Sözcükler: kaos, karmaşa, kuram, ikinci dil, edinme

1. INTRODUCTION

Teachers have always known that the language classroom is a system; and that teachers and students together create a mini-society, with its own characteristics, properties, roles, restrictions and expectations. Until qualitative research appeared, however, the method of researching this learning environment was to identify and examine contributory factors in isolation, in the manner of experimental science. It was hoped that objective investigation of isolated parts would reveal methods of more efficient and effective teaching. This approach was mainly based on the physical sciences which have since moved on to a different view of reality, however, and in seeing the universe and its components as complex dynamic systems (Finch, 2002).

Systems theory provides a means of exploring items in terms of their internal connectivity / interactions and their external relationships with their surroundings. In view of these considerations, it is argued that EFL research should be built on recent advances in scientific thinking, and should adopt systems theory as a means of investigating and describing the language class. In this way, a more comprehensive picture of the factors involved in learning can be drawn. Looking back at the history of education, it can be seen that the ancient Greek and Chinese philosopher-educators defined education holistically, insisted on the education of the whole person, and aimed at raising awareness of individuals' positions in the universe. Later, these views were modified by some Renaissance thinkers, and then a mechanistic, cause-and-effect view of the universe appeared, following the Industrial Revolution. In this world-view, learning was seen as a mechanic process. This eventually gave birth to a behaviorist school of thought in which a person was seen as a machine who gives predictable responses to the given stimuli. According to this view, the role of language research was to discover appropriate stimuli which would predictably trigger the response of effective language learning. This approach mirrored the view of contemporary scientists that if the position and velocity of every atom in the universe could be known, then the future could be predicted with certainty. This was Laplace's claim that scientists can measure the position and velocities of all particles in the universe (Larsen-Freeman, 2002).

Relativity and quantum mechanics changed this view in the 20th century, when it was shown not only that the position and the velocity of atoms could not be observed at the same time, but also that atoms could be in two different places all at once (Horgan, 1996, cited in Finch, 2002). Heisenberg's uncertainty principle, in quantum physics, was an attempt to describe the limits to which anything at the quantum or subatomic level could be known for certain (Larsen-Freeman, 2002). Labov's paradox added another dimension when it became clear that the very act of observing electrons forced them to choose a state and location; prior to this, they existed in indeterminate states (Finch, 2002). In terms of current complexity theories, classical (Newtonian) physics was unable to solve a problem of fundamental interest in physics: the "Many-ball problem" (Brown, 1972, cited in Finch, 2002), in which bodies not interacting in a simple linear fashion could not be described according to the Laws of Motion. And finally, the more recent discovery of another kind of unpredictability in nature, i.e., the unpredictability which accompanies much larger, more complex, nonlinear systems, discredited Laplace's claim regarding the predictability of the position and velocities of all particles in the universe (Larsen-Freeman, 2002). In fact, it was found that with certain phenomena, randomness was inherent. As a whole, new insight into physics, mathematics and biology pushed the boundaries of Newtonian science, and studies of isolated structures, nonlinear equations, and the like, toward the emergence of the chaos and complexity in sciences (van Lier, 2004).

Taking a more holistic view of reality, physical sciences have recently acknowledged new fields, e.g. chaos and complexity theory, and have discarded the isolationist methodology of researching individual factors out of context. According to this view, it is the connectivity / interactions inside a system that determine its character. Unlike traditional scientific approaches that analyze systems into their components and study them in isolation, chaos / complexity theory (C/CT) considers the synthesis of emergent wholes from studying the interaction of the individual components. From these unpredictable interactions, larger structures emerge, taking on new forms, and it is assumed that the whole is greater than the sum of its parts. If the researcher is to investigate the characteristics of a natural system, it is necessary to look at the subject in its own context and to describe the interactions that take place between the subject and its environment. Finch (2002) clarifies the point with an example: consider a tree; the tree can be defined as a living organism which lives with other living organisms (insects, birds, animals, plants, bacteria), and which interacts with the soil, other trees around, and the climate. In order to understand the tree, the researcher needs to take all of its surrounding and interactions into consideration, rather than studying its parts (e.g. a leaf) in isolation. The tree is more than the sum of its constituent parts, since the way it grows and interacts with its environment determines the shape it takes and its success as a living system.

Larsen – Freeman (1997) defines chaos/complexity science as the study of complex, nonlinear, *dynamic* processes as they occur in the physical world. It is the "science of process rather than state, of becoming rather than being" (Gleick, 1987, p.5, cited in Larsen – Freeman, 2002). Capra (1996, cited in van Lier, 2004) emphasizes the need for studying 'processes' rather than causal mechanisms or fixed structures. Van Lier (2004) notes that when the patterns are 'sedimented' into structures, these structures channel, guide, delimit the processes while stabilizing the patterns of relationship. In this present article, a brief look at chaos/complexity theory and its applications to second language acquisition is discussed.

2. FEATURES OF COMPLEX NONLINEAR SYSTEMS

Chaos / complexity scientists have identified a number of describing features of complex nonlinear systems. The main features of complex nonlinear systems are known to be "*dynamic, nonlinear, chaotic, unpredictable, sensitive to initial conditions, open, self-organizing, feedback sensitive* and *adaptive*" (Larsen-Freeman, 1997, p. 142). In addition to these, such systems have *strange attractors*, which have *fractal* shape. These features are briefly discussed below.

Chaos / complexity theory is concerned with the behavior of *dynamic* systems, i.e., the systems that change in time. The study of chaos (the randomness generated by complex systems) is a study of process and becoming, rather than state and being. Dynamic systems move through space / time, following a path called an *attractor*, i.e., the state or pattern that a dynamic system is attracted to (Larsen-Freeman, 2002). The interesting point here is that no cycle ever follows the same path or overlaps with any other cycle. de Bot (2005) claims that the main characteristics of dynamic systems are that all variables interact and this continuous interaction keeps changing the system as a whole over time. Briggs and Peat (1989, cited in de Bot, 2005) argue that smaller systems are part of greater systems; in other words, complex systems may be *nested*. There seem to be different nested levels, with different descriptions, which all have originated in the same way.

Chaos / complexity theory focuses on *complex* systems. To Larsen-Freeman (1997), systems are complex for two reasons. First, they often include a large number of components, and second, the behavior of complex systems is more than a product of the behavior of its individual components. In fact, the outcome of a complex system emerges from the interactions of its components; it is not built in any one component. As such, the *interactions* (connectivities) amongst the components in the system are the essential building blocks of the unpredictable structures that may emerge in the future. The "avalanche effect" predicts that minor events can have outcomes exceeding their proportion and informs us greatly on understanding systems by and large. As Finch (2002) articulates, a pebble thrown onto a pile of pebbles on a mountain can trigger a landslide and a butterfly flapping its wings in South America can initiate a hurricane in Puerto Rico. These examples tell us that the final "global" outcome of an event, then, is predictable. The exact moment of occurrence, however, is unpredictable at the "local" level. Thus, we can predict the reliability that it will rain in a particular city on a given day (global level), but we cannot predict that it will rain in a given playground in a given school due to many limitations.

Complex systems attain energy from their environments to reorganize themselves so that they become more complex (Larsen-Freeman, 2002). According to the second law of Thermodynamics, entropy, lack of order is inevitable in systems since they inevitably move towards equilibrium with no regular form or pattern. However, as Larsen-Freeman notes, at the end of the last century, it was found that living systems evolved from disorder to order. Now, if the dynamic system is open, and is far from the state of equilibrium, spontaneous restructuring occurs in large scale; if it is near equilibrium, it shows certain stability. As open systems evolve, they increase in order and complexity by absorbing energy from the environment. This flow of energy forces the system away from its initial disorder and chaos towards order and complexity (Churchland, 1988, cited in Larsen-Freeman, 1997).

Another feature of complex, nonlinear systems is that they are *feedback sensitive* (Larsen-Freeman, 1997). Darwin's great insight was to posit that a basic feedback mechanism was built into nature, namely, natural selection. Positive feedback kicks evolution forward (Briggs, 1992, cited in Larsen-Freeman, 1997). As complex systems in biology naturally select and self-organize, it is supposed that they are *adaptive* (Kauffman, 1991, cited in Larsen-Freeman, 1997). Moreover, the dynamic, complex systems are *non-linear*, which means that the effect is disproportionate to the cause (Larsen- Freeman, 1997). This means that a cause of a particular strength may not result in an effect of equal strength, for example, a rolling little stone can trigger an avalanche. As it was mentioned before, as these systems are sensitive to initial conditions, there is unpredictability inherent in such systems (Larsen-Freeman, 2002). The sensitivity to initial conditions means that a slight change in initial conditions can have great implications for future behavior. A simple trigger might be enough to put the entire system into a chaotic state. It seems that complex nonlinear systems enter into chaos unpredictably. Although the chaos may seem predictable, the onset of this period of complete randomness is in fact unpredictable (Larsen-Freeman, 1997). It may be that complex systems behave orderly until a critical point, in which they go chaotic. Following this chaotic period, they may become orderly again (Briggs, 1992, cited in Larsen-Freeman, 1997).

Apart from all these, dynamic systems are attracted to paths that can be traced in time and space. Larsen-Freeman (1997) notes that a complex nonlinear system has a *strange attractor* because although its cycle repeats itself, no cycle follows the same path or overlaps with any other cycle. What is common to all strange attractors is that they have *fractal* shape such like "a geometric figure that is self-similar at different levels of scale" (p.145). An example is the tree; in spite of the fact that trees have different shapes, we can easily distinguish a tree from other objects as we zoom at any level of magnification, it always reveals a reproduction of itself.

3. COMPLEX NONLINEAR SYSTEMS AND LANGUAGE

There seems to be much in common between language and complex nonlinear systems. Language can be viewed as a *dynamic* system. This can have two usual interpretations. The first common meaning is that language can be described as a collection of static units, but their use in actual speech involves an active process (Larsen-Freeman, 1997). The other common meaning of 'dynamic' is equated with growth and change. Rutherford (1987, cited in Larsen-Freeman, 1997) suggests that an organism is a better metaphor for language than a machine, because machines are constructed, but organisms grow. Language, seen synchronically or diachronically, is undeniably dynamic (Larsen-Freeman, 1997).

Moreover, as Larsen-Freeman (1997) puts it, languages undergo nonlinear changes diachronically. New forms enter and leave the language in a non-additive and non-predictable way. Different speakers may use different forms to mean the same thing. The best thing we can do is to explain a change after its occurrence, without making exact predictions of what change will occur next. Being inspired by the chaos/ complexity theory, Larsen-Freeman has a third interpretation of the word 'dynamic' which focuses on the assumption that there is no difference between the current use and change/ growth because they are isomorphic processes. As this view suggests, any time a language is used, it changes. Diller (1995, cited in Larsen-Freeman, 1997) asserts that, "a language such as English is a collaborative effort of its speakers, and changes in the system of English are 'emergent'" (p.116). This view suggests that language grows and organizes itself from the bottom up and in an organic way, as other complex nonlinear systems do.

Larsen-Freeman (1997) asserts that other qualities of dynamic systems also hold true for language among which the first one is *complexity*. Language is complex and composed of many different subsystems which are all interdependent. Regarding *sensitivity to initial conditions*, language is no exception. Larsen-Freeman calls Universal Grammar (UG) the initial condition of human language, which contains certain principles that constrain the shape of human languages. These principles have impact on defining the 'strange attractor' of human language. Mohanan (1992, cited in de Bot, 2005) posits UG as 'fields of attraction' that permit infinite variation in a finite grammar space. Nonetheless, unlike in Chomskyan UG, these principles do not depend on clear 'yes' or 'no' choices, that is, 'parametric choices', but on general tendencies or fields *of attraction* that languages may exhibit (de Bot, 2005). Hence, the fields of attraction will define the most natural and unmarked state that a system is attracted to (Larsen-Freeman, 1997). Considering the fractality of complex nonlinear systems, language is also fractal. Winter (1994, cited in Larsen-Freeman, 1997) argues that all information systems need to be fractal in shape in order to make them comprehensible and thus shareable.

4. COMPLEX NONLINEAR SYSTEMS AND LANGUAGE ACQUISITION

This new systems view of research focused on organization rather than isolation. Instead of dissecting the subject into parts and further examining these in isolation, it observed the organization of the interactions that held the parts together (Finch, 2002). Finch (2002) argues that human bodies as supra-organisms could be seen from this perspective as open systems which have ordered complexity, and continually receive input, and therefore do not conform to the second law of thermodynamics, which states that closed systems tend toward entropy. Van Lier (1996, cited in Finch, 2001) suggests that it is useful to consider the classroom as a complex system in which it is fruitless to search for casual relations. Larsen-Freeman (1997), drawing a number of chaos / complexity parallels in the language class, asserts that languages go through periods of chaos and order just like other living systems. In fact, she sees "many striking similarities between science of chaos/ complexity and second language acquisition" (p.141). According to Finch (2001), the educational context, and specifically the classroom, is considered as a complex system in which events do not occur in linear causal fashion, but in which a number of forces interact in complex, self-organizing ways, creating changes that are partly predictable and partly unpredictable. Applying the notions of chaos/

complexity to language learning can have a number of consequences for the way in which we think about ‘learning’. Van Lier (2004) notes that within a complex system, a large number of influences are present in a partially chaotic, that is, unpredictable way, and among all the interaction, a complex order emerges. This dynamic order provides affordance for active participants in the setting, and learning emerges as part of affordances are picked up and exploited for further action. Larsen-Freeman (1997) argues that SLA is as dynamic, complex, nonlinear system as are physics, biology, and other sciences. Although she does not think that teaching and learning are physical sciences, she asserts that a chaos/complexity theory lens helps us look at what we do in new ways. In fact, language learning is often viewed as an additive, linear process. We teach this piece and then that piece and we expect that our students will acquire them one by one.

Regarding the similarities between complex nonlinear systems and SLA, Larsen-Freeman (1997) emphasizes that language learning is a dynamic, complex, open, self-organizing, feedback sensitive, and constrained by strange attractors. The dynamism of SLA is seen in the ever-changing character of learners’ internal L2 grammars. It is complex because a multitude of interacting factors are involved in the SLA process. As Herdina and Jessner (2002, cited in de Bot, 2005) argue SLA, from a dynamic system theory, is reacting to external input and its entire organization changes with new input; it constantly reorganizes itself to obtain equilibrium, but even then it does not come to a complete standstill. Moreover, learning linguistic items is a nonlinear process, for example, you are learning the tenses, and you are doing fine; you learn the simple present, the present progressive, the simple past, and the teacher introduces the present perfect, and then, rather than making progress, your performance actually becomes less proficient, because you have added another tense and the system you have constructed implodes. However, as Larsen-Freeman (1997) argues, there are orderly periods followed often by periods of chaos. This happens when something new is introduced and students have to figure out how it fits into the system, or they have to revise their understanding of the system in order to accommodate their new awareness. Fortunately, through interaction with others, eventually, order is restored. That does not mean that what the student now produces is target-like, but a new interlanguage stage may have been reached. Larsen - Freeman (1997) concludes that the conceptualization of language as a fixed, static, atomistic entity is being challenged by one that is much more nonlinear, organic, and holistic.

Further the SLA process is open, that is, there is continuous input, and the interlanguage system is self-organizing. This means that there is restructuring in the interlanguage, the return to order. The restoration of order is promoted by the fact that the system is feedback sensitive. According to Larsen-Freeman, despite the similarities among interlanguages of speakers with different L1s, they are constrained by the strange attractors of their L1s, which can affect more than the strange attractor of English. What she emphasizes is that SLA is not a linear process, but full of peaks and alleys; learners are not speaking something that is deficient, but rather a language of their own. It is a creative process. But if the students’ interest does not wane and they continue to have fruitful exposure to the target language, things do move along and sort themselves out usually.

Larsen-Freeman (1997) believes that there are issues in SLA that can be illuminated by the chaos/complexity theory, for example, mechanisms of acquisition, definition of learning, the instability and stability of interlanguage, differential success, and the effect of instruction. She also suggests a number of potential contributions of chaos/complexity theory to various aspects of language and language acquisition. Van Lier (2004) also has added his interpretations from his ecological perspective to her suggestions. They argue that chaos/complexity theory:

1. Encourages a blurring of boundaries and dichotomies.
2. Warns against settling for simple solutions prematurely, as well as against rejecting contrasting viewpoints.
3. Provides some fresh light on SLA phenomenon.
4. Refocuses our attention in the light of emergent phenomena, foregrounding certain problems, and obviating others.
5. Discourages cause-effect –based theories.
6. Underscores the importance of details.

7. Reminds us to hold the whole and to find a unit of analysis that allows this.

What we can get from chaos /complexity theory is outlined by Brown (2000) as a summary of the lessons put forward by Larsen-Freeman (1997). According to this outline the following must be taken into consideration while researching:

a) Beware of false dichotomies, and look for complementarity, inclusiveness, and interface,

b) Beware of linear, causal approaches to theorizing. SLA is so complex with so many interacting factors that we cannot assign a single cause for it,

c) Beware of overgeneralization, and pay attention to details; the smallest, apparently insignificant factor can turn out to be very important, but on the other hand, beware of reductionism in thinking.

According to Larsen-Freeman (1997), languages go through periods of chaos and order, and their creative growth occurs at the border between these two, a region between order and complete randomness or chaos, where the complexity is maximal. This borderline between chaos and order has been termed *the edge of chaos* by Waldrop (1992, cited in, Finch , 2001). It is argued that systems at the 'edge of chaos's exhibit the most interesting behavior, such as information processing and creation. For Finch (2001), the concept of a classroom 'on the edge of chaos', that is, in a maximum state of learning, implies sensitivity to every variation in input, for example, the difference between a smile and a shrug of the shoulders on the part of the teacher, 'openness' to different types of new input, being 'adaptive' to changing learning needs and preferences, and 'emerging' of new learning structures. Larsen-Freeman (1997), using the metaphor of dropping penny, asserts that, in chaotic systems, it is not possible to know which penny will lead to development. The same applies to the development of interlanguage. She argues that in the development of interlanguage it is not clear which penny causes the great restructuring, however, it is at that point that creative growth is possible, that is, the edge of chaos. Larsen- Freeman (1997) states that a teacher should throw the system into initial chaos out of which will emerge a system that is in alignment with the target language. In conclusion, the chaos/ complexity theory supports a social participation view of SLA, without excluding the psycholinguistic perspective, and thus provides us with a wider perspective towards SLA, which encourages thinking in relational terms (Larsen-Freeman, 2002).

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* Islamic Azad University of Tabriz - IRAN, nasrin37@hotmail.com

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