Complex Dynamic Systems Theory (CDST) Approach in SLA
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Abstract

The essence of Complex, Dynamic Systems Theory is that there is no stasis, only change. The processes of change are the consequences of interactions of variables over time. At least forty theories of SLA have been proposed, but it seems none of them gives a complete explanation of this complex process. The purpose of the study to recognize CDS features, controlling parameters, and SLA theories to support the idea that SLA is a complex and dynamic process. Considering the proposed theories in SLA, features of complex systems and controlling parameters in SLA, the researcher has proposed a model based on CDST approach to explain the complexity involved in learning a second language. The method was narrative review research. Results will be advantageous for methodologies, theoreticians, syllabus designers and teachers, to involve social, cultural, factors in SLA processes. It will be also helpful to solve some of the long-lasting problems and present the fascinating, promising approach of CDST.

Keywords: CDS, CDST, SLA, language learning theories, CDS features.

1. Introduction

This study maintains that previous endeavors to explain SLA and FLL should not be ignored. When different learning theories are combined, they provide a deeper and broader view of the learning process. The present study will also try to investigate the chaos/complexity theory and complexity theory approach in teaching English as a foreign language. Complex Dynamic Systems theory (CDST) investigates items in terms of their internal connectivity and external relations with their environments (De Bot & Lowie, 2007). Larsen-Freeman (2000) argued that language can be depicted as a dynamic system, i.e., a set of variables that interact over time, and language development can be shown as a complex dynamic process. Language development represents some of the basic features of dynamic systems: complete interconnectedness of subsystems, sensitive dependence on initial conditions, variation both in and among individuals and emergence of attractor states in development over time. In the study of language development, we should include both the social and the cognitive and the interaction between systems. DST is proposed as a promising candidate of an overarching theory of language development.

1.1. Significance of the Study

The significance of this study is to provide a new perspective of language learning and an examination of underlying factors that are inherent to the success of a language. As chaos/complex theory was successful for predicting more exact weather patterns, it has been applied to understand the complex, incomprehensible factors and patterns in the field of language acquisition. The findings of this study can help second and foreign language teachers to utilize better teaching class approach and principles. Organ (1995) believes that the promise of chaos/complexity theory is very optimistic.

1.2 Background

1.2.1 Chaos theory applications in different fields
Chaos theory is used generally in mathematics and has a lot of applications in physics, engineering, economics and biology and so on. It studies dynamic systems that are very sensitive to their initial conditions, which is referred to butterfly effect. For example, small differences (like rounding error in numerical computations) produce very drastic results and make long term prediction generally impossible. In many natural systems, for example, weather, jungle, desert, chaotic behavior can be observed. Chaos in common usage means “a state of disorder”, but in chaos theory, it has been defined more exactly. Complexity theory has been applied to ecology (Wu & David, 2002), epidemiology (Galea, 2010), economics (Westeroff, 2003), sociology (Hoffer, 2009), geology, finance, psychology, physics, politics, robotics, philosophy, mathematics, population dynamics, biology, microbiology, meteorology.

1.2.2 The general features of SLA as complex, nonlinear, dynamic systems

Everything that is natural and real is also chaotic like: deserts, space flight, the stock market, electronic circuits, national economies, and ecology of jungles etc. The list of natural and chaotic systems is endless. A dynamic system has the following characteristics: They are chaotic, unpredictable, sensitive to initial conditions, dynamic, complex, non-linear, strange fractors, fractal shape, open, self-organizing, feedback, adaptive, attractors, bifurcation, the edge of chaos. Larsen- Freeman (1997) explained that many similarities are present between complex dynamic nonlinear system and second language acquisition. Moreover, this theory has been used in the field of second language acquisition. The principal characteristics of chaos/complexity theory will be introduced to analyze the classroom instruction. An efficient class is dynamic since it always changes, and there are multi-level elements working together, and it is nonlinear since learning does not follow in steady, unchanging upward way.

Dynamic:
Both complex system and SLA are in a continuously dynamic process. In fact, recently, there has been a challenge of how to study the dynamism in the evolution of learner interlanguages (ILS). Dynamic features of ever-changing internal second language grammar cannot be explained by researcher’s static rules of grammar. Also as learners or proficient speakers of a given language use the target language, that specified language is transformed. In fact, the most used ‘target language’ is misleading. There is no endpoint in language acquisition, and the target is always moving continuously.

Complex:
The second language acquisition process is also complex. Many interacting variables determine the trajectory(route) of the developing interlanguage (IL), which include the source language, the target language, the markedness or unmarkedness of the first language, the markedness or unmarkedness of the second language, the quantity and sort of input, the amount and type of collaboration and interaction in a an ecological perspective, amount and type of output, amount and type of feedback received, whether second language or foreign language is acquired in tutored or untutored environments, and so on. Also there are a lot of interacting variables that determine the successful second language acquisition process. For example: aptitude, age, sex, socio-psychology variables such as attitude, and motivation, cognitive style, learning strategies, personality factors, interests, birth order and so on (Larsen-Freeman & Long, 1991). Therefore, the interaction between these various factors in an ecological system determines the ultimate effect.

Nonlinear:
Learning language and linguistic items are nonlinear process. Second language learners do not learn one item completely and then move to another language item. In reality, learning curve for learning a single item is nonlinear. The curve is full of progress and going back and backsliding. Learning is brimmed with ups and downs. A good example is when language learners begin acquiring the past tense of regular and irregular verbs. These verbs are mastered increasingly at a lexical level, it means they learn one verb and its endings simultaneously. After further interaction and exposure to the target language chaos follows. It takes one more instance in the input of a past tense verb ‘to break the camel’s back’. While the interlanguage has many correct examples of past tense, a period of randomness of the -ed follows. So the -ed is overgeneralized to irregular verbs, e.g., sitted, eated, sleeped, while earlier correct targets were being produced before. As the example was given, learners learn the past tense in a U-shape form. They first produce the correct form like ate or slept, and then they overgeneralized the regular –ed ending to all verbs and produce forms like eated or sleeped. Later in their interlanguage, they revert to the correct verb; ate or slept.

Open:
If there is continuous input, the interlanguage system is self-organizing itself, and the chaos which is related with
past tense ending subsides gradually. The term that is used in language acquisition research is ‘restructuring’ of the interlanguage, which means returning to order that occurs. Reverting to order is assisted by sensitivity of the system to feedback.

**Sensitivity to feedback:**

“The presence of enough positive evidence in the environment or the explicit provision of negative evidence can help learner adapt their interlanguage grammar closer to that of target language users” (Larsen-Freeman, 2008). Fossilization occurs when there is no learning in a language and learners’ grammar system becomes closed and stops to a fixed point attractor. By comparison, “in biology, the agents are organisms, the feedback is supplied by natural selection and the steady development of the models is called evolution. But in cognition, the agents are minds; the feedback comes from direct experience and teachers”. (Waldrop, 1992, p 179). The teachers’ attitudes or choices may help one student to win and the other to lose. For example, students may react differently to teachers who don’t believe in them. Students may feel extremely discouraged and one may be challenged and succeed.

**Bifurcation**

A point that a critical decision or choice is made. For example it is to study this field or another field. To continue to learn or to give up learning. The system of a learner may bifurcate towards the acquiring of another complex language system

**Edge of chaos**

Complex learning system moves to the edge of chaos because equilibrium means the death of the system. For example, those learners who end up their attempts to learn the language have gained equilibrium. Moreover, the classroom is not the perfect idealized “cooperative paradise” that teacher may dream of about it, but a place that some learners protect their identities against their teachers and partners. Despite of that, when learners reach their edge of chaos, new behaviors may emerge. In the complex learning system, the important notions of individuality, identity, agency and autonomy should be taken into account. The autonomous students will find their ways out, and overcome barriers and construct their identity as a second language speaker.

1.2.3 Second Language Acquisition theories and models

Although there is a great number of SLA theories and hypotheses, the researcher will summarize only some of them: behaviorism, acculturation, comprehension hypothesis, semantic theory, sociocultural theory, universal grammar hypothesis, input hypothesis, monitor model, interaction hypothesis, output hypothesis, competition model, connectionism, noticing hypothesis, processability, automaticity, declarative/procedural model, memory and second language acquisition. These are the theories which have more effect on the field. Theories and models of second-language acquisition are various theories and hypotheses in the field of second-language acquisition about how people learn a second language.

**Behaviorism**

Behaviorism gave birth to a stimulus-response (S-R) theory which understands language as a set of structures and acquisition as a matter of habit formation. Ignoring any internal mechanisms, it takes into account the linguistic environment and the stimuli it produces. Learning is an observable behavior which is automatically acquired by means of stimulus and response in the form of mechanical repetition. Thus to acquire a language is to acquire automatic linguistic habits. According to Johnson (2004), “Behaviorism undermined the role of mental processes and viewed learning as the ability to inductively discover patterns of rule-governed behavior from the examples provided to the learner by his or her environment (p. 18)”.

**Acculturation**

Another environmental-oriented theory is proposed by Schumann (1978). In his famous, longitudinal investigation of some syntactic aspects with six learners (2 children, 2 adolescents, 2 adults), Schumann (1978) used questionnaires, observed spontaneous conversation during ten months, and applied a quantitative treatment to the data. He found out that “the subject who acquired the least amount of English was the one who was the most socially and psychologically distant from the TL group” (p. 34). In his view, SLA is the result of acculturation which he defines as “the social and psychological integration of the learner with the target language (TL) group” (p. 29). The acculturation model argues that learners will be successful in SLA if there are fewer social and psychological distances between them and the speakers of the second language.

**Comprehension Hypothesis**
Influenced by Chomsky’s assumptions on language as an innate faculty, Krashen (1987), developed an influential proposal with emphasis on the contrast between learning and acquisition to explain SLA. First, he named it as monitor model, then he called it input hypothesis (1985), focusing on the data which feed acquisition, and more recently, comprehension hypothesis emphasizing the mental process as responsible for acquisition. According to Krashen (2004), The Comprehension Hypothesis is closely related to other hypotheses.

**Sociocultural theory**

Sociocultural theory was originally coined by Wertsch in 1985 and derived from the work of Lev Vygotsky and the Vygotsky Circle in Moscow from the 1920s onwards. Sociocultural theory is the notion that human mental function is from participating cultural mediation integrated into social activities (Lantolf, J. P., & Beckett, T. G., 2009). The sociocultural theory (SCT), based on Vygotskian thoughts, claims that language learning is a socially mediated process. Mediation is a fundamental principle and language is a cultural artifact that mediates social and psychological activities. As highlighted by Mitchell and Myles, “from a social-cultural perspective, children’s early language learning arises from processes of meaning-making in collaborative activity with other members of a given culture” (p. 200).

**Universal grammar hypothesis**

From the field of linguistics, the most influential theory by far has been Chomsky's theory of Universal Grammar (UG). The UG model of principles, basic properties which all languages share, and parameters, properties which can vary between languages, has been the basis for much second-language research. From a UG perspective, learning the grammar of a second language is simply a matter of setting the correct parameters. Take the pro-drop parameter, which dictates whether or not sentences must have a subject in order to be grammatically correct. This parameter can have two values: *positive*, in which case sentences do not necessarily need a subject, and *negative*, in which case subjects must be present.

**Input hypothesis**

Learners' most direct source of information about the target language is the target language itself. When they come into direct contact with the target language, this is referred to as "input." When learners process that language in a way that can contribute to learning, this is referred to as "intake. Generally speaking, the amount of input learners take in is one of the most important factors affecting their learning. However, it must be at a level that is comprehensible to them. In his Monitor Theory, Krashen advanced the concept that language input should be at the "i+1" level, just beyond what the learner can fully understand; this input is comprehensible, but contains structures that are not yet fully understood.

**Interaction Hypothesis**

Long's interaction hypothesis proposes that language acquisition is strongly facilitated by the use of the target language in interaction. Similarly to Krashen's Input Hypothesis, the Interaction Hypothesis claims that comprehensible input is important for language learning. In addition, it claims that the effectiveness of comprehensible input is greatly increased when learners have to negotiate for meaning (Ellis, 1997).

**Output hypothesis**

In the 1980s, Canadian SLA researcher Merrill Swain advanced the output hypothesis, that meaningful output is as necessary to language learning as meaningful input. However, most studies have shown little if any correlation between learning and quantity of output. Swain (1980) contended that small amounts of meaningful output are important to language learning, but primarily because the experience of producing language leads to more effective processing of input.

**Competition model**

Some of the major cognitive theories of how learners organize language knowledge are based on analyses of how speakers of various languages analyze sentences for meaning. MacWhinney, Bates, and Kliegl (1998) found that speakers of English, German, and Italian showed varying patterns in identifying the subjects of transitive sentences containing more than one noun. English speakers relied heavily on word order; German speakers used morphological agreement, the animacy status of noun referents, and stress; and speakers of Italian relied on agreement and stress. MacWhinney et al. interpreted these results as supporting the Competition Model, which states that individuals use linguistic cues to get meaning from language, rather than relying on linguistic universals (MacWhinney, Bates & Kliegl, 1984).

**Connectionism and second-language acquisition**
Connectionism attempts to model the cognitive language processing of the human brain, using computer architectures that make associations between elements of language, based on frequency of co-occurrence in the language input (Christiansen & Chater, 2001). Frequency has been found to be a factor in various linguistic domains of language learning (Ellis, 2002). Connectionism posits that learners form mental connections between items that co-occur, using exemplars found in language input. From this input, learners extract the rules of the language through cognitive processes common to other areas of cognitive skill acquisition.

**Noticing hypothesis**

Attention is another characteristic that some believe to have a role in determining the success or failure of language processing. Richard Schmidt (1990) states that although explicit metalinguistic knowledge of a language is not always essential for acquisition, the learner must be aware of L2 input in order to gain from it (Schmidt, 1990). In his “noticing hypothesis,” Schmidt posits that learners must notice the ways in which their interlanguage structures differ from target norms.

**1.2.4 Controlling Parameters**

Larsen-Freeman (1987) in her seminal article states that there are many interacting factors and controlling parameters at play that control the trajectory of developing interlanguage which include the source language, the target language, the markedness of the first language, the markedness of the second language, the amount and kind of input, the amount and kind of interactions, the kind of feedback received from the different sources, whether second language is acquired in untutored or tutored contexts. Moreover, Larsen-Freeman and Long (1991) emphasized that a plethora of interacting factors determine the degree to which the SLA process will be promoted and the learners will be successful. These parameters consist of age, aptitude, some socio-psychological controlling parameters such as attitude, motivation, personality factors, cognitive style, learning strategies, hemisphericity, sex, interests, and birth order and so on. They add that may be no one of these controlling factors by itself is a determining parameter, however; the interaction of these factors has a very remarkable influence.

**2 Relevant Studies**

The literature on the application of DST in SLA is still rather restricted. After the groundbreaking work by Larsen-Freeman in 1997, it was silent for five years, until Herdina and Jessner (2002) published their book *A dynamic model of multilingualism* and Larsen-Freeman supplemented her earlier work in 2002. Stimulated by this work, and a number of publications (Verspoor, De Bot and Lowie, 2004; De Bot, Lowie and Verspoor, 2005 a, b; De Bot and Makoni, 2005, Menzes, 2013). Menzes in her study of 40 LLHs in Brazil (2013) states that there is evidence to support the claim that second language acquisition (SLA) is a complex adaptive system due to its inherent ability to adapt to different conditions present in both internal and external environments. She added that in order to justify this assumption, excerpts from some English language learning histories (LLH) were provided to exemplify how learners describe their learning processes. The final claim was that SLA should be seen as a chaotic/complex system.

**3. Methodology**

The method was narrative review which summarized, classified, analyzed and compared different primary studies from which conclusions were drawn and contributed by the researcher’s own experience, existing theories and models. One of its strengths is that it tries to comprehend the diversities and pluralities of understanding around CDST. Narrative Review is taken best suitable for comprehensive topics like Complex systems. It critically evaluates features of SLA as a complex system, various interacting factors, and SLA theories. And the researcher proposes a model for CDST approach to include all variables.

The data sources include seminal works by Larsen-Freeman and De Bot et.al. The researcher included current studies on chaos theory and CDST and their applications in SLA.
4. Results

4.1. Complexity method or complexity approach?

Larsen-Freeman (2000b) and Cameron (2012) don’t believe in the value of methods; nevertheless, they think that approaches and post-method strategies are perfect devices. One reason is that they think restricting the teacher or learners to special activities or techniques is opposite to complexity theory. Due to the complexity of language and learners, a capable teacher will require to use a wide range of techniques and activities that promote learning. A complexity-compatible approach to language teaching is not eclectic and anything doesn’t go into it. Moreover, a complexity approach is not relativistic (Cilliers, 2000). In abstract anything goes in, but any special moment in a lesson can be rich with new learning potential and some decisions and directions to take can be better than others if a more effective way of learning a language is the goal (Allwright, 2003). Another reason is that advancing a special method would be futile, as methods are adaptable in use. Anyone who has visited English classes in which teachers profess to be using communicative language teaching will certify that what is occurring in such classes is very different, one from another. So any methodologist should predict, and encourage adaptation (Larsen-Freeman & Cameron, 2012).

4.2. A complexity (CDST) approach to language classroom action

In classroom, the language that is the goal and the content of instruction, is a moving target for learners. Moving targets are hard to grasp, so students must be helped in several ways. Therefore, they can deal with the dynamism and complexity of the target language by providing feedback through teacher-initiated, peer-initiated or self-initiated means in an affectively and socially supportive way. Complexity theory provides wonderful and potentially paramount ways of thinking about class action and the role of the teacher. To build a complexity approach to language teaching and learning the four components are suggested (Larsen-Freeman & Cameron, 2008):

4.2.1. It is all connected: A complexity prospect on the language classroom emphasizes connections across different human and social organization, from individual minds up to the socio-political situation of language learning, and from the minute by minute of classroom activity to teaching and learning lifetimes. Any action in language teaching and learning is connected into a web of connections to multiple systems which can affect and restrict it (van Lier, 2000).

Learning includes the connected brain-body-world of continuity psychology (Gibbs, 2006; Spivey, 2007) and ecological approach (Kramsch, 2002; Clark, 2007). The metaphor of the web is a good way to describe the complexity involved in complex systems. Unlike the steps in a ladder, the strands in a web are not fixed in a certain order but the joint product of the web builder’s constructive activities and the supportive context in which it is built. This means that any syllabus is unique, emerging from interactions and learners’ and teachers’ decision (Larsen-Freeman, 2003).

4.2.2. Language is dynamic: Considering language as a separate entity is a prescriptive fiction (Klein, 1998); it only exists in the flow of language use in a given speech community. The goal of learning is to learn the dynamic system of the living language (Larsen-Freeman, 2003). It means that even if a frozen version of the language is used in a syllabus, test, and grammar book, as soon as it is released into the classroom or into the minds of learners, it becomes dynamic. The dynamics of language using by teachers and students lead to the emergence of the individual learners’ growing language and classroom dialects, and beyond the class, to the emergence of lingua franca varieties (Jenkins, 2000; Seidlhofer, 2001).

4.2.3. Co-adaptation is a key dynamic:

Co-adaptation is change in connected systems, where change in one system produces change in the other. Language classroom are full of people co-adapting: students with each other, teacher with students, teacher or students with learning situations. Pattern of action emerges from co-adaptation on different timescales. All sorts of forces can push a system to stability. The aim of language teaching is not to cause conformity to uniformity by transferring what is in the teachers’ head to the students’ heads (Larsen-Freeman, 2003). Students need opportunities to work with the language using patterns of the speech community because using and learning are congruent processes.
4.2.4. Teaching is managing the dynamics of learning:

Teaching is managing the dynamics of learning, using the complex, adaptive nature of action and language use while at the same time co-adaptation works for the benefit of learning. This is done by finding ways to perturb the systems out of attractors and into new trajectories (Larsen-Freeman, 2010). Teachers do not control their students’ learning. Teaching does not cause learning; learners make their own paths (Larsen-Freeman, 2000b, 2006). This does not mean that teaching does not affect learning, not at all; teaching and teacher-learner interaction construct and limit the learning affordances of the classroom. What English teachers can do is managing their students’ learning in such a way that is congruent with their learning processes. Thus, any approach, we may support would not be learner-centered nor curriculum-centered, but it would be learning centered—where learning guides the teaching and vice versa (Larsen-Freeman & Cameron, 2012).

4.3. Modeling the language classroom and role of teachers

Language classroom systems will challenge modelers, both in finding validity ways to decrease complexity to be suitable for possible models and in explaining for the human aspect of the systems. Agent-based simulation models seem to offer most promise for future. Even if a productive computer simulation does not materialize the process of construction a model, it can be very useful since it pushes the modelers to decide about the features of the systems and their interconnections.

In CCTA (Chaos/Complexity Theory Approach) or CDST, the language teachers’ roles are as follows:
1. Teachers require to provide the multiple intelligences, multilingualism, multiculturalism, multi-literacies and multiple critical periods in syllabus design, teaching and assessment.
2. The input or affordances for students should be well-timed and well-placed, powerful enough, i.e., within students’ Zone of Proximal Development (their ZPD).
3. English teachers require to use various mediation and scaffolding processes like teacher, peer, realia, and maximum use of ecology principles (relationships of students and teachers with their environment and with each other).
4. They should employ dynamic assessment systems (testing and teaching simultaneously). English teachers should establish and develop the strongest attractor for the system.

4.4. A model of Complex Dynamic Systems Theory (CDST) approach

Although the emergence of CDST has a long history in the hard sciences and mathematics, it was Diane Larsen-Freeman’s seminal article in Applied Linguistics (AL) in 1997 that caused a sudden turn in this field. As she states, it took a long time for this kind of thinking to be seen as a remarkable development. Language use, change and learning occur on many timescales and levels of complexity. They are contextually and temporally dependent processes. Taking account the proposed theories in SLA, features of complex, dynamic systems and controlling parameters that determine the trajectory of second language acquisition, the researcher has proposed a model to explain the complexity and dynamicity involved in learning a second language.
During last decade, de Bot et al. (2005, 2007, and 2015), Larsen-Freeman and Cameron (2008), Dornyei (2009) and Verspoor et al. (2011) have played a part in the development of this approach. CDST has the following characteristics (De Bot. 2015):

1. CDST is the science of the development of complex, dynamic systems over time. Complex systems are sets of interacting variables from which something novel emerges.
2. In many complex systems the outcome of development over time cannot be predicted.
3. Dynamic systems are always part of another system, with systems nested within other systems.
4. Systems develop through iterations of simple procedures that are applied over and over again.
5. Complexity emerges out of the iterative application of simple procedures; so that it is not essential to postulate innate knowledge.

5. Discussion, Conclusions, and implications

The research question was answered by the model which was proposed by the researcher. It includes all the underlying factors, SLA features as a complex, dynamic system and different SLA theories that have been proposed so far to explain SLA. Therefore, CDST approach can solve some of the problems in SLA field and provides an overarching model to represent the complexity and dynamicity that are involved in learning a second language.

Understanding SLA as a complex, dynamic system theory can elucidate why a learner remains in balance, for a special amount of time and suddenly a fast change happens, demonstrating an advance in acquisition. Namely, in learning we have periods of stability followed by “explosions” and change. It can also explain why the same teaching and learning strategies do not have the same results for all learners and that small stimuli can have unpredictable results, dramatically negative or positive. Consequently, in formal situations, the teacher can not only instigate learning mechanisms, but also make challenging barriers.

It is the role of the teacher to inspire persistent contact of the student with as various forms of input as possible and to encourage interactions among different speakers (learners, proficient speakers and native speakers). Language learning is also a social phenomenon and relies on interactions among speakers. Along these lines, our role as teachers is to “disturb” a zone of stability and incite the chaos that results in a zone of creativity (edge of chaos) where small changes can happen, creating important outcomes on learning processes (Paiva, 2005)

The study will be advantageous for methodologies, theoreticians, teachers, syllabus designers, and material designers because it will provide a more elaborate and dynamic view of SLA and represent a more thorough explanation of parameters involved in developing a foreign language. The advantages of the findings will be also
helpful to solve some of the chronic problems in SLA and present the fascinating, promising approach of CDST. Adopting and familiarity with the CDST, teachers will involve social, cultural, cognitive and metacognitive, cognitive factors in SLA processes and provide various sources of input and interactions to their language learners.

The practical applications of CDST approach needs further investigation. Further research and case study should be done to know more about the real process of language learning.

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7. References


Quarterly, 315-350.