


FIRST PERSON SINGULAR

Complex dynamic systems theory: A webinar with Diane Larsen-Freeman

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(Received 1 September 2022; accepted 16 September 2022)

1. Introduction

The following is an edited transcript of a webinar that took place on 11 June 2022 between Diane Larsen-Freeman and seven colleagues (in alphabetical order: Anne Burns, Hossein Farhady, Mathias Schulze, Scott Thornbury, Benjamin White, Henry Widdowson, and Yasin Yazdi-Amirkhiz), who generously took the time to formulate and submit questions in advance of the webinar and to participate in the event. The focus of the webinar was on Complex Dynamic Systems Theory (CDST). Coincidentally, the webinar took place on the 25th anniversary of Larsen-Freeman's first publication on the same theme (Larsen-Freeman, 1997).

The webinar was organized and then transcribed by Dr. Yazdi-Amirkhiz. Following the initial round of questions and answers, there was a more spontaneous interaction.

2. Questions and Answers

Hossein Farhady (IUST, Iran; Yeditepe University, Turkey)

Diane has been my teacher, colleague, and mentor over the last few decades. She was popular for her empirical SLA (second language acquisition) research at UCLA, working on a morpheme accuracy order and T-units as a measure of language proficiency. If I want to talk about her contributions to the field, it will take forever. Therefore, I am taking advantage and asking her the following question.

'As a quantitatively-oriented researcher in SLA, you shifted the focus of your research to complexity theory. Would you please share with us your motivation for this shift and its contribution to improving SLA research?'

Thank you for your kind words, Professor Farhady, and for encouraging me to reminisce about our time together at UCLA many years ago. I also appreciate your giving me the opportunity to say something about the evolution of my own thinking. I tell my own students that it's important to understand a theory at the time when and the place where it originated.

I enrolled in graduate school around the start of what came to be called the Cognitive Revolution, a leading contributor to which was Noam Chomsky. I was trained in his Transformational Generative Grammar, later reformulated as Universal Grammar. The rationale for the theory was to try to explain the universal success in the acquisition of a native language by children, who, despite receiving allegedly impoverished, ungrammatical input, acquired their native language in relatively short order. Chomsky postulated the existence of a Universal Grammar that would facilitate children's accomplishing this feat. His hypothesis fueled the search for formal abstract linguistic universals.

This was an intellectually rich time for those of us interested in second language development (SLD). Corder's (1967) notion of an innate/built-in syllabus and Larry Selinker's (1972) of an inter-language inspired second language (L2) research projects that attempted to account for developmental sequences and the acquisition of mostly English grammatical morphemes by learners of diverse language backgrounds. In my own research, I studied the accuracy with which English morphemes were used by speakers of different languages, and although I found some evidence of native language influence, the accuracy ranks among learners were positively correlated.

This finding led me to seek an explanation for the commonality. I considered many possible causes: phonological complexity, perceptual salience, processing strategies, etc. What I found in the end was a correlation between the accuracy order and the frequency of morpheme use by English speakers. In other words, there wasn't evidence for a built-in syllabus; rather, it was learners' exposure to English that gave rise to the order. Now, correlation is neither causation nor explanation, so if there were indeed a frequency effect, I wondered what it was due to. Habit formation? Or was there a more cognitive explanation regarding rule formation? I realized any answer would be premature because – and this was an important lesson for me – frequency was a finding, not an explanation. I needed a theory, with which to interpret the finding, and a satisfactory L2 theory did not yet exist.

So, I put that research agenda aside, and I went on to join others in the search for a developmental yardstick for language proficiency – a quest I hoped could ameliorate the internecine feuding that was taking place between researchers claiming differing degrees of native language influence on L2 development. I reasoned that if we could avoid using vague proficiency labels, such as 'beginners' and 'intermediates,' we could begin to compare learners at the same stage of development (since L1 (first language) influence would perhaps wane with increasing proficiency). And, in my research, I found some candidates for such a yardstick. I identified some measures with T-units that showed promise. However, my research showed that they only worked to distinguish groups of learners; they didn't work for individuals, many of whom didn't conform to group averages – another important lesson for me.

I was also dissatisfied with approaches to language teaching that treated learners as computer input processors, which I found disrespected their agency. In addition, I wasn't happy with the volume of research that pointed to an ever-increasing number of individual differences that were said to affect the learning process. While the large number was likely appropriate and would accord with my finding of individual variability, I worried that a reductionist search for ever-more explanations would impede a more general understanding of SLD.

Finally, I felt that experimental research wasn't going to be of much help with its decontextualization and its requirement to study only one variable at a time. And, even cross-sectional studies, where one could look at more than one variable, weren't entirely satisfactory because in L2 development it is important to trace the developmental process over time.

So, I was discontent. However, my dissatisfaction meant that I was receptive to a new perspective. The need for a different way of understanding SLD became more urgent because of my desire to address a commonly observed problem in language teaching – 'the inert knowledge problem' (Whitehead, 1929). The problem occurs when students appear to learn something, but then they aren't able to activate their knowledge for their own purposes at a later time.

Then, quite by chance, I began reading James Gleick's (1987) book, *Chaos. Making a new science*. There, on page 24, I found inspiring words: 'In a nonlinear system the act of playing the game has a way of changing the rules.' Now, Gleick wasn't writing about grammar rules. However, it was easy for me to extrapolate to language: playing the game – using the language meaningfully – has a way of changing language. A language and its use are mutually constitutive (de Bot, 2015a). Of course, how else would a language change except through use? But this observation, contrary to what I had been taught about language, made sense to me: language evolution, language change more generally, and of interest to us, the language resources of language learners all change with meaningful use. This idea of language as a dynamic system resonated with me, in contrast with my previous understanding of language as a set of static rules that were said to underlie all languages.

A complex system is not only dynamic; it also operates within a specific spatial-temporal context. Rather than seeking to understand complexity through reductionism, what is called for is a more holistic, ecological, and relational systems account, at least as a complement to more traditional accounts (Larsen-Freeman, 2018). Furthermore, it proposes that a complex system is made up of interacting constituents that give rise to new patterns through self-organization, much as a bird flock emerges from the interaction of its birds; there's no one central authority that instructs birds on how to form their distinctive patterns in flight.

I now had a partial answer to my concern about the inert knowledge problem. When students make meaning and position themselves as they want, grammatical patterns will emerge in their repertoires, given appropriate conditions. To encourage this outcome, I coined the term *grammaring*: the practice of teaching grammar as a skill – guiding students to use grammar structures accurately, meaningfully, and appropriately.

I came to understand that teaching language is not about teaching students to conform to a linguistic straightjacket, but rather teaching students to adapt their language resources to a changing context. Masumeh Taie (2020, p. 751) noted ‘Larsen-Freeman (2003) has used the term *grammaring* and “organic dynamism” ... According to Larsen-Freeman (1997), language grows and arranges from the bottom up organically and the changes are emergent, not rule-governed.’

Of course, one can write grammar rules to describe a language; I have done so myself (Larsen-Freeman & Celce-Murcia, 2015), and some students benefit from being shown the regular patterns, especially when contrasted with the language(s) they already know, but these are neither the deep structure rules of Universal Grammar (UG), nor are they static or invariant; this is because languages are always changing.

Indeed, Nick Ellis and I edited a book called *Language as a complex adaptive system (CAS)* (2009) to highlight the fact that change comes about through adaptation – co-adaptation, it might be better said – where the language resources of interlocutors are shaped in coordinated interaction. Adaptation introduces variation into the system. By perceiving increasing flux in the learner's language system, we know that change in the system is imminent (Verspoor et al., 2021). Moreover, systematic variation in the language of individual learners may suggest that an intervention, a teachable moment, is at hand.

In short, CDST is a theory of change that sees language as a contextualized dynamic system that is continually being transformed through use. Through reciprocal causality (Larsen-Freeman & Cameron, 2008), there is a balance between innovation and stability, but never stasis. I believe that this is a much better way to conceive of and research the dynamic process of SLD.

Benjamin White (Saint Michael's College, USA)

Language acquisition is often framed through the metaphor of a graph on a coordinate plane (linear growth, U-curve, plateau in development, etc.). In discussing development and emergence through a complex adaptive systems approach, you have made use of a topology metaphor. Could you explore the potential such a metaphor has for both language learners and language teachers? For example, how might learners and teachers re-conceptualize language development in general as well as what it takes to progress in a language in particular? What possible impact might a topology metaphor for development have on teaching practices such as classroom interaction, curriculum development, and assessment?

Images can be powerful in helping us to think. In the case of complex systems, researchers adopt a topological mapping procedure. Spatial or topographical images are mapped according to four dimensions: height, length, depth, and time. So one possible multidimensional, metaphorical way to visualize a dynamic system is to imagine the system's wandering over time across a landscape of hills and valleys, occasionally entering a valley with steep walls that prevent the system from easily getting out but then resuming its journey once it escapes (Larsen-Freeman & Cameron, 2008). At the summit of hills, the possibility exists for the system to venture forth in any direction.

Landscapes represent what's called the state space of the system. The state space is a collection of all possible states of a system. So, from another perspective, we might imagine a language learner walking across the state space of the language system, where the learner's state is his or her current behavior. As the learner moves through the successive states, the path of the walker is called its trajectory. Because it's based on the path each learner has tread, and thus depends on the learner's experience, each developmental trajectory is unique. Sociologist David Byrne (2005, p. 97) put it this way: '... knowledge is inherently local rather than universal' and '... complexity theory challenges the nomothetic program of universally applicable knowledge at its very heart – it asserts that knowledge must be contextual.'

Now, there have been other topological images used to envision complex systems. For instance, network topology refers to how various nodes, devices, and connections in a network are physically or logically arranged in relation to each other – think of the internet as an example, with its nodes and connecting lines. (See Kiss & Pack (2022) for a recent L2 application.)

Fractal topology is another. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple algorithm over and over in an ongoing feedback loop. Driven by recursion/iteration, fractals are images of dynamic systems. They are exquisite images, and truthfully, another reason I like complexity theory is that its images are so compelling and ubiquitous in the natural world. But fractals are present in language as well, as attested by scale-free power laws (Larsen–Freeman, 2017a).

You ask about the usefulness of plotting a language development graph on a coordinate plane. On such a graph, the vertical *y* axis, shows the learner's performance highs and lows, and the horizontal *x* axis plots time. While I have created such graphs myself, what is missing is the dimension of depth.

In other words, if learners show that they have developed a particular form for a particular function, are there other ways to fulfill this function that have yet to be developed, and if they were to be so would give learners a range of forms with which to adapt to any given situation? Then, too, change in one area of language is often the result of change in another. So, I think simple bi-directional graphs are inadequate for showing this dynamic relation. They show one feature of the learner's developing system, but they don't show how it fits into the whole.

You asked about the implications of this topological metaphor for classroom interaction, curriculum development, and assessment. Typically, classroom interaction has been described as learner-centered, or teacher-centered, both of which may have their place. But from a CDST standpoint, the important point is that the interaction should be learning-centered. In a dynamic learning-centered approach, teachers teach in response to where students are – what they have not yet learned and are interested in learning – not merely teaching something because it's the next chapter of the textbook. Where are the students on the landscape? So, for example, if the language learner's behavior is in a deep well, the learner might benefit from a contrastive analysis between languages, followed by intensive practice. But if some aspect of the learner's language system is poised at on the summit of a hill, then it would be the teacher's job to try to determine what the learner wants to or needs to be able to say and then offering choices to the learner for moving in one direction or another. So, that would be my answer for curriculum development. I am inspired by Smith et al.'s (2018) powerful CDST claim that infants create their own curriculum for learning. Why not extend this idea to more mature learners, second or foreign language learners? I think that there is evidence of learners' enacting their agency in this way in both natural and instructed language learning.

You might wonder how a teacher can possibly manage the particular learning trajectory and style of each student. A common reply is that the teacher should practice differentiated instruction. The teacher should create a variety of different activities so that at least some of the students' needs are being attended to at a particular time. That is very demanding for teachers, especially with large classes. But there is an alternative, *PERSONALIZED LEARNING*, where agentic students design their own learning paths, based on their identities, their interests, and the way they learn best. Project-based learning might be an example of personalized learning.

So, curriculum development is organic; it grows naturally out of classroom interaction in a learning-centered way. As teachers work together with their students to identify affordances for

learning, teachable moments become apparent. They are not something preordained, there is no innate syllabus, but appropriate targets of instruction emerge in interaction. However, what if a teacher is responsible for ‘covering’ certain material? In that case, the teacher needs to think of the syllabus as a checklist, not necessarily a sequence to be followed unwaveringly. As learning opportunities arise and are attended to, they are checked off.

And, finally, you ask about assessment. Given the uniqueness of each learner’s developmental trajectory, the answer is that CDST favors self-referential assessment, assessing what learners know or can do now that they did not know or couldn’t do before. Self-referential assessment is consistent with an asset model of teaching, which highlights students’ capabilities, rather than their deficiencies. In a similar spirit, it would welcome abandoning the notion of static competence and opt instead for assessing students’ developing capacity – the ability to create in another language, to allow for the emergence of new constructions, not simply to conform to a standard language.

Helpful in conducting STANDARDIZED assessment might be the use of artificial intelligence. Taie (2020) notes that AI and CDST are compatible in that both take individual differences into account. Nowadays, there are adaptive and intelligent learning systems, such as Computerized Adaptive Testing. CAT involves delivering items to test takers which are gradually tailored to their apparent ability level. I note Professor Schulze has used CDST to inform adaptive systems in his MOCHA project (Schulze & Penner, 2008).

Anne Burns (Curtin University, Australia)

You have described complex systems as ‘dynamic, nonlinear, open, interconnected with the environment, and comprised of many components’ and have also argued that ‘as the components interact, new unanticipated patterns emerge’ (Larsen-Freeman, 2020).

I have spent a large part of my career introducing teachers to action research, which enables a focus on change that can emerge through interacting systems in their own environment.

- **Question 1: To what extent, if at all, would you consider research methodologies such as action research to be aligned with complex systems theory?**
- **Question 2: What opportunities do you then see for greater adoption of such contextualized methodologies into SLA research?**
- **Question 3: And who should participate in such forms of research? What is the nature of the scope for transdisciplinary research between the academy and the classroom?**

I certainly think there’s an alignment. Perhaps I’m stating the obvious, but let me start by saying that complex systems are ever-present in the classroom – in the interactions between the students and teacher, and they, in turn with other components in the classroom ecology: the curriculum, the materials, the books, the classroom layout, the schedule, the seating arrangements, the textbooks, the syllabus, etc. And, although these components are at the level of the classroom, they’re nested within other systems, namely the complex system of the school, the community, the district, and so forth. So you have complex systems from individual brains all the way up to a grand scale, to national language policy, for instance.

Then, too, there is a time dimension to a complex system. In the classroom every teacher knows that lessons are differentially successful, depending on whether they are delivered at the beginning or end of the week, in the morning or afternoon, before or after recess, before or after a holiday. It is therefore inadequate to study complex classroom behavior at one point in time. The trajectory of complex systems can best be mapped through emergent patterns of a learner’s behavior over time in a spatial-temporal context.

Second, as I’ve observed, CDST is centrally a theory of change. This corresponds with action research’s focus on change and its protocol for practitioners to select a problem area, make a plan,

change what they do, and reflect on the consequences. Importantly, like CDST, action research is concerned with systems and prizes possibility rather than prediction.

In a complex system, change can happen continuously, but it can also happen suddenly. In either case, change may lead to a phase shift, where the system leaves one attractor state and enters another. An attractor is a signature or a pattern that a complex system adopts – its path through state space. Action researchers seek to intervene in a problematic area and thus, in CDST parlance, to create a new attractor.

Now, you ask, Professor Burns, about using action research in researching SLA and about who should undertake it. Those are, of course, political questions, and it is difficult to know these days how the political winds will blow. However, I do think there's a shift occurring. I note that a great deal of SLA research these days is introduced as 'exploratory' or 'pilot,' much in keeping with the ethos of action research and CDST's rejection of making predictions in laboratory experiments. Researchers generalize, teachers particularize (Larsen-Freeman, 2009), and I do think researchers need to do more particularization, for which teacher knowledge can be invaluable. CDST's insistence that context matters can be addressed by 'the untapped potential of practitioner research in which the actors living within the ecology share insider information ...' (Chong, 2022, p. 7).

There has also been an increase in multiply authored articles, often with practitioners among the authors. The journal *Language Learning* now includes an appendix, an accessible summary of the articles, called 'What this research was about and why it was important,' presumably in an attempt to demystify the research process.

For better or for worse, any social media user is potentially a newsmaker, perhaps leading to a democratizing of knowledge generation (Powichit, 2022). Indeed, Donald Freeman and I (Larsen-Freeman & Freeman, 2008) wrote that these days the features of knowledge creation and dissemination in general are blurring the boundary between the authorship of knowledge and its use.

So, I am not a politician nor can I forecast with confidence that action research will become more acceptable within the academy, but it seems to me that there's more potential for that now than ever before, especially due to the problem orientation of applied linguistics.

Henry Widdowson (University of Vienna, Austria)

If the complexity and dynamism of language derive from its end-driven use to achieve communicative purposes, how can it be non-teleological? Or does CDST conceive of complexity and dynamism as determining the variable adaptive uses of language but not determined by them – i.e. as self-regulating properties intrinsic in the language system, itself independent of human agency?

Everything we know about the origin and evolution of language suggests that it arose for communicative purposes (Lee et al., 2009). Language doesn't exist apart from agentive users. So, it's teleological in that sense; however, at the same time it's non-teleological.

The 'telos' of teleology refers to aim or goal, so this justifies calling language teleological in the first sense; however, 'telos' also refers to end or finality, such as in the writings of Aristotle. The complexity and dynamism of language derives from its goal of achieving communicative purposes, but it doesn't have an endpoint, and in this latter sense, it's non-teleological. Open complex systems evolve indefinitely over time without a predetermined, fixed goal. This was my position in 2012 when I was invited to deliver a paper on the 40th anniversary of the publication of Larry Selinker's article, 'Interlanguage.' Interlanguage, as defined by Selinker, has an end point that is commensurate with native speaker usage. Now, of course there may be increasing alignment between the learner's interlanguage and the language of the community, but interlanguage is an open system without an endpoint. It's therefore non-teleological (Larsen-Freeman, 2014).

That's why in my AILA plenary in Beijing in 2011 (Larsen-Freeman, 2015), I recommended that we not use SLA, 'A' for acquisition, because that suggests that language is a commodity to be acquired – something one has, complete and final. Rather, from a complex systems perspective, we should call our field Second Language Development to suggest it has no endpoint (or even better, multilingual

language development, acknowledging that many of our students are plurilingual to start with). As I wrote a long time ago, ‘there is no end and there is no state’ (Larsen-Freeman, 2006a) in contrast to an end-state grammar. Language isn’t a fixed code as Roy Harris (1998) put it. Along with this myth of a fixed code is the inappropriate metaphor of a developmental ladder that has evenly spaced steps, which learners climb in a linear fashion to full proficiency (Larsen-Freeman, 2006b). In addition to the fact that learning is nonlinear, and that not all learners aspire or even need to conform to native speaker norms, it is likely that there will be considerable fluctuation and variation in performance, depending on environmental demands and conditions and the timing of exposure.

Furthermore, language learners’ and users’ repertoires aren’t simply a record of their past experiences; they have the capacity to create new patterns – their own patterns – and to expand the semiotic potential of a given language, not just to conform to a ready-made system. This is especially so given the ‘social, cultural, and political realities of multilingualism, and ever-changing forms of hybridity between multiple languages, as learners adopt and adapt various identities in diverse circumstances of life’ (Byrnes, 2013, p. 221).

Regarding the self-regulating intrinsic properties of language, I would say that in keeping with the ‘invisible hand’ metaphor of Adam Smith, a language grows and changes with very little conscious intention of humans (Keller, 1985). Each meaningful adaptive experience in the ‘here-and-now’ of a specific context contributes to stable, but mutable, attractor states emerging on a longer timescale. I’ll say something more about the invisible hand later, but for now, let me note that this position does away with the preformationism of UG. All that’s required to account for the complexity is a sensitive dependence on initial conditions and a language-using context within which language users adapt their resources, and by so doing change the system.

Mathias Schulze (San Diego State University, USA)

This question is about analyzing teaching-and-learning processes as a complex adaptive system. The characteristics give workable guidance to analyzing the qualities of a specific CAS under observation. However, taking the ‘sensitivity to initial conditions’ as one example, how does one delineate the one CAS from other complex processes that go on before or even overlap in time? In other words, how can the researcher determine which conditions are the initial ones? When does a CAS begin and end?

Indeed, you have pointed out a nettlesome problem. With all the interaction within and between complex systems, how can one say where one complex system ends and another begins? As the late South African philosopher Paul Cilliers (whom I had the good fortune to meet in Stellenbosch) wrote:

... it seems uncontroversial to claim that one has to be able to recognise what belongs to a specific system, and what does not. But complex systems are open systems where the relationships amongst the components of the system are usually more important than the components themselves. Since there are also relationships with the environment, specifying clearly where a boundary could be, is not obvious. (Cilliers, 2001, p. 5)

In the same article, Cilliers makes two important observations. First, we can think of boundaries not as that which separate a system, but rather that which constitutes it. In other words, there is an enabling nature to boundaries, as long as we recognize that drawing boundaries of a system can be political because, depending on where you draw a boundary, some will be in and others left out. Second, we usually conceive of boundaries in spatial terms. But, when it comes to social systems, parts of the system may be found in different spatial locations, so a system can be virtual, too.

Gregory Bateson (1987, p. 465) offers this advice: ‘The way to delineate the system is to draw the limiting line in such a way that you do not cut any of these pathways in ways which leave things inexplicable.’ Drawing the line in a way that does not leave things inexplicable is a challenge for complexity theory, which seeks an integrative understanding. At the very least, from a complexity theory

perspective, we would not want to draw the line between a person and context because development is never a function of a person or context alone, but results as function of their dynamic interaction (Thelen & Smith, 1998, p. 575).

Karen Barad, a theoretical physicist and author of the much-cited book *Meeting the universe halfway* (2007), offers a pragmatic solution for a researcher:

[T]he deeply connected way that everything is entangled with everything else means that any act of observation makes a cut between what is included and what is excluded from being considered, nothing is inherently separate from anything else, but separations are temporarily enacted [for research purposes] so one can examine something long enough to gain knowledge about it' (Wikipedia, entry for Agential Realism, accessed 14 June 22).

An announcement for a Workshop on Complexity and Real World Applications in Southampton, England, 21–23 July 2010, puts it much the same way:

Life is defined by where we draw the lines. The fact that defining these boundaries is so difficult is part of what makes life interesting. All boundaries are no more than temporary patterns resulting from a filtering process ... As such, they are to some degree arbitrary and require ongoing review to understand how they shape our context of interest – and how our context of interest shapes them.

The key words here are 'ongoing review.' We don't draw boundaries once and for all. We need to continually revisit them. A good example is design-based research, where one defines a system to investigate, but then continually revises it as updated understanding dictates.

Another answer is to think in terms of *SIMPLEX SYSTEMS*. Fogal (2021) advocates for the use of simplex systems as 'praxis-based forms of representing complexity (Van Geert & Steenbeek, 2014, p. 22)' that are able to maintain a 'focus on the properties that make education a complex system' (p. 37). He explains that we need to examine phenomena without overtly breaking the object of study away from the larger system within which it is embedded, and he recommends *SYSTEM MAPPING* as an approach to doing this.

One final point: by using a complexity lens for research we need to select, out of all that is connected and interacting, a particular subsystem to foreground. The 'initial conditions' of the focal systems, i.e. the state of a system when it commences the activity we are interested in, are very important to understand, since these conditions form the system's initial landscape and influence its trajectory as it changes over time. However, initial conditions are not one-off phenomena. Every time that a system's updated, new initial conditions are established. For a teacher, what the students currently understand and don't understand at that moment are the initial conditions of their language systems.

Benjamin White (Saint Michael's College, USA)

Some worry that a complex dynamic systems approach to language development weakens the importance of agency – both for learners and instructors. How would you respond to this concern?

Mathias Schulze (San Diego State University, USA)

What role do you see for considering agency and human perception in CAS research? Depending on this role, how important is it for each student or teacher engaged in a CAS teaching-and-learning process to become more aware of the complex and non-linear nature of the CAS and of their role in it and their perception of it?

I have worried about language learners' being seen as not having agency for a long time. Already in this dialogue, I have singled out both the search for universals and learners' being treated merely as

input processors as implicitly denying learners' agency. It is not difficult to identify other times when the agency of learners is overlooked – ironically, even research on INDIVIDUAL differences, as important as it is, categorizes learners into groups and compares the average performance of groups, so that the agency of individual members of the group is not considered.

Now, the self-organizing nature of complex systems may make it appear that human volition or intention has no part to play in shaping language resources; that is, once the system is set into motion, it 'self-organizes.' However, it's not that human agency is ignored in language change. Humans enact their agency to make choices in how they deploy their shared semiotic resources, including linguistic ones, to realize their transactional, interpersonal, self-expressive, etc., goals and the multiple dimensions of self and identity, affective states, and social face. At the same time, it is not contradictory to state that while humans are operating in an agentive way, the language resources of the individual and in the speech community are being transformed beyond the conscious intentions of their speakers. As I indicated in my earlier answer to Professor Widdowson, it is not that we plan to change language, language changes. As historical linguist, Rudy Keller (1985, p. 211) observes: 'Language is thus a consequence of human actions, albeit actions which are only unintentionally transformative.'

Complexity theorists are intent in understanding the dynamics in a system. For instance, the theory has been used to account for weather patterns, flocking birds, and even human dynamics – how we align ourselves in a food market or traffic jam. Humans don't intentionally create a pattern, but by their selecting what they perceive to be the shortest line when they check out at a market, they create an optimal pattern. Given the right conditions, many things in life tend to sort themselves out even better than if those involved had sat down and tried to force a top-down solution. This is evident in the strategic practice of the landscaper who allows a new park or college campus to first be trod upon and only later returns to pave the pathways that the walkers have created. The savvy landscaper knows that the optimal solution is emergent.

This isn't to say that humans never exercise intentional agency. They do. The study of human social systems implicates agency – whether this is individual or collective – and makes it necessary to include within any human system an agent or agents capable of exercising intentional action that contributes causally though not deterministically to the system's outcome and processes of change (Hiver & Larsen-Freeman, 2020).

At the same time, it is important to acknowledge that agency isn't inherent in anybody; it's enacted in relationship with others (Larsen-Freeman, 2019; Miller, 2014). So, for example, it's in the purview of a teacher to create the ENABLING CONDITIONS for learners to enact their agency. One way of doing this, which is embedded in Professor Schulze's question, is for teachers and students to become more aware of the nature of complex adaptive systems. Other enabling conditions help students express their agency by giving them choices where possible, having them establish their own learning goals, and inviting them to contribute content to the course (Larsen-Freeman et al., 2021).

Yasin Yazdi-Amirkhiz (Tehran University of Medical Sciences, Iran)

Chaos/Complexity Theory has been taken from physics (i.e., a natural science). Philosophers active in the hermeneutic tradition – such as Hans Gadamer – argue that natural sciences seek and require a different form of knowledge than social sciences, meaning that the two 'types' of knowledge emanate from different epistemological foundations. I wonder whether this extrapolation (from natural to social sciences) is plausible in the first place?

My answer is that it depends on whom you ask. Gadamer's position on the matter is clear. But there are also people like the esteemed evolutionary biologist Stephen Jay Gould, who invites us to focus on the commonalities between the humanities and the sciences. He stresses the danger of presenting cut and dry dichotomies, and explores the historically complex relationship between the sciences and the humanities in scholarly discourse.

But your question specifically deals with the sciences and social sciences, so to give another example (discussed in Epstein, 2008), Paul Samuelsson, when he was awarded the Nobel Prize in

Economics, explained that if you look at a firm on the one hand and you look at a thermodynamic system on the other, you will find that they are characterized by analogous processes. The absolute temperature and entropy of a thermodynamic system have a relationship to each other that wages have to labor in a company. A huge variety of seemingly unrelated processes have the same underlying formalism or dynamics.

It is not coincidental that there's a common pattern:

Rather it involves thinking about the social world and its intersections with the natural world as involving dynamic open systems with emergent properties that have the potential for qualitative transformation, and examining our traditional tools of social research with this perspective informing that examination' (Byrne, 2005, p. 98).

It is uncontested that certain physical laws, such as water freezing at zero degrees centigrade, don't apply to humans. Nevertheless, there is still causality in the human realm that needs to be understood, and according to Williams and Dyer (2017), Chaos Theory has led to new insights into both natural and social phenomena.

Moreover, the Douglas Fir Group (2016) group, of which I was a member, promoted a transdisciplinary stance which, we claimed, was necessary for understanding the development of multilingualism in a complex world. 'After all, language development is not a purely mental process taking place within individual learners: it is a complex and layered process involving biological, cognitive, emotional, reflexive, pedagogical, critical and social engagement' (Bouchard, 2021, p. 264). When it comes to tackling complex real-world problems, such as climate change or pandemics (Duff, 2019), it's even more clear why a transdisciplinary perspective must be brought. A transdisciplinary perspective 'treats disciplinary perspectives as valid and distinct but in dialogue with one another in order to address real-world issues' (Douglas Fir Group, 2016, p. 20).

I will let French philosopher Edgar Morin (2001, pp. 5–6) have the last say on this issue:

One of the greatest problems we face is how to adjust our way of thinking to meet the challenge of an increasingly complex, rapidly changing, unpredictable world. We must rethink our way of organizing knowledge. This means breaking down the traditional barriers between disciplines and conceiving new ways to reconnect that which has been torn apart.

Yasin Yazdi-Amirkhiz (Tehran University of Medical Sciences, Iran)

Different criteria have been suggested for judging scientific theories in philosophy of science. Two of the fundamental requirements for a 'good' theory include 'being predictive' and 'being testable'. Given that CDST is quintessentially contingent upon the percepts of indeterminacy, unpredictability, idiosyncrasy, and variability, which render testability and reproducibility further elusive, could CDST yet be seen a 'good' theory? And, would a CDST-driven applied linguistics be suitable enough to address and resolve 'practical' language-related problems in the actuality of language learning-teaching contexts?

A good theory can be predictive and testable. However, importantly, not all good theories involve prediction and testability. Not even all scientific theories do. Think about geology or paleontology.

Epstein (2008, p. 3) put it this way:

One crucial distinction is between explain and predict. Plate tectonics surely explains earthquakes, but does not permit us to predict the time and place of their occurrences. Electrostatics explains lightning. We cannot predict when or where the next lightning bolt will strike. In all but certain quarters ... evolution is accepted as explaining speciation, but we can't even predict which flu strain will occur next year.

It seems that Stephen Jay Gould (2002) would agree. A Wikipedia entry concerning his masterpiece, *The hedgehog, the fox, and the Magister's pox: Mending the gap between science and the humanities*, summarizes thusly:

There exist new entities, properties, and interactions that *emerge* in some complex systems which cannot be predicted from knowledge of properties of the components, or of laws governing at the level of those components alone. Thus reductionism can only fail in attempts to model, explain, or describe such systems, and we must search for and depend upon new emergent principles embedded in higher, more complex levels.

Prediction can be a goal if one uses statistics with stationary distribution averages and groups. For example, we can predict that children who are read to by their caregivers will learn to read at an early age. But, if we're interested in complex dynamic systems at the level of the individual, we need a process-oriented approach to research, not a predictive one. We need to 'understand the after by looking to the before.' (van Geert & Steenbeek, 2005). Indeed, a process ontology is fundamental to a complex system. There are also classroom implications and applications of CDST (e.g., Larsen-Freeman, 2014): creating iterative, not repetitive activities where language patterns can be used and adapted to changing situations and where students are led to perceive and to act on the affordances present in the context.

Scott Thornbury (New School, New York, USA)

In the final chapter of the excellent collection of papers honoring the work of Dr. Larsen-Freeman (Ortega & Han, 2017), Han, Bao & Wiita take issue with the complex systems view of L2 acquisition as being 'forever open, dynamic, and adaptive' (p. 226) and instead propose that 'the system is closed with its total energy conserved' (p. 226). They argue, for example, that the driving forces in the system (motivation, aptitude, exposure ...) are constrained, and that their impact is finite, in the face of 'repellent' effect of the distance between the starting point (the L1) and the goal (the L2) such that input, for example, 'ceases to have an instrumental impact on learning past a certain threshold of sustained exposure to it' (p. 214), and that it is these constraints – this 'energy conservation principle' – that accounts for 'inter-learner differential attainment' and – dare we mention it? – fossilization.

I have to say that this rings true with my own experience as a user of L2 Spanish with over 30 years exposure, reading one-and-a-half million running words a year, at a rough estimate, yet incapable of increasing my productive vocabulary beyond a mere 5000, nor – by extension – my fluency beyond B2 level. As a devoted fan of Dr. Larsen-Freeman over many years, I am very curious as to know now she might respond to this challenge to her characterisation of L2 acquisition as being open, adaptive, self-organizing, etc., and with no end-state. In short, is it terminal, Doctor?

The question is both a good and a vexing one. Well, maybe it's a good one because it is vexing. I guess one answer might be to embrace the 'good enough' theory. You may remember Wes, who was studied by Dick Schmidt (1983) in Hawaii. Wes was a successful art dealer, a Japanese-American, whose English was functional, but never became grammatical. Schmidt speculates that at least one reason is that Wes really had no interest in the grammatical aspect of the language (p. 169). Another is that he expected English speakers to accommodate to his interlanguage (p. 167), so not all the responsibility for successful communication rested with him. So, one answer to your question is that the agentive learner can choose to some extent whether they want to learn.

But, I understood from your question, that 'good enough' isn't good enough for you. You do want to continue to learn. A few years ago, you conducted a wonderful webinar (Thornbury, 2017) on hyper

polyglots. So, I would ask what you learned from the hyper polyglots? Maybe hyper polyglots have something we can all emulate. For instance, I know that Andrew Cohen has learned many languages, and he relies extensively on the use of language learning strategies to do so (Cohen & Wang, 2019).

A second explanation is entrenchment. Entrenchment has been simulated in neural network research. ‘Once a network has been trained to respond to a large variety of stimuli, it settles in to an attractor state that is very hard to modify’ (MacWhinney, 2017, p. 3). However, entrenchment is a potential neurological explanation when it comes to the acquisition of morphosyntax. In contrast, your goal is to expand your vocabulary and develop your fluency, so these may be less affected by any putative entrenchment.

The same is true of fossilization – the absolute cessation of learning. It has been used most commonly with morphosyntax and discourse factors, not vocabulary acquisition. However, even with regards to the former, I think most researchers no longer accept that there’s an absolute threshold to learning overall, although there may be a gradual decline, and there may be particular forms that persist (Han, 2014). Nevertheless, there are successful L2 learners who have become fluent later in life. Of course, there are intra-individual factors, such as persistence, identity, and memory strength, which may account for differential success among learners.

One way of thinking about your situation, using the topographical image that I discussed earlier, is to say that the absence of learning in a language occurs when the learners’ system becomes closed and settles down to a fixed-point attractor or enters a deep well. As Long (2007) pointed out, though, fossilization (or the complete cessation of learning) can only be attested to at the end of one’s life. In other words, there may be stabilization to the system, but there is always potential for the L2 attractor to become reanimated. One can always climb out of the well. There are times, typically at a learner’s intermediate level of proficiency, when the system appears to plateau; at other times, development takes place, although it may be uneven, i.e., centered on one linguistic subsystem and not others. A complex system operates on many different timescales (de Bot, 2015b), so it may appear to be stationary at one, but mutable at another.

So, what does it take to climb out of the well? My advice would be to work with a teacher. After all, Schmidt’s (1990) observation still holds, I believe, which is that for optimal development, a learner’s attention needs to be guided. And though you were careful to say ‘affordances,’ you also said ‘input,’ and we know that the two are not the same. In fact, CDST suggests that for a full understanding of development we need to replace computer input/output models with more situated experiential and ecological views, which foreground embodied learners engaging with the affordances of the social environment.

One definition of affordance is what is available in the environment. However, there’s an important second meaning. The second order of affordance is defined by which opportunities learners perceive and take advantage of from all that are available (Larsen-Freeman, 2017b). The learner isn’t a passive recipient of data, but an active participant in the learning process. So, the second definition becomes relevant when learning-centered teaching is being practiced. This practice involves teachers managing the second order affordances between the students and what is being learned. That’s why I say a teacher can be really helpful. It is not the input, but the learner’s perception of and action on the affordances in the ever-changing context that is fundamental to learning.

Yasin Yazdi-Amirkhiz (TUMS, Iran)

How does CDST fit in with Critical Theory?

Some have raised questions about the possibility of adopting a critical stance in complexity theory. Can the theory really deal with issues of power and control? Can it be transformative in the sense of seeking social change? If self-organization and sensitivity of the system to initial conditions suggest inevitability, then is the system simply fated to go on reproducing itself? I think not. As Cameron and I have written, ‘While Complexity Theory may not show us what kind of intervention will make right an unjust system, it does help us understand the system better’ (Larsen-Freeman & Cameron, 2008, p. 8).

As with any theory, the responsibility for how it is used lies with its users. Moreover, one of the relevant issues arising out of a complexity theory understanding is that in our efforts to rectify injustice, we do so in OPEN complex systems. Complex systems are open to change, little if anything is foreordained. Within our own field, for instance, Kramsch and Zhang (2018, pp. 22–23) have written: ‘... the teaching of a language, other than the dominant language, always inserts the possibility of change within the dominant system of symbolic power relations.’

So, according to CDST, a complex system has the freedom to develop along alternative trajectories, following what Osberg (2007) calls ‘a logic of freedom.’ Since emerging processes are not fully determined, they contain within themselves the possibility of freedom. Thus, while a complex system’s potential might be constrained by its history, it’s never fully determined by it.

Having said this, I should call attention to critical realists Alison Sealey and Bob Carter (Sealey & Carter, 2004, p. 84) who wrote, ‘[T]he concepts of complexity and emergence are indispensable to a realist conception of language and social action.’ And Jeremie Bouchard’s (2021) book makes a case for combining critical realism with CDST for the very reason you ask – the need for a critical perspective.

Finally, a long-time proponent of complexity thinking, Claire Kramsch, said just a few short weeks ago as a discussant for an AAAL symposium (March 2022) – that what we need is a theory of criticality to accompany complexity theory. And critical realism may be a good candidate for this role (Cochran-Smith et al., 2014). So, given the state of the field and of the world, contributing a critical perspective to complexity theory will be the next big challenge – and an important one.

3. Informal Discussion

Professor Widdowson began the informal part of the webinar by quoting from a poem by Wallace Stevens, ‘Metaphors of a Magnifico.’

Professor Widdowson:

Twenty men crossing a bridge,
 Into a village,
 Are twenty men crossing twenty bridges,
 Into twenty villages,
 Or one man
 Crossing a single bridge into a village.

I am just wondering whether there is not a danger of neglecting one particular perspective just in furthering the cause of another. Because I think our perspectives are different. I don’t have a complexity theory perspective, but I do have thoughts about the nature of language from a different perspective.

Professor Larsen-Freeman:

It has never been my intent to dissuade anyone from their perspective. Of course, I have set forth arguments for how complexity theory contrasts with others, but I have always done it in the spirit of ‘I found this to be of interesting – to be helpful – and perhaps you will as well.’ Your unique contribution, Henry, has been enormous. However, I do think that metaphors come into being contemporaneous with conditions in the world. Given the seemingly insurmountable problems we’re facing now, it seems to me that a theory that adopts an ecological approach can prove enlightening. If we don’t recognize the interconnectedness of all beings, we are doomed.

So, that is why this theory has appealed to me. Also, it is appropriately processual. For example, its dynamism is in keeping with the seemingly ever-increasing diversity and dynamism of the world, as evidenced in the international flows of migrants, refugees, sojourners, and travelers. But you have your own way of elucidating applied linguistics issues, and I have learned from it. I am not trying to say that there can only be one way of understanding, surely not. But for me, complexity theory makes sense. It

helps me understand teaching and learning better, and I believe that it is a theory for our time. After all, the late great physicist and cosmologist, Stephen Hawking (2000), called the present century ‘the century of complexity.’

Professor Widdowson:

I think the essential question is whether the theory is so to speak verbalizing the views and theories and attitudes and values which scholars have already formulated, but under a different name, or whether it is genuinely a revelation of a different way of seeing things.

Professor Larsen-Freeman:

Yes, now I think another point then to make is that not every insight associated with complexity theory is novel. The Greek philosopher Heraclitus wrote that ‘The only thing that is constant is change.’ So dynamism is not a new concept, and it has even been applied to describe language. However, what is new is when these insights come together to form an integral whole. It is easy to cherry pick the ideas, but complexity theory offers a crucible in which they intermingle and reciprocally influence one another. That is, I think, new. Certainly, there are scientists, social scientists, and even humanists who would agree.

Professor Thornbury:

I just want to return to my earlier question and extend it somewhat because you are quite right that I focused on lexis and vocabulary learning in my particular example of Spanish. But I am getting intrigued by the conservation of energy principle because I see it running across the whole gamut of systems in language learning, especially L2 learning, where we are very familiar with the kind of trade-off that you get between, for example, accuracy and fluency. You get better in one respect, and you lose the other.

You know that I am very sympathetic to complexity theory, and I see that it does help address a lot of the key issues in the field. Yet, I still come back to this thing: that there does seem to be a limited amount of energy, and the fact is that 99.9% of L2 learners never achieve anything like target proficiency. So, I guess I am just reiterating my question again as to what extent would you agree or not that it’s possible that the system, if not closed initially, does close down, falling into a permanent attractor state?

Professor Larsen-Freeman:

As I said, yours is a vexing question. However, I believe nothing is permanent when it comes to language learning. We used to think there was a critical period beyond which you couldn’t learn, at least not in the same way. I think we’ve been disabused of that notion at this point. There’s even a move now to teach languages to seniors with the goal of maintaining their cognitive flexibility. I understand limited energy, and certainly as I get older, I understand it more! But the educator in me wants to say there is always potential. I’m not a fatalist, and I don’t want to ever give up, or see my students doing so. In an open complex system, where everything is interconnected, nothing is precluded. That’s important to me.

Professor Thornbury:

Yes, and it’s important to me, too. and that’s why I mention Han et al.’s (2017) chapter. While I didn’t want to agree with it, I did feel that the point they made about the influence of input, or whatever you want to call it, tails off after a point and that is also true with motivation and aptitude. I keep thinking of Xeno’s paradox of Achilles and the tortoise that you can never get to the end of the race because each time you have to cross half the distance that you’ve already crossed. And that seems to characterize SLD for many people.

Professor Larsen- Freeman:

What did your study of the hyper polyglots teach you, Scott?

Professor Thornbury:

Aptitude would seem to be extraordinarily important, but then a lot of them started young so they got in there at the right time. You are right about needing a teacher ... needing a guide. You know my signature methodology, if you like, does not say, 'leave the classroom;' it simply means try to change the classroom more into a kind of immersive experience because I do think providing affordances is what it's all about. You just said it brilliantly. That was a wonderful sound bite about what teaching is – leading learners to take advantage of the affordances that are available. And I think teachers are supremely positioned to be able to do that. But, I get the question in every talk I have ever given: what do I do with my fossilized students? And I like to say there's no such thing as fossilization. That there's always hope, but you know the fact is that it is like Achilles who is never going to reach the end of the race, and at some point I guess we have to tell students, 'You might never get to the top of the mountain, but the view from halfway up is pretty spectacular.'

Question from a Member of the Audience:

How can research methods such as Retrodictive Qualitative Modeling have implications on a language classroom if the goal is to go back instead of predict? What other research methods would you propose?

Professor Larsen-Freeman:

The idea of retrodiction is that one can't confidently predict what emerges from a nonlinear system because with the large number of interacting factors (all of which do not make a consistent contribution), a small difference in one factor can result in a large difference later ('the butterfly effect'). Of course, we may have expectations of how a process will unfold, based on prior experience, but we cannot predict exactly what will happen.

I think that happens in our classrooms. We plan our lessons, anticipating what will happen. However, only after the fact can we reflect on and attempt to explain what has happened. The idea is to separate prediction from explanation.

Complexity theory has ushered in several methods, not that we have to leave behind some of the ones that have worked well for a long time – ethnography, for example, or case-based methods. There are several books on research methods and complexity theory. One that I would recommend is *Research methods in complexity theory* (Hiver & Al-Hoorie, 2020).

One example of a CDST-compatible method is design-based research. Unlike a classic experiment, where everything is controlled and things do not change once they are set in motion, in a design-based study, you establish a research question, but then once the research project has begun, you make adjustments along the way. That what I meant in my answer to Professor Schulze's question about how we delineate one CAS from another. My answer was that you need to set boundaries, but then you revisit and adjust the boundaries along the way. So, the theory has application in research, and I do think it has application in language teaching and learning.

Professor Anne Burns:

I think some of my questions touched on the relationship between design-based research and action research. In action research, you don't necessarily know what endpoint is going to be as you start out. It is that kind of immersive, highly contextualized situation where the directions of the research and the responses to the research process are certainly not in any way fixed. So, many different kinds of influences and reactions are likely to change that situation as you go along.

Professor Larsen-Freeman:

The protocol of design-based research and action research are similar in that both make adjusting part of the process. The other advantage to action research from a CDST perspective is that it brings to every

situation the practitioner's intimate knowledge of the context. CDST valorizes context and therefore recognizes that one can anticipate, but not predict, the outcome of a complex, emerging system.

Professor Anne Burns:

Yes, because one of the things I really noticed in working with teachers conducting action research is the total unpredictability of what's going to appear at the end of the research process, so it's actually quite energizing and inspiring and exciting. That is the situation because it often takes those professionals much further and deeper than they'd anticipate to begin with.

Professor Larsen Freeman:

Yes, I would say it's a learning-centered approach to teacher education.

Thank you, and I am grateful to you one and all for your magnanimous participation, and for giving me a chance to learn myself. As I always say, 'Teaching begins with learning.'

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