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A Dynamic Approach to Second Language Development

Methods and techniques

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Introduction

Kees de Bot, Wander Lowie & Marjolijn Verspoor

It has now been 13 years since Diane Larsen-Freeman published her seminal article on complex systems and second language acquisition (Larsen-Freeman 1997). As she has noticed herself in various publications, it took the applied linguistic world a few years to realize that a paradigm shift was about to take place. Several publications and meetings on both sides of the Atlantic have taken place since that time and this repetitive mentioning – iterations in dynamic parlance – of relevant aspects of complexity and dynamic systems theories has now led to a solid position of this perspective on language learning and teaching.

In several publications, the short history of the complexity/dynamic approach to second language development SLD has been spelled out and there is no need to do so here. However, it may be useful to look at the most recent and important set of articles on this issue: the special 60th anniversary issue of Language Learning on language as a complex adaptive system (December 2009, issue 59, supplement). In their opening position paper, Clay Beckner, Richard Blythe, Joan Bybee, Morten H. Christiansen, William Croft, Nick C. Ellis, John Holland, Jinyun Ke, Diane Larsen-Freeman, Tom Schoenemann, or the 'Five Graces group', as they call themselves, lay out the most important aspects of language as a complex adaptive system (CAS). In this article – compulsory reading for all students of applied linguistics (AL) interested in this new approach – the authors show that a multitude of factors play a role in the emergence of first and second languages, but their conclusions on how to do research on language as a complex system are disappointing:

> In the various aspects of language considered here, it is always the case that form, user and use are inextricably linked. However, such complex interactions are difficult to investigate *in vivo*. Detailed, dense longitudinal studies of language use and acquisition are rare enough for single individuals over a time course of months. (....) However there are other ways to investigate how language might emerge and evolve as a CAS. A valuable tool featuring strongly in our methodology is mathematical or computational modeling. (Beckner et al. 2009, 12)

Although the authors are careful to mention the limitations of modeling as empirical research, they see modeling as the only viable approach, probably a reflection of several of the authors' scientific histories and preferences. In our opinion, however,

the current paucity should not lead to an "either or" choice: Modeling can not replace empirical data but should simulate empirical data to test theoretical insights.

First of all, language development itself, with its many distinct constructions at different levels (sounds, morphemes, words, phrases and clauses) that can easily be observed and counted, lends itself par excellence to contribute to our knowledge of complex systems. Secondly, there are already several longitudinal data bases that provide detailed and dense data of language development over longer stretches of time (see van Dijk & van Geert 2007, or Steinkrauss 2009 on L1). Of course, simulations are valid and may be the way to move forward, but only in interaction with real data, especially when they simulate real data, can test hypotheses, or consider possible alternative developmental tracks when factors interact in specific ways.

The ultimate test of a theory, following Jordan's (2004) insightful discussion of theories on second language development, lies in its ability to generate powerful and testable hypotheses. Whether CAS, complexity theory (CT) or dynamic systems theory (DST) meets this requirement remains to be seen because prediction is not what the dynamic approach is after. It predicts that systems and variables will influence each other's change over time, but the outcome of these interactions is by definition unpredictable at lower levels of the system. One of the most important outcomes of this perspective is that the focus is once more on the learner, but this time not as a generalized hypothetical representative of a larger sample, but as a developing system on its own.

The main thrust of this book is to show different ways of looking at the development of individual learners. One aspect of the focus on the individual learner is the renewed interest of intraindividual and interindividual variation over time. Inspired by the groundbreaking work by Paul van Geert and his colleagues, we are now more than before aware of the relevance of information on variation and its sources. This is one of the perspectives that is elaborated in more detail in various contributions in this volume. Variation can be studied as the outcome of interactions between variables, and only through carefully looking at such variables and their interaction in longitudinal data can we slowly expand the range of variables we know to play a role in the developmental processes we are interested in.

The aim of this volume is to show how different types of data can be gathered and analyzed to inform us about the process of language development from a dynamic perspective. In contrast to Beckner et al., the contributors to this volume do not see mathematical modeling and simulations as the only approach. There are different types of data that we can study using the tools of DST and CT. Data on variation, dense data gathering and analysis, but also simulation data related to longitudinal data on development are seen as important sources of information. Applied linguists are not cognitive scientists, and though they should inform themselves about the contributions of modeling and simulations, they should not rely on them without carefully analyzing linguistic data first.

This book is meant for researchers and students who would like to apply dynamic systems methods and techniques such as variability analyses and modeling to longitudinal language data. The chapters explain the general principles with many actual examples from previously published and new data. In addition, starting from chapter three and continuing to chapter six, readers are directed to the 'How to' sections in Chapter 8 at the end of the book, which provide detailed information about the actual techniques and tools we used to code, analyze, present and model the data. Finally, on our website SLD_Methods (DOI:10.1075/lllt.29.website), readers can find the original files that we worked with and practice doing the analyses or examine the exact formulae we used.

The first two chapters present the theoretical framework for a DST approach.

Chapter 1, "Researching SLD from a DST perspective" by Kees de Bot and Diane Larsen-Freeman, reviews the basics of DST and shows the relation between traditional research and a DST approach to applied linguistics. One of the main questions is what the major contribution of a DST approach to language development is.

Chapter 2, "DST and a usage-based approach to SLD" by Marjolijn Verspoor and Heike Behrens, examines to what extent different usage-based approaches to language development are in line with DST thinking and address the research questions that a DST perspective to SLD could focus on.

Chapters 3 to 6 discuss actual case studies, each focusing on a different linguistic subsystem, to present different aspects of DST inspired research questions, techniques and methodologies. All four chapters use the data of real learners and show that even though they all keep developing, there is a great deal of variability as they discover and try out new words and constructions at all levels.

Chapter 3, "Coding and extracting the data" by Monika S. Schmid, Brian MacWhinney, and Marjolijn Verspoor, discusses the type of variables at different levels (e.g. lexical, syntactic, morphological, and so on) that may interact over time. It discusses an advanced Dutch learner of English in terms of how her sentence complexity and lexical sophistication develop over a three-year period. The main objective of this chapter is to show which variables may be interesting to look at and how to operationalize them. The *How to* sections at the end of the book show efficient techniques to code and extract data using existing software (CHAT), how extra tiers may be added to code for variables not automatically coded in CHAT, how to automatize processes using macros, and how the data may be extracted in CLAN, and then become available for analyses by importing the data in Excel pivot tables. CHAT/CLAN is widely used in the AL community (and includes an enormous shared corpus). The *How to* sections will explain the general principles and refer to the existing CHAT/CLAN handbooks where necessary. They also explain which data can be extracted automatically and which data can then be further analyzed using Excel pivot tables.

Chapter 4, "Variability analyses in language development" by Marijn van Dijk, Marjolijn Verspoor and Wander Lowie, points out the differences between traditional

analyses that usually ignore variability and DST. The chapter discusses how eight Spanish learners of English acquire the grammatical negative formation subsystem. The main objective of this chapter is to show what variability can tell us about development and how to test whether the patterns found are meaningful or not. From a DST perspective, variability can actually be analyzed as data because the different patterns may give insight into the developmental process. Different techniques are shown to make the variability and general patterns visible within a spreadsheet program. Then techniques such as "detrending" and "Monte Carlo Analyses" are introduced to see if the patterns found are meaningful or not. The *How to* sections at the end of the book explain in detail how to make variability graphs in a spreadsheet program, make min-max graphs, make a moving window of correlations, detrend the data and run a Monte Carlo with software that can be downloaded for free.

Chapter 5, "Visualizing interactions between variables" by Marjolijn Verspoor and Marijn Van Dijk, is a preparation for the chapter on modeling. It first discusses the different relations variables may have to each other: They may support or compete with each other, and one may be conditional for another. The chapter then revisits the advanced learner from Chapter 3 to show various techniques to make the interactions such as support, competition or condition among different variables more visible so that they can be tested through simulation. The *How to* section at the end of the book shows how to do a moving window of correlations.

Finally, Chapter 6, "Modeling development and change" by Wander Lowie, Tal Caspi, Henderien Steenbeek, and Paul van Geert, shows how patterns that have been found in variability analyses as presented in Chapters 4 and 5 can be generalized in computer simulations. The chapter first explains what the differences are between deterministic and dynamic models and the main principles dynamic models are based on. Then by means of a case study on the development of the lexical subsystem of an advanced learner of English, it shows how theoretical assumptions about relationships between variables can be tested using growth models that simulate iterations. By comparing the outcomes of the growth models to empirical data, we can test whether our theoretical assumptions were justified. The *How to* sections at the end of the book gives details on how to use the program Van Geert (2003) has developed in Excel-VBA code and model data.

In our book we have limited ourselves to second language development as that has been our own expertise, but we hope that other researchers may find ways to apply these techniques to other areas of applied linguistic research as well.

Researching Second Language Development from a Dynamic Systems Theory perspective

Kees de Bot & Diane Larsen-Freeman

1. Introduction

The objective of this book is to present recently developed research methods and techniques in second language development (SLD) from a dynamic systems theory (DST) perspective. The objective of this chapter is to introduce DST briefly. It begins with a brief discussion of theory construction and goes on to introduce characteristics of dynamic systems. It concludes by suggesting some ways that research from a DST perspective can be conducted.

2. Theories in applied linguistics

The aim of scientific research is to develop theories that can describe and explain phenomena. In the history of science some of the greatest minds have developed thoughts about what constitutes a good theory, what phenomena should be described and what explanation actually is. It is of course beyond the scope of the present chapter to give a full treatment of the thinking about theorizing in science, but it may be useful to touch upon some of the issues because many of them are still debated today as fiercely as they have been in the past. In a way, applied linguistics (AL) is a young branch of science, and therefore some of the discussions that have more or less settled in "older" sciences still go on in this field. On the other hand, some would argue that it is also a sign of maturity that a research community reflects on what its main theories and paradigms are. That is certainly the case in AL. We are fortunate to have several books on theories of SLA (Mitchell & Myles (1998[2004]), Larsen-Freeman & Long (1991), Gass & Selinker (2001), Nortega (2009)) and an excellent overview of general issues in theory building in science as they apply to AL in Jordan's "Theory Construction in Second Language Acquisition" (2004).

The focus of this chapter is on one domain of AL, namely second language development (SLD). It is traditional in AL to refer to this domain as second language

acquisition (SLA); however, we prefer "development" for the reasons we give below. Long gives the following much quoted definition of an SLA theory:

> SLA theory encompasses the simultaneous and sequential acquisition and loss of second, third, fourth, etc. languages and dialects by children and adults learning naturalistically or with the aid of instruction, as individuals or in groups, in second or foreign language settings. (Long 1993: 225)

While this is already a fairly broad definition, we would like to broaden it even further by moving from acquisition to development and from development to use. This leads us to the following definition:

> A theory of SLD describes and ultimately explains the development and use of more than one language in individuals.

By including the notion of "use", we want to make it clear that in our view several issues of multilingual processing, such as L1 interference and code-switching, are explicitly part of what we consider to be SLD. This allows for the inclusion of research on psycholinguistic aspects of multilingualism that in our view is crucial for our understanding of SLD. By using "development" rather than "acquisition", we want to make it clear that linguistic skills can grow and decline, and that accordingly, language acquisition and language attrition are equally relevant outcomes of developmental processes. Also implicit in the use of the term "development" is our belief that there is no one point at which it can be said that a language is completely acquired. Its development is ongoing. Our own perspective on development is based on notions in dynamic systems theory in which there is basically no distinction between development and use (we will come back to this later in this chapter), but we acknowledge that in most research and theories the two notions are treated separately.

It follows from our definition of a theory of SLD that theories can be descriptive and explanatory. Most theories are descriptive, and such descriptions are essential for our understanding of many phenomena, but very few theories are actually explanatory. The difference between descriptive and explanatory theories can be easily illustrated with the theory that the earth moves around the sun. This is a theory that describes the earth's path, but it does not explain why the earth moves around the sun. Even though most SLD theories aim to be explanatory, few theories actually are, partly because for many phenomena there are no comprehensive accounts for all outcomes and partly because making absolute claims about human phenomena is problematic. Nonetheless, for many researchers, explanation is the highest goal and they frown upon "mere" description.

There are two ways that theories form: through induction and through deduction. These two approaches can be summarized as "research then theory" and "theory then research" respectively. Jordan (2004) discusses this inductive/deductive distinction in

detail and gives it a historical perspective, but we will limit ourselves to the discussion of some examples to show how these two approaches are used in SLD research.

In the *inductive* approach the researcher begins with gathering data on the phenomena to be studied. There is no preconceived theory that is used to gather the data. However, we must be aware that there is no description without a theory: There will always be some basic assumptions concerning the nature of acceptable data, such as "language phenomena are not completely random" or "words are relevant units of analysis". An example could be a study on prosody in L2 learning. First, the researcher has to define what she will be looking for: pitch contours, stress patterns, variation in volume or other phenomena. Then she will try to categorize phenomena to find out whether there is any systematicity in the data. Following that categorization process, she will then try to arrive at some general statements that aim at explaining the relations between the phenomena. This is then the core of a theory. The researcher doesn't start with a theory and try to find data to support or falsify it, but takes the data as a starting point and attempts to distill some underlying principles. As a next step, these principles can be used as a starting point in order to find further support and eventually arrive at a more generalisable theory.

In the *deductive* approach, the theory is the starting point. On the basis of the theory, a number of testable hypotheses are set up and data are gathered that provide evidence to support or falsify the hypothesis. The hypothesis has to be narrow enough to get relevant information on the phenomena studied. An example could be the role in second language development of watching subtitled TV, in which the subtitles are in a known language. The theory predicts that comprehensible input leads to acquisition, so watching more subtitled TV will lead to more acquisition, "all other things being equal". The normal procedure will then be to set up an experiment in which two groups are compared: one group who watches a large amount of TV and the other group who watches a smaller amount and performs some other task in the L2 for the time equivalent to the first group's television-watching. The gain scores in proficiency over time are used as the dependent variable. If the first group outscores the second group, the hypothesis is confirmed, and the theory supported. Of course, this example is a simplification, and we will come back to it to show that this kind of experimentation needs to be much more complex.

In the evaluation of theories, the notion of what constitutes proof is essential: A theory makes certain assumptions, and empirical data are gathered to test whether these assumptions hold or not. An assumption could be that there is a relation between the storage capacity in working memory and SLD: More capacity leads to development; less capacity may lead to stagnation or even decline of language skills. What would be proof for such an assumption? If we can establish that one group of learners has a small working memory capacity and another group has a large working memory capacity, the prediction is that the first group will show less development than the

second group. But even if our expectations are confirmed, can we be sure that we have proof for our assumption? There may also be other aspects in which the two groups differ; for example, the group with the larger working memory may also have a higher aptitude for language learning, so we cannot be sure that the differences found in language proficiency are caused by the larger working memory. Another possibility is that people who practice learning an L2 a lot will have a larger working memory, so the larger memory capacity is a result and not a cause of language learning.

It seems, then, that proving a theory is not as simple as it may seem. It is in the end the community of researchers that defines whether a theory is adequate or not. However, within the SLD community, there is not much explicit discussion on whether a particular theory is valid, probably because many theories in AL have come from different fields where their worth has already been proven.

2.1 DST as a theory of SLD

This is not a chapter on the details of dynamic systems, also known as complex systems, and complex adaptive systems. While the history of the application of complex dynamic systems in the field of applied linguistics is fairly brief, a range of publications have been published in recent years (de Bot 2008; de Bot, Lowie & Verspoor 2005; de Bot, Verspoor & Lowie 2007; Jessner 2008; Larsen-Freeman 1997, 2002, 2006, in press; Larsen-Freeman & Cameron 2008a, 2008b; van Geert 1998, 2008; Verspoor, de Bot & Lowie 2004; Verspoor, Lowie & van Dijk 2008). More detailed information on various aspects can be found in these publications. In this chapter we will focus on issues that are relevant for the methodology of researching SLD from a DST perspective.

3. The basic characteristics of dynamic systems

"Systems" are groups of entities or parts that work together as a whole. We talk about the economic system, the social system, the system of a computer, and so on. At the human level we use terms such as the circulatory system, the articulatory system, and the cognitive system. Systems consist of subsystems and are themselves part of a larger system. Systems are embedded in other systems. The term "dynamic" also has a fairly straightforward meaning. Dynamic refers to the changes that a system undergoes due to internal forces and to energy from outside itself.

The theoretical framework we will present in this chapter is based on DST, and in its most basic form, it is exactly that: systems that change through forces. Sometimes the system changes continuously, sometimes discontinuously, even chaotically.

Despite its relative newness, DST has attracted much interest, and this interest has resulted in whole institutes devoted to the study of DST and more books and

articles on this topic than anyone can ever read. In areas germane to our interests there are several articles and books on language and language learning as dynamic systems (Larsen-Freeman 1997, 2002; Van Geert 1994b; Herdina & Jessner 2002; de Bot, Lowie & Verspoor 2005; de Bot & Makoni 2005; Larsen-Freeman & Cameron 2007, 2008b; Verspoor, de Bot & Lowie 2008) and on DST approaches to the human cognitive system (Thelen & Smith 1994; Port & van Gelder 1995; Beer 2000; Spivey 2007).[1]

DST started as a branch of theoretical mathematics, and its initial aim was to model the development of complex systems. Later on, the mathematical tools that had been developed proved to be useful for the analysis of problems such as the movement of the moon under the influence of the sun, the earth and other planets. Because there are systems on every level in the physical world, DST has found applications in a wide range of fields, ranging from epidemiology to economics to meteorology, and it has been used to solve practical problems ranging from heartbeat control to drilling holes for oil. What all these fields and applications have in common is that the phenomena they want to study or to change do not seem to follow predictable patterns of development.

In order to understand dynamic systems better, in this section we discuss their basic characteristics. These include:

a. Sensitive dependence on initial conditions
b. Complete interconnectedness
c. Nonlinearity in development
d. Change through internal reorganization and interaction with the environment
e. Dependence on internal and external resources
f. Constant change, with chaotic variation sometimes, in which the systems only temporarily settle into "attractor states"
g. Iteration, which means that the present level of development depends critically on the previous level of development
h. Change caused by interaction with the environment and internal reorganization
i. Emergent properties

We will discuss each of these characteristics here with some indications as to how they may play a role in SLD.

1. There are numerous web sites on DST. A very informative one is: http://www.calresco.org/sos/sosfaq.htm#2.11 Checked August 12, 2009

3.1 Sensitive dependence on initial conditions

Sensitive dependence on initial conditions has become famous as "the butterfly effect", which refers to the well-known example of the meteorologist Edward Lorenz, who showed that minimal differences in beginning conditions of systems can have massive effects later on. This has potentially a far-reaching impact on processes of change. For language learning it may mean that minimal differences between learners may, even when they go through similar learning experiences, lead to very different learning outcomes. In other words, similar teaching approaches do not necessarily lead to similar learning. For our research this means that we need to have detailed information on the initial conditions if we want to be able to explain differences and similarities in learning outcomes.

However, here we have already encountered one of the really complicated aspects of DST: In order to predict how development will take place, we need an extraordinary amount of information about those initial conditions. And, as we will see later on, at the start we don't know what the complete list of relevant conditions looks like: Does your grandmother's level of proficiency in French when she was young play a role in your learning of Swahili? Probably not, but it is possible – her aptitude or enthusiasm for French may have been passed on to you. Paulson (2005: 345) maintains that "the impossible amount of information needed for exact predictions is typical of chaotic systems".

It is not only our limitation in identifying all of the relevant variables and initial conditions. Our predictions are still limited by the next two characteristics of dynamic systems: their interconnectedness and their nonlinearity.

3.2 Complete interconnectedness

In a dynamic system all parts are connected to all other parts. Looking at language as a dynamic system means that subsystems such as the lexical system, the phonological system and the syntactical system are interconnected, which in turn means that changes in one system will have an impact on all other systems. This is not to say that all connections between systems are equally strong: Some systems will be only loosely connected, while for other systems the connections are very strong and the mutual impact of changes will be equally effective. In Figure 1 this complex interaction between variables is represented. It concerns the relationship between changes in proficiency at three moments in time and the relation with language contact, attitude/motivation and the use of strategies. A change in proficiency from Time 1 to Time 2 will be affected by proficiency in other languages, attitudes and motivation, language contact and language awareness at Time 1. But the change in proficiency will in turn have an impact on these factors: Enhanced skills may lead to a change in attitude and contact with the language and use of strategies. These changes will then impact on the