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Dynamic systems in second language learning: Some general methodological reflections

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In this rich and provocative article, De Bot, Lowie and Verspoor provide a clear and informative description of the central tenets of dynamic systems theory and apply this to a number of theoretical and empirical issues in second language acquisition. The authors see dynamic systems theory as a promise for the future, an overarching theory in second language acquisition that takes into account the interconnectedness that is so characteristic of complex, developing systems, including the cognitive and social factors that help shape the process of second language acquisition. Having pioneered in dynamic systems for quite some time now (see Van Geert and Steenbeek, 2005, for a recent overview), I cannot be but supportive of their vision and their hope that this particular approach will lead to a fuller understanding of second language acquisition that is not only of theoretical but also of applied importance. However, the authors' remark about "some unresolved issues" in Dynamic Systems Theory may be somewhat over-optimistic. Nevertheless, I consider the dynamic systems approach as the quintessential future approach to human action, cognition and behavior, including language. All these phenomena are about change, about process in time. And this is exactly what dynamic systems approaches provide: an explicit model of change of some phenomenon of interest.

Of the many possible points of commentary and elaboration that De Bot, Lowie and Verspoor offer, I have opted for some conceptual and methodological ones. The major issue I wish to elaborate on deals with the possible tension between formal and informal dynamic systems models. A formal model has a specific mathematical format, e.g. a dynamic equation (see the example of the growth equation the authors provide), a set of coupled equations (see the example of the Robinson and Mervis study of 1998) or some other algorithmic format, such as a connectionist network (see the example of the Meara study of attrition in lexical networks). An informal model is one that applies certain dynamic systems properties by analogy or similarity. An example is the application of the notion of attractor to universal aspects of language, UG for instance, or to certain peculiarities or errors in a particular L2-speaker. What is the analogy between an attractor state and, for instance, a specific, relatively stable linguistic error in a particular L2-speaker? An attractor state is a relatively stable state of a system, and the error is relatively stable in that it remains fixed for a long time (or forever, for that matter). An attractor state is insensitive to (small) perturbations. For instance, if an L2-speaker is made aware of the error, it is likely that he or she is capable of correcting it once, but then spontaneously falls back on the error state. An attractor state can be reached from many different starting points. The typical error of the L2-speaker may also result from different acquisition trajectories in different speakers. Finally, an attractor state may change if the system is dramatically altered or enriched or if a significant perturbation is applied. Thus, a typical error may disappear if the speaker receives extensive training or moves to a different linguistic environment in which the exposure to the L2 by L1-speakers is considerably greater. The background of these attractor properties lies in the notion of emergence: an attractor emerges spontaneously, or self-organizes as a result of the interplay (or interconnectedness, as De Bot et al. call it) of all the variables or "forces" that constitute the dynamic system at issue.

The confluence of these properties lends credibility to the fact that the error – or any other temporarily stable property of an L2 speaker – may be treated as an attractor of a dynamic system, the formal properties of which are not known (a comparable approach has been taken in the search for discontinuous phase transitions, see Ruhland and Van Geert, 1998 for an application to language development).

The mere presence of certain qualitative properties itself is no proof of the fact that the property is indeed an instance of an attractor (or any other dynamic phenomenon marked by particular qualitative properties). The main question is: is there a better alternative theory? One alternative could be that the property allegedly identified as an attractor state has been pre-wired in the system, for instance in the form of particular genetic instructions. This is the sort of hypothesis that has been invoked to explain the presence of certain universal grammatical properties or UG. Another alternative explanation could be that the error, or UG or any other sort of relatively stable property is "just so" and accidental. Although under the first alternative some of the qualitative properties ascribed to attractors can be quite well explained (e.g. the

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robustness of the phenomenon, its resistance to change, etc.), the second alternative is not compatible with those properties. If the second alternative is true, we should expect any perturbation to have a proportional effect on the phenomenon at issue, and thus, expect some sort of "random walk" (which, by the way, is another example of a dynamic system, although a very elementary one).

What about formal models? Are formal models at all feasible in this highly complex domain of inquiry, second language acquisition? Do we know enough about the underlying processes of first and second language acquisition to specify and empirically test mathematical models? Take, for instance, the dynamic growth model that de Bot et al. explain in the section on DST and language learning (see Van Geert, 1991). The equation describes the change in a quantitative variable over time. Let me, by way of example, define a general variable relating to the mastery of a particular L2 and call this variable M, for mastery. If a person knows nothing of the L2 in particular, the level is 0 and if the person is a mature L1 speaker of the language, the level is 1 (by convenience). Can this variable be measured? Yes, but only to a limited extent. We can test the speaker and rank the test results in terms of more or less mastery of the L2 in question. Maybe we can make a test for L2 mastery and use the test score as an estimation of the person's M-level. The main point here is that the formal definition of such a variable and its use in a dynamic model is different from the measurement issue. Of course, if nothing of the variable can be measured or ranked, it makes very little sense to build a model of the change in that variable. However, all we need is some empirical indicators in M-levels in order to fruitfully apply the model, irrespective of the fact that the M variable as such is a rather abstract entity.

Once we have defined a variable, we must define the variable's so-called "evolution law", i.e. the basic principle describing its change. The growth model basically states that the change in the variable DEPENDS on the level of the variable, which, in the simplest possible way, means that the change is PROPORTIONAL to the level of the variable. This means that, all other things being equal, the increase in the mastery M of L2 over some fixed time interval (e.g. a month) is greater for a higher level of L2 than for a lower level. Think about the feasibility of an alternative hypothesis, which is that the change in M is NOT dependent on the level of M. It implies that change is either fixed or random, but at any rate not dependent on the actual level of M. Can this hypothesis be reconciled with what we know about learning? My bet is that it cannot, or, more precisely, that the odds for the dependency hypothesis are better. In addition, the growth model is based on a second hypothesis, which is that the growth of M depends on a variety of resources. These resources include anything that eventually affects the person's mastery of L2, ranging from the amount of exposure, exercise, talent, the person's L1 and so forth. Thus, the whole set of interconnected variables is implied in the notion of resources. An important assumption is that the whole of resources corresponds with a certain, maximal level of M. Thus, all other things being equal, the final level of mastery of L2 will be greater in a context with more exposure to L2, or in a person with more linguistic talent, or any combination of such factors. In order to check the feasibility of this resource hypothesis, let us think of the alternative hypothesis, namely that the growth of M does NOT depend on, and is NOT bound by, the available resources. According to this alternative, M would grow independent of anything that eventually supports it, which is hard to maintain. Or, M would grow without bounds and increase with no observable reduction until some external event stops the growth process (death, for instance). This is again hard to defend. However, if we combine the two hypotheses, which seem quite plausible in light of the implausibility of their alternatives, we end up with the logistic growth equation, which is a formal, computational model of change and which can be tested against the available empirical evidence. In summary, the building of a formal model depends in the first place not on the available, explicit knowledge of the underlying growth process, but on a combination of hypotheses that are more plausible than their alternatives.

A second major issue relates to a problem that features rather prominently in the field of linguistics and concerns the tension between quantitative variables and qualitative patterns. The L2-mastery represents a single variable, whose presence in the system is independent of the quantitative amount by which it is represented (the variable is present in the system as soon as it obtains some value, however small the value is). In language development, however, change often concerns the emergence of new patterns and forms, the emergence of a grammar or grammatical rules, the emergence of linguistic categories, and so forth. Hence, its main form of change is that of qualitative transformation and emergence, in which variables are transformed into other variables and new variables emerge. This phenomenon cannot be modeled in the form of purely quantitative growth patterns. However, if a new form (grammar, category, rule) emerges, its occurrence in the speaker's language use will also take the form of a quantitative pattern, in that the frequency of use of the new form will increase, gradually or suddenly. An important question for dynamic systems thus concerns the emergence of new forms and in addition to that, the link between qualitative and quantitative change. In order to describe dynamic phenomena in general, dynamic systems theory follows a geometric approach. Thus, it represents patterns or structures, such as a grammar, as a particular place in a multi-dimensional space. The space is of an abstract nature and consists of all dimensions necessary to specify the qualitative pattern at issue. It is

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often represented by the metaphor of a landscape, with hills and valleys that represent likely and unlikely places for the system to be in (i.e. attractors). It is important to note that this abstract space representing a person's mono- or multi-grammar knowledge must contain all dimensions that are necessary for the implementation of the grammar(s) in that particular person. Hence, the abstract space also contains dimensions relating to the biology of the speaker, to social interaction, cognition and so forth, in addition to dimensions that specify the specifically linguistic aspects. At present, the geometrical representation of grammar or linguistic knowledge and performance is little more than a metaphor, suggesting a new look on the phenomena in question, but not yet entailing any further explanation. It will be necessary to look for empirically meaningful formal similarities between the geometric representation with its favored places (attractor states) on the one hand and linguistic properties and language-learning phenomena on the other hand. In this way, the abstract geometric representation will hopefully enable linguists to rephrase questions about language learning by focusing on the underlying dynamics of the learning process.

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