



# Explaining after by before: Basic aspects of a dynamic systems approach to the study of development

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## Abstract

The basic properties of a dynamic systems approach of development are illustrated by contrasting two simple equations. One,  $y_{t+1} = f(y_t)$ , is characteristic of dynamic systems models. The other,  $y_i = f(x_i)$ , refers to what, for the sake of simplicity, is referred to as the standard developmental approach. We give illustrations from cognitive, language and social development to show the characteristic differences of these two types of models and show their complementarity. The article further compares the “Bloomington” with the “Groningen” approach to dynamic systems theorizing in developmental psychology. It continues with a discussion of two important questions. One involves the issue of measurement and the nature of developmental variables from the viewpoint of dynamic systems. The second concerns the question of short- and long-term time scales in developmental models, which is discussed on the basis of an example, namely dyadic interaction of young children in the context of different social statuses.

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## Dynamic systems gets you into problems. . .

Being a developmental psychologist and applying dynamic systems theory is almost like begging for trouble. A quick look through handbooks on dynamic systems theory (for

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instance Jackson, 1991; Katok & Hasselblatt, 2005) reveals an amassment of abstract terms and mathematical equations most of which are simply not accessible for the mathematically untrained reader, which the developmental psychologist is likely to be. It gets worse if instead of the handbooks the real mathematicians working in this field are consulted. As a rule, the mathematician will treat the developmentalist's dynamic models the same way as a kindergarten teacher evaluates a toddler's proudly made scribbles, knowing that the child in question deserves encouragement and that the way leading to a decent drawing of say, a horse, is still extremely long and arduous. And it also does not get really better if the developmental psychologist decides to turn to books discussing applications of dynamic systems to fields he or she feels at least a little bit accustomed with, such as biology or economics (see for instance Hofbauer & Sigmund, 1988; Murray, 1989; Ruth & Hannon, 2004). The problem now is not only the mathematics, but also the biologist's or economist's data, that seem to be so much more comprehensive and applicable than those normally available in studies of psychological development. And this is only one side of the problem. At the other side, in developmental psychology itself, dynamic systems is not really a very big issue. *Child Development*, for instance, has published 5 articles that have "dynamic(al) system(s)" in the title between 2005 and 1990. In the same period, *Developmental Psychology* published only such article with "dynamic(al) systems" in the title and so did *Development and Psychopathology*. *Developmental Science* published a special issue on the link between connectionism and dynamic systems (September 2003). Other examples are the issue of the *Journal of Abnormal Child Psychology* of December 2004, devoted to advances in process and dynamic system analysis of social interaction and the development of antisocial behavior, a special issue of the *Journal of Experimental Child Psychology* of October 1994 on dynamic modeling of cognitive development, and the current issue of *Developmental Review*. It seems as if the relative lack of publications applying dynamic systems theory to developmental processes has everything to do with the first kind of problem, namely the demands of dynamic systems theory both in terms of mathematics and formalization and of data collection.

Those of us working in the dynamic systems tradition have tried to overcome these problems in diverse ways. An important solution to the aforementioned problems originated from the work of Esther Thelen (we will call it the "Bloomington version"), represented by researchers such as Thelen, Smith, Spencer, Schöner and several others. Thelen and Smith (Thelen & Smith, 1994) took a number of general qualitative properties from dynamic systems theory—self-organization, complexity, attractors, phase shifts—and applied these notions to various developmental phenomena. A comparable approach, that is, via the qualitative properties, is represented in the work of Marc Lewis and co-workers (see for instance Lewis, 2000, 2004; Lewis, Lamey, & Douglas, 1999). Perhaps the smartest "move" of the Bloomington approach is that it has turned dynamic systems theory into a specific theory of development. Although the Thelen and Smith, 1994 volume is titled "A dynamic systems approach . . .," it basically presents a particular theory of development as a process that takes place in real time and real action and that involves a close loop of interaction between an acting person and an acted-upon environment. It is highly empirically oriented and has led to a number of original experimental studies. The recent assimilation of dynamic field theory into Thelen and Smith's dynamic systems theory has opened the possibility of rigorous mathematical modeling of a kind similar to that discussed in the general dynamic systems literature (Erlhagen & Schöner, 2002; Schutte & Spencer, 2002). However, according to an aphorism of the world-famous Dutch soccer

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