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Published in:
Psychosocial Development in Adolescence

DOI:
10.4324/9781315165844-1

Publication date:
2019

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INTRODUCTION TO A DYNAMIC SYSTEMS APPROACH TO PSYCHOSOCIAL DEVELOPMENT IN ADOLESCENCE

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Over the past decades, researchers who study adolescent development slowly reached an unnerving conclusion: much of the scientific knowledge on development that we have generated by studying groups, does not directly describe processes that unfold within individuals over time (this so-called *non-ergodicity* is explained in the next section). This is a shocking realization indeed, as one would expect developmental psychology to describe individual-level processes, and individual differences in change therein. Instead, most of what we have generated is knowledge about groups of individuals, and truths about averages that may or may not be true for any one individual (Blaauw, 2018; Molenaar, 2004). Subsequently we have a huge gap in our knowledge (see also Lichtwarck et al., 2008), which spans all domains of adolescent development. Uncertainty about whether and when group-to-individual generalizations are valid is particularly detrimental for our ability to effectively inform interventions (e.g., Fisher et al., 2018), as these typically deal with changes within individuals over time.

The lack of knowledge on individual processes in the social sciences is at least partly because many advanced tools were developed in the twentieth century to address differences between groups of people, whereas the development of techniques to study individual processes lagged behind (Lamiell, 1998; Rose, 2016). We lacked the practical tools to frequently measure individuals, we lacked the analytical tools to analyze such individual time-serial data, and we lacked the theoretical tools to understand these individual processes. These difficulties made individual process studies somewhat of a rarity.

But now, the field of research into adolescent development is changing in fundamental ways. Over the last decades, we have seen a rapidly increasing amount of research that is more person centered (rather than variable centered) and based on the analysis of processes over time, beyond the comparisons of groups.

Technological developments have facilitated this change. There is currently a rapid development of tools for frequent data collection (e.g., apps for smartphones) as well as tools for the analysis of such data (e.g., Hamaker et al., 2015; Kunnen, 2012). And, importantly, theoretical developments have allowed us to understand individual change processes over time. One major theoretical approach that helps researchers in describing individual developmental process is the dynamic systems theory. This theory deals specifically with individual processes of change and stability over time, and is well established in the fields of physics, chemistry, and biology (Broer & Krauskop, 2000; Haken et al., 1990; Von Bertalanffy, 1968). In recent decades, pioneers such as Thelen and Smith (1994) and Van Geert (1994, 2008) used the dynamic systems approach as a theoretical tool to study individuals over time and zoom into processes that lead to change and stability within individuals. These studies showed the potential of dynamic system approaches in developmental psychology.

With this book, we aim to share some of the theoretical insights that have been gained from a dynamic systems approach to the study of psychosocial development in adolescence. In 2012, Kunnen published a book entitled *A Dynamic Systems Approach to Adolescent Development*, which presented new techniques for the study of adolescent developmental processes from a dynamic systems perspective, and claimed that this approach would generate fundamentally new insights and knowledge. The aim of the current book is to substantiate this claim. Although we cannot be exhaustive, the following chapters demonstrate a broad variety of applications of dynamics systems principles and methods to the study of adolescent development. Importantly, in doing so, this book demonstrates how the application of dynamic system principles contributed to theories in many important areas of adolescent development. Before we present the chapters and the rationale for including them, we first explain the problem of non-ergodicity in more detail, followed by a definition of what we consider to be a dynamic systems approach, and an overview of the consequences that both have for research.

Ergodicity and the relevance of a dynamic systems approach for adolescent development

The problem of ergodicity is becoming more and more salient in developmental research. Non-ergodicity means that the relation that exists between variables in a group of people may be different from the relations that exist within people (Molenaar, 2004, 2008; Molenaar & Campbell, 2009). The famous example involving typists illustrates this nicely: in a group of typists, a positive relation is found between speed and accuracy, because better typists are faster and more accurate (Hamaker, 2012). However, when this static group association is applied to a developmental process within one person (i.e., where we are interested in the *change* of x and the *change* of y for individuals), the relation between speed and accuracy is negative: if an individual begins to type faster, this is usually associated with an increase in mistakes. Furthermore, relations between variables can differ between individuals, as person A may be inclined to react to frustration with anger, while person B may become depressed. Thus, in person A, intra-individual correlations over time will show a positive relation between frustration and anger, but no relation between frustration and depression. In person B, frustration will correlate with depression, but not with anger. Furthermore, mechanisms may also differ within individuals over time. A frustrating event may be experienced as a challenge for person C, and result in an increase in motivation when she has slept well and has enough time, but it may result in a drop in motivation when she is tired or has too much to do already. Together, the continuum of differences between relationships at the group (between-person) and individual (within-person) levels, and differences in causal mechanisms over time, are all characteristic of non-ergodicity.

Non-ergodicity is sometimes also described as Simpson's paradox, which is an illustration of how misleading averages can be. The paradox includes instances of erroneous conclusions drawn from group averages when causality is attributed or when "time" is not considered in correlational associations. The paradox has been found to be a common feature in findings concerning psychological processes (Fisher et al., 2018; Kievit et al., 2013; Molenaar, 2004). For example, a study by Keijsers (2016) about parent–adolescent relationships shows that, on a group-level, adolescents who are closely monitored by their parents show less delinquent behavior, whereas this relation is inverted on the individual level: an adolescent will show more delinquent behavior if the parents start monitoring more closely. Another example is a study by Van der Gaag and colleagues (2016) on micro-level identity development. They demonstrated that the commonly found relation between a large amount of exploration of alternatives and weaker commitments does not hold on the individual level: on an individual level this relation varied wildly, from being positive for one half of the individuals to negative for the other half.

The realization that the majority of psychological processes are non-ergodic has far-reaching consequences. It means, for example, that knowledge and insight that is derived from group analyses can often not be assumed to hold for individual development, which requires additional evidence. When studies find that, on average, positive development is related to a high level of some variable in a group of adolescents, it does not necessarily mean that increasing that variable in individuals will stimulate optimal development. Yet most of our knowledge nowadays is derived from group studies, and many intervention programs – explicitly aimed at development within individuals – are based on such studies. To address this issue, many researchers are becoming interested in studying developmental processes on an individual level as well. A dynamic systems approach can provide theoretical and methodological tools for studying individual processes and changes over time. As explained in detail below, this means the study of individual *systems*, which does not necessarily mean an individual *person*.

The ergodicity problem highlights the need for an individualized, process-oriented approach, which dynamic systems theory can offer. Additionally, a dynamic systems approach is ideal for the study of adolescent development in particular, as it is characterized by rapid and jumpy changes (irregular patterns, turbulence, bumps, delays, and regressions).

How can we define dynamic systems based research?

Given that the focus of this book is "dynamic systems based research" it is necessary for us to first define what we mean by dynamic systems based research. To start with, we would like to state that there is not one strict definition of "dynamic systems research" (for an overview of different schools and centers see https://en.wikipedia.org/wiki/Dynamical_system). Even within our own research group in Groningen – or indeed among the editors of this very book – there is no consensus. In fact, now that dynamic system approaches are become increasingly popular, this stream of research is becoming more diversified, development that we believe should be embraced and celebrated. Indeed, one of the objectives of this book is to illustrate this diversity. While we think that some criteria are necessary in order to provide guidance to interested researchers, these criteria are not exclusive. There are many ways of applying a dynamic systems approach to research, each with its own purpose and strengths. What is important is that all of these approaches share theoretical principles and some basic methodological characteristics that tie them together and make them "dynamic systems based research." These principles and characteristics are outlined below as assumptions that characterize how dynamic systems research is done – as an approach, which may also form the basis of a dynamic systems theory of development.

Assumptions

First, we believe that the most important assumption in dynamics systems approach is that development and change is always *individual based*. This assumption reflects the phenomenon of non-ergodicity (described above). The individual-based approach to development does not necessarily refer to the study of an individual person, but pertains to the study of individual systems. An important first step in any dynamic systems study is deciding what will be the target system of the study. This choice depends on the phenomenon in question and can in principle be defined at any level: from the level of a cell, to an individual, to dyads, to groups, to whole societies, or cultures. After defining a system, the researcher may then ask whether or not relations between variables within that individual system (for example, within-person affect and autonomy) or trajectories of development of the system, may vary between different individual systems. Thus, from a dynamic systems approach, the objective does not have to be solely to understand individual development, the objective may also be to find similarities or differences between individuals in order to generalize a specific finding to a larger group. At the core of the individual-based assumption is that the individuals that make up a group are always the starting point of the analysis.

Second, a pivotal assumption in a dynamic systems approach is that development is inherently *iterative*, such that $y_{t+1} = f_{(yt)}$, causing a system to continuously evolve over time (see Figure 1.1). Simply put, this means that the researcher takes into account that development proceeds step by step, and the next step builds upon the previous step (e.g., Van Geert, 2003; Von Bertalanffy, 1968, p. 45). The outcome of each iteration, a task or an interaction for example, changes the system, and that changed system is the starting point for the next iteration. Consequently, the aim of studies that adopt a dynamic systems approach is most generally to understand or describe how a system (person/dyad/group) changes across these iterative steps (which can occur across real time, the short term, or the long term).

A third key assumption in a dynamic systems approach is that there is *interdependency* between the system's states and the *context* (see Figure 1.1). In a dynamic systems approach, the role of the context is not considered to be a stable background variable, but as continuously and bi-directionally related to the system and its changes over time. That means that if we study adolescent autonomy, for example, and we define parental attitude as the context, we have to define how the adolescent *and* parental attitudes change over time, and how they mutually affect each other over time.

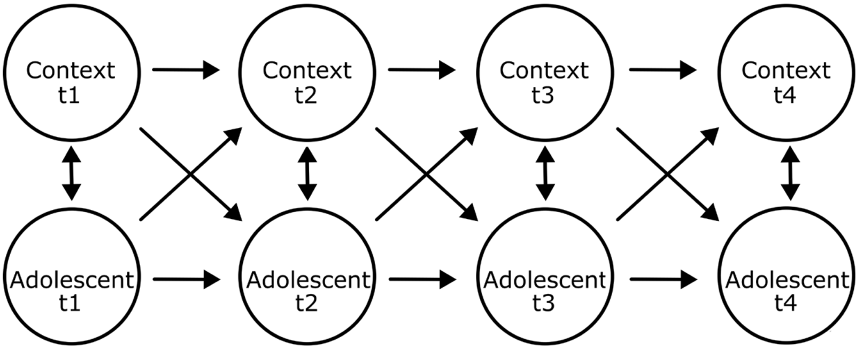

FIGURE 1.1 *Iterativity and interdependency*. This figure illustrates *iterativity* and the *interdependency* between the systems states and its *context*. In this case the system represents an adolescent. In each time point, the adolescent interacts with the context, and both the adolescent and context change as a result of this. This changed state is then the building block for the state of the adolescent and the context in the next time point, this is known as iterativity.

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Fourth, in dynamic systems research we assume that there are *bi-directional relationships* between *components of the system* across time (see Figure 1.2). A dynamic system can be defined as a system, or a network, of mutually interacting components. Changes in one of the components may influence another component in the system, which in turn can affect other components, etc. (e.g., Van Geert, 2008; Von Bertalanffy, 1968). What these components are, and how they influence each other (i.e., positively or negatively), depends on the system under study. A researcher may study a neurological system and define neurons and synapses as components. In processes of human psychology, components can, for example, be thoughts, feelings, perceptions, actions, motivations, etc. (Kunnen, 2012). The choice of components is one of the tasks of the researcher while designing a study. Of course, this does not mean that all components have to be included in the study of a system. That would be both impossible and unnecessary. In fact, it is possible to derive knowledge about the behavior of an entire system by studying the trajectory of one component (Takens, 1981). In general, a theory-driven selection is made of the central components of the system, such that the specific theory or domain of study informs which components are relevant to consider. Therefore, while it is of course possible to focus on the changes of only one or a few components of a system while actually studying the system, the underlying assumption remains that all components are mutually interacting.

Conceptualizing phenomena as a network of interacting components has an important fifth implication for the developmental trajectory of systems. Specifically, in a dynamic systems approach, it is assumed that developmental trajectories of individuals are almost always *nonlinear*. This is in contrast with the assumptions behind many traditional statistical techniques, where linearity or log-linearity is assumed. If we approach a phenomenon, or concept, not as a single variable, but as a network of interacting components, it becomes clear why nonlinearity is assumed. Continuous interactions between components will not occur uniformly, but some components will reinforce others in the same or opposite directions, while others will have an inhibitory effect, these interactions are collectively referred to as *feedback loops*. Depending on reinforcing or inhibitory interactions occur between components, the shape of the developmental trajectory will change (e.g., Hollenstein, 2015; Lewis, 2005). Interactions between two reinforcing components will result in rapid growth, while interactions between inhibitory components will result in stability (see Figure 1.2). Inhibitory feedback loops can continue for a long time, resulting in long-term (periodical) stability (Figure 1.2b). Reinforcing feedback loops, and the growth resulting from it, can only continue for as long as other components in the system do not interfere. For example, an increase in academic motivation will not endlessly lead to an increase in performance, as there are limits to energy (Figure 1.2a).

This means that the *relationship* between any two components of a system (i.e., variables) is not necessarily linear, as it is dependent on the actual value of the variables themselves and other intervening variables. Thus, the influence of one variable on the other at a given time may be positive, negative, or absent. As a result of the changing relationship between components, the resulting changes in the system can become unpredictable and irregular, such that the developmental trend is also not linear. In living systems, trajectories that result from varying types of feedback loops will not show endless growth at a stable rate. The feedback loops result in boundary conditions that limit the development in a certain direction, and may also generate regular and irregular patterns of fluctuations, bumps, and periods of fast development or stability. While linear growth may occur at some point during the general

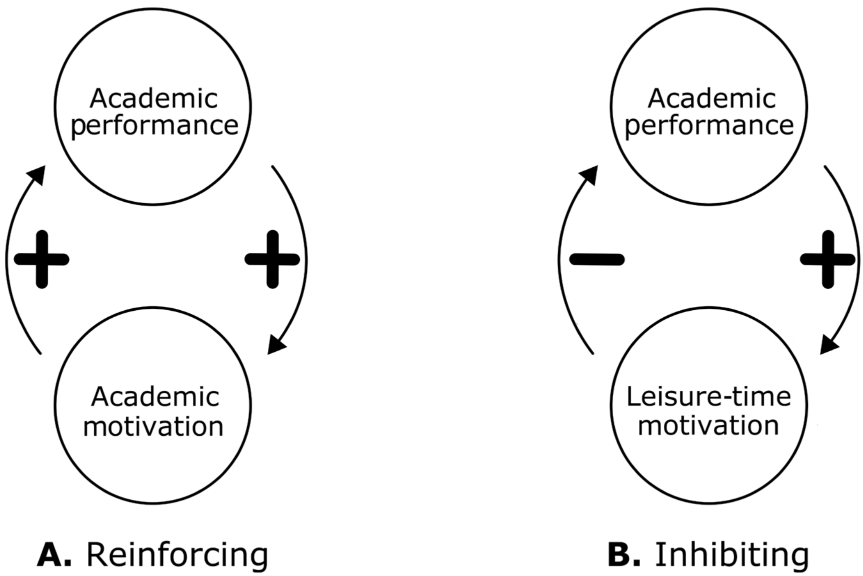

FIGURE 1.2 *Feedback loops*: a reinforcing (or positive) feedback loop (A) and an inhibiting (or negative) feedback loop (B). These types of *bidirectional relationships between components within a system* result in either rapid growth or stabilization. Example A represents an adolescent who, when performing well in school, is motivated to focus more on her studies, leading to better performance, and then again higher motivation until some boundary condition is met (e.g., energy limits). Example B represents a different adolescent who, when performing well in school, becomes motivated to focus on leisure time as a self-reward for a job well done. However, this focus on leisure time decreases her academic performance, which in turn decreases her focus on leisure time, which increases her performance, etc., leading the individual to stably oscillate (i.e., *nonlinearly*) between higher and lower performance states.

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trajectory, we would not assume that this kind of development is constant. Considering this, the characteristics of a trajectory (including patterns of stabilities and fluctuations) form an important and informative feature of the developmental process. Characteristics of the developmental process are not only interesting in and of themselves, but they can also inform us about the state of the system (Hollenstein, 2015), which we will see in many of the contributions to this book.

In summation, nonlinearity is a core characteristic of a dynamic system. This often has consequences for the complexity of the techniques that are used to analyze a system. However, it remains a matter of debate between dynamic systems researchers whether nonlinear techniques are required to study the behavior of a system. We suggest that, at the very least, a dynamic systems approach requires explicit awareness and consideration of nonlinear relationships and development in terms of research questions, designs, analyses, or in the interpretation and discussion of results.

Sixth, a dynamic systems approach assumes that, through the interaction of elements within a system, the potential for *self-organization* occurs. This means that the continuously interacting components may begin to "move together," such that their interactions give rise to a relatively stable pattern that is more than the sum of these components (Von Bertalanffy, 1968). In this way, the interactions between components can be seen as lower-level processes, and the stable pattern that they form can be seen as a higher-level process that is emergent. This is indeed a general characteristic of living systems (Kauffman, 1996; Kelso, 1995), one that explains how a system becomes a coherent whole.

Self-organization is a key concept for conceptualizing the relation between different *timescales*. In human development, elements such as emotions, actions, and thoughts can be considered as occurring on a lower-level timescale, and that the constellation of these elements may self-organize into one concrete experience at a slightly higher-level timescale, i.e., a state. Self-organization can then continue at yet higher timescales when these lower-level networks (i.e., states) of emotions, actions, and thoughts give rise to relatively stable and coherent patterns that can be characterized as habits or traits, such as identity styles or coping styles (i.e., De Ruiter et al., 2017) (see Figure 1.3). The relationship between the timescales is mutual. Not only do the lower-level states give rise to the higher-level timescales traits, but the emergence of the higher-level traits subsequently restricts the possible lower-level states.

In a dynamic systems approach, higher-order characteristics are also described as "attractors." Attractors can have different qualities and are as such relevant characteristics of a systems behavior (Kauffman, 1993). They can be weak or strong, the latter meaning that their so-called basin of attraction is broad and deep (see Figure 1.4). A broad basin covers a large "surface" of possible situations, which means that many situations pull the system into the attractor. When an attractor is deep it is very difficult for the system to escape from the attractor. An example of a

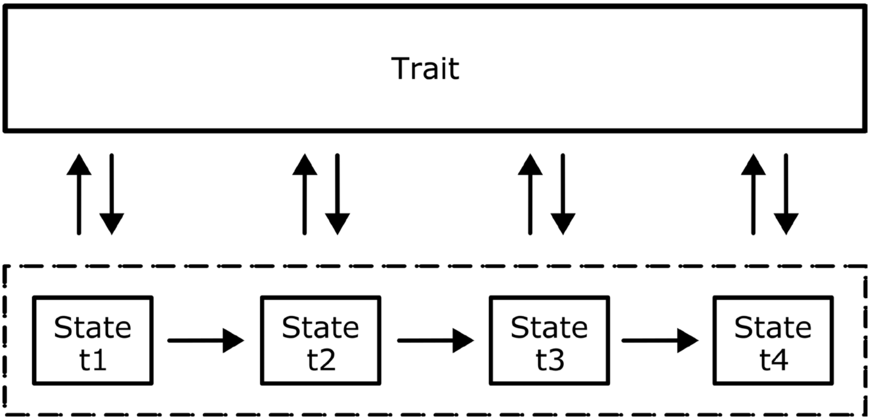

FIGURE 1.3 *Self-organization*. Higher-order structures, such as individual traits, emerge from the iterative sequence of system states over time. In turn, the individuals' states are constrained by the higher-order trait. This means that the states of an individual are stabilized as a result of traits that have developed.

Source: Van der Gaag (2018d).

strong and deep attractor is an individual who has a pervasive negative self-esteem. Almost all evaluative situations trigger negative self-thoughts for this individual (broad attractor), and strong feedback loops keep these negative thoughts and self-experiences in place (deep attractor), such that potential perturbations out of that state (i.e., positive feedback and praise) do not actually remove the person from that negative state (i.e., praise is experienced as pity, or successes are attributed to luck). Generally speaking, strong attractors are habits or styles that are very salient for an individual, are triggered very easily, are experienced very often, and, as such, are difficult to change.

Consequences of dynamic systems principles for research

What consequences do these principles have for research? These consequences may concern the very phenomena that are studied, the research questions that are asked, the data that are collected, the methods that are applied, and the way in which the outcomes are interpreted. Not all of these principles are (or need to be) salient in each dynamic systems study. Here we discuss some ways in which the above principles can be translated more concretely into research decisions. The pivotal assumption of an *individual-based* focus means that a researcher needs to think carefully about what the system is that s/he wishes to study and to make theoretical or methodological decisions accordingly. Which system one

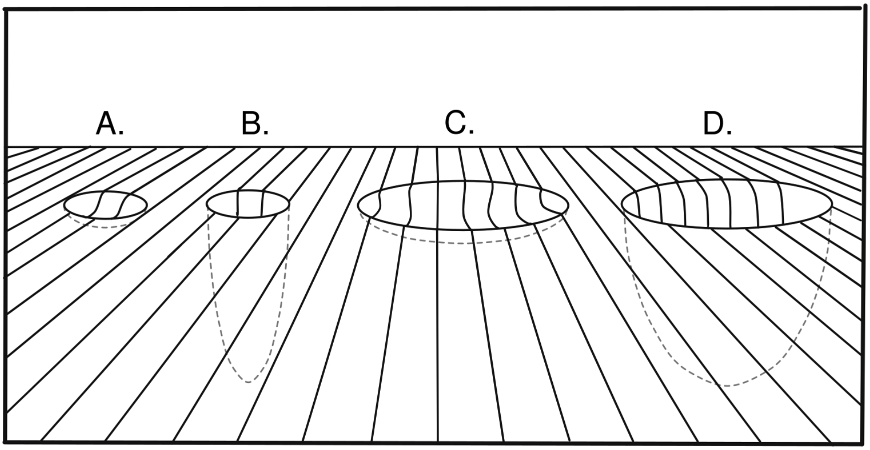

FIGURE 1.4 *Attractor landscape.* An attractor landscape consists of attractor basins that can vary in both their width and depth. The depth of a basin represents the strength of a state: deep basins are strong states that are hard to get out of, such as B and D. The width of a valley represents the pervasiveness of a state: wide basins are pervasive states that become active easily as they encompass more aspects of an individual's life, such as C and D. Narrow and shallow basins, such as A, are states that are of little consequence to the individuals' life, as these states are visited infrequently and are easy to get out of.

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selects has consequences for the time interval between measures (as development occurs at different rates for different systems), and for the components that are studied (as different systems consist of different sets of components).

Additionally, due to the essential characteristics of *iterativity* and potential *nonlinearity*, a dynamic systems study is often characterized by a time-varying coefficient. This means that whatever the object of study – a mean of a variable, a correlation between two variables, or an autocorrelation between a variable at t and t_{+1} – it can change over time. This is in contrast to two general approaches: either time is not considered at all (i.e., most cross-sectional research) or the interaction *with time* is studied (i.e., including "time" or "age" as a separate variable). In the latter, researchers may examine, for example, how teachers' behaviors influence students' learning behavior one month later (i.e., a uni-directional focus) and whether this effect is moderated by "age of the student." A conclusion based on this study may be that teachers' behavior X predicts students' learning behavior Y, and that this effect is stronger for older than for younger students. A dynamic systems approach, in contrast, may aim to understand how teachers' behavior at time t affects students' learning behavior at t_{+1}, and how students' learning behavior at t_{+1} influences teachers' praising behavior at t_{+2}, etc. This kind of focus resembles those of more common methods such as longitudinal structural equation modeling.

Alternatively (or additionally), the essential characteristics of *bi-directionality* with the *context* may inspire a researcher to examine the concrete ways in which teachers' behavior influence students' behavior *and* how students' learning behavior influences teachers' behavior, thus studying their interplay. This focus may call for a more qualitative approach, where the researcher zooms in on the lower-level timescale, studying concrete teacher and student actions, verbalizations, and emotions in real-time, in order to understand *how* teachers' behavior influences students' learning behavior.

Finally, the characteristic of *self-organization* of emergent patterns may lead a researcher to search for the system's stable properties, such as the increase of "order" or attractors. For example, a researcher may ask whether and when "order" increases or decreases over time with regards to the student–teacher interactions that occur at each time point, such that the higher-level and emergent properties are the focus. This kind of focus resembles those of more complexity-based methods such as recurrence quantification analysis. These kinds of studies are quite unique to a dynamic systems approach. Rather than predicting specific outcome values or identifying relationships between variables, this focus revolves around describing the dynamic *properties* of the system. This may be the strength of attractors, the level of variability of a process, or transitions made by the system. Researchers may ask how these properties change across time (i.e., are there peaks or dips in variability, or transitions in the nature of the attractors)? This implies a shift from the values of specific variables to a description of the system as a whole, and as such, is a form of *person-centered* research.

As such, we refer to "dynamic systems research" as an umbrella term that encompasses any research that follows at least some of the above-mentioned assumptions, which can be evidenced by the researchers' choice of research questions or methods.

This book

The chapters in the current book illustrate a variety of ways in which researchers have incorporated (some of) the above-mentioned dynamic systems assumptions. The various contributions cover different characteristics of a dynamic systems approach, they answer different kinds of questions, and indeed, define different systems. The chapters in this book all address the application of a dynamic systems approach to some domain of adolescent development. We ordered the chapters on the basis of their main aim and topic.

The first chapters by Hollenstein and Tsui (Chapter 2) and Darling and Burns (Chapter 3) start from a broad, domain-overarching perspective. They focus on the way in which dynamic systems perspectives shape our thinking about development in general. Hollenstein and Tsui explore the implications of defining adolescence as a phase transition in which the structures of childhood break down, reorganize, and then become the structures of adulthood. They elaborate an ideal research design for directly and definitively testing the adolescent phase transition hypothesis and then delineate several appropriate analytical approaches. Darling and Burns argue why adding dynamic systems modeling techniques to our repertoire of analytic tools is worthwhile, and what kind of new knowledge that method can generate.

The next cluster of chapters focuses on the re-conceptualization of specific domains relevant for adolescence based on a dynamic systems approach to knowledge. The authors give an overview of the principles applied in their particular dynamic systems approach and demonstrate the new theoretical, and practical, insights that this approach can bring.

Schiepek and colleagues (Chapter 4) present an alternative framework, based on complex self-organizing systems, to conceptualize clinical change and psychological interventions in a way that fits better with empirical and clinical evidence. Lougheed (Chapter 5) addresses the role that parent–adolescent conflicts play in the metamorphosis of the parent–adolescent relationship during adolescence. De Ruiter (Chapter 6) presents the socially embedded self-esteem model, in which adolescents' self-esteem components and parents' relevant behaviors are described as interacting on a moment-to-moment basis, giving way – over time – to the self-organization of socially embedded self-esteem attractors. Jeronimus (Chapter 7) elaborates on how dynamic system perspectives can propel our understanding of anxiety and depression across different nested timescales, from affect and emotions to moods and personality, as they develop as an integrated whole within individuals. Van der Gaag and colleagues (Chapter 8) present a process-oriented study of university dropout. They demonstrate that such a process perspective generates new theoretical insights, and offers directions for understanding and predicting university dropout. In some domains empirical research from a dynamic systems perspective is not available. Kunnen (Chapter 9) demonstrates what new knowledge can be acquired and has already been acquired when vocational identity development is studied from a dynamic systems perspective. Van de Bongardt (Chapter 10) and Kaplan (Chapter 11) explain in their chapters why the domains of sexual development and moral motivation respectively are especially well suited to a dynamic systems approach and they give examples and suggestions for specific types of study.

In the last two chapters, Huitsing and colleagues (Chapter 12) and Van der Sluis and colleagues (Chapter 13) describe how the application of a specific method (longitudinal network approach and a method to measure, understand, and visualize developmental processes in an individual case, respectively) generates insights that are directly applicable in practical settings.

Finally, in the last chapter the editors give an overview of the contents, the commonalities, and the differences of the dynamic systems approaches in the different chapters. They elaborate future directions, and signal potential pitfalls and challenges for a dynamic approach of adolescent development. They sketch how the chapters in this book, diverse as they are, give an overview of the broad range of possibilities of the application of a dynamic systems approach in adolescent research.

The chapters demonstrate the huge diversity in approaches in different ways. For example, in some chapters systems are defined as individual persons (Chapters 8, 9, 11, 13), while other chapters focus on dyads or groups (Chapters 5, 6, 12). Of course, a dynamic systems approach is not only applicable in empirical studies. Aside from methodological choices that can be made, adopting a dynamic systems approach can also have consequences for theoretical research. The aim of these theoretical chapters is often to change the way we think about the nature of a property or its development, often inspired by the characteristics of self-organization. As such, dynamic systems based theoretical work is often less about proposing specific relationships between concepts as it is about what these concepts are by nature or the mechanisms of their change. This kind of research may or may not be the basis for empirical work, where the empirical work is used to illustrate the theoretical point being made. This kind of research falls into the category of theory-driven research. The current book demonstrates a number of examples of theory-driven research. De Ruiter (Chapter 6) outlines how the nature of adolescent self-esteem is inherently contextualized within parent–child interactions, and she provides an example of a technique that can be used to study this contextualized development from moment to moment (Kohonen's self-organizing maps). Van de Bongardt (Chapter 10) discusses sexual development from a comparable angle, and shows that what we know about sexual development in fact points in the direction of a dynamic systems conceptualization of sexual development. Kaplan (Chapter 11) describes how moral motivation shows two characteristics of a dynamic system, arguing that morality should be studied as a dynamic system if we want to understand the emergence and change of moral motivation.

Most chapters address the more "fundamental" goals of dynamics systems based research, that is, focus on the ontology of phenomena, the nature of developmental processes, or relationships between concepts. However, the dynamic systems approach is also highly suited for "practical" research as well. This is because practical research is, like dynamics systems research, inherently interested in how *individuals* develop. For example, questions like, how can teachers best support student learning? Or, how do clients improve in a therapy setting? These are both research questions that can be approached with a dynamic systems toolkit. In this book, Van der Sluis and colleagues (Chapter 13) illustrate a straightforward way in which the development of sport performance and psychosocial factors can be studied as an iterative process of interactions with sport, school, and family. Schiepek and colleagues (Chapter 4) address a fundamental and theoretical issue *and* provide very practical directions of how to design and evaluate psychological interventions.

Also, Huitsing and colleagues (Chapter 12) elaborate how the results of their network analysis can be applied in a practical way in classroom management in order to prevent bullying.

The book as a whole is meant for researchers interested in applying dynamic systems ideas and methods in their own work. It is meant for those who want to explore how a shift to a dynamic systems approach can be made in tackling different domains of adolescent development, how to apply or integrate principles or methods from dynamic systems to their own research topics, and what the potential gains might be for their own research. In fact, these questions are the main trigger for the development of the present book.

In the following chapters we provide an overview of state-of-the-art dynamic systems based research in adolescent and emerging adulthood development. The overview of topics is in no way exhaustive, as we have selected a diverse range of topics that are especially salient in adolescent development. The chapters demonstrate a broad variety of applications of dynamics systems principles and methods to various topics relevant to adolescent development. With it, we hope to demonstrate that applying a dynamic systems approach, first, can be used to asses a wide range of research questions resulting in different kinds of insights, and second, that it need not be difficult. Some of the chapters in this book demonstrate an explorative approach, used to generate research questions or new theoretical knowledge, while others ask very specific research questions. Some chapters illustrate easy-to-follow methods that can be readily used, and others demonstrate more advanced techniques that can be learned. As such, our hope is that this book can provide both inspiration and practical support for researchers at any point on the road to a dynamic systems approach; both at the beginning and further down the road. IN the discussion at the end of this book we will return to our main question: exactly what are the gains of applying this dynamic systems approach in research on adolescent development, and whether and how it generates fundamentally new insight and knowledge.

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