CHAPTER 1

Concepts, Theory, and Method in Developmental Science

A View of the Issues

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The study of the development of living organisms generally, and humans, in particular, has itself developed and significantly so, as compared to past editions of this *Handbook*. For example, across just these early years of the 21st century, scholarship in developmental science has involved several important philosophical, theoretical, and methodological changes and, together, these changes constitute a paradigm shift for the field (Overton & Lerner, 2012).

The outcome of this paradigm shift involves the reanalysis and rethinking of a number of issues in the field, followed by the generation of new data, and new powerful methodological tools. One of the issues affected by the paradigm shift is the hoary nature–nurture debate (i.e., the issue of inheritance). Here, advances in epigenetics and a broader understanding of the genome itself have made the route from genotype to phenotype complex to the point that the classic Cartesian position, which claims that who we are and what we become to be is a simple additive function of gene × environment interactions has become highly untenable (see Bateson, Chapter 6, this *Handbook*, this volume; Lickliter & Honeycutt, Chapter 5, this *Handbook*, this volume; Overton, Chapter 2, this *Handbook*, this volume). A second broad issue affected by the paradigm shift entails the relation of evolution and ontogenetic development (see Bateson, Chapter 6, this *Handbook*, this volume; Lickliter & Honeycutt, Chapter 5, this *Handbook*, this volume; Overton, Chapter 2, this *Handbook*, this volume). Here, the field is rapidly moving away from implications of the classic *Modern Synthesis* (i.e., the integration of Mendelian genetics with neo-Darwinian variation and natural selection), which splits evolution off from individual ontogenetic development.

This view of evolution is rapidly being replaced with a position in which individual ontogenetic development is understood to be an integral part of the fabric of evolution. A third issue affected by the paradigm shift concerns cognition and cognitive development. Here the standard Cartesian-framed analysis had held that mental processes are exclusively located in the brain. This position has increasingly been challenged by the view that mental processes extend out into the body as embodied action, and into the technological and cultural worlds (see Marshall, Chapter 7, this *Handbook*, this volume; Mascolo & Fischer, Chapter 4, this *Handbook*, this volume; Overton, Chapter 2, this *Handbook*, this volume). One final example of the impact of the paradigm shift appears in the area of sociocultural development. In this area rethinking has resulted in a distinctive movement away from positions that at one time identified individual development and culture as separate and distinct, if interacting, entities, and toward a position that recognizes their coconstruction, codetermination, and codevelopment (see Mistry & Dutta, Chapter 10, this *Handbook*, this volume).

All the above and other changes that have occurred in developmental science over the past decade or so have been framed by fundamental philosophical and theoretical thinking about the nature of living organisms, the nature of development, and the nature of science, as well as by methodological innovations that have revolutionized the ability of developmental scientists to study developmental change and the mutually influential relations between organism and context that constitute the basic process of intraindividual change across the life span. In regard to the philosophical and theoretical bases of this paradigm

shift, it is clear that, whether studying infancy, childhood, adolescence, or the adult and late-adult phases of the life span, contemporary scholarship in developmental science aims to articulate and understand the coacting relational processes that operate between individuals and their contexts (i.e., reciprocally bidirectional, synergistic, or fused relational processes) that serve as the ground for individual action and development. Contemporary developmental scientists focus on systematic and successive alterations in the course of these relations, and focus on the integration of multiple processes of individual functioning (e.g., cognitive, emotional, motivational) and multiple levels of the ecology of human development, ranging from the biological through the sociocultural and historical levels, including designed and natural environments.

Contemporary developmental science recognizes that scientific advances entail the need for new conceptual systems, new theories, and new methods capable of coherently accounting for the highly complex nature of the processes of individual functioning and development. New theories and methods are themselves rooted in novel conceptual systems. Accordingly, the cutting edge of developmental science has increasingly recognized the inadequacies of the classic Cartesian-Split-Mechanistic research paradigm and the theories and methods this paradigm has generated. As an alternative, developmental science has been developing new theories and new methods rooted in an alternative Process-Relational and Relational-Developmental-Systems research paradigm (see Overton, Chapter 2, this *Handbook*, this volume). Lerner, in the Preface to this edition, delineates many features of relational developmental systems theories and their conceptual metatheoretical roots (see Table P.1 in the Preface to this edition of the *Handbook*, and Overton, Chapter 2, this *Handbook*, this volume).

The study of the development of living organisms, including humans, has evolved from a field dominated by dichotomous either/or approaches (e.g., either psychogenic explanation or biogenic explanation) to an interdisciplinary approach to the life span that recognizes the scientific value of integrating multiple perspectives—biological, psychological, sociocultural, historical—into a synthetic, holistic, complex, coactional system. Cartesian reductionistic accounts that treat the complex organism ←→ context system as an additive aggregate of simple elements have been rejected by scientists who approach research within the context of relational developmental systems theories (see, e.g., Lerner, Lerner, Bowers, & Geldhof, Chapter 16, this *Handbook*, this volume; Mascolo & Fischer, Chapter 4, this *Handbook*, this volume; Turiel, Chapter 13, this *Handbook*, this volume). The Cartesian-Split-Mechanistic research paradigm splits as dichotomous competing alternatives perspectives on issues that have traditionally been central to developmental inquiry such as those discussed above. Today, such splits are rejected by developmental scientists who operate within a Process-Relational and Relational-Developmental-Systems research paradigm. The various relational developmental system theories and methods framed by this paradigm convert all such splits into relationally joined integrations of developmental processes as they operate at all levels of organization across the life span. Thus, the conceptual emphasis of various relational developmental systems theories is placed on the nature of mutually coacting relations between individuals and contexts, represented as individual ←→ context relations.

As discussed by Overton (Chapter 2, this *Handbook*, this volume), all levels of the relational developmental system are integrated within relational developmental systems theories, ranging from variables involved in biological/physiological processes, through behavioral and social relationship processes, through physical ecological, cultural, and historical processes. The embeddedness of all levels within history imbues a *temporality* into individual ←→ context relations, and means that there is a potential for *relative plasticity*, for organized and systematic change in these relations, across person, time, and place (see Elder, Shanahan, & Jennings, Chapter 2, this *Handbook*, Volume 4). Accordingly, relational developmental systems theories focus on the "rules," the processes that govern developmental change and exchanges between individuals and their contexts. Brandtstädter (1998) termed these *developmental regulations*, and noted that when developmental regulations involve mutually beneficial individual ←→ context relations, they constitute *adaptive* developmental regulations.

The possibility of adaptive developmental relations between individuals and their contexts and the potential plasticity of human development are the distinctive features of this approach to human development. These features of developmental theory raise, however, important methodological issues. That is, three core features of Relational-Developmental-Systems models provide a rationale for making a set of methodological choices that differ in study design, measurement, sampling, and data analytic techniques, from selections made by researchers using split, dichotomous, or reductionist approaches to developmental science (see Molenaar, Lerner, & Newell, 2014; Molenaar & Nesselroade, Chapter 17, this *Handbook*, this volume;

Nesselroade & Molenaar, 2010; Ram & Grimm, Chapter 20, this *Handbook*, this volume; von Eye, Bergman, & Hsieh, Chapter 21, this *Handbook*, this volume). These three features of relational developmental systems are:

1. The conceptualization of development as the result of multiple coacting influences, which are context sensitive and contingent. This implies that development is inherently subject-specific and stochastic (probabilistic or random).
2. Development is understood to be a constructive process in which nonlinear epigenetic influences play central roles (see Lickliter & Honeycutt, Chapter 5, this *Handbook*, this volume). The most successful class of mathematical-biological models explaining such epigenetic influences are the so-called nonlinear reaction-diffusion models. These are nonlinear dynamic models generating emergent qualitative developmental changes that are not caused by genetic or environmental influences but instead are the result of dynamic self-organization. Such nonlinear epigenetic influences create substantial subject-specific variation which reinforces the subject-specific effects due to contingent contextual influences.
3. There is a focus on the potential for change evolving at multiple time scales and at multiple levels. This implies that dynamic systems models inspired will include time-varying parameters located at different levels and changing with different rates.

Along with these methodological implications, the emphasis on how the individual acts within the context, to contribute to the plastic relations with it, fosters an interest in individual agency (see Sokol, Hammond, Kuebli, & Sweetman, Chapter 8, this *Handbook*, this volume) or on intentional self-regulation (see McClelland, Geldhof, Cameron, & Wanless, Chapter 14, this *Handbook*, this volume), and this focus is best instantiated by person-centered (as compared to variable-centered) approaches to the study of human development (see von Eye, Bergman, & Hsieh, Chapter 21, this *Handbook*, this volume) and thus, to individual difference (diversity) oriented developmental scholarship (Molenaar & Nesselroade, Chapter 17, this *Handbook*, this volume).

In addition, the person-centered focus, as well as the emphases on relative plasticity and on mutually influential person ←→ context relations, has resulted in relational-developmental-systems theories being used as a frame for modeling the changing structure of ontogenetic trajectories, and has resulted in the view that developmental science is a nonergodic field (Molenaar & Nesselroade, Chapter 17, this *Handbook*, this volume). The ergodic theorem holds that data sets are marked by (a) homogeneity across individuals in a three-dimensional matrix that involves persons, variables, and time and (b) stationarity of individuals' scores on variables across time. Framed by the Process-Relational and Relational-Developmental-Systems research paradigm, however, developmental scientists argue that there is variation across individuals both within time and within individuals across time in their trajectories of individual ←→ context relations (i.e., across time differences). In other words, people differ in their paths across the life span. Because of this, the assumptions of homogeneity and stationarity of the ergodic theorem are rejected in contemporary developmental science. As a consequence of nonergodicity, developmental scientists emphasize the fundamental value of both person-centered and change-sensitive methods.

The chapters in this volume collectively document the paradigm shift to a process-relational and relational-developmental-systems research paradigm that has emerged in developmental science. All chapters focus on the implications for scholarship in different substantive areas of developmental science of process-relational and relational developmental systems thinking. The chapters in this volume also present and discuss contemporary research and new data analytic methods that have emerged within this new paradigm, and reflect the paradigm's focus on concepts of *process and system* with the aim of describing, explaining, and optimizing intraindividual changes and interindividual differences in intraindividual change across the life span (see Lerner, Preface to this edition). The dual and integrated contributions of this volume—to instantiating a paradigm shift by advancing both theory and method in developmental science—are exemplified within the chapters in this volume. A brief summary of each of these chapters describes these contributions.

THE PLAN OF THIS VOLUME

In Chapter 2, Overton compares and contrasts the classic Cartesian-Split-Mechanistic scientific research paradigm with the contemporary process-relational and relational-developmental-systems scientific research paradigm. In this presentation, he discusses the scientific advantages of a holistic approach that treats *endogenous activity, change, becoming, process, necessary organization*, and *relations*

as fundamental categories in constructing relational developmental systems theories and research methods. Overton goes on to demonstrate how these fundamental categories lead to a characterization of the organism as an *inherently active, self-creating (autopoetic, enactive), self-organizing, and self-regulating, relatively plastic, nonlinear complex adaptive system*. The system's development occurs through its own *embodied activities and actions* operating *coactively* in a lived world of physical and sociocultural objects, according to the principle of *probabilistic epigenesis*. This development leads, through positive and negative feedback loops created by the system's organized action, to increasing system differentiation, integration, and complexity, directed toward adaptive ends.

In the next chapter, Witherington, explicitly operating within a process-relational context, discusses dynamic systems in developmental science, noting that in its mathematical, methodological, and conceptual grounding, the dynamic systems approach to development offers a unique, relationally focused model for understanding developmental process. Proponents of the dynamic systems approach, however, are metatheoretically divided with respect to what constitutes the very nature of explanation in developmental science, resulting in two distinct ontological frameworks within the approach: a relational inclusive, pluralistic framework, and a split exclusive, monistic framework. The author explains that the purpose of this chapter is to articulate the metatheoretical divide that currently exists within the dynamic systems approach and to address the implications of this divide for realization of the approach's potential as a part of the Process-Relational and Relational-Developmental-Systems paradigm. The chapter begins with an overview of historical influences on the dynamic systems approach to development, specifically targeting the multidisciplinary frameworks of von Bertalanffy's *general systems theory* and *nonlinear dynamical systems theory*. Alternate ways of marrying these multidisciplinary influences are discussed and used to anchor the chapter's delineation of the dynamic systems approach to development through its ontologically distinct variants. The chapter ends by framing metatheoretical division within the dynamic systems approach in terms of the Relational-Developmental-Systems and Cartesian-Split-Mechanistic paradigms.

The following chapter by Mascolo and Fischer represents one the most comprehensive illustrations of a relational developmental systems theory in the contemporary field of developmental science. The theory spans the development of cognitive, affective, and action systems from infancy through adulthood. Flowing from this *dynamic systems* and *skill* theory, along with the associated empirical research the theory has generated, the authors find that qualitatively new abilities emerge naturally in learning and development, transitioning from one form of action or representation to another, and they argue that "humans are self-creating, self-organizing, and self-regulating systems grounded in meaning through the action of our bodies and our cultures." Throughout the chapter, they repeatedly demonstrate empirically that development involves dynamic transformations in the structure-function of behavior.

Relational-Developmental-Systems incorporates a variety of systems perspectives. In their chapter on biology, development, and human systems, Lickliter and Honeycutt take a psychobiological systems perspective, and discuss the interwoven genetic, epigenetic, developmental, ecological, and evolutionary components of contemporary biology as they contribute to our understanding of developmental processes. As is the case with all the sciences, progress in biology depends on advances in theory building, empirical research, and modeling. Development, as one of the central processes of biology, has been the focus of both empirical and theoretical attention for centuries. Research techniques and methods used in biology to study development have evolved dramatically over the past several decades, generating a wealth of detailed empirical data. Metatheoretical frameworks, theories, and modeling have likewise advanced, calling into question established interpretations and assumptions about development, including the relation between genotype and phenotype, the nature and extent of heredity, the links between development and evolution, and the biological bases of behavior and cognition. The authors review the history and current status of biology's perspective on development and discuss the broader implications of this view understanding human development.

In the next chapter, Bateson presents an ethological perspective on how developmental processes become integrated, and he points to the contributions that ethology has made to an understanding of human development and evolution along with how these contributions are being integrated with modern studies of epigenetics. He notes that ethologists have focused on behavior that is characteristic of the species and adapted to its biological requirements. Studies of development have brought ethologists together with those working in many other fields of biology, psychology, psychiatry, and epigenetics. Contemporary ethology maintains a distinctiveness in

taking an active view of the organism and focusing on biological function. Bateson points out that the old static view divided behavior into the innate and the acquired and—much in keeping with a Process-Relational and Relational-Developmental-Systems paradigm—the innate versus acquired position has been replaced by a much more dynamic systems view of underlying processes. Attention is now focused on how an individual develops and the interplay between the processes generating the robust features of an individual's behavior and the many processes involved in plasticity. Individuals make choices and control their environment. Their adaptability is crucial. All these activities have an impact on the evolution of their descendants.

Marshall's chapter on neuroscience, embodiment, and development focuses on the problem of the relation of contemporary neuroscience, psychology, and human development. He describes the separatist perspective that neuroscience is unrelated to psychology and human development, and the reductionist view of behavior reduced to brain function. Marshall argues for a more relational understanding based on the concept of *embodied action* and *embodied development*. This concept, Marshall argues, must be an essential feature of any theory of developmental cognitive neuroscience. The argument is made that embodiment has the potential to reframe the ways in which neuroscience data are considered in relation to other kinds of data. However, key developmental features of this reframing are currently underspecified, and Marshall argues that a Relational-Developmental-Systems perspective provides a productive path to integration. The implications of this approach for forging a new biologically grounded perspective for developmental science are profound, and Marshall discusses these in detail.

The chapter by Sokol, Hammond, Kuebli, and Sweetman considers the development of agency as a relational developmental conception that makes clear that the most basic form of agency is already present in the dynamic, self-organizing activities of living systems. The authors discuss how from the earliest point in the development of persons, agency manifests in different forms and grows through the interrelations of various biopsychosocial processes. These processes can be organized into the general levels, including the levels of biophysical agency, psychosocial agency, and sociocultural agency. The authors further describe how the most flexible and richest forms of agency seen in adulthood build from developmental processes evidenced throughout the life span: infants' sensorimotor and perceptual functioning, toddlers' symbolic representational and linguistic functioning, the child's self-regulatory functioning, and adolescents' and young adults' moral functioning.

The dialectic and transactional coactions are constitutive features of the Process-Relational and Relational-Developmental-Systems paradigm. In their chapter, Kuczynski and De Mol employ these concepts to describe contemporary dialectical models of socialization. They argue that dialectics draws attention to ideas of context, change, and nonlinear synthesis, which are best fitted to model the lived experiences of socialization processes. The authors note that despite contemporary acceptance that children are active agents in their own socialization, the influences between parents and children are still often viewed as unidirectional. They argue that a most important advance in the area of socialization has been the move to relationally bidirectional (←→) models and to recognize the complex causal structure of the socialization process. The chapter describes *social relational theory* as a framework for translating four assumptions of a dialectical ontology—*holism, agency, contradiction*, and *synthesis*—to reformulate major transactional processes in parent-child relations and socialization. The chapter concludes with a discussion of applied and methodological implications of social relational theory.

The chapter by Mistry and Dutta discusses conceptual and methodological advances that have been made toward an integration of human development and culture. Beginning as separate and separated fields of inquiry, cross-cultural psychology, cultural psychology, and human development achieved several steps toward integration beginning in the late 20th century and continuing into the 21st century. These are described along with the contemporary trend toward a relational integrative approach. In this analysis the authors point to parallels between contemporary sociohistorical perspectives and relational development science perspectives. In particular, they call attention to four key convergences: (1) the relation of person and culture as embodied or mutually constitutive, (2) the integration of meaning-making as part of context, (3) action and epigenesis as the source and process of developmental change, and (4) the simultaneous focus on both idiographic and nomothetic levels of analysis.

In the next chapter, Lewis discusses the development of emotions and the importance of the emergence of consciousness in the child's emotional development. This discussion begins from the Relational-Developmental-Systems premise that both emotional development and the child's growing knowledge of the world entail the active

reciprocal bidirectional (←→) coactions among biological and environmental systems. Lewis argues that the first signs of what will be emotions are found in the newborn's adaptive patterns of action, which developed in utero in the context of an evolutionary background and according to processes of *probabilistic epigenesis*. These action patterns, which have been termed by others as *primary emotions* (anger, contempt, fear, disgust, happiness, sadness, and surprise) engage the child's social and object worlds; shape these worlds, and are shaped by them. However, it is not until the child has the capacity to think and think about him- or herself that these action patterns become *emotions*. Thus, the development of consciousness as self-reflective thought, as evidenced by *self-referential behavior*, becomes a constitutive feature of the development of emotions.

The development of personal and cultural identities is discussed in the next chapter by Chandler and Dunlop. The authors present their chapter in the context of a discussion of dualisms in general and, more particularly, those Cartesian dichotomies of thought that set selves apart from society, and conceptually isolate individuals from their communities. Because these familiar cleavages between persons and collectives can only be understood in the context of centuries of commitments to Cartesian substance dualisms more generally, the chapter begins with an introductory detour through earlier crash sites of contested claims about the alleged vices and virtues of dualistic thought more generally. They explain that it is obviously not enough to simply document common isolationist tactics. Rather, they argue that a promising first step out of this doctrinaire dilemma involves the use of common concepts that already exist at the margins of the problem. The concepts of personal and cultural continuity are offered up as provisional examples of such shared constructs, and are enlisted in the service in a post-Durkheimian account of differential suicide rates in indigenous and nonindigenous cultures.

The chapter by Turiel represents another comprehensive relational developmental systems theory. This chapter, while focusing on moral development presents the author's social domain theory, a *constructivist-relational* approach, which has led to many empirical demonstrations showing that judgments in the moral domain begin at a very early age and are distinct from the formation of other social and personal domains of judgment. A key feature of Turiel's work is the insistence that differentiations that children, adolescents, and adults make among the domains (moral, social, personal) reflect *relational* processes of thought and emotions as well as flexibility of thought. The emphasis throughout is that this relational position means that although thought and emotion can be looked at from one point of view or another, the two processes cannot be dichotomized as separate disconnected processes.

McClelland, Geldhof, Cameron, and Wanless examine the development of self-regulation, especially intentional self-regulation, in the context of the Relational-Developmental-Systems paradigm and action theory, which is a highly prominent theory within the Relational-Developmental-Systems perspective. The authors define the *concept* of self-regulation as referring to taking in information, weighing choices and consequences, and making adaptive choice(s) to attain a particular goal. They note that self-regulation has received heightened attention as a key process, which predicts a variety of developmental outcomes across the life span. However, beyond the general agreed-upon definition, there are a number of debates about the scientific *constructs* that represent self-regulation. The authors discuss the various key conceptual and methodological issues surrounding self-regulation and conclude that the term *self-regulation* is itself an oversimplification. They argue that individuals constantly regulate their behavior in reaction to, and with support from, the opportunities and constraints afforded by their environment. Consequently, optimal self-regulation requires orchestrating a diverse set of self-regulatory skills and abilities. Thus, similar to the conceptual shift away from deficit models, which describe where children are lacking in comparison to other children, is an acknowledgment that people develop the most adaptive regulatory strategies for a given context. The authors say that, in other words, it is not as accurate to say a child "has" or "lacks" self-regulation, but to instead to describe the nature of his or her self-regulatory behaviors and the conditions under which he or she self-regulates in ways that optimize development. The chapter concludes with a discussion of the next steps needed for studying self-regulation in context, improving intervention efforts, and advancing analytical and measurement methods.

In the next chapter, Cummings and Valentino begin their presentation of developmental psychopathology with a consideration of the definition of the field, the gaps it addresses in the study of child psychopathology, theoretical assumptions about the nature of human development, and its relation with other disciplines. The authors demonstrate the close association with a Relational-Developmental-Systems perspective in the key conceptual components of developmental psychopathology they examine. Like relational developmental systems, these components include a holistic approach, an emphasis on plasticity, and a dynamic, process-oriented perspective on both normal development and developmental psychopathology. The

notions of developmental pathways, resilience, and the consideration of both risk and protective factors are all important components in the study of developmental psychopathology. In discussing *holism*, Cummings and Valentino introduce the concept of *floating holism* to emphasize the already well-accepted fact that holism does not preclude analysis, but encourages systematic analyses. The authors also emphasize that the evaluation of what is considered disordered or adaptive must take into account the context in which the pattern occurs; for instance, the family and community. The implications for prevention, intervention, diagnosis, and classification are also discussed. The authors close with a consideration of new directions and emerging themes in the field.

Lerner, Lerner, Bowers, and Geldhof's chapter presents a relational developmental systems model of positive youth development. The authors explain that interests in the strengths of youth, the plasticity of human development, and the concept of resilience coalesced in the 1990s to foster the development of the concept of positive youth development (PYD). As discussed by Hamilton (1999), the concept of PYD was understood in at least three interrelated but nevertheless different ways: (1) as a developmental process; (2) as a philosophy or approach to youth programming; and (3) as instances of youth programs and organizations focused on fostering the healthy or positive development of youth. The authors use concepts drawn from the Process-Relational and Relational-Developmental-Systems paradigm and the tripartite conception of PYD suggested by Hamilton as frames to review the literature on (a) the different theoretical models of the PYD developmental process; (b) philosophical ideas about, or conceptual approaches to, the nature of youth programming with a special emphasis on the model of PYD with the most extensive empirical support, the Five Cs Model of PYD; and (c) key instances of programs aimed at promoting PYD. The authors also discuss the conceptual and practical problems in integrating these three facets of PYD scholarship. This chapter concludes by explaining why understanding complex development requires multimethod integration as well as an integration of ideographic and nomothetic perspectives.

Turning to the methodological innovations that have emerged to enable ideas derived from relational-developmental systems theories to be tested, Molenaar and Nesselroade present an overview of new powerful approaches to statistical dynamic systems analysis. They begin their chapter with a heuristic description of a general mathematical theory—ergodic theory—that as mentioned earlier in this introduction implies that the study of developmental processes requires a fundamental change in methodology in which the focus is on analysis of intraindividual variation (time series analysis). A canonical multivariate time series model—the dynamic factor model—is introduced to organize the ensuing presentation of statistical methods for the analysis of intraindividual variation. Special emphasis is given to new methods for inferring valid nomothetic dynamic systems models of heterogeneous developmental processes. The chapter closes with an in-depth description of successful nonlinear dynamic systems approaches to the study of *stagewise* developmental processes.

In the next chapter, on neuroscientific methods with children, de Haan notes that neuroscientific methods can be used to capture the structural and functional changes happening in the human nervous system as it develops throughout infancy, childhood, and adolescence. This chapter provides an introductory overview of the non-invasive neuroscientific methods used in developmental research involving humans. It covers measurement of both the central and the autonomic nervous systems, considers the relative strengths and weaknesses of the methods, and provides examples illustrating their use. Special emphasis is given to general issues in measurement, methods for measuring brain structure and function (in particular an extensive overview of techniques based on magnetic resonance imaging [MRI]), and methods for studying genetics. The chapter concludes with a discussion of challenges that neuroscientific methods with children need to address and the role they will play in future research.

Qualitative and mixed methods models are discussed by Tolan and Deutsch. They note that mixed methods are increasingly recognized as advantageous and particularly informative for developmental science research. Initially and typically referring to the combination of quantitative and qualitative methods within or across studies, the approach can be considered more general than that, referring to the juxtaposition of different analytic methods to increase how informative a study or set of studies can be. This approach recognizes that different methods, within and across quantitative and qualitative types, each have different assumptions and capabilities. Multiple methods help to overcome limitations that occur with any single analytic method and bolster clarity and robustness of understanding. The chapter outlines the theoretical, design, and practical issues in use of mixed methods in developmental science. The key constructs, epistemological framework, theoretical considerations, approaches to different qualitative and quantitative methods and different arrangements in mixing methods are

described. Limitations, critical and emerging issues, and exemplars of mixed methods applications are provided.

Ram and Grimm present a review of latent growth curve models and longitudinal factor models and consider how these models can be applied to individual-level and sample-level inquiry to examine intraindividual change and interindividual differences in change. They begin by presenting a taxonomy of change processes, and tether a selection of contemporary models to that taxonomy. Next an extensive list of increasingly complex growth curve models is described, culminating in a number of innovative nonlinear growth curve models (exponential, sigmoid, sinusoidal). This is followed by an insightful theoretical discussion of the relations between growth curve models, latent change models and dynamic systems theory. The chapter continues with the presentation of factor analytic methods, including P-technique, dynamic factor analysis, and latent Markov modeling. Ram and Grimm finish their chapter with emphasizing the need to embrace nonlinearity to capture the intricacies of developmental processes—including the use of differential equations for representing this nonlinearity—as well as the need to measure more frequently (intensive longitudinal designs).

In the next chapter, von Eye, Bergman, and Hsieh discuss person-oriented methodological approaches. They explain that person-oriented approaches to social and behavioral developmental sciences proceed from the fact that aggregate-level descriptions of constancy and change usually fail to represent individuals. Protagonists of a person-oriented approach, including relational developmental systems theories, therefore, have presented tenets stating that development can be person-specific and that psychometric instruments must possess dimensional identity to be applicable over time, and to enable researchers to perform comparisons of individuals or groups of individuals. Protagonists of idiographic psychology have shown that cross-sectional information can be used as substitute for longitudinal information only under conditions that are atypical of developmental processes. In the first part of this chapter, the authors present the main lines of person-oriented and idiographic research, and compare these approaches with differential psychology. In the second part of the chapter, the authors discuss methods of analysis that are suitable for person-oriented research. These methods include, but are not restricted to, hierarchical linear modeling, time series analysis, longitudinal factor analysis, configural frequency analysis (CFA), and item response theory (IRT). Examples with empirical data are given for CFA and IRT. In the discussion, perspectives of the research planner, the data analyst, and the applied developmental scientist are taken.

CONCLUSIONS

As documented by the contributions to this volume, philosophy, theory, and method in developmental science are converging on concepts and empirical tools of design and analysis that enable the mutually influential relations between an individual and his or her context to be better understood and better investigated. The paradigm shift represented by Process-Relational and Relational-Developmental-Systems research paradigm to frame Relational-Developmental-Systems models and theories of human development has advanced sufficiently to enable ideas pertinent to such theories to be aligned with methods elucidating the holistic, embodied development of the individual $\longleftrightarrow$ context relations constituting the basic process of human development.

The scholarship within this volume and, as well, across the four volumes of this edition, attest to the fact that the field of development of developmental science is in the midst of an exciting period. The paradigm shift involves increasingly greater understanding of how to think about and how to describe, explain, and optimize the course of human life for diverse individuals living within diverse contexts. As documented by the chapters in this volume, the years ahead hold great promise for important, and perhaps profound, advances in knowledge about the bases, and evidence for enhancing, human development across the life span.

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