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INTRODUCTION

A New Approach to the Study of Emotional Development

Marc D. Lewis and Isabela Granic

Emotional development traces a detailed pattern across the lifespan. This pattern is comprised of periods of rapid change alternating with periods of consolidation and stability, self-amplifying individual variations on universal developmental themes, and progressive complexity in feelings, thoughts, personality, behavior, and self-regulation. We know that the patterning of emotional development is not a direct expression of some species-specific or genetic program. Nor is it simply a readout of socialization practices, family experience, or any other set of environmental contingencies. Despite our attempts to predict it, emotional development is indeterminate and malleable at almost any age. Despite our normative classifications, it is characterized by idiosyncratic and unique trajectories. In short, emotional development is organized and orderly without being prespecified or programmed. How do we account for its intrinsic organization? How does emotional development achieve its coherence, complexity, and patterning without design or instruction?

As in other developmental domains, the best answer to this question seems to depend on principles that extend well beyond developmental psychology. These principles express a new approach to change and novelty across the natural sciences, an approach variously called nonlinear dynamical systems theory (or dynamic systems theory, for short), complex systems theory, or chaos theory. At the heart of this perspective is the idea that natural systems behave very differently than the simple, idealized systems so well described by Newtonian mechanics. Systems in nature are characterized by interactions among many components, whether molecules in a fluid, cells in a body or brain, organisms in an ecosystem, or individuals in a society. This complexity is not just a detail. The interactions among the elements of complex systems are reciprocal, with constituents influencing each other simultaneously, and they recur over time, as systems

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continue to evolve or perpetuate their own stability. Thus, cause-effect relations take the form of feedback loops. Effects grow or shrink due to the activity of the system itself, and change does not rely on information received from the environment. The most important and dramatic result of this kind of system dynamics is the emergence of novel forms at higher levels of organization. This process is called self-organization.

In the sciences at large, self-organization refers to the emergence of order from disorder, and in particular the emergence of coherent, higher-order forms from the interactions of many lower-order components. Prigogine and Stengers (1984) explain how recurring chemical reactions give rise to global patterns of molecular coherence. Haken (1977) describes how the movements of atoms in a laser synchronize spontaneously to produce light of a uniform frequency. Haken's theory has been extended to living systems in which coherent actions arise from the automatic cooperation of muscular and sensory components (Kelso, 1984; Turvey, 1990). The cybernetic scientists Ashby (1952) and von Neumann (1958) discovered the emergence of recurrent patterns in electronic circuits, providing the first glimpse of cognitive self-organization. Today's neural networks are descendants of these efforts. Biologists such as Eigen (1992) and Kauffman (1993) have explored self-organizing patterns in networks of organic molecules such as DNA strands, leading to models of molecular evolution, gene expression, and the origins of life. Finally, Maturana and Varela (e.g., 1987), spanning cell biology, immunology, and perception, have coined the term ''autopoiesis'' to describe the self-organization and self-maintenance of living and cognitive systems. These and other contributions have collectively changed scientific thinking and practice in the last twenty years, leading to talk of a paradigm shift to a ''science of complexity'' (e.g., Lewin, 1992).

Self-organizational approaches have recently been imported into the social sciences as well, where they are used to model growth and stabilization in economics, anthropology, social organization, and psychology. In psychology, they have proliferated so quickly that it is difficult to trace their path, but at least two broad routes of theoretical progress can be delineated. The first is the study of self-organizing cognitive systems, first introduced in the 1960s and currently expressed in biological and connectionist approaches to cognitive science (e.g., Elman et al., 1996; Varela, Thompson, and Rosch, 1991) and neuroscience (Freeman, 1995; Tucker, 1992) as well as in dynamic models of basic cognitive processes (Port and van Gelder, 1995). The second is the study of self-organizing developmental systems, beginning with Piaget's model of equilibration (Chapman, 1991) and recently elaborated in dynamic systems models of motor, cog-

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nitive, social, and neural development (e.g., Fogel, 1993; Thatcher, 1991; Thelen and Smith, 1994; van Geert, 1991). These pathways, like the boughs of a tree, support a proliferating network of branches that extend to clinical, physiological, social, abnormal, and personality psychology.

In the midst of all this proliferation, the study of emotion and its development has been slow to incorporate principles of self-organization; but movement in this direction is now gaining momentum. By looking at emotional development as self-organization, investigators are beginning to view its intrinsic orderliness as an emergent form, accruing from recurrent, self-perpetuating emotional processes in real time. This approach links emotion and emotional development in a single field of inquiry, and it demands detailed attention to the elements and interactive mechanisms that contribute to emerging structure. In order to encourage this trend, help give it shape, and suggest new directions for its growth, the present volume gathers together the ideas of developmentalists, other psychologists, and neurobiologists who have started to look at emotion and emotional development as self-organizing processes. But before going on to introduce these contributions in detail, we start by asking why the study of emotional processes has lagged behind other domains in embracing principles of self-organization, and we show how recent work in emotion theory, developmental theory, and particularly emotional development has set the stage for renewal.

Theoretical progress in emotion theory has been constricted by traditional cognitivist approaches (Lewis and Granic, 1999a). In particular, much of emotion theory derives from cognitive psychology, where linear (i.e., step-by-step, incremental) information processing has been the dominant metaphor for decades. This computationalist dictum is clearly evident in appraisal theories of emotion. These theories propose that cognitive activities compute the significance of events and thereby give rise to emotional reactions. Much of the work on mood-congruent cognition has also reflected this orientation, with its depiction of moods as control signals or stable belief states. Such linear thinking may have slowed theoretical progress by perpetuating the debate over cognitive versus emotional primacy in one form or another, hampering our ability to model relations between goals, emotions, and emotion regulation in a convincing way, and supporting an overly reductionist approach to clinical and personality processes. It is interesting to note that many cognitive psychologists are starting to embrace nonlinear dynamic ideas, and traditional emotion theory may be one of the last strongholds of orthodox cognitivism.

In the last few years, however, some emotion theorists have begun to

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circumvent traditional cognitivism or openly criticize its implications. Some make explicit use of constructs such as graded influences, nonlinearity, feedback, emergence, and context-sensitivity, which are antithetical to computationalism and suggestive, instead, of emergent emotional processes. The mood models of Teasdale and Mathews have important feedback components, and context-sensitivity in the work of Parkinson and Manstead is congenial with self-organization. Frijda and Scherer have advocated nonlinear models of appraisal-emotion processes, and Scherer has begun to explicitly model emotions as episodes of synchronization in a nonlinear dynamic system. Some of these emerging directions were voiced at an invited symposium at the 1996 convention of the International Society for Research on Emotions. Alan Fogel, Klaus Scherer, Linda Camras, and Marc Lewis presented papers on emotional self-organization, and Carroll Izard acted as discussant. The symposium generated considerable debate and excitement, and the present volume includes contributions from all of these participants.

The field of emotional development has also been dominated by traditional theoretical agendas. Nativist theories, with their emphasis on hard-wired or prespecified emotions, have a difficult time dealing with the emergence of new emotional forms in development and, in particular, with the contribution of cognition to complex emotional outcomes (from secondary emotions to personality styles). Constructivist approaches suggest that cognitive schemas are the vehicles of emotional development, and that emotions and their elicitors become more sophisticated as these schemas increase in complexity. But emotion itself gets lost in this portrayal and is treated as merely another component of an essentially cognitive process. Functionalist approaches see emotional development as a result of individual adaptations to social, cognitive, and biological circumstances. However, their view of adaptation is based on learning models, with their implication of ''best choices'' or optimal solutions, and they cannot easily explain developmental paths that are idiosyncratic and illogical. Critics have argued that developmental psychology cannot progress further without a scientific explanation for novelty, increasing complexity, and emerging coherence, free of innate programs, generic rules, and specific instructions from the environment (e.g., Elman et al., 1996; Molenaar, 1986). This certainly rings true for emotional development, where novel forms arise unpredictably and coherent outcomes are both complex and idiosyncratic.

In response to this challenge, theorists from across developmental disciplines have begun to focus on nonlinear, dynamical, self-organizing processes. These efforts are typified by developmentalists who refer to them-

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selves as dynamic systems (DS) theorists (e.g., Fogel and Thelen, 1987; Lewis, 1995; Thelen and Smith, 1994; van Geert, 1991), but they are joined by other contemporary systemic thinkers (e.g., Elman et al., 1996; Keating, 1990; Oyama, 1989; Sameroff, 1995; Sroufe, 1995; van der Maas and Molenaar, 1992). From a dynamic systems perspective, novel forms arise in development through the spontaneous coordination of system constituents that interact with each other recursively in the service of a particular function, task, or goal. In motor development, for example, recurring interactions among muscular and perceptual activities give rise to patterns of coordination underlying coherent skills such as walking (Thelen and Smith, 1994). In communicative development, consensual frames or rituals emerge within dyads through reciprocal coordination of actions, gestures, speech, and emotional expressions (Fogel, 1993). In cognitive development, new capabilities arise from the coordination (or, cooperation versus competition) of attentional, conceptual, and linguistic components (Smith, 1995; van Geert, 1991). DS theorists emphasize that these and other developmental phenomena can all be explained by a common set of principles concerning nonlinear causation and self-organization (Lewis, 2000).

Whereas DS approaches to motor and cognitive development have gained considerable attention, a DS literature on emotional development is just beginning to emerge. A few years ago, Fogel and colleagues (1992) proposed that emotions are self-organizing products of psychological and bodily processes that arise and develop within interpersonal transactions. Camras (1992) examined developing emotions as dynamic assemblies of hedonic, motor, appraisal, and expressive constituents. More recently, Lewis (1995, 1997) modeled emotional and personality development as the consolidation of cognition-emotion interactions that self-organize across occasions. Other theorists have proposed DS approaches to personality formation (Cloninger, Svrakic, and Svrakic, 1997), adult personality change (Magai and Nusbaum, 1996), identity development (Haviland and Kalbaugh, 1993), and self-referential emotions (Mascolo and Harkins, 1998). The development of the self (Schore, 1997) and the consolidation of temperament (Derryberry and Rothbart, 1997) have also been modeled as self-organizing coordinations of biological and social subsystems. Over a decade ago, Campos, Campos, and Barrett (1989) encouraged emotional developmentalists to seriously explore the DS perspective, as did Sroufe (1995) more recently. Theorists and researchers are finally beginning to take up this call in earnest.

In summary, emotion theorists have begun to turn away from cognitivist conceptions of mind and explore notions of nonlinearity and emergence.

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At the same time, developmentalists have started applying DS ideas, established in other domains, to the study of emotional, personality, interpersonal, and self development. Yet these contributions are still so few and so new that theorists of different persuasions are often unaware of the conceptual links among them. The present volume attempts to tie these strands together, highlight their common features, help guide their rapid and chaotic growth, and look toward future directions.

Most of the chapters in this volume take a developmental perspective, but some are concerned with real-time processes instead. This mix is intended to highlight theoretical links between emotional processes in real time and development, and it makes up for an unfortunate schism between emotion theory and emotional development. This schism becomes untenable when we view emotional processes as self-organizing, because the causal interdependence of different time scales is a critical assumption of the dynamic systems approach. Emerging emotions in real time forge links across occasions that give rise to developmental patterns. Conversely, developmental patterns strongly constrain real-time emotions and related processes such as regulation and action. Good explanations of the connections between emotional development and real-time emotional processes have long eluded psychologists in general and developmentalists in particular, but these explanations may finally be available through the study of self-organization.

Contents of the Volume

The first section of the book deals with emotional processes that are primarily studied within rather than between individuals. The contributions in this section are theoretically diverse, but they share an emphasis on subsystem coordination or coupling as the basis for the emergence of global emotional forms (e.g., emotions themselves, emotion expressions, emotional amalgams, moods, cognitive-emotional structures, and personality). In Chapter 1, Izard and his colleagues use dynamic systems principles to elaborate and complement key aspects of their longstanding *differential emotions theory*. They then provide a thoughtful analysis of matches and mismatches between dynamic systems and differential emotions perspectives. In the second chapter, Lewis models the relations among self-organizing cognition-emotion interactions at three time scales – emotions, moods, and personality development. At each of these scales, global intentional forms are proposed to arise from and entrain lower-order cognition-emotion interactions. Next, Scherer models emotions as episodes of syn-

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chronization among bodily subsystems, driven by appraisal, and falling into short-term attractor states. He then examines abrupt emotional transitions with an elegant application of catastrophe theory to appraisal processes. The fourth chapter presents Camras's research on the spontaneous coordination of muscular movements in global emotion expressions. Her depiction of muscular coupling and recruitment is one of the few empirically grounded models of self-organization in an emotion-related system. Finally, Mascolo and his colleagues look at emotional development from a social constructivist perspective incorporating both neo-Piagetian and self-organizational assumptions. Their picture of context-specific emotional constellations assembled from component subsystems is similar to Scherer's, but drawn in development rather than real time.

The second section concerns neurobiological perspectives, and it reveals a consensus on the self-organizing character of brain processes involved in emotion. In particular, the four chapters in this section point toward the biological underpinnings of the psychological coordinations that were the subject of the first section. In Chapter 6, Schore maps out the neural bases of appraisal, emotional experience, self-regulation, and interpersonal attunement in a detailed model of developmental self-organization. He shows how appraisals in the right orbitofrontal cortex emerge and how they regulate individual differences in early self-development. In the next chapter, Harkness and Tucker look at the impact of early abuse and neglect on neural organizations that later give rise to depression and other pathologies. Their model crisply explicates developmental self-organization as a cascade of neural outcomes that become more intransigent as the brain loses its plasticity. In Chapter 8, Freeman sketches a remarkable synthesis of a decade and a half of research into brain self-organization, and he examines the role of emotion in this process. According to Freeman, all brain activities become synchronized around self-organizing intentions or goals, and emotion is felt as both the anticipation of intentional action and the control of action in the service of rationality. Finally, in the ninth chapter, Panksepp provides an overview of theoretical and measurement issues related to the neurobiology of emotion, and he emphasizes the need for models and methods that examine nonlinear phenomena. Panksepp explains that all brain processes, and emotional processes in particular, are inherently nonlinear and self-organizing, but the means for studying them are still largely undeveloped.

The third and final section deals with socioemotional processes that can only be examined at the interpersonal level. Despite diversity in content and time scales, the chapters in this section demonstrate that emotional

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outcomes in relationships self-organize in much the same way as psychological and neural outcomes within individuals. This suggests a picture of nested systemic relations spanning biological, psychological, and social dimensions. In Chapter 10, Granic reviews contemporary models of bidirectional effects in parent-child relationships as a springboard toward the application of DS principles. For her, bidirectionality implies reciprocity and recursion, which in turn account for the self-organization of particular parent-child relationships and dyadic trajectories. Laible and Thompson view attachment theory through a self-organizational lens in the next chapter. They examine the emergence of attachment styles, their enactment in real-time exchanges, and their effects on subsequent development by applying key DS concepts such as phase transitions, attractors, and control parameters. In Chapter 12, de Weerth and van Geert provide theoretical and empirical strategies for studying the convergence of socioemotional stability from initial variability in infant development. Their approach grounds the study of developmental self-organization in new statistical methods for comparing developmental periods. The final chapter, by Ryan and her colleagues, reviews Gottman's theory of marital satisfaction, with emphasis on the affective processes central to this particular form of dyadic development. The authors demonstrate how theoretical predictions about the course of a marriage can be tied to nonlinear mathematical techniques for studying dyadic interactions.

A Word on Terminology

There is still a great deal of variability and dissonance in the terminology used to convey these new ideas (Lewis and Granic, 1999b). This seems to be the fate of any new paradigm before it stabilizes and becomes more broadly familiar. The authors in this volume have tried to achieve some consistency in their terminology, but even here disparities will appear. To help the reader through, we provide a brief synopsis of some generally agreed-on definitions.

Dynamic systems theory is a mathematical theory that predicts the future state of a system based on its present state. It does this by solving coupled equations (for different values of the variables defining the system) or by mapping out a spatial depiction of the tendencies of the system as a whole. Nonmathematical DS approaches, like most of those featured in this volume, rely on spatial depictions or on qualitative descriptions of how these tendencies might appear.

Spatial depictions often take the form of a *state space*, a map of all the

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possible states a system can assume, with paths or trajectories indicating its tendencies over time. Such a map is often shown as a topographical surface pocked by wells or valleys that stand for *attractors* and hills that stand for *repellors*. Attractors are defined as stable, recurrent, or resilient states in which systems tend to settle or get stuck. Attractors are surrounded on the state space by *basins* – regions of states that gravitate to the attractor. Repellors are states the system tends to move away from or avoid.

In *nonlinear dynamic systems*, the state of the system changes disproportionately (nonlinearly) with the values of the variables that define it. Nonlinear systems are extremely sensitive to interactions (or feedback) among these variables, and complex systems tend to show a high degree of nonlinearity. As a result, only complex nonlinear dynamic systems show the dramatic characteristics that are of interest to developmentalists.

The sensitivity of nonlinear dynamic systems often leads to abrupt shifts in the state of the system despite incremental change in external or internal conditions. These shifts, or *phase transitions*, have become key constructs for modeling developmental discontinuities (e.g., van Geert, 1994). A phase transition denotes a change in the state space of the system, whereby new states (and new attractors) may become available while old ones become inaccessible. The term is often used more loosely to describe any discontinuous change in the organization of a dynamic system.

Chaos theory describes a unique class of nonlinear systems whose future cannot be predicted, even approximately. But chaos also refers to instabilities (e.g., during phase transitions) in systems that usually behave in an orderly fashion. While chaos theory is sometimes substituted for self-organization theory and nonlinear dynamics, we avoid this usage. Here, chaos refers to noisy, unstable, or turbulent states.

Self-organization refers to a set of related principles (or a paradigm – Dalenoort, 1989) concerning the spontaneous emergence of order from the interaction of components of a (nonlinear dynamic) system. Self-organization is particularly useful for modeling the coming-into-existence of new forms or properties, not through prior programming or present instruction, but through processes intrinsic to the system itself. Models of self-organization describe the emergence of order, coherence, organized complexity, and true novelty in all natural systems.

Self-organization in psychological systems is generally described at two time scales, *real time* and *development*. Real-time self-organization refers to the convergence of a system to its attractor, or a shift from one attractor to another when that shift is indeterminate and self-propagating. Developmental self-organization describes the emergence of developmental forms,

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properties, or constraints through recurrent real-time interactions. Phase transitions and other DS phenomena can be demonstrated at both of these scales.

Intended Audience

This volume is intended to provide developmentalists working in this area with an anchor point for their emerging ideas and an inducement to explore new empirical methods. The volume offers researchers in the larger arena of emotional development, as well as those in related areas such as emotion theory, attachment, personality development, and developmental psychopathology, a package of self-organizational approaches that can resonate with their interests. Finally, this book provides psychologists outside these areas, and other developmentalists in particular, with a unique picture of the conceptual tool kit offered by DS approaches and models of self-organization.

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