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# Toward a Comprehensive Model of Antisocial Development: A Dynamic Systems Approach

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The purpose of this article is to develop a preliminary comprehensive model of antisocial development based on dynamic systems principles. The model is built on the foundations of behavioral research on coercion theory. First, the authors focus on the principles of multistability, feedback, and nonlinear causality to reconceptualize real-time parent–child and peer processes. Second, they model the mechanisms by which these real-time processes give rise to negative developmental outcomes, which in turn feed back to determine real-time interactions. Third, they examine mechanisms of change and stability in early- and late-onset antisocial trajectories. Finally, novel clinical designs and predictions are introduced. The authors highlight new predictions and present studies that have tested aspects of the model.

An enormous amount of high-quality research has focused on understanding the development of antisocial behavior. The study of aggressive and antisocial development encompasses a large variety of broad theoretical perspectives (e.g., behavioral, cognitive, social) and diverse disciplines (e.g., psychology, sociology, epidemiology). The mechanisms that are studied in relation to the emergence and maintenance of antisocial behavior are also varied (e.g., temperament, psychophysiology, parenting, peer relationships). Much work has been done to identify the vast array of risk factors associated with aggressive and antisocial behavior. However, "the sheer size of this list. . .betrays the field's lack of ability to synthesize or to tell a fully coherent story about the development and maintenance of externalizing behavior" (Hinshaw, 2002, p. 435). The purpose of this article is to develop a comprehensive model of antisocial development through the application of dynamic systems (DS) principles. Our model is preliminary and necessarily incomplete. We acknowledge at the outset that every risk factor and causal mechanism that has been empirically tied to antisocial behavior has not been included, but we hope that the DS framework will identify the most important factors and, critically, their relations to each other and suggest explicitly how additional mechanisms of interest could be integrated within this scheme.

Our DS model is built on the foundation of behavioral research in coercion theory. Myriad reviews on the risk factors and developmental outcomes of childhood aggressive and antisocial behavior have emphasized the important contribution of coercion theory to the field (e.g., Dodge & Pettit, 2003; Henggeler, 1997; Hill & Maughan, 2001; Hinde & Stevenson-Hinde, 1988; Hinshaw, 2002; Kazdin, 2002; Loeber, Burke, Lahey, Winters, & Zera, 2000; Moffitt, 1993; Offord & Bennett, 1994; Rutter & Giller, 1983). The impact of coercion theory on the development and evaluation of treatment programs is equally evident (Brestan & Eyberg, 1998; Forgatch & DeGarmo, 1999; Henggeler, Schoenwald, Borduin, Rowland, & Cunningham, 1998; Kazdin, 2000). Coercion theory (Patterson, 1982; Patterson, Reid, & Dishion, 1992; Reid, Patterson, & Snyder, 2002) was developed by scientists at the Oregon Social Learning Center (OSLC), who began collecting hundreds of observations of parents and children interacting in natural settings. In its most basic form, coercion theory is a model of the behavioral contingencies that explain how parents and children mutually "train" each other to behave in ways that increase the probability that children will develop aggressive behavior problems and that parents' control over these aversive behaviors will decrease. These interchanges are characterized by parental demands for compliance, the child's refusal to comply and his or her escalating complaints, and finally the parent's capitulation. Coercive interactions are the fundamental behavioral mechanisms by which aggression emerges and stabilizes over development.

Despite its success, coercion theory is limited in scope and has some gaps that can be effectively addressed through the application of DS principles. First, coercion theory and other approaches to antisocial development rely on models at two separate time scales: a microsocial (moment-to-moment) scale and a macrosocial (developmental) scale. The processes by which these real-time and developmental time processes are linked need to be explained and explicitly modeled; DS principles concerning interscale relations provide the tools to do so. Second, some of the most important advances in the field have come from social learning approaches to parenting and peer processes. However, this research has been relatively isolated from the burgeoning work on the psychobiological and cognitive–emotional elements that underlie antisocial development. Some preliminary efforts to link behavioral factors with cognitive and emotional variables have been made over the last two decades (Capaldi, Forgatch, & Crosby,

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1994; Forgatch & Stoolmiller, 1994; Snyder, Stoolmiller, Wilson, & Yamamoto, 2003), but much remains to be done. DS principles provide a systematic framework for bridging levels of analysis and hence reconciling these domains more thoroughly. Finally, although some longitudinal research on antisocial development attempts to address both stability and change in pathways (e.g., child onset vs. adolescent onset and trajectories that lead to no further offending), the empirical focus has been largely on stability or maintenance mechanisms (but see Patterson, 1993, 2002). Yet, by definition, a developmental theory needs to provide explanations (not just descriptions) of change as well as stability (Patterson, 1993; Thelen & Ulrich, 1991). This is particularly important for a theory that stipulates directions for prevention and intervention. DS principles point to mechanisms of change and stability and suggest analytic strategies for measuring these mechanisms.

Our main goal is to demonstrate the promise of the DS approach in providing a framework that can integrate disparate findings and offer an explanatory level of modeling that is often missing in other approaches (Hinshaw, 2002). For decades, DS principles have been successfully applied by theorists such as Esther Thelen (e.g., Thelen & Smith, 1994) and Alan Fogel (e.g., 1993) to uncover explanatory processes in normative development; following this tradition, we aim to apply these same principles to the development of psychopathology in general and antisocial behavior in particular. Our most optimistic hope is that we can provide a model that is detailed and compelling enough to inspire other investigators to use the DS scaffold to elaborate their own models of antisocial development, perhaps leading to an eventual convergence. To meet our goal, we begin by providing a brief overview of DS principles. Following this review are two main sections: one focuses on real-time family and peer processes, and the other focuses on these same processes over developmental time. In each section, we summarize past research findings, discuss how a DS approach extends our understanding of the data, and specify new predictions that emerge from our model. Throughout the article, we enumerate the specific hypotheses that emerge from our modeling efforts both as an organizing device and as a guide to ongoing and future research. Whenever possible, to illustrate the empirical feasibility of these new directions, we review studies that have begun to test DS-based propositions and highlight the unique insights they afford. We conclude by discussing a number of clinical implications as well as novel designs that have the potential to further inform theory development.

## DS Principles Relevant for Socialization Processes

For many psychologists, particularly developmentalists, systems approaches are not new. In fact, developmental psychopathologists have come to adopt an organismic, holistic, transactional framework for conceptualizing individual differences in normal and atypical development (e.g., Cicchetti, 1993; Cummings, Davies, & Campbell, 2000; Garmezy & Rutter, 1983; Sameroff, 1983, 1995; Sroufe & Rutter, 1984). These scholars often frame their models in terms of organizational principles and systems language. The systems theories that inform their models include general systems theory (Sameroff, 1983, 1995; von Bertalanffy, 1968), developmental systems theory (Ford & Lerner, 1992), the ecological framework (Bronfenbrenner, 1979), contextualism (Dixon & Lerner, 1988), the transactional perspective (Dumas, LaFreniere, & Serketich, 1995), the organizational approach (Cicchetti & Schneider-Rosen, 1986; Erickson, Egeland, & Pianta, 1989; Garmezy, 1974; Sroufe & Rutter, 1984), the holistic–interactionistic view (Bergman & Magnusson, 1997), and the epigenetic view (Gottlieb, 1991, 1992). As a class of models, these approaches focus on process-level accounts of human behavior and on the context dependence and heterogeneity of developmental phenomena. They are concerned with the equi- and multifinality of development, the hierarchically embedded nature of intrapersonal (e.g., neurochemical activity, cognitive and emotional processes), interpersonal (e.g., parent–child relationships, peer networks), and higher order social systems (e.g., communities, cultures). They are also fundamentally concerned with the mechanisms that underlie change and novelty (as well as stability) in normal and clinically significant trajectories.

What follows is a review of the core concepts of DS approaches to development. Formally, a dynamical system is a system that changes over time or a set of mathematical equations that specify how those changes occur. To describe the behavior of dynamical systems, scientists make use of a technical language originally developed in the fields of mathematics and physics. This language includes terms such as attractors, repellors, state space, perturbations, bifurcations, catastrophes, chaos, complexity, nonlinearity, far-from-equilibrium states, and so on. What we refer to as a DS framework is a metatheoretical framework that encompasses a set of abstract principles, described in these terms, that have been applied in different disciplines (e.g., physics, chemistry, biology, psychology) and to various phenomena (e.g., lasers, ant colonies, brain dynamics) at vastly different scales of analysis (from cells to economic trends and milliseconds to millennia).

DS principles provide a framework for describing how novel forms emerge and stabilize through a system's own internal feedback activities (Prigogine & Stengers, 1984; von Bertalanffy, 1968). This process is known as self-organization and refers to the spontaneously generated (i.e., emergent) order in complex, adaptive systems. We follow other developmentalists (e.g., Fogel & Thelen, 1987; Keating, 1990; Lewis, 1995; Lewis & Granic, 2000; Thelen & Smith, 1994; van Geert, 1991) who find that DS concepts, and especially notions of feedback, self-organization, and attractors on a state space, have important heuristic value for modeling the processes that give rise to and maintain developmental pathways. These concepts suggest new predictions as well as novel methodologies that go beyond the statistical armament traditionally available (Granic & Hollenstein, 2003).

### *Attractors and Multistability*

Patterns of interactions or stable states are called *attractors* in DS terminology. They emerge through *coupling*, or cooperativity, among lower order system elements. Attractors may be understood as absorbing states that "attract" the system from other potential states. Behavior moves toward these attractors in real time, and, to the extent that this movement is indeterminate, this can be described as self-organization at the scale of real time. Over developmental time, attractors represent recurrent patterns that eventually stabilize and become increasingly predictable. As noted by Thelen and Smith (1994), all developmental acquisitions can be described as attractor patterns that emerge over weeks, months, or years. As recurring stable forms, attractors have been depicted

topographically as valleys on a dynamic landscape. The deeper the attractor, the more likely it is for behavior to fall into it and remain there, and the more resistant it is to small changes in the environment. As the system develops, a unique *state space*, defined as a model of all possible states a system can attain, is configured by several attractors (Figure 1). Living systems are characterized by multistability (Kelso, 1995); that is, their state space includes several coexisting attractors.

Recurrent patterns of parent–child or peer–child interactions can be conceptualized as dyadic attractors. The advantages of viewing social interaction patterns as dyadic attractors that emerge over development have been articulated by Fogel et al. (e.g., Fogel, 1993; Fogel & Thelen, 1987). From this perspective, a dyad can be regarded as one system with unique properties that are irreducible to each individual member, a general perspective advocated by several socialization theorists (Bugental & Goodnow, 1998; Kochanska, 1997; Maccoby, 1992; Maccoby & Martin, 1983). At any one time, a number of attractors may be available to a dyad, and contextual constraints probabilistically determine the attractor toward which a dyad will move.

For example, Figure 1 shows a state space for one particular parent–child dyad. This representation captures a number of characteristics of this dyad. There are four attractors that are available to them: a playful, cooperative one; a mutually polite one; a mutually hostile one; and a disengaged attractor. The mutual hostility attractor is the strongest. Behavior moves toward this attractor from many places on the state space, and its depth suggests that once the dyad gets stuck there it will be difficult to get back out. The mutually polite attractor is rarely visited; it is the smallest and most shallow attractor, suggesting that very few contexts move the dyad there and, once there, the dyad is quick to shift away from this state.

A behavioral trajectory representing a day in the life of this dyad is overlaid on this state space. During a relaxed day at the cottage, members of this dyad may often find themselves in a playful attractor (Points 1 and 2). When neighbors come to visit, their mutually polite attractor may emerge (Point 3), but as soon as the mother stops paying attention to the child, the child may become hostile and coercive, which may, in turn, prompt the mother to become reciprocally hostile (Point 4). Although the mother and child may attempt to disengage and pull themselves out of the mutual hostility attractor (Points 5 and 7), their developmental history is such that this hostile pattern is very stable and resilient and any forays out of the attractor quickly bounce back to this hostile state. As we discuss in detail later, conceptualizing family patterns as dynamic (i.e., temporal, not static) and multistable has led to methodological innovations that point toward a comprehensive model of antisocial development. To understand the mechanisms underlying the emergence of dyadic attractors, a second DS principle is needed.

### *Feedback Processes*

Dynamic systems self-organize through the interplay of two basic mechanisms: positive and negative feedback (Prigogine & Stengers, 1984; von Bertalanffy, 1968). Feedback processes have powerful implications for understanding stability and change in developing systems. Positive feedback is the means by which interactions among system elements amplify particular variations, leading to the emergence of novelty. Through negative feedback, elements continue to be linked, deviations are minimized, and stability is realized. Thus, it is through negative feedback that the system converges to its attractor. Self-organizing systems develop and become complex through the interaction of both feedback

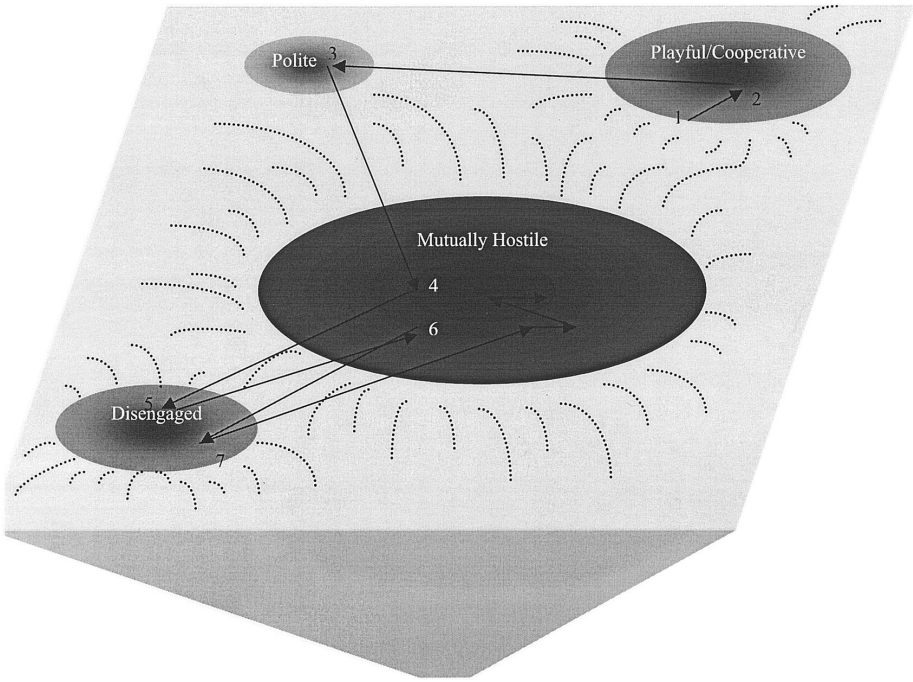


*Figure 1.* Dyadic state space with four attractors and a behavioral trajectory.

processes; positive feedback catalyzes reorganizations in response to environmental changes, and these new organizations are maintained through the self-stabilizing properties of negative feedback. These mechanisms of change and stability have been sufficient to explain phenomena ranging from cyclical chemical reactions (Prigogine & Stengers, 1984) to brain functioning (W. Freeman, 1995) to evolution (Goerner, 1995); they may be equally suitable for understanding antisocial family and peer processes.

Feedback on both real-time and developmental time scales may be the mechanism by which characteristic dyadic states emerge, develop, and stabilize. Several socialization theorists have recognized the importance of real-time feedback to describe dyadic processes, including mother–infant vocalizations, play, and family conflicts (e.g., Maccoby & Martin, 1983; Patterson, 1982; Schore, 1997; Snyder et al., 2003; Wilson & Gottman, 1995). As we discuss in detail later, coercion theory began by explaining the development of aggression through one type of feedback mechanism: negative reinforcement. A number of implications for considering additional feedback processes at the real- and developmental time scales are outlined later.

### *Circular Causality*

Another type of nonlinear mechanism that may help us model the link between real-time and developmental time processes is circular causality (Haken, 1977). Circular causality suggests that interactions among lower order elements provide the means by which higher order patterns emerge; in turn, these emergent patterns exert top-down influences to maintain the entrainment of lower order components. As we discuss in detail later, the notion of circular causality has prompted us to examine more closely the cognitive and emotional elements that interact and underpin the emergence of coercive family interactions (the higher order pattern); these interactions themselves further constrain emotional and cognitive elements.

### *Emergence and Phase Transitions*

The hallmark of dynamic systems is their tendency to exhibit discontinuous, or nonlinear, change. Open systems exist "far from thermodynamic equilibrium" in that they are constantly importing and dissipating energy from their environment (Prigogine & Stengers, 1984). Through the amplification properties of positive feedback, nonlinear changes in the organizational structure of a dynamic system can be observed. These abrupt changes are referred to as *phase transitions,* or junctures of reorganization in the system's development. Phase transitions are points of increased sensitivity, when small fluctuations, or *perturbations,* have the potential to disproportionately affect the interactions of multiple system elements, leading to the emergence of new forms. Novelty does not have to originate from outside the system; it can emerge spontaneously through feedback within the system.

Phase transitions are characterized by interrelated changes in real and developmental time. In developmental time, a period of stability and relative predictability is followed by a period of disequilibrium in which established patterns are destabilized. After this period of flux, developmental systems restabilize and settle into new habits. Corresponding to this developmental profile, real-time behavior during a phase transition is more variable, flexible, and sensitive to perturbations; behavior may change from one state to another frequently, and it is less likely to settle in any one state for very long (Thelen & Ulrich, 1991). However, before and after the phase transition, real-time behavior is far less variable; only a small number of behavioral states are available to the system, and these tend to be relatively stable (e.g., Thelen & Smith, 1994; van der Maas & Molenaar, 1992; van Geert, 1998). A number of examples of phase transitions are clearly relevant for antisocial development. The birth of a sibling, the beginning of day care, parental divorce, and the onset of puberty can all be considered phase transitions that can bring about novel behavioral patterns potentially including aggressive behavior. We argue that early adolescence can be understood as a phase transition in both normal and antisocial trajectories. Moreover, we model therapeutic interventions as deliberately induced phase transitions to help identify change processes underlying treatment effectiveness.

### *Interdependent Time Scales and Increasing Determinacy*

The interplay between different time scales has already been discussed in relation to attractors and phase transitions, but it is important enough to highlight as a key construct on its own and one that contributes to developmental determinacy. Self-organization at the moment-to-moment (real-time) scale constrains self-organization at the developmental scale, which, in turn, constrains real-time behavior (van Gelder & Port, 1995). For example, rivulets of rainwater during a thunderstorm carve a ditch through one's flower garden. This ditch then provides a predictable destination (an attractor) for the flow of rainwater by the end of the season.

Similarly, developmental parent–child patterns arise from real-time interactions that recur over occasions. As these patterns repeat hundreds of times, they produce and strengthen attractors on a dyadic state space. This increasingly specified dyadic state space can be said to reflect the history of the system (cf. Thelen & Smith, 1994). As such, it constrains the types of real-time interactions in which the dyad will engage. The likelihood of a parent and child interacting in a particular manner in real time is thus increasingly predetermined by a stabilizing developmental trajectory. Similar to any complex, self-organizing system, the developing parent–child relationship can be conceptualized as moving from a relatively undifferentiated organization toward one that is increasingly predictable.

The idea of cascading constraints (Lewis, 1997) is linked to the interrelations among time scales and the increasing predictability of dyadic trajectories. Over development, specific attractors arise from recurring real-time interactions. These attractors not only constrain ongoing real-time behavior, but they also constrain the development of future attractors and hence the dyad's behavioral trajectory. Development can be characterized as a sequence of constraints emerging over time, each one partially determined by the chain of constraints laid down so far. For example, a parent–child dyad may have developed two main interaction patterns: a cooperative, mutually positive pattern and a hostile–withdrawn pattern in which the parent berates the child and the child ignores the parent. As mutual positivity declines in early adolescence, existing habits of withdrawal will constrain the interactions that emerge next. A repertoire of distance and disengagement may characterize the adolescent period, leading eventually to complete

estrangement and alienation in adulthood. By this means, the degrees of freedom along the dyadic trajectory are pruned by developing habits. Other candidates for cascading constraints include the death of a parent, parental divorce, and associations with deviant peers; all these factors specify available real-time interaction patterns and probabilistically constrain the future direction of a developmental trajectory.

Many of the DS concepts and principles we have reviewed have been emphasized in other general systems accounts. Although there are many similarities between these systems approaches, there are two critical advantages of the DS framework that prove particularly important for our modeling purposes. First, real-time variability represents critical information in DS research, but older systems views have neglected or viewed variability as sources of noise. However, for DS theorists, variability is considered a rich source of information, indexing impending change and "the essential ground for exploration and selection" (van Geert & van Dijk, 2002). Theoretical models based on DS premises invoke variability to understand developmental processes of all kinds, and empirical methods that tap changes in variability are a mainstay for these researchers (e.g., Lewis & Granic, 2003; Thelen & Ulrich, 1991; van Geert & van Dijk, 2002). Second, scholars have often, for good reason, criticized systems or transactional approaches for being too metaphorical, vague, and empirically bereft (Cox & Paley, 1997; Reis, Collins, & Bersheid, 2000; Vetere & Gale, 1987). In fact, far from being less specific and more abstract than conventional approaches, researchers applying DS principles seek to specify precisely, and measure repeatedly, the drivers of change and stability. Instead of being content to measure overt manifestations of behavior or examine correlations among these manifestations, a DS approach mandates "careful experimental analyses [to] dissect the interacting systems to reveal the driving subsystems" (Thelen, 1989, p. 123). Moreover, DS researchers, particularly developmentalists, have been as concerned with operationalizing metaphorical concepts and devising new research designs, methodologies, and analytic techniques as they have with extending current designs and methods (for reviews, see Granic & Hollenstein, 2003, 2005). Although there is still a long way to go in terms of developing appropriate methodological tools, the mandate is an explicit one.

Having briefly reviewed the most relevant DS concepts for our purposes, we now examine their utility for modeling coercive family and peer processes. The real-time mechanisms underlying the emergence of antisocial behavior are considered first, followed by an examination of developmental processes and the fundamental links between the two time scales.

## Real-Time Processes

Moment-to-moment, or real-time, processes are the guts of the coercion model and the springboard from which we develop our DS-based theory of antisocial development. Most of the insights in coercion theory have emerged from the microsocial studies of parent–child interactions. Coercion theory is based on the proposition that real-time microsocial interactions are the proximal engines of development (Snyder & Stoolmiller, 2002; cf. Bronfenbrenner & Morris, 1998). Moment-to-moment, day-to-day direct experiences are the "materials" out of which antisocial outcomes emerge. This view resonates with DS theorists' core assumptions about development in general: "Habituation, memory, learning, adaptation, and development form one seamless web built on process over time—activities in the real world" (Thelen & Smith, 1998, p. 593).

### *Coercion in Family Interactions Through a DS Lens*

*Original conceptualization of coercive processes.* Before coercion theory was formalized, OSLC researchers began observing children in their nursery school settings. These early studies (e.g., Patterson, Littman, & Bricker, 1967) demonstrated that children are provided with repeated opportunities to reinforce their aggressive behavior. When victims of aggressive behavior cry, give up their toy, or leave the disputed territory, the aggressive child "wins," and he or she is, therefore, more likely to use the same aversive strategies in the service of future goals. However, where did the inclination to act aggressively toward fellow students come from? To better understand the origins of early aggressive behaviors in school, OSLC researchers moved their studies to the home and examined family interactions with at-risk youth. They hypothesized that specific reinforcement contingencies were causally linked to the development of childhood aggression. Through the sequential analysis of real-time family interactions, Patterson et al. (e.g., Patterson, 1982; Patterson et al., 1992) showed how parents "train" children to become aggressive and antisocial.

The training process begins innocuously enough, with the parent repeatedly requesting compliance from the toddler. Patterson et al. (1992) found that, in clinically referred dyads, an aggressive child is likely to experience an aversive intrusion from a family member at least once every 3 min. Typically, these intrusions are minor, characterized by a vague command in an irritated tone of voice (e.g., mother asks child to "quit playing video games all the time!"). In response to this intrusion, the child responds coercively (e.g., whining, tantrums). The parent, in turn, becomes frustrated and, after a short while, yields to the child's coercive behavior. Perceiving the parent's acquiescence, the child stops his oppositional behavior, and the mother's source of frustration is alleviated (Patterson, 1982; Snyder & Patterson, 1995). Thus, the child's aversive behavior is terminated in the short run, but these oppositional behaviors are reinforced and are more likely to recur in the future. The parent's withdrawing behavior likewise becomes reinforced because, as a result of letting the child win, the parent is rewarded with temporary peace (Patterson, 1982; Patterson et al., 1992). These reinforcement contingencies also apply to siblings who reward coercive behaviors through similar processes and who are, in turn, bidirectionally reinforced for their own aggressive behaviors (Patterson, 1984; Snyder & Stoolmiller, 2002). In a nutshell, this cyclical sequence of behaviors describes the coercion model. Three independent studies have demonstrated that coercive cycles in childhood predict long-term clinical problems (Forgatch & DeGarmo, 2002; Snyder & Patterson, 1995; Snyder, Schrepferman, & St. Peter, 1997).

Coercive cycles fit nicely with the definition of an attractor. Attractors are not static, template-like modes that reside in one or another person or dyad; they are dynamic forms that emerge in context-dependent episodes. Accordingly, the notion of a coercive cycle highlights the recursive yet transient nature of these patterns. However, it is important to note that the variables that were actually used to predict aggressive behavior did not represent a

cycle per se. Instead, studies of coercion were based on operant conditioning principles. Specifically, the relative rate of reinforcement for coercive behavior and the rate of conflict bouts were shown to predict the development of antisocial behavior. Behavioral contingencies among parents and children, expressed in reinforcement terms were, thus, the building blocks of coercion theory.

Consistent with the earliest formulations of coercion theory, we continue to maintain that "the child is an active participant whose behavior is a reaction to the behavior of the other family members and also constitutes a stimulus for their behaviors. A behavioral event is both an effect and a cause" (Patterson, 1982, p. 196). This suggests that early theoretical conceptualizations of coercive processes were already thinking systemically about feedback mechanisms. However, our current model places reinforcement contingencies at the beginning of the real-time story of antisocial development. In fact, negative reinforcement (or escape conditioning) for antisocial behavior is only one of several key feedback processes by which children learn to behave aggressively. We discuss other feedback relations next.

*Beyond operant principles.* There are a number of implications of understanding coercion as a DS process. The first has to do with the operant conditioning framework that served as the basis of the original coercion theory. Operant or learning theory approaches have long been criticized for ignoring the causal forces that give rise to behavior (e.g., Chomsky, 1959; Rand, 1982); however, this weakness is addressed when learning principles become nested in a DS framework.

First, reinforcement contingencies are usually calculated between two behavioral events over a constrained period of time. To measure contingencies in families, the conditional probability of any particular parent–child sequential event is calculated over one or a limited number of interaction sessions. This conditional probability is then used as a static predictor of developmental outcomes such as antisocial behavior. However, from a DS perspective, the strength of association between two or more events changes in important ways over the course of an interaction (e.g., on entering or exiting an attractor), and so does the probability that additional or different states will become available to the system. An older study by Snyder and Patterson (1986) showed that, as a mother's reinforcement rates for particular behaviors change, the probability values for her son's next reaction also shift. This means that the probability for a dyad to engage in a particular interaction pattern versus other patterns continuously changes as the interaction itself proceeds. From a DS perspective, the concept of a state space highlights the fact that parent–child behavior moves about on a landscape of probabilities, such that one static reinforcement contingency cannot adequately describe a real-world episode.

Second, operant principles are fundamentally unidirectional: The environment provides rewards according to certain contingencies, and based on these contingencies, the behavior of the individual is shaped in a particular manner. However, Patterson et al. have long emphasized the recursive, bidirectional nature of socialization episodes, suggesting an actual or perceived discrepancy between learning theory and coercion theory. It is not only the child who is being trained to be coercive but also the mother who is being trained by the child. This causal bidirectionality is a core premise of the coercion model, but it is not captured by operant principles.

A third potential problem with the original coercion model's exclusive reliance on the operant framework is its bottom-up explanations of real-time learning processes. We propose that coercion or any other socialization process that is fundamentally dyadic operates through both bottom-up and top-down effects or what we have discussed as circular causality. It is not only the parent's and child's behaviors, and reactions to one another's behaviors, that lay down predictable patterns of coercion. These processes are the observable characteristics of interacting (microscopic) elements, including psychological and neural events, that give rise to coercive (macroscopic) patterns, or systemic "wholes," while these wholes maintain the interactions among the constituent elements. Before we proceed to a discussion of the nature of these elements, how can we conceptualize the dyadic whole?

Although many writers have advocated viewing families or parent–child dyads as systems, psychologists are so used to thinking on an individual level that it is difficult to pinpoint exactly what this higher order form looks like. Studying the wholes in development means identifying relationship patterns, which cannot be explained by the behavior of any individual member in a relationship. The relationship itself has its own features and its own developmental history. For example, although I am a mature adult with reasonably high self-esteem, when my mother asks me if I really want that extra piece of cake I immediately become defiant and tell her to mind her own business. She, in turn, gets angry, and we are suddenly in the same old argument about my sensitivity and her lack thereof. Both of us believe the other started it, both of us vow each time never to repeat it, but both of us seem drawn by some invisible force beyond our control to repeat the same type of interaction. This invisible force was what compelled OSLC researchers to focus on nonconscious dyadic behavioral patterns. However, DS modeling permits an explicit analysis of the content of the higher order form (e.g., the coercive pattern) as well as the subsystem elements that interact to give rise to it. By paying attention to circular causal relations, we come closer to operationalizing the invisible forces that drive relationship systems from one such pattern to another.

Thus, the original coercion model went as far as specifying bidirectional causality, but it stopped short of understanding coercive processes as a function of reciprocal causality unfolding in real time and circular (vertical) causality across levels of analysis. Coercive processes are not unidirectional: They actually involve reciprocal causation. Moreover, they are not constrained to activities at the level of behavioral acts: They involve causal relations between levels of a hierarchy that includes psychological as well as behavioral elements. To extend the original coercion theory, we propose a DS position that includes, but goes beyond, operant principles. The next step toward this goal is to define some of the psychological processes that influence each other, along with observed behavioral events, at the microscopic level of interacting elements. Then we will be in a better position to fully explain the (macroscopic) coercive patterns that both arise from and maintain these interactions.

*Emotional and cognitive processes.* We argue that family processes are part of a complex system made up of reciprocally interacting lower order elements. Through circular (vertical) causality, the lower order elements produce macrolevel relationship patterns, and these patterns themselves maintain the interactions of the lower order elements. What are the lower order elements in

coercive dyadic patterns? So far in our discussion, our explanations of relationship patterns have focused exclusively on observable behaviors. By what means or processes do reinforcers affect action? Explanations of behavior patterns, dyadic or otherwise, require some knowledge not only of the external environment but also the internal structure of the organism and the ways in which it processes information (cf. Chomsky, 1959). A DS approach encourages us to specify these mechanisms. It provides the framework for integrating behavioral patterns with the underlying psychological factors that reciprocally interact to give rise to family processes. Like other psychologists, we focus specifically on cognitive and emotional elements.

Emotional developmentalists have suggested that emotions and cognitive appraisals (or their constituents) are the basic psychological elements that interact to form global personality structures (e.g., Izard, 1977; Lewis, 1995; Magai & McFadden, 1995; Malatesta & Wilson, 1988; Tomkins, 1962, 1963). Emotions emerge with cognitive evaluations of events relative to an individual's personal goals (Frijda, 1986; Lazarus, 1982, 1984; Oatley & Johnson-Laird, 1987). They focus attention on particular aspects of a situation, prompting changes in action readiness (Frijda, 1986). Thus, anger is elicited when a goal is perceived to be intentionally blocked and appraisals of blame coalesce, sadness emerges when a blocked goal is appraised as insurmountable, shame is elicited when attention is drawn to the self and appraisals of worthlessness are triggered, and so on. Over developmental time, recurrent emotion–cognition amalgams support individual styles of processing information and engaging with the world (Izard, 1977; Lewis, 1995; Malatesta & Wilson, 1988).

Several theorists understand the relation between cognitive processes and emotion as a feedback loop (e.g., Lewis, 1995, 1997; Teasdale & Barnard, 1993). Particularly relevant for our discussion is Lewis's model (1995, 1997) based on DS principles. He argues that positive feedback between emotions and cognitive elements is the basis for self-organizing interpretations in real time and personality patterns over development. Cognitive appraisals are conceptualized as emerging in concert with emotions, each amplifying and then constraining the other in real time. According to this view, emotion guides an individual's attention to particular goal-relevant elements in a situation. An appraisal forms, further generating emotion, which is, in turn, fed back into the system through repeated iterations. Precise neural underpinnings of these emotion–appraisal feedback cycles have also been proposed (Lewis, 2005). Over developmental time, repeated feedback cycles increase the tendency for particular emotional and appraisal elements to cohere. These cognition–emotion structures have been conceptualized as personality-specific attractors (Lewis, 1995).

To understand the elements that make up coercive dyadic patterns, we need to consider socioemotional processes in relationships. One way to extend Lewis's intraindividual personality model to dyadic coercive processes is to view the separate affective–cognitive mechanisms of the parent and the child as the interacting subsystems that self-organize in parent–child interactions. Through repeated dyadic feedback cycles, particular parent and child emotion–appraisal couplings may reciprocally select one another and become further coupled into a more complex amalgam. Behavioral acts contribute to this amalgam as the mechanisms of communication between the partners' psychological processes. Through circular causality, this configuration of interacting elements gives rise to a macroscopic dyadic state, characterized by coercive expectancies and habits, and this dyadic state maintains the interaction of the underlying cognitive, emotional, and behavioral elements. As a consequence of this process, complementary cognitive and emotional "biases" and behavioral habits are strengthened for both partners and are more likely to recur over occasions.

Research on appraisal–emotion processes in coercive dyadic relationships helps to ground the notion of coupled emotional and cognitive elements. Perhaps the most relevant emotions for both parents and children in coercive episodes are anger and contempt (e.g., Forgatch, 1989). One study of coercive family processes showed that mothers' and boys' tendency to show contempt toward one another predicted ineffective parenting practices, which, in turn, predicted delinquent behavior (Forgatch & Stoolmiller, 1994). Whereas this study was strictly developmental, a 2003 study with 5- to 6-year-old children addressed more closely the emotional feedback processes underlying aggressive children's real-time interactions with their mothers (Snyder et al., 2003). Through detailed real-time modeling procedures (hazard analysis), Snyder et al. (2003) showed that angry, contemptuous, and dismissive parental responses to children's anger were related to shorter latencies to the next anger display by the child (i.e., parental anger increased the likelihood that children would reciprocate with anger sooner than if the parent responded with positive or neutral emotions). This tendency for parents to reciprocate anger and perpetuate negative feelings was related to children's development of externalizing behavior problems. The authors explain these findings by suggesting a "synergistic effect. . .or positive feedback within the social system that amplifies [the child's] initial dysregulation and mismanagement of emotion" (p. 353). This study provides preliminary evidence for the role of a mutually hostile dyadic attractor—characterized by reciprocal, self-amplifying, angry emotional displays—in the early emergence of antisocial behavior.

In the same study, these authors also found that mothers' expressions of sadness and anxiety decreased the latency to children's next anger outburst. These findings suggest that, in conflict situations and other types of parent–child interactions, there are additional emotions to consider. Instead of eliciting anger from the mother, the child's anger and his appraisals of his mother as unfair and blameworthy may couple with the mother's feelings of anxiety and compatible appraisals that her child does not love her, she is a bad mother, or she is being unnecessarily punitive and harsh. We understand this attractor as constituting what other researchers have labeled *permissiveness*[1] (e.g., Baumrind, 1971, 1991), or inconsistent and indiscriminant parenting (Dumas & LaFreniere, 1993, 1995; Dumas et al., 1995), and it seems like a qualitatively distinct dyadic state from the mutual hostility pattern that has likewise been labeled *coercion.*

Although relevant, Snyder et al.'s study did not specifically tap feedback processes. How might we preliminarily model appraisal–emotion feedback relations more precisely, and how does this

[1] *Permissiveness* also has some positive connotations such as when parents of adolescents become appropriately more lax in response to youths' autonomy-seeking behaviors. In the current article, we use the term as coined by Baumrind, suggesting an overly lax, laissez-faire approach to discipline and child rearing.

exercise extend the original coercion model? To clarify the role of cognitive–emotional–behavioral feedback processes, we now revisit the classic behavioral description of the coercive cycle and consider its psychological underpinnings through an example.

A mother asks her son to comply to a vague request, for instance, "Help clean the house." Just before her request, she is feeling anxious, thinking about the many things she needs to get done by the end of the night. The child, playing a video game, hears his mother's request and begins to feel irritated, thinking that his mother always picks on him rather than his brother. As these low-grade negative emotions and appraisals coalesce, he rudely refuses his mother's request (e.g., "Go clean it yourself!"). Her attention is now fully tuned to her son's defiance and, through positive feedback, her anxiety increases with the expectation that her son will force them into a confrontation. She also begins to feel irritated with his defiance. In an attempt to regulate her anxiety and her irritation, the mother suggests that they could go out to a restaurant afterward if he would just help her. Perceiving his mother as a nag and an obstacle to his goal (i.e., to continue to play video games), the child's irritability grows into anger, expressed through loud complaining. In turn, through continued positive feedback processes, his mother's irritable feelings become amplified into anger, overriding her anxiety, and coupling with appraisals of her child as "selfish and nasty" and an obstacle to her goal of eventual rest. Her hostile emotion–appraisal amalgam motivates her to begin threatening her son with extreme consequences or to denigrate him in retaliation. Perceiving her rage, the child likewise escalates, becoming angrier while his appraisals change from mother as nuisance to mother as monster. Soon, these reciprocal interactions among appraisal components, emotions, and harsh words stabilize through negative feedback processes. The child goes on playing his video games, ignoring his mother pointedly and angrily, while his blameful perception of her stabilizes. His mother, feeling beaten and unable to continue the fight, shifts from anger to contempt, which stabilizes along with an appraisal of her child as "useless" and "always bad." Both dyad members remain in this seething state for the rest of the evening.

On a behavioral level, the example we have presented is a familiar one. What do we gain from hypothesizing emotional and appraisal interactions that become amplified and then stabilize? The attempt at identifying appraisal elements and emotional factors leads us to tease apart the coercive process into two potentially distinct patterns: one that involves the mother anxiously cajoling her son, in response to his rude remark, and another that is characterized by mutual hostility. By using a DS lens to probe the psychological elements underlying coercive behavioral patterns, we find that these patterns are fundamentally distinct. *Thus, the first testable hypothesis that emerges from our DS model is that the mutual hostility and permissive parent–child patterns, which have traditionally been discussed interchangeably as coercive family processes, are causally distinct patterns that should, therefore, resolve to two distinct attractor patterns. Finally, modeling these dyadic feedback relations suggests the conditions under which dyads will move from one attractor to the next. Specifically, mothers who are prone to feeling anxiety may start off responding to their children's defiance with positive, cajoling behaviors. However, when these same mothers begin to perceive increased emotional pressure, they may become hostile and contemptuous.* This is a second testable hypothesis developed from our current modeling.

*Multistability and perturbations.* Given that the variety of emotions and appraisals that we have hypothesized are involved in disciplinary interactions, and the different attractors that are associated with these emotion–appraisal amalgams, we need to broaden our investigative lens to examine several parent–child patterns at the same time. The DS principle of multistability is informative in this regard: Self-organizing systems have the potential to be drawn toward several attractors, depending on contextual constraints. Most research on aggressive parent–child interactions has focused exclusively on identifying negative behavior patterns. More recently, positive patterns, or the lack thereof, have also been studied (Gardner, Sonuga-Barke, & Sayal, 1999; Gardner, Ward, Burton, & Wilson, 2003), but exclusive attention to one or the other type of pattern seems unnecessarily narrow. Multistability suggests that all parent–child dyads are characterized by a landscape of diverse attractors. Even severely aggressive dyads sometimes play and laugh together and the most healthy dyads have hostile arguments that end in yelling. Our approach moves away from one-dimensional, trait-like descriptions of the parent, child, or even the dyad and encourages the study of several alternative interaction patterns and the transitions between them.

One way that DS-informed researchers explore a system's multistable states is to perturb the system and track its behavioral response (e.g., Thelen & Smith, 1994). Perturbing the parent–child system may provide researchers with a glimpse of interaction patterns that would not have otherwise been observable. This type of state space–wide approach prompts us to ask a set of novel questions. For example, researchers may ask how easily a dyad can shift from one state to another (e.g., from a hostile to a cooperative attractor). Perhaps the fact that dyads become hostile toward one another is not as important as the extent to which they are able to repair those interactions when they do occur.

Granic and Lamey (2002) conducted a study that aimed to identify the multistable states available to mother–son dyads with an aggressive child. The study addresses our first hypothesis: Coercive family processes, previously understood as one coherent parent–child pattern, may actually constitute two distinct attractors: mutual hostility and permissiveness. One of the goals of the study was to examine differences in the parent–child interactions of pure externalizing children (EXT) and children comorbid for externalizing and internalizing problems (MIXED). Past research on coercive processes has not identified any differences in the real-time interactions of these two subtypes. However, this may not be surprising: DS principles stipulate that one cannot know about the various behavioral states available to a system without perturbing it. Thus, a perturbation was introduced to the standard parent–child problem-solving paradigm, and we tested whether EXT and MIXED subtypes would differ in their interactions as a function of this perturbation.

Parents and clinically referred children discussed a problem for 4 min and then tried to "wrap up and end on a good note" within the next 2 min, after a loud knock on the door (the perturbation). The perturbation was intended to increase the emotional pressure on the dyad, potentially triggering a reorganization of their cognitive–emotional–behavioral system. We hypothesized that, as a function of differences in the underlying emotion–appraisal

structures of their relationships, EXT and MIXED dyads would be differentially sensitive to the perturbation and would reorganize to different regions of the state space. Before the perturbation, however, we expected dyads' interactions to look relatively similar.

We tested our hypothesis using a new DS methodology: state space grid (SSG) analysis (Lewis, Lamey, & Douglas, 1999). SSG analysis is a graphical and statistical approach that uses observational data and quantifies these data according to two ordinal variables that define the state space for any individual system. We extended the original SSG methodology to represent dyadic behavior. The dyad's trajectory (i.e., the sequence of behavioral states) is plotted as it proceeds in real time on a grid representing all possible behavioral combinations (Granic, Hollenstein, Dishion, & Patterson, 2003; Granic & Lamey, 2002). Much like a scatter plot, one dyad member's (e.g., parent's) coded behavior is plotted on the *x*-axis and the other member's (e.g., child's) behavior is plotted on the *y*-axis. Unlike scatter plots, however, each *x*–*y* coordinate represents a moment (e.g., second, event, bin) in time rather than a case in a group of cases. In dyadic grids, each point on the grid represents a two-event sequence or a simultaneously coded parent–child event (i.e., a dyadic state). A trajectory is drawn through the successive dyadic points in the temporal sequence they were observed. For example, a hypothetical trajectory representing 10 s of coded behavior is presented in Figure 2. The sequence begins with 2 s in hostile–hostile,[2] then 2 s in hostile–neutral, 3 s in neutral–neutral, 1 s in neutral–hostile, and 2 s in hostile–hostile.

A major advantage of SSGs is that they provide an intuitively appealing way to view complex, interactional behavior; thus, they are first and foremost a useful tool for exploratory analysis. They also allow for the representation of behavior on a systemic, dyadic level, an advantage shared by few conventional methodological approaches (Granic & Hollenstein, 2003). Parameters that describe attractor strength and other variables can be extracted for statistical purposes as well; we discuss these techniques further in the section on development.

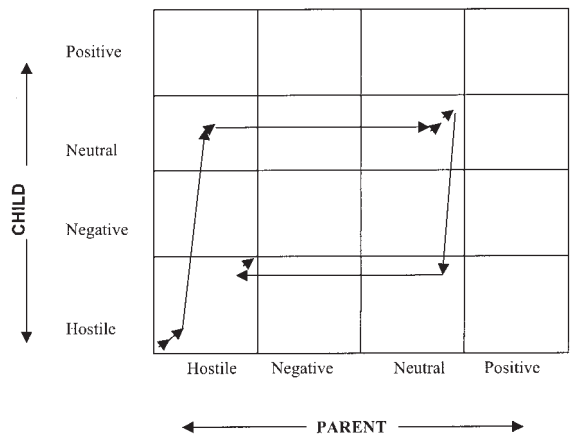


*Figure 2.* Example of a state space grid with a hypothetical trajectory representing 10 s of coded behavior, one arrowhead per second. From "Rigidity in parent–child interactions and the development of externalizing and internalizing behavior in early childhood," by T. Hollenstein, I. Granic, M. Stoolmiller, and J. Snyder, 2004, *Journal of Abnormal Child Psychology, 32,* 595–607. Copyright 2004 by Springer Science+Business Media, Inc. Adapted with permission.

Returning to the Granic and Lamey (2002) study, to examine the effects of a perturbation on subtypes' problem-solving behavior, separate grids were constructed for the pre- and postperturbation interaction sessions. For this study, the lines (trajectories) are less important to notice than the points, which show clustering in particular cells. Figure 3 provides an example of an interaction between a pure externalizing child and his parent pre- and postperturbation. EXT dyads tended to go to the permissive region (child hostile—parent neutral–positive) of the SSG as well as other regions (i.e., mutual neutrality and negativity) before the perturbation. After the perturbation, EXT dyads tended to remain and stabilize in the permissive region. Figure 4 represents the interaction of a MIXED dyad. Similar to EXT dyads, the MIXED dyads occupied the permissive region as well as other areas before the perturbation. However, in contrast with the EXT group, MIXED dyads tended to move toward the mutual hostility, or mutual negativity, region of the SSG after the perturbation. These graphical results were statistically confirmed using log-linear modeling procedures (Granic & Lamey, 2002). We concluded that the perturbation was a critical design innovation that provided the means to differentiate the parent–child patterns corresponding to clinical subtypes.

This microsocial study also suggested important extensions to the coercion model. SSGs provided a technique to parse interaction processes that have previously been assumed to represent one coherent coercive pattern. Both the hostile and the permissive styles of parenting have been previously shown to be related to the development of aggressive behavior (Baumrind, 1971, 1991; Dumas & LaFreniere, 1993; Olweus, 1980), but both have also been grouped under the heading of coercion. In our study, coercion was shown to constitute two separate microsocial patterns (two separate attractors on a state space): a permissive pattern in which the parent responded positively to the child's negative or hostile behavior and a mutually hostile pattern in which the parent reciprocates the child's hostility. This new insight advances our understanding of coercive processes, suggesting the importance of examining subtypes of parent–child dyads and their corresponding attractors. In addition, this DS-informed study helped us identify one of the potential conditions under which dyads would be drawn toward one attractor versus the other (i.e., when the context became more emotionally pressing). Thus, although this study did not measure emotions and appraisals in detail, the results are consistent with the first two hypotheses derived from our current DS model.

*Escalation processes.* Finally, the concept of attractors has also helped us reconceptualize the escalation process. After dyadic feedback cycles have repeated over many situations, a DS perspective suggests that less activation is necessary to catalyze the emergence of a steady state on any given occasion. It may be that early in their relationship the parent and child mutually annoyed each other for hours, and only a large insult resulted in a highly aversive and angry interaction. However, after the mutual hostility

[2] Note that the labeling of cells follows the *x*–*y* convention such that the first term represents the parent's code and the second term represents the child's code.

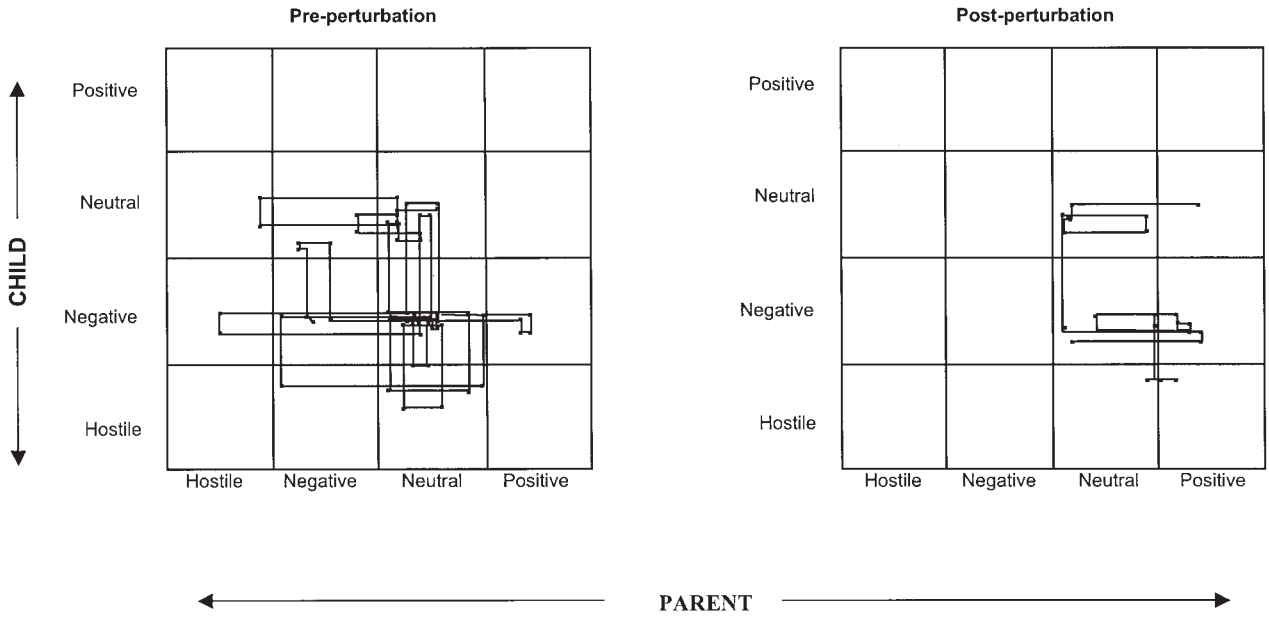


*Figure 3.* Pre- and postperturbation state space grids for an EXT dyad (parent–externalizing child; Granic & Lamey, 2002). From "Combining dynamic systems and multivariate analyses to compare the mother-child interactions of externalizing subtypes," by I. Granic and A. K. Lamey, 2002, *Journal of Abnormal Child Psychology, 30,* 265–283. Copyright 2002 by Plenum Publishing. Adapted with permission.

attractor has become deeply entrenched over time, the most subtle aversive behavior by one partner (e.g., child rolling his eyes, mother exaggerating her sigh) may initiate the spontaneous emergence of the full-blown hostile attractor. Patterson (1982) has suggested that in any given coercive episode that ends in hitting, one or the other partner "may move so quickly through a sequence that the victim is hardly aware that the confrontation has begun" (p. 157). To extend the original coercion model, we propose that

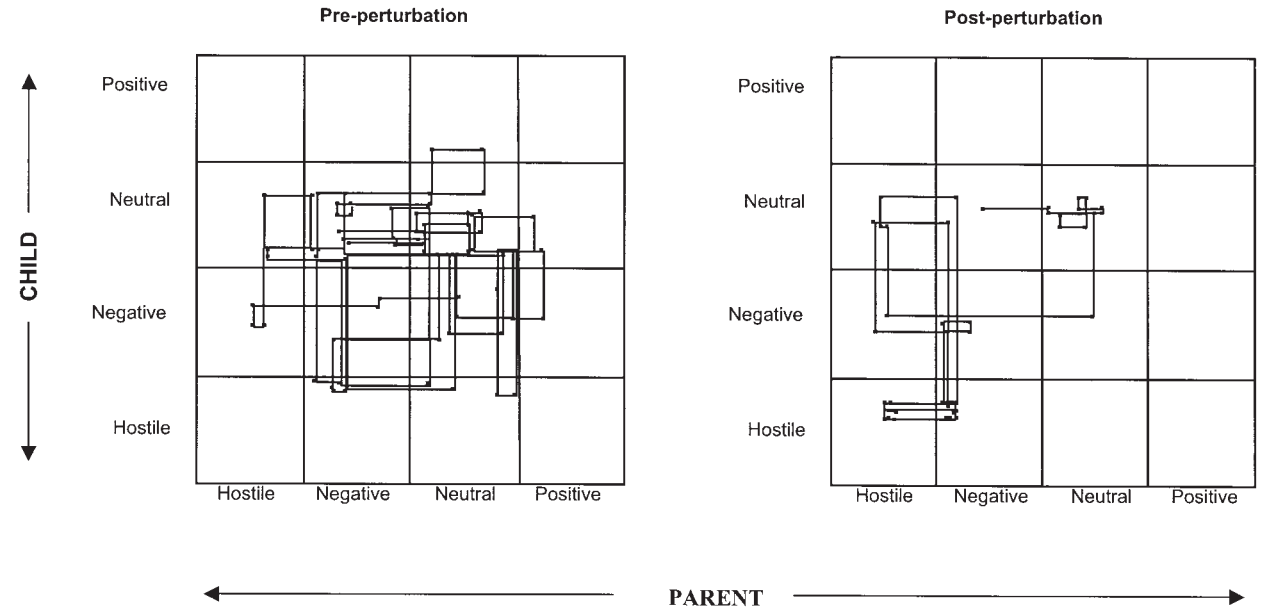


*Figure 4.* Pre- and postperturbation state space grids for a MIXED dyad (parent–child comorbid for externalizing and internalizing problems; Granic & Lamey, 2002). From "Combining dynamic systems and multivariate analyses to compare the mother-child interactions of externalizing subtypes," by I. Granic and A. K. Lamey, 2002, *Journal of Abnormal Child Psychology, 30,* 265–283. Copyright 2002 by Plenum Publishing. Adapted with permission.

coercive dyads are actually not moving through a sequence of behaviors at all: A nonlinear, emergent process is a more accurate description.

In terms of the psychological elements that may underpin these emergent escalations, we return to the research on emotion–appraisal processes in parent–child interactions. Studies have shown that once a mother's negative attributions toward her child have repeatedly elicited anger, the mother tends to become angry even when the child's behavior is not particularly aversive (Brunk & Henggeler, 1984; Mash & Johnston, 1982, reviewed in Dix, 1991). Even when anger is elicited from a situation that does not involve the child's actions, parents tend to anticipate that future interactions with the child will be aversive (Dix, 1991). In their meta-analysis of the relation between parenting and children's externalizing behavior, Rothbaum and Weisz (1994) argued that, over time, parents develop "generalized expectations" about their children that influence subsequent interactions. With respect to the child's expectations of the parent, much less has been empirically established. In one study, however, both aggressive children and parents tended to misattribute hostile intent to the other, and this was related to the extent to which they were aggressive toward one another (MacKinnon-Lewis, Lamb, Arbuckle, Baradaran, & Volling, 1992). Thus, there is some preliminary empirical support for the idea that, once particular dyadic emotions and appraisals have coupled and the behavioral patterns with which they are linked have stabilized, fewer and less intense triggers are necessary to drive dyads to their habitual attractors.

### *Deviancy Training in Peer Interactions Through a DS Lens*

In addition to the work conducted on real-time family processes that lead to childhood aggression, microsocial research at OSLC and elsewhere has focused on adolescents' real-time interactions with their peers. Similar to real-time coercive processes in the home, the findings on the interaction processes of peers are compatible with DS principles. Moreover, applying a DS lens provides theoretical extensions, specifies novel predictions, and suggests ways in which family and peer processes can be linked into one integrated model.

There is a well-documented connection between deviant peer affiliation and antisocial behavior (e.g., Elliott, Huizinga, & Ageton, 1985; Gold, 1970; Hawkins, Catalano, & Miller, 1992; Krohn & Thornberry, 1999; Patterson, 1993; Stoolmiller, 1994), but, until recently, the moment-to-moment process by which delinquent friends influence one another's behavior had not been examined. In the last decade, Dishion et al. have designed a series of studies to address this gap (Dishion, Andrews, & Crosby, 1995; Dishion, Patterson, & Griesler, 1994; Dishion, Spracklen, Andrews, & Patterson, 1996). Based on direct observations of peer interactions, these studies showed that the relative rate at which deviant peers reinforced each other (through positive affective responses) for talk about deviant topics (e.g., talk about stealing, lying, taking drugs) was related to the rate and duration of these deviant talk bouts. Sequential analyses showed that delinquent dyads reacted positively to one another in response to deviant talk, thus positively reinforcing one another for antisocial behavior. In comparison, nondelinquent dyads showed no such positive reinforcement pattern for deviant topics (Dishion et al., 1996). In addition, the mean duration of deviant talk bouts was higher for antisocial than prosocial peers. In its original conceptualization, this dyadic antisocial peer process was termed *deviancy training* (Dishion et al., 1995).

*Deviant talk.* Deviant talk may be understood as an attractor for antisocial, but not prosocial, peers; it is an affectively charged, dynamically stable state that antisocial dyads are drawn toward from other potential states (e.g., talk about schoolwork, problems with girlfriends). Moreover, positive feedback processes seem to underlie the emergence of this deviant talk attractor. Often the strategy shared by dyad members seems to be one of one-upmanship: When one friend says something with some antisocial overtones (e.g., "Last week I swore at the teacher in front of everyone"), the other will typically try to respond with an even more antisocial statement (e.g., "That's nothing, yesterday I told the principal to go to hell"). As these youth converse, they become more and more excited; each friend's excitement is picked up by the other, who, in turn, increases the emotional amplitude of his next statement and so on. This amplification process may stop only when dyad members become satiated; however, many of the antisocial dyads stop talking altogether at that point (Dishion, personal communication, January 15, 2001). This satiation phase suggests that antisocial dyads may simply lack any other attractor state in their behavioral repertoire. Similar to the parent–child emotion–appraisal feedback processes modeled earlier, the deviant talk attractor seems to involve amplification through the coupling of dyad members' emotions, appraisals, and the behavior by which they are linked. Each peer's excitement and interest couple with appraisals of the self and the peer as "cool," in control, and powerful.

*Measuring deviant talk as a dyadic attractor.* Reconceptualizing deviant talk as an attractor seems like a straightforward translation exercise, but there are specific predictions and theoretical extensions that are engendered by a DS approach. The first suggests that, although the frequency and amount of time spent talking about deviant topics are important, even more critical is the temporal patterning over the course of the interaction.

It is clear from previous studies that many normal peers discuss deviant acts and rule breaking as well. However, for antisocial adolescents, conversation topics focused on deviancy may be more engrossing and have more staying power. As a conversation proceeds, these antisocial peers may find it more and more difficult to disengage from talk about deviancy. Prosocial peers, in contrast, may still engage in deviant talk, but their behavioral patterns may be more flexible (i.e., they may have alternative topics that they find engaging; they have other attractors on their landscape) and, as a result, they may not become stuck in deviant conversations.

*The third hypothesis that emerges from our current DS model is that, over the course of an interaction, antisocial adolescents are repeatedly drawn toward deviant topics that exert an increasingly stronger hold on their interactions.* Prosocial peers also talk about deviant topics, but, in contrast to their antisocial counterparts, they move in and out of these deviant interactions without becoming stuck in them. One way to explore this hypothesis is to examine whether, over the course of an interaction, antisocial dyads spend increasingly more time in a deviant talk pattern. We conducted a study that provided a first step toward testing this hypothesis (Granic & Dishion, 2003). We elaborate on this study next to present preliminary support for our hypothesis and to provide an

example of another methodological strategy informed by a DS perspective.

Deviant (or "rule-break" [RB]) and normative talk was coded continuously from videotaped interactions between best friends. Time-series plots were derived for each dyad, with the duration of each RB talk bout plotted on the *y*-axis and the succession of bouts represented along the *x*-axis. The slope of that time series (i.e., the standardized beta) was then calculated using simple regression analysis. Figure 5 shows an example of a time series for an antisocial dyad. We used the slope measure in a somewhat unique way to highlight a key DS principle. If deviant talk indeed functioned as an attractor for antisocial youth, then we expected to see a time series that showed a positive slope (see Figure 5). If it was not an attractor for a dyad, then we expected to see a time series with either a flat or a negative slope. Thus, each dyad was assigned an RB talk slope value, and these values were then used in regression analyses to predict antisocial outcomes 3 years later.

The results are summarized in Table 1. As hypothesized, the attractor index (the slope of RB talk bouts) predicted serious antisocial behavior (e.g., number of arrests, school expulsion) and drug abuse 3 years later, whereas mean duration of deviant talk failed to predict outcomes. These results are particularly compelling because they remained statistically significant even after controlling for arguably the three most predictive risk factors in childhood: prior deviant child behavior, family coercion, and deviant peer associations in childhood.

The predictive power of the attractor measure was greater than that of the mean duration measure used in previous studies. From a DS perspective, central tendency measures such as mean duration do not capture the temporal patterns that may be critical for understanding how deviant talk becomes organized in peer interactions. Thus, our findings suggested that the average amount of time spent talking about deviant topics is not as important as the extent to which dyads become stuck in these topics over time.

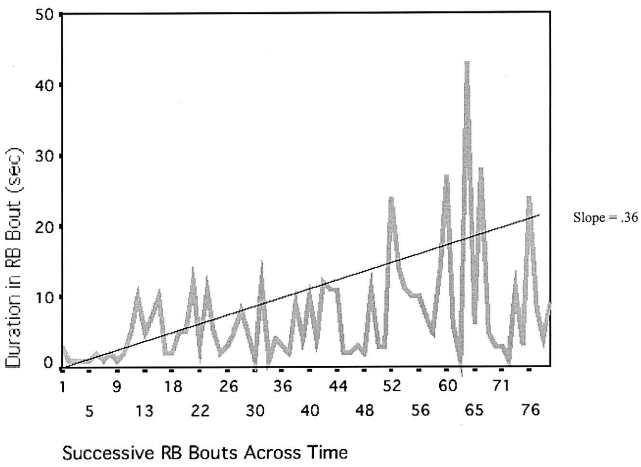


*Figure 5.* Example of a time series for an antisocial youth and peer with a positive rule-break (RB) bout slope. From "Deviant talk in adolescent friendships: A step toward measuring a pathogenic attractor process," by I. Granic and T. Dishion, 2003, *Social Development, 12,* 314–344. Copyright 2003 by Blackwell Publishing.

Table 1
*Summary of Results for Deviant Talk Study*

| | Antisocial behavior | | Substance abuse | |
|---|---|---|---|---|
| Steps in regression | $\Delta R^2$ | Total $R^2$ | $\Delta R^2$ | Total $R^2$ |
| 1. Child deviancy | .28*** | | .16** | |
| 2. Family coercion | .02 | .30 | .02 | .18 |
| 3. Child deviant peers | .07** | .36 | .06* | .24 |
| 4. Mean duration of RB talk | .00 | .37 | .00 | .24 |
| 5. Attractor strength (slope of RB talk) | .05** | .41 | .06* | .30 |

*Note.* $N = 102$ for both groups. RB = rule-break.
* $p < .05$. ** $p < .01$. *** $p < .001$.

## Interrelations Between Real-Time and Developmental Time Scales

We have discussed in a great deal of detail the real-time dynamic processes that underlie the development of antisocial behavior. We have focused on these real-time processes because we conceptualize microsocial interactions as the proximal causal generators of development (Snyder & Stoolmiller, 2002; cf. Bronfenbrenner & Morris, 1998). They are the day-to-day direct experiences by which developmental outcomes, including antisocial behavior, are shaped. Because direct observations are the only means by which real-time behavioral dynamics can be captured, we are strongly attracted to observational methods.

Most research in the field of antisocial development has not been concerned with real-time processes and, instead, has focused on identifying the developmental risk factors associated with antisocial outcomes (e.g., global predictors, such as number of deviant peer relationships, used in longitudinal and epidemiological research). This type of research is critical for understanding the large-scale developmental progression from early forms of antisocial and aggressive behavior to later, more serious forms of violence and delinquency (or desistence from these pathways). However, research on the micro- and macrolevel scales has remained largely unintegrated. In the developmental model that follows, our aim is to explain the emergence of well-documented developmental outcomes along different antisocial trajectories by linking them with the proximal real-time causal processes we have thus far laid out.

On the basis of the DS principle of interrelated time scales, we argue that real-time family and peer processes are the mechanisms through which global, macrolevel risk factors exert their influences on child development. This proposition is in line with Bronfenbrenner and Morris's (1998) bioecological theory, which posits that proximal processes operating over time (e.g., family and peer interactions) are the "primary engines of development." We argue that negative (self-stabilizing) feedback is the mechanism by which microsocial processes determine macrolevel outcomes. In turn, these macrolevel factors function as cascading constraints, serving both as outcomes (of previous processes) and as risk factors (for subsequent processes). These propositions provide the foundations for

modeling the developmental implications of family coercive processes and deviant peer mechanisms.

Two main trajectories of antisocial behavior have been consistently identified (Farrington & Hawkins, 1991; Moffitt, 1993; Patterson, Capaldi, & Bank, 1991; Patterson, DeBaryshe, & Ramsey, 1989; Nagin, Tremblay, 1999). These trajectories are differentiated by the age at which a child begins to exhibit antisocial behavior (for review, see Hinshaw & Zupan, 1997; Moffitt, 1993; Patterson, 2002): child onset (or early starter and life-course persistent) and adolescent onset (or late-onset and adolescent-limited). In general, compared with the adolescent-onset subtype, child-onset individuals are more physically aggressive, exhibit oppositional behavior earlier, experience more serious forms of peer rejection, are less likely to succeed academically, are more likely to show neuropsychological impairments, and are more likely to develop antisocial personality disorder in adulthood (Hinshaw, Lahey, & Hart, 1993; Moffitt, 1993). However, these are only general taxonomic descriptions of the two types of paths. In the following sections, we review a broad body of work that specifies the macrolevel risk factors and outcomes associated with these two developmental trajectories and integrate them with the real-time processes that serve as the engines generating these antisocial paths.

Figure 6 summarizes a DS account of the processes that may contribute to the early-onset antisocial trajectory. The two parallelograms at the bottom of Figure 6 are two types of state spaces representing real-time processes (parent–child and child–peer). The ovals embedded in these state spaces are attractors. The top part of the figure depicts a sequence of macrodevelopmental outcomes. The squares at the top of the figure represent sets of coordinated behavioral habits, specifically overt and covert antisocial behavior. The circles at the top represent sets of early (left circle) and late (right circle) risk factors or developmental outcomes (construed as cascading constraints).

The phrase *cascading constraints* does more than replace old reliable terms with obscure DS concepts. What researchers label a risk factor versus an outcome is arbitrary, depending on the focus of a particular study and the available data. For example, in one study, deviant peer association may be called a risk factor for the development of antisocial behavior. In another study, deviant peer association may be considered an outcome of antisocial behavior. The same can be said for almost all developmental factors that

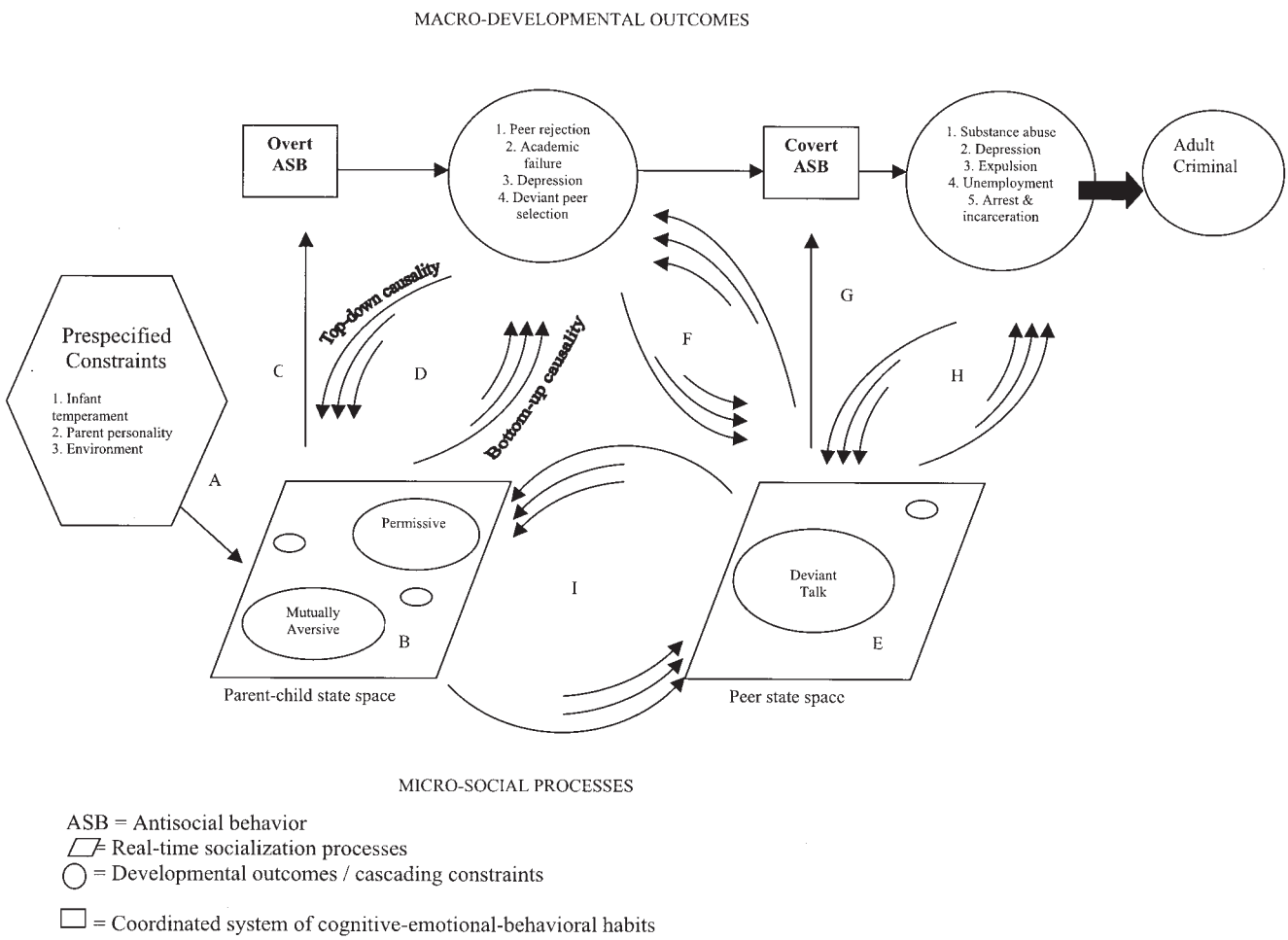


*Figure 6.* Top-down and bottom-up causal relations among interrelated time scales in the early-onset trajectory of antisocial behavior (ASB).

have been studied: Whether something is a risk factor or outcome has little to do with its nature and everything to do with whether one is predicting from or to that particular variable. This is not much of a dilemma in isolated empirical studies. However, in trying to construct a comprehensive model of antisocial development, these labels are misleading. Many factors such as deviant peer association are indeed both risks and outcomes, and that is precisely what the concept of cascading constraints is meant to convey: Particular real-time and developmental factors lead to certain developmental outcomes, and these outcomes themselves predict or constrain further outcomes. Cascading constraints also help identify a causal mechanism of developmental stability. As described earlier, cascading constraints are the means by which developmental trajectories become more and more refined and more predictable (i.e., developmental degrees of freedom become compressed). These distinctions are clarified as we describe the specifics of the early-onset antisocial trajectory.

### *Early-Onset Antisocial Trajectory*

We begin by discussing the early-onset developmental pathway, and we focus our review on boys, given that most research has not included girls until recently (Moffitt, Caspi, Rutter, & Silva, 2001; Pepler, Madsen, Webster, & Levene, 2005). Behavioral problems identified as early as infancy are related to the development and maintenance of antisocial behavior in childhood and adolescence. Given how early these at-risk behaviors emerge, it is important to begin modeling the early-onset trajectory before the birth of a child, before the development of the parent–child system. Following Lewis's (1997) developmental model, we refer to these factors as *prespecified constraints:* constraints that are part of the original structure of the system and provide the initial conditions to which self-organizing systems are highly sensitive. Over time, these prespecified constraints probabilistically influence the emergence of microsocial coercive family patterns (Path A in Figure 6). Consistent with the original formulation of coercion theory (Patterson, 1982), prespecified constraints are related to antisocial development to the extent that they influence real-time parent–child interactions (cf. Forgatch, Patterson, & Ray, 1996; Forgatch, Patterson, & Skinner, 1988). Although this core insight has been articulated before, our current DS formulation goes further by indicating the range of prespecified constraints and the mechanisms by which these constraints interact with emergent family interactions.

*Infant factors as prespecified constraints.* The first set of constraints may be broadly classified as the infant's biological predispositions, and they include genetic, prenatal, and other biological factors. It has become clear from twin and adoption studies and molecular genetic studies that there are genetic influences on antisocial behavior (see Raine, 2002, for a review), particularly for the child-onset, aggressive trajectory (Eley, Lichtenstein, & Moffitt, 2003; Taylor, McGue, & Iacono, 2000). In general, genetically informed investigations have shown a moderate level of heritability for aggression and antisocial behavior (e.g., Cadoret, Yates, Troughton, Woodworth, & Stewart, 1995; Eley, Lichenstein, & Stevenson, 1999; Rowe, 2001; Taylor et al., 2000). Prenatal factors such as exposure to toxins (e.g., lead, alcohol, marijuana, cigarettes, opiates, narcotics) and birth complications (Brennan, Mednick, & Raine, 1997; Brown et al., 1991; Fagot, Pears, Capaldi, Crosby, & Leve, 1998) have also been linked to child and adolescent antisocial behavior (e.g., Day, Richardson, Goldschmidt, & Cornelius, 2000; de Cubas & Field, 1993; Needleman, Riess, Tobin, Biesecker, & Greenhouse, 1996). In part, these genetic and prenatal factors likely influence antisocial development through their direct and indirect effects on psychophysiological factors such as low resting heart rate and low levels of skin conductance activity (e.g., Maliphant, Hume, & Furnham, 1990; Raine, Venables, & Mednick, 1997).

As well, prenatal risks can lead to difficult temperament styles (Bates, Bayles, Bennett, Ridge, & Brown, 1991), which, in turn, are related to the development of child and adolescent aggression and delinquency (e.g., Caspi, Henry, McGee, Moffitt, & Silva, 1995; Coie & Dodge, 1988; Goldsmith & Campos, 1986; Patterson & Bank, 1989; Rutter, Giller, & Hagell, 1998). Finally, individuals who begin to exhibit antisocial behavior during early childhood often show signs of attentional difficulties and hyperactivity (Hinshaw, 1987, 1994) as well as significant impairments in executive functioning and verbal abilities (Moffitt, 1993; Rutter et al., 1998; Tremblay, Pihl, Vitaro, & Dobkin, 1994). From birth, difficulties in attention and impulse control result in poor emotion regulation capabilities. Thus, prespecified genetic, in utero, psychophysiological, and other early biological constraints may contribute to the emergence of coercive family attractors.

*Parent factors as prespecified constraints.* Parents also begin their relationship with the infant with their own set of prespecified constraints that probabilistically limit the types of parent–child interactions that will emerge. Maternal depression may be one such initial constraint. Depression in new mothers has been shown to influence perceptions of the infant, perhaps even before birth (e.g., Brody & Forehand, 1986; Elder, Caspi, & van Nguyen, 1986; Goodman & Gotlib, 1999). On a cognitive level, depressed mothers are more likely to think of themselves as bad parents (Gelfand & Teti, 1990; Goodman, Sewell, Cooley, & Leavitt, 1993), they believe they have little control over their children's development, (Kochanska, Radke-Yarrow, Kuczynski, & Friedman, 1987), and they generally have more negative appraisals of their children (e.g., Friedlander, Weiss, & Traylor, 1986; Radke-Yarrow, Belmont, Nottlemann, & Bottomly, 1990). According to the emotion–cognition interactions described earlier, these negative appraisals likely couple with emotions of anxiety and anger. Indeed, depressed mothers display irritable affect (e.g., Cohn et al., 1990) and are less emotionally positive, more negative, and more angry and retaliatory (Field et al., 1990; Hammen, 1991). Behaviorally, depressed mothers spend less time gazing at, touching, and talking to their infants (Field, 1995). These mothers also tend to withdraw from their infants. Consistent with Lewis's (1995, 1997) model of cognition–emotion feedback processes, evaluations of the self as a bad parent likely coarise with feelings of anxiety and sadness, whereas evaluations of the infant as inherently blameworthy couple with anger. These emotion–cognition amalgams are likely to couple with the infant's own anxiety, anger, and frustration, increasing the probability of coercive exchanges early in the relationship. Of course, the impact of maternal depression on children's development has generated an enormous amount of research in its own right; it is a complex enough issue that probably warrants its own review from a DS perspective.

The parent's own tendency to exhibit antisocial behavior is another prespecified constraint that will impact on the parent–

child relationship (e.g., Bank, Forgatch, Patterson, & Fetrow, 1993; Capaldi & Patterson, 1991; Farrington, 1979; Patterson, 1999). Antisocial parents often have not acquired prosocial problem-solving skills through their own development; thus, they tend to begin their relationship with their infant with deficient parenting skills. Parents who exhibit antisocial behavior are more likely than their normal counterparts to use coercive discipline strategies such as scolding and threatening, and they are more likely to be permissive in their parenting style (Patterson et al., 1992).

*Prespecified environmental constraints.* The impoverished environmental contexts into which some children are born are another set of constraints that influence the subsequent development of the parent–child relationship and, in turn, the development of antisocial outcomes. Children born into families with low socioeconomic status (SES; measured by low income, unskilled parental occupation, and undereducated parents) and to families living in poverty have been found to be at higher risk for antisocial behavior (Bradley & Corwyn, 2002; Elder et al., 1986; Loeber, Green, Keenan, & Lahey, 1996). Children from crowded inner city neighborhoods with high crime rates (Offord, Boyle, & Racine, 1991) and children of divorced parents (Amato, 2001; Furstenberg, 1988) are also at increased risk for developing behavioral problems. The effects of these macrolevel environmental constraints are all understood as having an indirect influence on child development through their impact on the parent–child relationship (e.g., Capaldi, DeGarmo, Patterson, & Forgatch, 2002; Elder et al., 1986) and, more specifically, the real-time interactions that comprise that relationship. For example, studies at OSLC have shown that the effects of divorce-related stress on child antisocial outcomes are mediated through parental discipline and family problem-solving strategies (Forgatch et al., 1988, 1996).

From the moment of a child's conception, prespecified infant, parent, and environmental constraints are interrelated, and their coactivation makes it increasingly probable that parent–child coercive attractors will emerge. Specifically, environmental constraints influence the likelihood of particular infant and parent prespecified constraints in the first place. One example comes from a study by Farrington (1997), who found that children with low resting heart rates were significantly more likely to be rated by their teachers as aggressive if the child's mother was a teenager when pregnant or the family was from a low SES background. As well, prenatal difficulties that dispose the child toward fussiness may evoke particularly ineffective or harsh behaviors from mothers who are already disadvantaged (Chamberlain & Patterson, 1995; Clark, Kochanska, & Ready, 2000; Ge et al., 1996; Lytton, 1990). Thus, in our model of early-onset antisocial development, prespecified constraints often co-occur, initiating early parent–child patterns of interaction that tend to develop into coercive attractors (Path A in Figure 6).

*Emergence and stabilization of coercive attractors.* Coercive exchanges between parents and children can emerge as early as 18 months of age (Path B in Figure 6; Martin, 1981; Shaw, Keenan, & Vondra, 1994; Shaw & Winslow, 1997). Aggression in some form is normal at this early stage of childhood. At about 18 to 24 months of age, most children become oppositional, begin to say "no," and throw occasional tantrums (Maccoby, 1980). In general, overt forms of aggressive and oppositional behavior peak at the end of the second year of life (Tremblay et al., 1999). We hypothesize a developmental transition point at which these normative, early childhood behaviors become atypical and lead to clinically significant problems. Research suggests that the transition is triggered by inappropriate parental responses to oppositional outbursts (Belsky, Woodworth, & Crnic, 1996; Shaw, Winslow, Owens, Vondra, Cohn, & Bell, 1998). As outlined previously, two types of attractors may emerge and stabilize at this point: a mutually hostile attractor and a permissive one. Once these patterns have developed, they become increasingly predictable: Dyads spend longer periods of time in them and alternative behaviors become more rare (Snyder, Edwards, McGraw, Kilgore, & Holton, 1994; Snyder & Stoolmiller, 2002).

This loss of degrees of freedom over development is a key proposition for DS modeling. We conceptualize the developmental loss of behavioral possibilities as a series of dyadic state spaces that become increasingly more specified. As development proceeds, behavioral landscapes become more and more articulated such that some attractors become larger and more accessible, whereas others (e.g., playful interactions, cooperative problem solving) become smaller and less accessible. Thus, over development, fewer interactional possibilities become available to the dyad. The loss of degrees of freedom is an instantiation of Waddington's (1966) classic epigenetic landscape, which depicted the process of "canalization." (Waddington wrote explicitly about attractor landscapes later in his theoretical articles). Canalization represents the intrinsic self-stabilizing, irreversible nature of biological development.

*Rigid parent–child interactions and the emergence of overt antisocial behavior.* According to our model, all parent–child dyads, aggressive or not, are characterized by multistable states. In addition to identifying the content of these states, assessing dyads' ability to move from one state to another and the conditions under which dyads do so flexibly may be critical for understanding children's development.

Clinical researchers have long viewed psychopathology as overlearned, automatized problem behavior patterns that are impervious to changes in the environment and interfere with an individual's ability to function socially (e.g., Cicchetti & Cohen, 1995; Mahoney, 1991). In terms of family interactions, Minuchin (1974) described maladaptive family interactions as rigidified role relationships and the original account of coercion theory also characterized distressed families' interactions as overlearned coercive exchanges (Patterson, 1982). However, these accounts imply that particular problem behaviors become more rigid in developing psychopathology. The DS notion of multistability and the claim that even antisocial dyads have access to several attractors on their behavioral state space lead to the proposition that rigidity is a general feature of the state space of antisocial dyads regardless of the specific attractors characterizing their exchanges. *Hence, the fourth novel hypothesis that has emerged from our application of the DS framework is that children on the early-onset trajectory are characterized by an overall rigidity in their parent–child interactions regardless of the content of those interactions* (path C in Figure 6).

Parents and children are confronted with a variety of contexts every day (e.g., clean-up time, playing games, problem solving when conflict arises, eating dinner together). From our perspective, the extent to which parents and children can flexibly and appropriately respond, emotionally, cognitively, and behaviorally, to

shifts in contexts may tap a repertoire of alternative strategies that correspond to how children will adapt to future challenges at school and with peers. Until now, no studies have empirically tested the association between parent–child rigidity and negative child outcomes. We argue that a DS focus is necessary to do so because (a) a focus on the structure of interactions (i.e., their relative flexibility vs. rigidity) derives from a DS emphasis on the organization of behavior (e.g., attractor strength, multistability) and (b) DS constructs are instrumental for providing tools to measure the rigidity of interaction patterns.

We tested the fourth hypothesis by applying DS concepts and using the SSG method to study the relation between rigid parent–child interactions and the early onset of aggressive and antisocial behavior (Hollenstein, Granic, Stoolmiller, & Snyder, 2004). The study included high-risk children in kindergarten ($N = 240$) and their parents. Each parent–child dyad was observed for 2 hr across seven different contexts that ranged from snacks and game playing to academic tasks and talking about conflicts. These varied tasks provided children and their parents with opportunities to display a wide range of affective behavior in response to each other and the changing contexts. We expected that healthy, well-adjusted dyads would flexibly adapt to one context after another, changing affective states when the task demanded (e.g., frustration in the teaching task, joy in game playing). In contrast, we hypothesized that dyads with children who would develop externalizing problems would be more rigid and less able to adapt to changes in context.

The observational sessions were coded with the Specific Affect Coding System (Gottman, McCoy, Coan, & Collier, 1996); these codes were subsequently collapsed into four categories: positive engagement (e.g., humor, affection), neutral (e.g., talk, question), negative disengagement (e.g., sadness, fear), and negative engagement (e.g., anger, contempt). SSGs were constructed with these four categories, and two measures of rigidity were derived from the grids: (a) transitions: the number of movements between cells on the grid (a lower value indicated less frequent changes of dyadic behavioral states and, therefore, more rigidity; and (b) average mean duration (AMD): each cell's mean duration as calculated by dividing the total duration in that cell by the number of different times the dyad occupied that cell (the average of these 16 values across the whole grid was the AMD value). High AMD values indicated a more rigid dyad that tended to remain in each state for an extended period of time. We combined the $z$ scores for these measures into one overall rigidity construct ($\alpha = .82$).

Teacher reports of antisocial behavior were collected at four points in time: fall of kindergarten (Time 1), spring of kindergarten (Time 2), fall of first grade (Time 3), and spring of first grade (Time 4). At each of these time points, we grouped children into two groups: those who scored among the highest 10% on the Externalizing subscale of Achenbach's (1991) Teacher Report Form and those who fell below this cutoff. Figure 7 shows the mean rigidity construct score for antisocial behavior at each of the four time points. All results were in the hypothesized direction. Mean rigidity scores were significantly higher for the highest 10% on the Externalizing subscale at Time 2, $t(233) = 2.67$, $p < .01$, $d = .48$, Time 3, $t(226) = 3.40$, $p < .01$, $d = .69$, and Time 4, $t(208) = 3.49$, $p < .01$, $d = .73$, although there were no significant differences at Time 1, $t(234) = 0.65$, *ns*. Thus, as hypothesized, rigidity in parent–child interactions during early childhood differentiated antisocial children from their normal counterparts up to 18 months later. Moreover, as shown by the increasing effect sizes, the impact of early parent–child rigidity grew with age; this implies a honing of the developmental trajectory or a loss of degrees of freedom for dyads gravitating toward an antisocial trajectory.

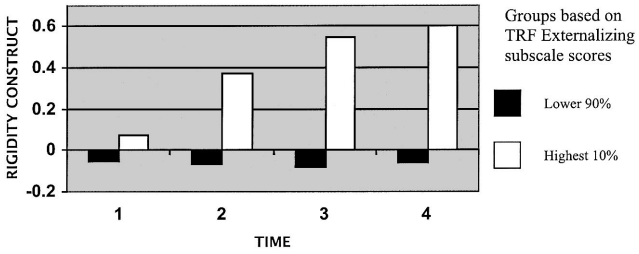


*Figure 7.* Comparisons between the highest 10% (white bars) and the lower 90% (black bars) on teacher-reported externalizing behaviors at each of the 4 time points (TRF = Teacher Report Form; Hollenstein et al., 2004). From "Rigidity in parent-child interactions and the development of externalizing and internalizing behavior in early childhood," by T. Hollenstein, I. Granic, M. Stoolmiller, and J. Snyder, 2004, *Journal of Abnormal Child Psychology, 32,* 595–607. Copyright 2004 by Springer Science+Business Media, Inc. Adapted with permission.

We extended these results by examining the relation between dyadic rigidity and profiles of growth in antisocial behavior (Hollenstein et al., 2004). Children's growth profiles of externalizing behavior across the four time points showed four distinct types of trajectories (based on a clustering procedure): growers (who started low and became increasingly more antisocial), desistors (who started high and became less antisocial), stable high dyads, and stable low dyads. As expected, results indicated that the growers and stable high dyads were significantly more rigid in their parent–child interactions compared with the stable low and desistors: Post hoc analyses of variance (ANOVAs) revealed a significant difference between the low–desistor clusters ($M = -.09$, $SD = .83$) and the high–grower clusters ($M = .30$, $SD = .81$), $t(206) = 2.70$, $p < .01$, $d = .43$.

All results held even after the content of the interactions (i.e., mutual hostility, permissiveness, mutual positivity, and child startup) was controlled for. Thus, the extent to which parent–child interactions were rigid was a unique predictor, above and beyond the content of these interactions. These findings provide preliminary support for the fourth hypothesis derived from our DS model; they have also been replicated in a separate sample with older children (Granic, 2003).

Our results were particularly exciting because of their potential implications for diagnosis, prevention, and intervention. Specifically, the growers and stable low groups began at approximately the same level of antisocial behavior. What distinguished them was the extent to which parent–child interactions were rigid at the first (fall kindergarten) wave. When we compared the growers and stable low group in a simple post hoc contrast, the growers were significantly more rigid in the first wave than the stable low group ($M_{low} = -.09$, $SD = .85$; $M_{growers} = .29$, $SD = .82$; $p = .02$). This means that the DS measure of rigidity could potentially be used to identify families at greatest risk for developing problem behaviors, and prevention efforts could be targeted at this group, even before children show the first signs of antisocial behavior.

Why would rigidity in family interactions, even interactions that are not negative, be a contributing factor to the development of antisocial behavior? Recall that, in our study, parents and children were asked to engage in a variety of tasks for 2 hr. Tasks such as resolving a conflict and teaching a child a novel skill may normally pull for frustration, anger, or disengagement. In contrast, playing a game or sharing a snack is more likely to elicit positive emotions. The ability to transition from one task to another and to experience a broad array of affective states shows a sensitivity to contextual demands and an ability to regulate these states as contexts shift. Alternatively, the tendency to remain in one or very few affective states, even if these states are neutral or positive, may indicate an insensitivity to environmental demands (e.g., remaining neutral throughout a conflict may be less effective than expressing some anger and then trying to resolve the issue). In addition, without the opportunity to experience a range of affective states and the dyadic regulation of those states, children may develop a very narrow set of coping behaviors. This proposition is supported by studies showing the benefits of increasing children's awareness of emotion and providing them with opportunities to engage in modulated emotional expression (Gottman, Katz, & Hooven, 1996; Izard, 2002). Children who learn to express a range of emotions tend to become adept at regulating their physiological arousal and emotional expressions.

In the early stages of coercion theory, Jones, Reid, and Patterson (1975) conducted a study with repeated home observations for normal and antisocial boys. The findings resonate well with our current theoretical formulations: Normal boys' various behaviors could be explained statistically by changes in their context. In contrast, antisocial boys were shown to be insensitive to contextual demands, behaving similarly across multiple contexts. At the time that the study was conducted, the authors had no way of explaining those results, nor did they have a theoretical framework in which to interpret them. However, these findings appear consistent with our hypothesis that antisocial children's deficits include an inability to adjust their affective behavior according to contextual demands. Discussing antisocial youths' behavior at the developmental scale, Moffitt (1993) endorsed a similar perspective: "Life-course persistent antisocial behavior is thus maladaptive in the sense that it fails to change in response to changing circumstances" (p. 685). Note also that children who cannot adjust their behavior to contextual changes at home are likely to be ill prepared for the adaptive demands of a very new set of contexts: the peer and school environments.

It is at this phase of our modeling efforts that we begin discussing in detail the interrelations between time scales in the development and maintenance of antisocial behavior. The developmental path depicted on the top row of Figure 6 has been well established by a number of research teams. Our model attempts to expose the underpinnings of this trajectory and to specify the mechanisms by which real-time interactions provide bottom-up influences that are reciprocated by top-down influences on real-time processes (circular causality). Moreover, these causal relations are viewed as recurring over time in an iterative fashion (represented as multiple arrows in the various loops).

*Bottom-up and top-down relations between real-time family interactions and cascading constraints on development.* At the 3- to 5-year age range, children's environments generally change as a result of entering day care or school settings. From our DS perspective, this abrupt shift from the family environment to institutional care can be characterized as a phase transition, and a child who has developed an overly rigid repertoire may be especially disadvantaged during this period. As discussed earlier, the system is particularly sensitive to small perturbations during phase transitions, when these perturbations are most likely to become amplified through positive feedback mechanisms. This principle is critical for understanding the novel emotional and behavioral patterns that may emerge in early and middle childhood, potentially amplifying aggressive tendencies and further constraining the developmental trajectory (path D in Figure 6).

Although some children are in child-care settings from as early as the first year of life, we suggest that, because of their cognitive immaturity, these children are not experiencing the same sort of radical shift as children entering day care, nursery school, or kindergarten between 3 and 5 years of age. At about this age, children develop a theory of mind: the ability to understand that others may hold beliefs about the world and about themselves that are different from their own (Perner, 1991; Wellman, 1990). With the advent of theory of mind, children are able to understand that other children or teachers may not like them or may think of them as "bad." They can also understand that the teacher likes some children more than others and that many peer situations are just "not fair." Suddenly, peer and teacher interactions become fraught with new meaning and potential peril. At the age of 5, children acquire the skills to play cooperatively, whereas before this age they generally play in parallel (Case et al., 1996). Children at the age of school entry are, therefore, more vulnerable to social comparisons and cognizant of the dominance hierarchies that self-organize in peer groups.

Thus, between the ages of 3 and 5, a number of normative developmental acquisitions come on line, sensitizing children to fluctuations in the social environment (e.g., rejection by teachers and peers, failure in games, teasing, social comparisons). These fluctuations or perturbations, corresponding with the timing of a phase transition, tend to become amplified, leading to a nonlinear increase in aggressive behavior. *Thus, the fifth prediction that emerges from our DS model is that children from rigid parent–child relationships will abruptly become aggressive (or significantly more aggressive) after entry into day care or school. Moreover, after taking into account day care or school entry, age should not be a strong predictor of increased aggression.*

We go on now to elaborate the details of this phase transition and its impact on development as a cascading constraint. According to our model, children from coercive and rigid family relationships develop a limited behavioral repertoire that may include overt aversive and antisocial behaviors (Path C in Figure 6). The first box in Figure 6 represents this coordinated system of behavioral habits. Studies by Snyder and Patterson (1995) and Snyder et al. (1997) have shown that observed coercive interactions at home were correlated at a magnitude of .83 with overt aggressive behavior in school. For many children, entry to day care or school brings with it some of the first experiences they have with social comparisons. Certainly, many of these children will have had to compare themselves with siblings, but the new opportunities for both social success and failure are profoundly multiplied in the context of large peer groups and classrooms.

The unskilled and overtly aggressive child enters school unable to cooperate, share, attend quietly, and flexibly regulate and inhibit

his angry and distressing emotions when they arise (Eisenberg et al., 2000; Kochanska, Murray, & Coy, 1997; Zahn-Waxler, Schmitz, Fulker, Robinson, & Emde, 1996). As a result, the opportunities for social comparisons afforded by day care and school entry most often lead to peer rejection and neglect (Dishion et al., 1995; Dodge & Coie, 1987; Laird, Jordan, Dodge, Pettit, & Bates, 2001; Patterson et al., 1992). These experiences of rejection are often fueled by peers' contempt, the most corrosive interpersonal emotion (Gottman & Notarius, 2000; Izard, 1977, 1991), early in the child's exposure to the school setting. Coie and Kupersmidt (1983) have shown that, when new peer groups begin to form, it only takes 2 to 3 hr of contact with an aggressive child for that child to be labeled by others as "disliked." Erhardt and Hinshaw (1994) likewise showed that, by the end of the first day of summer camp, children with conduct problems were already being rated as disliked and rejected. These early experiences of peer rejection likely trigger an abrupt amplification of anger and overt aggressive behavior.

Moreover, as peer relations become more and more important, repeated rejection and contempt from classmates have the potential to trigger novel painful self-evaluative emotions, most significantly shame (Tangney, Miller, Flicker, & Barlow, 1996). In response to these shaming experiences, victims often react by becoming angry and aggressive (Izard, 2002). Consistent with this perspective, empirical evidence suggests that the shame → anger → aggression pattern is characteristic of violent individuals (Fabes & Eisenberg, 1992; Tangney et al., 1996). Thus, the emergence of shame as a result of rejection may act as an amplifying and self-maintaining mechanism, as well as a cascading constraint, for antisocial development: In reaction to, or to regulate, his shame, the aggressive child may continue both to aggress against his normal peers and to actively avoid them when possible. As we discuss later, these painful experiences also lead aggressive children to select like-minded deviant peers, who will be less likely to reject them and more likely to share the same aggressive tendencies and attitudes.

Academic failure is also a likely outcome for the undisciplined, inattentive, and aggressive child (Hawkins & Lishner, 1987; Hinshaw, 1992; Moffitt, Gabrielli, Mednick, & Schulsinger, 1981). For example, one study at OSLC showed a path coefficient of .42 between antisocial behavior and rejection by peers and an even stronger association of antisocial behavior with academic failure (Patterson et al., 1992). Classroom observations have shown that aggressive children spend significantly less time focusing on academic tasks than normal children (Shinn, Ramsey, Walker, Stieber, & O'Neill, 1987), and aggressive children are less likely than their prosocial counterparts to complete homework (Dishion, Loeber, Stouthamer-Loeber, & Patterson, 1984). Because they perform poorly in school, the negative feedback that children receive about their academic performance and competencies (Higgins & Parsons, 1983) may be an additional source of shame for children who have already been rejected by their peers. Thus, academic failure may further amplify the shame → anger → aggression pattern (cf. Izard, 2002).

By Grades 3 and 4, an additional cascading constraint that may arise from peer rejection and academic failure is depression (Patterson & Capaldi, 1990; Patterson & Stoolmiller, 1991). After reviewing a series of studies that applied structural equation modeling, Patterson and Capaldi (1990) put forth a dual-failure model that proposed that the combination of peer rejection and poor school performance leads to depressed mood in antisocial children. From emotional developmentalists such as Izard (e.g., Izard & Harris, 1995), we know that depression has been associated with repeated experiences of shame throughout development. Aggressive children's experiences of rejection and academic failure instantiates the shame → anger → aggression pattern. These cognitive–emotional habits are strengthened across occasions and contribute to the early development of depression, another cascading constraint.

Rejection by prosocial peers, academic failure, and depressive mood further compress the degrees of freedom in aggressive children's development by providing them little choice but to seek membership in deviant groups (Dishion, Patterson, Stoolmiller, & Skinner, 1991; Snyder, Dishion, & Patterson, 1986). After continual rejection by normal peers, aggressive children predictably seek out antisocial peers who will accept them and share with them deviant attitudes and tendencies. Associating with deviant peers not only helps children avoid the pain of rejection but, just as importantly, helps them find acceptance from new friends: This increases children's chances of experiencing interpersonally triggered positive emotions (e.g., joy, excitement, and even affection).

Returning to loop D in Figure 6, through top-down causal processes, failure at school, failure with normal peers, and the tendency to associate with deviant peers amplify microsocial coercive interactions at home. School failure likely becomes an issue of contention with families; parental anger and the child's anger and shame may lead to mutual blame, further deepening the mutually hostile attractor. In addition, based on our current model of coercive processes, the permissive attractor will also become strengthened. New emotions and appraisals surface and contribute to digging the permissive attractor deeper. For example, a mother may begin to feel increasing anxiety about her aggressive child's friends and her deteriorating relationship with her son. The child, in turn, feeling further shame about his failure at school, may strongly defend his desire to associate with his deviant friends. Thus, anger toward his mother for blocking his goal of hanging out with his new cool friends is likely to abruptly increase. As this dyadic emotion–appraisal feedback cycle continues, the mother becomes more likely to give in to her child's demands for autonomy and, eventually, is less likely to effectively monitor her child, a critical factor in controlling delinquency (Patterson, 1982; Patterson et al., 1992).

The top-down and bottom-up causal influences between microsocial parent–child interactions and the first set of cascading constraints on development continue over time (the multiple arrows around loop D in Figure 6). Research from OSLC provides piecemeal support for many iterations of this causal loop. The more limited and coercive parent–child interactions become, the more likely it is that the aggressive child will continue to seek the company of his like-minded peers and become less invested in academic pursuits, and this will increase conflict in the home and so on. As coercive parent–child exchanges grow longer in duration and escalate in amplitude, physical assault becomes more probable (Snyder et al., 1994). Feeling rejected and angry, the preadolescent will begin to go out unsupervised, further increasing his exposure to deviant peers. These periods of unsupervised time outside the home will grow longer, and the parent and child will interact less and less (Patterson & Bank, 1989). They may no longer have even

brief episodes of pleasant interchanges, and discipline and monitoring likely disappear from the dyadic repertoire (Patterson et al., 1992). The result is the eventual stable coupling between poor behavior at home and deviant peer affiliations at school. In these later periods, the parent–child state space may become almost exclusively characterized by permissiveness and rejection. Patterson maintains that this early-onset trajectory characterizes two thirds of the hundreds of families he and his colleagues have seen at their clinic (Patterson et al., 1992).

*Bottom-up and top-down causal relations between real-time peer interactions and cascading constraints on development.* According to our DS model of antisocial development, in the same way that microsocial parent–child interactions are causally related to developmental factors such as academic failure, peer rejection, and the selection of deviant friends, these factors lead to, and are further constrained by, real-time antisocial interactions between deviant peers (paths E, F, and H in Figure 6; causal loop F in Figure 6). In our previous discussion about real-time peer interactions among deviant friends, we showed that deviant talk functions as an attractor for antisocial youth (Granic & Dishion, 2003). Figure 6 (E) represents these antisocial real-time peer interactions as one large attractor on a state space (one of very few available patterns). Although the actual identity of antisocial friends may often change, deviant discussions and experiences continue with new antisocial peers who replace old ones. Snyder and Stoolmiller (2002) summarize this process: "Youth seek peer relational and activity niches congruent with their own repertoires, and in so doing, establish and iteratively recreate experiences that amplify and diversify that repertoire" (p. 120).

As youth spend more time with their peers talking about deviant topics, they are more likely to continue to be rejected by prosocial peers, and their academic success will be further compromised, potentially maintaining recurrent depressive moods. In turn, lacking appropriate models and successful regulatory experiences, antisocial peers are less likely to develop prosocial emotion-regulation and problem-solving skills. Real-time antisocial peer processes may also have a profound effect on academic achievement. The more time youths spend engaged in mutually amplifying deviant talk, the less likely it will be that they will value academic achievements and spend time on academic pursuits.

At the 12- to 14-year age range, spending increasingly more time engaging in deviant interactions with antisocial peers will lead to the emergence of new forms of antisocial behavior, specifically covert forms such as stealing, lying, truancy, cheating, and using drugs and alcohol (Patterson, Dishion, & Yoerger, 2000; Patterson & Yoerger, 1997, 1999). Path G in Figure 6 summarizes the longitudinal data from the Oregon Youth Study sample that showed a path coefficient of .72 from deviant microsocial interactions among antisocial adolescents and later growth in covert behavior, another coordinated set of antisocial behavioral habits (Patterson & Yoerger, 2002). A number of additional studies provide evidence for the link between real-time deviant peer interactions and the emergence of covert antisocial behavior. Two studies have shown that the shift from engaging in primarily overt forms of antisocial behavior to covert forms is mediated by the extent to which youth engage in real-time deviant peer interactions (Patterson, Dishion, & Yoerger, 2000; Snyder, 1998). Also, a study using monthly telephone interviews with adolescents and parents showed that the best predictor of nonlinear monthly bursts in substance use was increased time spent with substance-using deviant peers (Dishion & Medici-Skaggs, 2000). The monthly covariation between substance use and deviant peer association was interpreted as being recursive. That is, substance use led to more associations with deviant peers, which, in turn, led to further substance use.

These findings point to an additional bottom-up and top-down causal relation between cascading constraints and microsocial processes. Represented as H in Figure 6, this loop is between real-time deviant peer interactions and later developmental outcomes, including school expulsion, unemployment, arrest and incarceration, and marital difficulties. As indicated in the previous section on real-time peer interactions, longitudinal evidence shows that the strength of the deviant talk attractor predicts developmental factors, including arrests, school expulsion, and drug abuse (Granic & Dishion, 2003; feedback loop H in Figure 6). Deviant talk among antisocial adolescents also predicts escalations in violence (Dishion et al., 1995) and problems in young adult adjustment, including sexual promiscuity and relationship problems (Patterson & Yoerger, 1999).

This last set of developmental factors (i.e., arrests, school expulsion, relationship difficulties) feed down through circular causal relations and constrain the types of real-time interactions in which youth will engage. Antisocial youth have limited contexts available to them at this point (i.e., jail, the streets); thus, they have few opportunities to develop new relationships with prosocial youth and adults. Further defining their trajectory, antisocial young men predictably choose antisocial women as partners, promoting ongoing problem behaviors (Moffitt, Robins, & Caspi, 2001). As the peer state space becomes more and more rigid and constrained, so too do the developmental options along the trajectory.

*Feedback relations between real-time family and peer interactions.* The final causal loop (I) in Figure 6 involves the reciprocal relationship between the two key real-time interaction processes that have been discussed: parent–child coercive interactions and deviant peer interactions. We have already touched on how these real-time interactions may be mutually influential. Unlike the causal loops brought up thus far, these processes occur at the same time scale and are reciprocally, rather than recursively, interactive. That is, a constrained, rigid parent–child state space primarily characterized by permissive and mutually hostile interactions will increase the likelihood that children will spend more time interacting with like-minded peers who rigidly focus on deviant interactions. More time with antisocial peers will mean that children will spend less time at home with parents and the time that they do spend will lead to more aversive, angry interactions, and so on.

*Adult criminality.* Finally, focusing only on the developmental factors linked by arrows at the top of Figure 6, our model ends with adult criminality. Boys on the child-onset trajectory are at a high risk of becoming chronic offenders (Farrington, Gallagher, Morley, St. Ledger, & West, 1986; Loeber, 1982; Moffitt, Caspi, Harrington, & Milne, 2002). Growth in new forms of covert antisocial behavior is strongly predictive of adult arrest (Patterson & Yoerger, 1999). In one study, the probability of adult arrest given a trajectory that begins with early forms of overt aggressive behavior followed by the emergence of covert antisocial behavior was .49 (Patterson & Yoerger, 1999). Similar strong findings documenting the developmental sequence of overt to covert forms of antisocial behavior have been shown in three longitudinal

studies reviewed by Kelley, Loeber, Keenan, and DeLamatre (1997). We interpret this progression from overt to covert forms of antisocial behavior as resulting from a systematic sequence of cascading constraints. It is also important to note that, although in general antisocial behavior shifts from mostly overt to covert forms, a small but significant proportion of youths continue to behave aggressively throughout their development (e.g., Patterson et al., 1992).

### *Late-Onset Antisocial Trajectory*

Using the same DS principles that we have discussed throughout this article, we move to modeling the late-onset antisocial trajectory. Our DS-based developmental theory needs to address two main phenomena that have been empirically documented. First, youth on this trajectory do not begin engaging in antisocial acts until they reach early adolescence, at which time delinquency and antisocial behavior emerge abruptly (Elliott, Ageton, Huizinga, Knowles, & Canter, 1983; Farrington, 1986; Moffitt, 1990; Patterson & Yoerger, 2002): What accounts for this discontinuous profile? Second, just as abruptly, most youth on the late-onset trajectory desist from engaging in antisocial acts after adolescence (Moffitt, 1993): What are the processes that account for the nonlinear decrease in antisocial behavior in young adulthood?

A good deal of evidence suggests that antisocial behavior is more common than not in adolescent boys. Studies have repeatedly shown that more than half of all adolescents engage in some form of antisocial behavior. For example, Farrington, Ohlin, and Wilson (1986) provided evidence that one third of adolescent boys have been arrested for a serious criminal offense and four fifths have had police contact for minor offenses. Epidemiological data with self-report measures also show that virtually all adolescents commit some crimes (Elliott et al., 1983). In her review of several self-report studies, Moffitt (1993) concludes that it is "statistically aberrant to refrain from crime during adolescence" (p. 686).

Although it may be considered normative to engage in some form of antisocial behavior, there are critical distinctions between youth who have exhibited this type of behavior throughout their childhood and persist through adolescence and those who only begin during early adolescence. In their review of more than a decade's worth of studies comparing early- and late-onset trajectories, Patterson and Yoerger (2002) argue that late-onset adolescents come from less coercive and more prosocial families. Although the families of late-onset boys engage in mild forms of coercive interactions, the parents are equally likely to reinforce prosocial solutions and to teach effective problem-solving strategies. According to our DS model, the specific content of these interactions is less important than the structure. *Thus, our sixth prediction is that the parent–adolescent state space of late-onset youths should look significantly more flexible (less rigid) than the state space of early-onset youths.*

A more flexible parent–child state space means that late-onset children are more likely to learn effective emotion-regulation skills and they will tend to be more adept at navigating the transition to day care or school. Moffitt (1993) similarly theorized that these adolescents' strengths depend on their ability to flexibly adapt to changes in their context; they sometimes "engage in antisocial behavior in situations where such responses seem profitable to them, but they are also able to abandon antisocial behavior when prosocial styles are more rewarding" (p. 686). Why do children who are relatively successful academically and with peers, who exhibit prosocial skills and come from relatively healthy families characterized by flexible parent–child interactions, begin to smoke, drink, and commit crimes?

*A DS approach to understanding normal adolescent development.* To understand the late onset of antisocial behavior and why it is almost normative, it is important to understand what the majority of youth are experiencing during this stage. For all youth, early adolescence is one of the most dramatic developmental transitions, second only to infancy in the magnitude and breadth of concomitant changes (e.g., Lerner & Villarruel, 1994; Petersen, 1988). For boys, a good deal of evidence points to the 13- to 14-year age range as the period during which most of the dramatic changes occur (Feldman & Elliott, 1990): the onset of puberty (Paikoff & Brooks-Gunn, 1991), the emergence of formal operational thinking (Inhelder & Piaget, 1959/1964; for reviews, see Graber & Petersen, 1991; Keating, 1990), massive restructuring of emotion centers in the brain (for a review, see Spear, 2000), and the transition from junior or middle school to high school (e.g., Eccles, Wigfield, Midgley, Reuman, MacIver, & Feldlaufer, 1993).

Intricately connected to the biological and psychosocial changes is the emergence of a compelling new goal: autonomy from parents (Collins, Laursen, Mortensen, Luebker, & Ferreira, 1997; Erikson, 1968). A number of scholars have theorized that family relationships during early adolescence go through a period of reorganization during which roles and responsibilities are renegotiated, the frequency of conflicts increases abruptly (Laursen, Coy, & Collins, 1998; Montemayor, 1983), and relationships become realigned to represent a more equal balance of power (Collins, 1992; Hartup, 1989; Steinberg, 1990). Our claim is that early adolescence constitutes a phase transition during which the goal for increased autonomy emerges and parent–child patterns reorganize. Antisocial behavior is an attractive means by which this goal may be met or partially met. *The seventh novel hypothesis based on our DS model suggests that the parent–child system in early adolescence demonstrates the properties of a phase transition: There is a temporary increase in variability in parent–child interaction, and this disequilibrium later settles into new, more predictable patterns.*

We recently completed a study that was aimed at testing the phase-transition hypothesis, we examined, through direct observations, changes in the variability of family interactions before, during, and after early adolescence (Granic, Hollenstein, et al., 2003). Longitudinal observational data were collected in five waves. One hundred forty-nine parents and boys were observed problem solving at 9 to 10 years of age and every 2 years thereafter until the boys were 17 to 18 years old. Based on these data, SSGs were constructed for all families across all waves. Figure 8 shows the characteristic pattern for the sample: Consistent with our hypothesis, the sequence of SSGs showed that behavior became more variable (i.e., occupied more cells and moved around the grid more frequently) at the third wave when the boys were in early adolescence (13–14 years of age). Before and after this period, dyadic behavior looked more stable and less flexible; fewer cells were occupied, and there were fewer changes between cells. Two parameters indexing the variability of the interactions were derived from these grids (number of transitions between cells and number

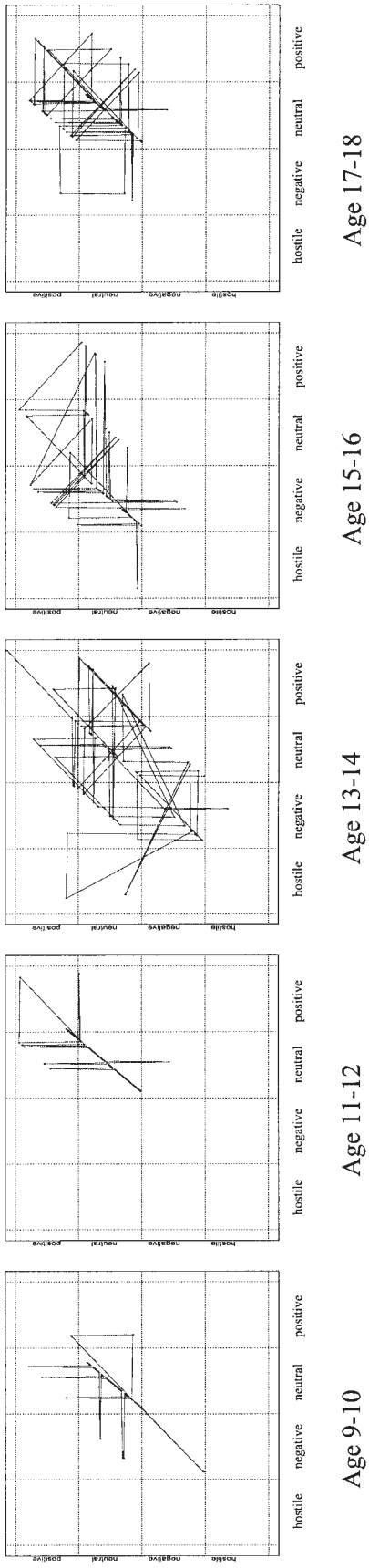


*Figure 8.* Sample state space grids for one family across five longitudinal waves (Granic, Hollenstein, 2003).

of unique cells occupied). Repeated measures ANOVAs on these variables revealed significant quadratic effects, $F(1, 148) = 52.18$, $p < .001$, and $F(1, 147) = 23.5$, $p < .001$. These results suggest that early adolescence is indeed characterized normatively by a reorganization of the parent–child system. During this period of flux, the parent–child system is highly sensitive to small environmental or internal perturbations, which may radically alter the developmental trajectory.

*Discontinuity of adolescent-onset antisocial behavior.* What are the implications of the phase-transition hypothesis for modeling adolescent-onset delinquency? The increase in degrees of freedom during the adolescent-phase transition may mean that minor incidents (e.g., the parent allows her adolescent to stay out all night with friends, an attractive girl offers a boy a joint) can result in a cascade toward a major change in the parent–adolescent system and a major shift in the adolescent's developmental pathway. It is this extreme sensitivity to perturbations that provides the foundation from which new antisocial behaviors can abruptly emerge, especially in highly charged interpersonal contexts. It may seem to the parent that overnight her son changed from an amiable, affectionate child to a secretive, nonconforming adolescent.

New behaviors, goals, and attitudes on the part of the youth will likely lead to resistance from the parent, triggering an increase in conflict episodes. Although generally normative, from our perspective, the development or strengthening of the parent–adolescent mutual hostility attractor (during conflict episodes) and the permissive attractor increases the risk of adolescents developing antisocial tendencies. It may be that, as the hostility attractor grows, so too does the permissive one, because over time the parent may try to avoid conflicts and begin to give in to the adolescent's demands. Thus, a well-worn path may be carved from the mutual hostility attractor to the permissive one. The emergence and stabilization of these two attractors may be critical factors that contribute to the emergence and maintenance of late-onset antisocial behavior.

Research on coercion theory has repeatedly pointed to the critical role of parents' ineffective monitoring in the development of antisocial behavior in adolescence (e.g., Patterson et al., 1992). During this period, parents need to incorporate new skills that allow them to maintain a positive relationship with their adolescents while also setting firm rules of conduct and ensuring they know who their child's peers are and where the child spends time outside the home. The novel interaction patterns that self-organize through this phase shift will depend partially on previously established structures. Monitoring skills emerge from earlier, positive parent–child interactions during which effective problem solving was encouraged, families maintained mutual regard and involvement, and low levels of coercion were present (Dishion et al., 1995).

Monitoring is so critical primarily because adolescents learn new antisocial behaviors from their peers. Peer acceptance becomes of paramount interest as children enter school, and these social concerns peak during adolescence. As a few teens begin experimenting with drugs, skipping school, drinking alcohol at parties, and shoplifting, their friends may begin mimicking them to feel more mature, gain peer acceptance, and participate in exciting new adult activities (Moffitt, 1993). There is clear evidence from numerous studies that exposure to delinquent peers, particularly during early adolescence, is directly related to the late onset of

adolescent delinquency (e.g., Caspi, Lynam, Moffitt, & Silva, 1993; Magnusson, 1988; Patterson et al., 1992; Reiss, 1986; Simmons & Blyth, 1987). Thus, another key reason for the nonlinear increase in adolescent-onset antisocial behavior seems to be the association with delinquent peers.

But why do delinquent peers suddenly become so attractive to otherwise prosocial adolescents? New peer patterns emerge during this phase transition in part because early adolescence ushers in a new set of socioemotional goals, including, foremost, autonomy from parents and identity development (Granic, Dishion, & Hollenstein, 2003). Moffitt (1993) suggests that delinquent peers are often regarded by other adolescents as having achieved these adolescent milestones; therefore, previously prosocial youth are more and more attracted to these peers. Here we should distinguish antisocial behavior that is overt and aggressive versus generally covert delinquent behaviors (e.g., drinking under age, experimenting with illegal drugs, early sexual activity). Adolescent-onset youths mainly engage in the latter type of antisocial behavior (Moffitt, 1993; Patterson et al., 1992) presumably because these acts mimic adult freedoms and privileges.

Emulating deviant peers who are perceived to have achieved adult status seems to us to be an important factor; however, it seems to tell only part of the story. A DS approach highlights the critical role that small perturbations and positive feedback mechanisms play in the emergence of novel antisocial behaviors. During phase transitions, positive feedback mechanisms can abruptly and unpredictably amplify small fluctuations in the system. This means that seemingly random events (e.g., when an adolescent is offered a beer by someone he has a crush on or when he is asked to skip school with an admired peer) can act as small perturbations to the previously stable prosocial adolescent. Recall, however, that perturbations during phase transitions simply have an increased potential to trigger a qualitative change. We propose that the best chance for these minor perturbations to trigger a developmental bifurcation is in highly emotional, interpersonal contexts. These peer contexts provide rich microcosms through which positive feedback mechanisms can amplify novel experiences: The adolescent acquiesces and takes the beer or agrees to skip school; as a result, he feels well-liked, admired, and accepted, and, in turn, peers are more likely to offer him alcohol or to invite him along the next time there is a plan to skip school. The previously prosocial youth becomes another adolescent on the late-onset trajectory.

*Contextual changes and adolescent-onset antisocial behavior.* In addition to small perturbations that arise and are amplified in highly charged peer environments, additional contextual perturbations need to be considered. Following Bronfenbrenner's framework (e.g., 1986, 1989) and consistent with developmental DS approaches in general, particular changes in the adolescent's ecology may put an adolescent at risk for developing antisocial problems. In particular, decreases in SES (e.g., from parental job loss; DeGarmo & Forgatch, 1999; Farrington et al., 1986; R. B. Freeman, 1983), marital conflict (e.g., Grych & Fincham, 1990), and parental divorce (e.g., Cherlin et al., 1991; Capaldi & Patterson, 1991; Forgatch et al., 1996; Hetherington, Cox, & Cox, 1979) may, alone or interactively, constitute significant perturbations that can lead to the development of externalizing behavior problems in adolescence. However, these contextual risks act as perturbations to the normal adolescent's trajectory only to the extent that they influence parent–adolescent interactions and cause disruptions in parental monitoring (Capaldi et al., 2002). Thus, the normal fluctuations that characterize early adolescence can become extreme; too much variability and flux in the parent–child system can have disorganizing effects from which it will be difficult to recover. Notice that our modeling here parallels our considerations of prespecified constraints, which were also hypothesized to lead to the development of antisocial behavior in early childhood through their influence on real-time family interactions.

Of course, divorce and other contextual disruptions occur earlier in childhood as well and can have an impact on children's development before they reach adolescence. However, according to developmental DS principles, perturbations to a developmental trajectory are most likely to alter trajectories during phase transitions. Because these periods are characterized by instability and flux, deviations in the system during this time have a better chance of influencing the subsequent course of development than during more stable periods (e.g., middle childhood). *Thus, the eighth prediction that results from our model is that a significant proportion of youth on the adolescent-onset antisocial trajectory have experienced at least one contextual perturbation during early adolescence.* To date, we are unaware of any studies that have directly tested this hypothesis.

*Discontinuity in the desistence of antisocial behavior.* Most youth who begin exhibiting antisocial behavior in adolescence abruptly stop doing so by early adulthood (Moffitt, 1993). The most likely mechanisms accounting for this discontinuous shift parallel those factors that accounted for the abrupt onset; that is, a rapid change in socioemotional goals and context. As adolescents mature, they inevitably gain autonomy from their parents, and most well-adjusted youth begin to perceive the negative potential consequences of antisocial behavior as untenable (Moffitt, 1993). New adult goals emerge, including attaining enough education to secure a desirable job, developing a career, earning money, finding a mate, and having children. Taking drugs every night, fighting in bars, and shoplifting no longer fit with these new priorities. Consistent with this formulation, research has demonstrated that most adolescents desist from antisocial behavior after they have married a prosocial spouse or secured full-time employment (e.g., Sampson & Laub, 1990).

Why do youth on the adolescent-onset trajectory desist from problem behavior, whereas youth on the child-onset trajectory do not? We suggest that the DS concept of flexibility is the core mechanism that differentiates the two trajectories. On the basis of their developmental history, youth on the adolescent-onset trajectory have a larger, more flexible behavioral, emotional and cognitive repertoire than child-onset youth (see our sixth prediction). This more flexible system allows youth to sensitively adjust to shifting contingencies and changing goals. For youth on the child-onset trajectory, cascading constraints have narrowed their degrees of freedom for a much longer period of time; these youth are more entrenched in antisocial tendencies and are less sensitive overall to contextual changes; thus, adult criminality becomes one of only a very few choices.

## Clinical Implications

Any developmental theory of antisocial behavior should stipulate some clear implications for intervention. Because DS principles explain change processes, and the study of psychopathology

often breaks down into the study of individual patterning, one of the most exciting potential applications of the DS framework may be in treatment research. Although randomized controlled trials have helped to identify the most effective interventions for antisocial children and youth (e.g., parent management training [PMT], Forgatch & DeGarmo, 2001; multisystemic therapy, Henggeler et al., 1998; Fast Track, Conduct Problems Prevention Research Group, 1999), there remains variability in outcomes and almost no understanding about the mechanisms of change (Kazdin, 2002).

For example, several comprehensive reviews (Dumas, 1989; Miller & Prinz, 1990; Nathan & Gorman, 2002; Southam-Gerow & Kendall, 1997) have concluded that PMT (Forgatch & Degarmo, 1999; Martinez & Forgatch, 2001) is one of the most effective treatments for aggressive youth. The intervention, based on coercion theory, directly targets coercive family interactions and attempts to change hostile and permissive parenting; when these parenting practices change, children become less antisocial (Forgatch & Degarmo, 1999; Martinez & Forgatch, 2001). Despite its success, there remains considerable variability in treatment outcome, and effect sizes are generally moderate (e.g., Brestan & Eyberg, 1998; Dumas, 1989; Kazdin, 2001). The same may be said for all evidence-based interventions for antisocial youth (Kazdin, 2002). This problem highlights our lack of understanding of the change process itself. Information about the mechanisms responsible for the success of interventions is critical for guiding clinicians in making informed decisions about how to tailor interventions to different contexts and for unique individuals and families. Also, identifying mechanisms of change is a crucial step toward more effective program dissemination in community settings (Kazdin, 2000).

DS principles and methods should be able to provide a microsocial, process-level account of how family and peer relationships change over the course of treatment and why some may fail to do so. In the following sections, we present three hypotheses based on our model, which can be generalized to any evidence-based intervention for antisocial youth. Strategies for testing these predictions are also discussed.

### *Phase Transitions Can Inform the Timing of Interventions*

Phase transitions in normative development may be critical to mark because they allow clinicians and researchers to more efficiently, and perhaps more successfully, access and manipulate mechanisms of change. There may be normative stage transitions in children's development during which, as a result of maturational processes, the coordination among system elements begins to break down, previous attractors are destabilized, and new patterns have the potential to emerge (e.g., Lewis et al., 1999). During phase transitions, the system is much more open to environmental shifts, and seemingly small changes have the potential to radically alter the trajectory of relationships and individuals. As a result, prevention and intervention efforts that target antisocial behavior and are aimed at strengthening family and peer relationships may have their maximal effect during these periods. In our DS model, we specifically identified early childhood (3–5 years) and early adolescence (about 11–14 years depending on the sex of the child) as two such potential transition periods. Phase transitions triggered by divorce or similarly major disruptions may likewise be windows of opportunity for effective intervention. *The ninth prediction based on our DS model is that clinical interventions and prevention efforts will be most effective if they are targeted at these sensitive periods. The same intervention targeted before or after a phase transition is hypothesized to be less successful.*

Results from a prevention program aimed at recently divorced mothers and their children provide some preliminary evidence for this hypothesis. Mothers were randomly assigned to PMT or a control group; mothers had been divorced between 3 months to 2 years. At the 30-month follow-up, children with mothers in the PMT group were significantly less aggressive than the comparison group (Forgatch & DeGarmo, 1999). However, there was, of course, some variability in the prevention effects. Supporting our phase-transition hypothesis, the less time that had transpired between the divorce and participation in the intervention, the more effective the program was in preventing children from developing problem behaviors. Thus, PMT seemed to be most effective for families in the midst of a phase transition (i.e., very recently divorced). It may be that the program was less effective for families that had been divorced for a longer period of time because new parent–child patterns that emerged during the divorce had already stabilized.

These prevention results are certainly encouraging and do indeed support the phase-transition hypothesis. However, the extent to which firmly entrenched, rigidly aggressive parent–child interactions can be perturbed, even during a normative period of destabilization, is still an open empirical question. To test this hypothesis rigorously, it would be important to design treatment studies that examined the differential impact of the same evidence-based intervention before, during, and after a recognized transition period.

### *Interventions Induce Phase Transitions*

Psychotherapy researchers suggest that, in order for improvements to be made, treatment must trigger a reorganization of affective, cognitive, and behavioral systems (e.g., Caspar, Rothenfluh, & Segal, 1992; Greenberg, Rice, & Elliott, 1996; Mahoney, 1991). To induce a major reorganization, "old patterns must be shaken loose or destabilized to allow for new configurations to emerge or to be discovered" (Hayes & Strauss, 1998, p. 940). Thus, "destabilization is viewed as a necessary and natural process that allows for growth and change" (Hayes & Strauss, 1998, p. 940). Although this destabilization period has been theoretically proposed, very few empirical studies have investigated this profile of change in therapeutic contexts partly because, until recently, we lacked the appropriate methodological tools for doing so (Cicchetti & Cohen, 1995). On the basis of the concept of a phase transition, we can operationalize a destabilization period as a sudden increase in the variability of a system. As discussed earlier, SSG analysis has already been used to identify a destabilization period over a normative developmental transition (i.e., early adolescence; Granic, Hollenstein, et al., 2003). This same procedure could be applied to examine changes in variability in parent–child interactions over the course of treatment.

Bertenthal (1999) emphasizes the importance of variability at phase transitions. He suggests that variability is not just an index of change but actually helps drive change. The theoretical implications for understanding intervention effects are compelling. Suc-

cessful interventions may induce a phase transition causing behavioral, cognitive, and emotional variability to increase, thus providing the fertile ground from which better regulated, or less distressing, patterns can be selected and repeated.

*Our tenth prediction based on DS principles proposes that treatment gains will be evident only after a phase transition, operationalized as a significant increase in the variability of behavioral patterns. Without evidence of a destabilization period, treatment is expected to be less successful.* This prediction can be tested by tracking parent and child behavior repeatedly over the course of intervention. Simple descriptive statistics (e.g., looking for an increase in standard deviations and variance in parent and child behaviors, and a breakdown of correlations) can be used. More formal DS techniques can also be applied. For example, parent–child interactions can be tracked weekly or biweekly with SSGs. Measures tapping the strength of particular attractors of interest could be computed (e.g., mutual hostility, permissiveness, mutual positivity). Evidence of rapid changes from week to week in these attractors would provide evidence of a phase transition. An increase in variability should precede improvements in children's antisocial behavior. Those families that fail to show evidence of this phase transition should be less likely to benefit from treatment.

### *Flexibility as an Outcome of Treatment*

According to our developmental DS model, rigidity in parent–child and peer interactions gives rise to a variety of cascading constraints that contribute to the emergence and maintenance of antisocial behavior. Moreover, children on the early- versus late-onset trajectory are expected to have more rigid interaction patterns. *Applying these premises to intervention processes, parent–child and peer interactions are predicted to become more flexible as a function of successful treatment. This is our final prediction.*

There are a variety of ways to operationalize and measure flexibility. Changes in peer interactions and sibling interactions, group behavior in the playground, and individual behavior in a variety of contexts can be examined in terms of increases in flexibility. For example, we could assess the problem-solving strategies that antisocial peers generate and measure whether these strategies increase in number and become more diverse over the course of treatment. Alternatively, parent–child interactions could be observed in a number of different contexts before and after treatment, and the breadth of the behavioral repertoire, as well as the ease with which dyads shifted from one state to another in response to changes in context, could be assessed. To a certain degree, the operationalization and measurement of flexibility will vary depending on the particular treatment being assessed.

## Conclusion

Our main goal in the current article was to lay the foundations for a comprehensive model of antisocial development through the use of DS principles. Given its strong theoretical and empirical foundations, coercion theory provided a springboard from which to begin our modeling exercise. A number of objectives were addressed. First, we allocated a good deal of discussion to real-time parent–child and peer processes because it is our (and others') contention that this is the raw material of development. Developmental variables are critical to measure and explain, but they are, to a certain degree, abstractions that psychologists use to summarize behavior at particular points in time. Individuals live in the here and now, and it is moment-to-moment interactions, repeated over many occasions, that "grow" developmental outcomes, including antisocial behavior. Coercion theory has, from its early roots, been primarily concerned with these proximal causes, and this is one of the main reasons why the DS framework was particularly potent for updating and extending the model. More specifically, we argued that the operant conditioning principles that were used to originally explain parent–child and peer processes remain relevant but could be more parsimoniously incorporated into the larger DS metatheoretical framework, which can offer a number of fresh insights and novel predictions. Second, a DS approach moved us toward a more explicit account of the interactive elements that underlie behavioral patterns; thus, our current model integrates psychobiological factors in infancy and emotional and cognitive processes in parent–child and peer relationships with previously well-established behavioral processes.

The third objective focused on applying DS principles to explain the feedback and reciprocal processes by which microsocial interactions were linked to cascading constraints in development. Our main contribution was to explicate the bottom-up, real-time processes that underpin well-established developmental outcomes along antisocial trajectories and, in turn, the top-down causal processes by which these factors continue to iteratively determine real-time interactions among families and peers. Fourth, we applied DS modeling to explain both change and stability in early- and late-onset antisocial trajectories. The principles of cascading constraints, flexibility in parent–child and peer interactions, and phase transitions were used to characterize and distinguish youth on the two trajectories. Finally, we discussed a number of predictions for interventions, focusing on identifying change processes associated with successful outcomes. Throughout the article, we have proposed novel hypotheses based on our DS model. For some of these hypotheses, we reviewed studies that have provided some preliminary support for our claims.

It is clear to us that many models in developmental psychopathology, including those focused on antisocial development, have begun to point to the importance of context, feedback processes, and microsocial and macrodevelopmental processes. Our DS model builds on a great deal of this work. In systems-based models, causation is understood differently: Instead of linear relations, we are more concerned with complex interactive elements and recursive reciprocal and circular causality. Several other writers in the field of antisocial behavior have suggested the importance of nonlinear dynamic processes (e.g., Deater-Deckard & Dodge, 1997; Dodge & Pettit, 2003; Snyder et al., 2003); however, these insights are often left untested, and they are not integrated into larger, more comprehensive theoretical models.

Of course, the current DS framework remains incomplete, in part because there are a number of speculations built into the model that require empirical support but also because it was impossible to include all the relevant studies and theoretical perspectives that have been presented in the literature. It is important to note some specific limitations in our current model. We did not discuss the role of fathers in the development of antisocial behavior, and siblings were only touched on in a cursory fashion. Certainly our model would be enhanced if these additional socialization agents were included. Also, there are many exciting new

findings emerging from the field of affective neuroscience. Much of this research takes as a given the self-organizing nature of emotion and cognition (e.g., W. Freeman, 1995; Lewis, 2005). Ensuring that our psychological model of emotion-appraisal feedback processes in parent–child interactions is commensurate with neuroscientific evidence will be an important step in our future modeling efforts. In fact, we suspect that the feedback processes that have been so difficult to operationalize in our psychological model may be more easily concretized in neural terms. Another gap in our DS model is our lack of attention to issues of comorbidity. Although we discuss how depression may develop with antisocial tendencies, we offer little discussion about where the development of concurrent attention-deficit/hyperactivity disorder or anxiety symptoms might fit. Finally, except for the brief explanation of environmental prespecified constraints, we have not discussed the effects of neighborhoods; this is an important future direction for extending our model.

Our goal, however, was not to be exhaustive. Instead, we hoped to provide a scaffold that will prompt other investigators to use DS principles to elaborate their own models of antisocial development, whether they are based on behavioral, emotional, cognitive, neural, or psychophysiological mechanisms. We know of no other scientific set of principles that can bridge these diverse domains. By using the same metatheoretical language, we may come closer to realizing the goal of an eventual convergence among our models.

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