CHAPTER 4

A Dynamical Systems Approach to Conceptualizing and Studying Stability and Change in Attachment Security

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In his 1973 volume, *Separation,* Bowlby analyzed the concept of developmental pathways by exploring the metaphor of a complex railway system. Bowlby asked his readers to consider a railway track that begins in a large metropolitan center. If a traveler were to begin his or her journey by selecting the main route, the traveler would eventually reach a point at which the railroad branches into a number of distinct tracks. Some of these tracks will lead to distant, unfamiliar lands; other tracks, although deviating from the main route, will run more or less parallel to it. As the traveler's journey progresses, he or she will be faced with new choices at each juncture. The choices that traveler makes will have important implications for his or her destination, making some locations more accessible and placing others further out of reach.

Bowlby believed that the railway metaphor was an apt one for characterizing personality development. Early in life, for example, there are a multitude of pathways along which people may develop and a variety of destinations at which they may arrive (see Sroufe & Jacobvitz, 1989). Some of these "destinations" may involve well-functioning relationships with family, peers, and partners, whereas others may not. As people navigate alternative pathways, they generate a certain degree of momentum, making their life trajectories more entrenched and increasingly difficult to transform. In Bowlby's view, one of the key goals of developmental science is to map the pathways by which people develop and, importantly, uncover the processes that either keep people on a specific developmental course or allow them to deviate from routes previously traveled.

Although developmental psychologists have made substantial progress toward documenting the life events that may lead a person to follow one route as opposed to another, they have yet to elucidate the dynamic processes that allow these life events to shape personality development. Our objective in this chapter is to take a novel step in this direction by exploring Bowlby's ideas on development, stability, and change from a dynamical systems perspective (see Smith & Thelen, 1993; van Geert, 1994). Briefly stated, a *dynamical systems approach* to development emphasizes the ways in which a system of coordinated variables evolves over time. One of the themes of this approach is that interesting properties of behavior can emerge from processes that are not explicitly represented in the system's "rules" per se. For example, the global schematic properties of memory systems appear to emerge from the local interactions among interconnected neurons, none of which is designed to behave in a schematic manner (Rumelhart, McClelland, & the PDP Research Group, 1986). Understanding the rules that underlie the global and emergent properties of such systems is one of the major objectives of a dynamical approach.

By adopting a dynamical systems perspective, we hope to answer some unresolved questions in contemporary attachment theory and research. The first is, What are the dynamic mechanisms that contribute to both stability and change in attachment organization? We focus less on the *specific kinds of events* (e.g., divorce) that may lead to change in security and emphasize instead the more *general processes* that allow such events to sustain and contribute to personality dynamics. In doing so, we hope to provide a general framework within which future researchers can conceptualize the ways that specific life events influence the dynamics of attachment. The second question we address is, What are the implications of these dynamic mechanisms for how we understand the stability of attachment patterns over time? The issue of how much stability exists in attachment patterns is a hotly debated one in contemporary research (e.g., Lewis, Feiring, & Rosenthal, 2000; Waters, Merrick, Treboux, Crowell, & Albersheim, 2000). One of the arguments that we make in this chapter is that, when Bowlby's ideas about stability and change are formalized, they do not necessarily lead to the prediction that attachment patterns will be highly stable across different developmental periods. Although Bowlby's ideas have some fascinating implications for how we should conceptualize stability, these implications are much more complex and nuanced than has been previously assumed.

We begin this chapter by reviewing Bowlby's ideas on development, stability, and change. As we discuss, many of Bowlby's thoughts were shaped by the writings of C. H. Waddington, a developmental embryologist whose work has had an enormous impact on developmental science and the study of biological systems. We review Waddington's ideas in some depth and summarize the relationship between his ideas and Bowlby's thinking on continuity, change, and personality development. Next, we use simulation techniques and mathematical analysis—the common methodological tools of dynamical systems approaches—to model the theoretical mechanisms that Bowlby discussed. As we illustrate, the forms of stability that emerge from the formalization of these mechanisms have important implications for the way attachment researchers should conceptualize and measure attachment stability across the life course. Finally, we review empirical data on stability and change and discuss the implications of those data for Bowlby's ideas about the role of early experiences in shaping adult relationships. It is our hope that this chapter will help clarify attachment theory's predictions about the degree of stability that should (and should not) be observed over the life course, as well as highlight some innovative avenues for research that may lead to advances in our understanding of attachment and human development.

THE CONCEPTS OF DEVELOPMENTAL PATHWAYS AND CANALIZATION

Bowlby's railway metaphor was inspired by C. H. Waddington's (1957) discussion of the cybernetics of cell development. Because Waddington's ideas had a profound influence on Bowlby, as well as on other developmentalists, we explore them in some depth in this chapter. Waddington, an esteemed developmental embryologist writing in the middle of the 20th century, was trying to understand how a cell may maintain a specific developmental trajectory in the face of external disturbances. Waddington and others had observed that, once a cell begins to assume specific functions (e.g., it becomes integrated into a structure that will become part of the visual system), weak experimental interventions are unlikely to alter the cell's developmental trajectory. Although a cell has the potential to assume many different fates early in its development, once a developmental trajectory becomes established, Waddington argued that the trajectory becomes *canalized* or buffered to some degree, making it less and less likely that the cell will deviate from that developmental course.

To illustrate these dynamics more concretely, Waddington compared them to the behavior of a marble rolling down a hill (see Figure 4.1). In Waddington's well-known analogy, the marble represents a cell, and the various troughs at the end of the landscape represent alternative developmental functions or "fates" that the cell can assume. Waddington considered the specific shape of the landscape to be controlled by the complex interactions among genes, hence leading Waddington to refer to it as the *epigenetic landscape.*

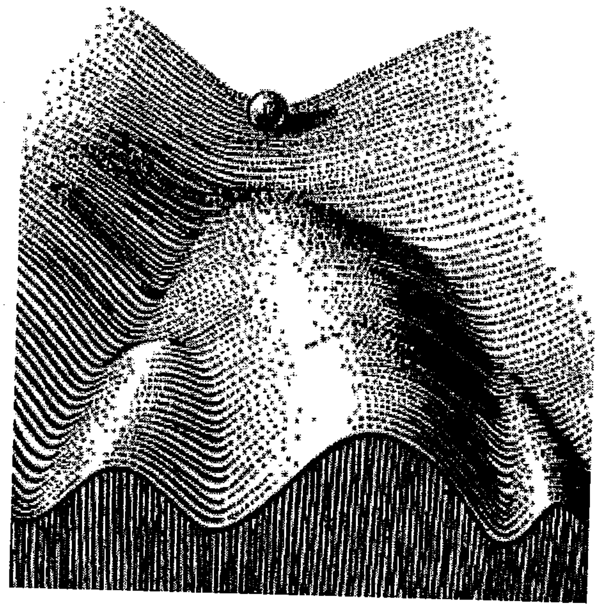

FIGURE 4.1. Waddington's (1957, p. 29) epigenetic landscape.

After the marble begins its descent, it settles into one of several pathways defined by the valley floors of the epigenetic landscape. A slight push may force the marble away from its course, but the marble will eventually reestablish its trajectory. As the marble continues along the basin of a specific valley, it becomes increasingly unlikely that external forces will cause it to jump from one valley to the next. Certain features of the marble, such as its smoothness and momentum, help to keep the marble moving along the previously established path. Features intrinsic to the landscape itself also help to maintain the marble on its original pathway. The steepness and curvature of the hills, for example, serve to cradle the marble and buffer it from external forces.

Waddington (1957) considered the tendency for the marble to maintain its initial course in the face of external pressures to be an analogue to a fundamental self-regulatory process in cell development, one he called *homeorhesis.* Homeorhesis refers to the tendency of a system to maintain a specific developmental trajectory—or a course toward a specific developmental outcome—despite external perturbations. Although many biologists had discussed a similar concept, *homeostasis,* Waddington considered homeostasis to be an inadequate concept for understanding certain features of development. In Waddington's view, the concept of homeostasis placed too much emphasis on the steady state being regulated by the system. For example, in the physiological regulation of body temperature, there may be a tendency for the nervous system to activate or terminate certain physiological processes that function to minimize the discrepancy between a "desired" temperature and the current body temperature. Although Waddington recognized that the dynamic quality of homeostatic processes was critical to understanding certain features of physiological functioning, Waddington argued that self-organizing developmental processes function to maintain a *pathway* or *trajectory* toward a specific *end state* rather than a steady state per se: "We are not dealing with the maintenance of a steady state but with the attainment of some particular end-state in spite of temporary deviations on the way there" (Waddington, 1957, p. 42).

Waddington (1957) argued that the specific pathways available to the cell early in development are determined by the way the genes interact to initiate and control biochemical reactions. Moreover, as symbolized in Figure 4.1, he believed that these reactions operate in a manner that leads the valleys of the epigenetic landscape to become more entrenched over time. Thus, once a cell settles into one of several available pathways, it becomes increasingly likely to follow that specific pathway.

The notion that the cell's development might be buffered or canalized to some extent was a critical aspect of Waddington's (1957) analogy. Waddington, however, also recognized that different kinds of physiological systems may require a stronger degree of canalization than others. For some systems, external influences are critical for organizing the system in a way that will allow it to function appropriately. For example, cortical cells in the visual system may not develop appropriately without specific forms of feedback from the external world (O'Leary, Schlaggar, & Tuttle, 1994). Other systems, however, develop in a fairly specific way despite external perturbations (Geary & Huffman, 2002; Rakic, 1988).

Homeorhetic Mechanisms in Personality Development

The concept of "degree of canalization" was highly influential in Bowlby's thinking, and he often wrote of "environmentally labile" traits to refer to properties that were less subject to canalization. For example, Bowlby (1969/1982) argued that the development of the attachment behavioral system was highly canalized, in the sense that the rudimentary set of control mechanisms and behavior programs needed to allow a child to regulate his or her proximity to a caregiver effectively would emerge despite a diverse range of environmental experiences. Bowlby believed, however, that the *specific way* a child comes to regulate his or her attachment behavior is highly influenced by interpersonal experiences and that, for the system to function appropriately in a specific caregiving environment, it needs to be calibrated, more or less, to that environment. Bowlby believed that early experiences within the family—especially those concerned with separation or threats of loss—were particularly influential in shaping the way the attachment system would become organized for an individual. According to his railway metaphor, early experiences in the family help to determine which of many possible routes the individual may travel.[1]

In the context of personality development, Bowlby believed that once an initial pathway has been established, a number of homeorhetic processes keep an individual on that pathway. Bowlby separated these homeorhetic processes into two broad kinds. The first is concerned with the *caregiving environment* itself. To the extent to which the individual's environment is stable, he or she is unlikely to experience interactions that challenge his or her representations of the world. The powerful nature of this variable was emphasized by Bowlby's (1973) observation that a child is typically born into a family in which he or she has the same parents, same community, and the same broad ecology for long periods of time. It is during periods of transition (e.g., parental divorce, relocating to a new town, tragedy, or good fortune), Bowlby believed, that an individual is most likely to be forced off of one developmental track and onto another.

Bowlby (1973) also discussed *intraindividual* or *psychodynamic* homeorhetic processes that may promote continuity. Bowlby noted that people often select their environments in ways that maximize the overlap between the psychological qualities of the situation and the expectations and preferences that the individual holds. Moreover, the mind, Bowlby argued, operates in a way that is likely to assimilate new information into existing schemas (see Collins & Read, 1994, for an excellent discussion of this point in the context of theory and research on social cognition). Consistent with these ideas, empirical research has shown that people's working models influence the kinds of reactions they elicit from others (Arend, Gove, & Sroufe, 1979; Troy & Sroufe, 1987; Waters, Wippman, & Sroufe, 1979) and the kinds of inferences they make about people's intentions during experimental contexts (Brumbaugh & Fraley, 2004; Collins, 1996; Pierce, Sarason, & Sarason, 1992; Pietromonaco & Carnelley, 1994). Such dynamics allow working models to shape the kinds of interactions the person experiences and, in concert, help to maintain the individual on the pathway that is already being traveled. To the extent to which the individual diverges from that pathway, it would seem unlikely that he or she would wander far.

MODELING THE DYNAMICS OF STABILITY AND CHANGE

One of the challenges of trying to understand psychological development is the recursive, iterative nature of the dynamics involved. Bowlby, for example, believed that a child's working models are constructed on the basis of the early experiences he or she has in the family environment but that the nature of those experiences is based, in part, on the working models that the child holds. In this view, the child's beliefs and the social environment in which he or she is situated have reciprocal influences on one another. Although it is possible to speculate on the implications of such dynamics for the way attachment representations evolve over time, the feedback mechanisms entailed by such a process may produce patterns that are difficult to anticipate on the basis of intuition alone (see van Geert, 1997, for an excellent discussion on the nature of recursion and theoretical modeling). In order to understand better the precise implications of such processes, we formalize Bowlby's ideas using dynamic modeling techniques and explore those models via computer simulation and mathematics.

Simulation of the Dynamics of Waddington's Epigenetic Landscape

We begin with a computational simulation of Waddington's epigenetic landscape because it provides the theoretical foundation for Bowlby's ideas on stability and change. As discussed previously, Waddington's analogy is often used to illustrate the ways in which homeorhetic processes can keep an individual on a specific developmental course despite the existence of perturbations. Unfortunately, the role of external influences on the behavior of the marble is often overlooked when considering Waddington's analogy. If we were to give the marble a strong push toward an alternative pathway, the marble would clearly jump over the valley wall and assume a new fate. When Waddington's analogy is invoked, however, it is often assumed that external factors rarely come into play and that, when they do, the forces they exert are weak or inconsequential. Although external factors may, in reality, be weak, it is necessary to recognize that, because the marble *can* be pushed into a new valley with an appropriate amount of force, the model may not *ensure* stability.

Why does this matter? Bowlby clearly believed that there was a strong tendency for working models, once constructed, to maintain an individual on a specific developmental trajectory. At the same time, however, Bowlby (1969/1982, 1973, 1980) emphasized that working models need to be open to change in order to be adaptive. In fact, according to many perspectives on psychopathology, the persistence of previously established beliefs and expectations in light of evidence to the contrary is a sign of poor psychological adjustment (e.g., Horowitz, 1991). The fact that the theory allows for people to change implies that, even if we postulate the existence of homeorhetic mechanisms, Bowlby's basic model, like Waddington's, does not ensure stability. If this is the case, the predictions that psychologists often derive from attachment theory regarding the long-term stability of attachment patterns may be oversimplified.

Whether this is the case or not, of course, needs to be demonstrated in a formal manner. In the following set of investigations, we explore a computer simulation of Waddington's epigenetic landscape to obtain a better understanding of the implications of this analogy for the way personality ebbs and flows over time. Our first step was to simulate an epigenetic landscape. We generated a landscape that was similar to the one illustrated by Waddington in several important respects. As can be seen in Figure 4.2, the simulated surface is placed on an incline, thereby compelling the marble to move downward in the direction depicted by the arrow. Moreover, the various valleys become deeper (i.e., the pathways become more canalized) as the marble moves from one end of the surface to the other.

Next, we programmed some physical rules to govern the behavior of the marble. Specifically, the simulation was constructed so that the marble's direction of travel at any one point in time was a function of three factors: (1) the slope of the local (i.e., immediately surrounding) landscape, (2) the direction of the marble's current motion and its momentum, and (3) the relative magnitude of those two forces (i.e., the slope of the landscape with respect to the momentum of the marble).

To see how the simulation works, consider Figure 4.2. If we place a simulated marble in the upper left side of the surface, the marble descends into the first or left-most valley and settles into a trajectory defined by that valley floor (see the left-hand panel of Figure 4.2). When we place the marble in other locations, the marble settles into other pathways (see the right-hand panel of Figure 4.2).

What are the implications of the basic "rules" of this dynamic system for understanding global or emergent patterns of continuity and change? To systematically explore this issue, we simulated numerous trials in which we dropped a marble on the surface and traced its pathway over time. We conceptualized the different tiles, moving from left to right in Figure 4.2,

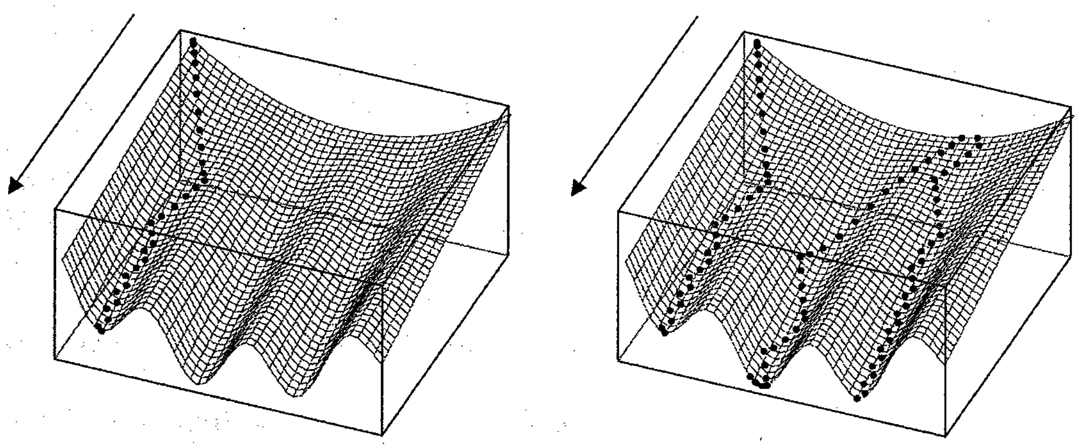

FIGURE 4.2. The canalization of developmental trajectories within Waddington's epigenetic landscape. The arrow depicts the flow of time.

as representing graded variation in a trait, such that marbles placed toward the left side of the surface exhibit less of the trait and marbles at the right side of the surface are better defined by the trait. By conceptualizing the surface in this manner, we could quantify the stability of the trait by computing the correlation between starting positions and ending positions for a population of marbles. The analogy to personality development should be clear: If we conceptualize the trait or property as being attachment security, the marble's trajectory over time represents the individual's developmental pathway with respect to attachment, and the correlation between the marble's position at Time 1 and the last time point represents the degree of stability in security from infancy to adulthood.[2]

In this example, the correlation between the starting positions and ending positions of the marbles is very high ($r > .90$). It is less than 1.00 because the shape of the landscape ensures that there are fewer viable ending positions than there are starting positions. In fact, this feature of the landscape creates a situation in which knowing the *precise* starting point of a marble (as opposed to the *general* vicinity of the marble's starting point) does not help us predict its fate. Because marbles that begin anywhere between the first and third tile all end up at the same point (the end of the first valley), information about the exact starting position is inconsequential. If we were to quantify the starting position with respect to the *bifurcations* imposed by the surface (i.e., if we were to classify an individual's starting position with respect to the developmental pathways afforded by the system rather than exact position), we would have perfect knowledge (i.e., $r = 1.00$) of the marble's end state simply by knowing its beginning state.

The fact that the surface has this *channeling effect* on the marble's pathway leads to an interesting pattern in the test–retest correlations. We have illustrated these patterns in Figure 4.3 through the use of *stability functions.* Stability functions provide an efficient way to portray graphically the information contained in a test–retest correlation matrix for a trait assessed over multiple points in time (see Fraley, 2002; Fraley & Roberts, in press). A Time k stability function characterizes the degree of stability observed between Time k and all points in time. For example, a Time 1 stability function describes the stability between Time 1 and Time 1, Time 1 and Time 2, Time 1 and Time 3, and so on. Similarly, a Time 25 stability function describes the stability between Time 25 and all time points (i.e., Time 1 through Time 50). Figure 4.3 illustrates the Time 1, Time 25, and Time 50 stability functions for the simulation described previously.

There are a couple of noteworthy features of these functions. First, the Time 1 stability function initially decreases rapidly but then levels off at a very high value ($r \cong .94$). This occurs because, once the marbles settle into their pathways, their position on the left-to-right axis does not

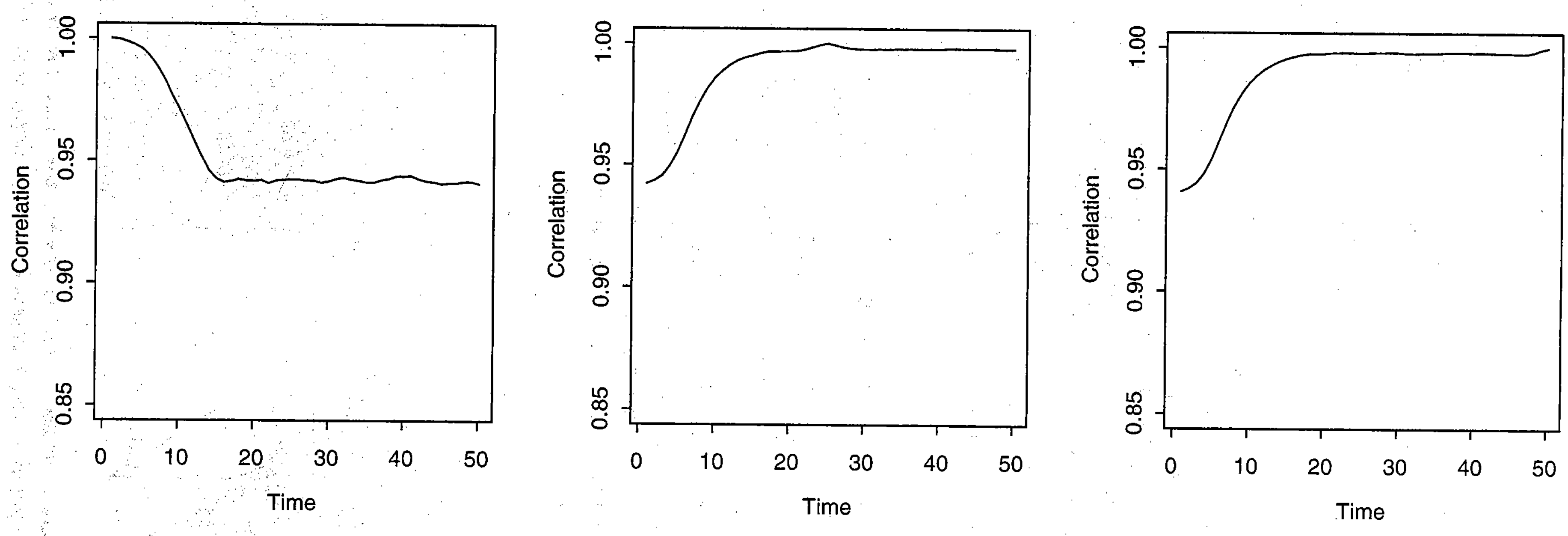

FIGURE 4.3. The effects of canalization on the test–retest correlations expected at different points in time. The left-hand panel illustrates the Time 1 stability function; the middle panel illustrates the Time 25 stability function; the right-hand panel illustrates the Time 50 stability function.

change. As a consequence, given knowledge of a marble's position at Time 1, it is possible to predict the position of a marble at Time 50 with the same degree of accuracy as at Time 25—despite the fact that the time span differs considerably. Another feature of the curves worth noting is the asymmetry involved in predicting a marble's position forward in time versus backward in time. At Time 25, for example, it is easier to predict where the marble will be at Time 50 ($r \cong .99$) than it is to infer where the marble was at Time 1 ($r \cong .94$; see the middle panel of Figure 4.3). Although both time points are exactly 25 units of time away from Time 25, the degree of predictability is not equivalent.

We elaborate on these findings in more detail in subsequent sections. For now, however, it should be noted that these distinctive *patterns* (but not necessarily the precise quantitative *values*) of stability should be observed in empirical research on attachment if, in fact, the abstracted dynamics of Waddington's system apply to personality development.

Up to this point, we have simulated the behavior of marbles on the epigenetic landscape in the absence of external influences. What happens when we introduce a disturbance to the system? As a single-trial illustration, consider the left-hand panel of Figure 4.4. This figure illustrates the trajectory of a marble that begins near the upper right side of the landscape. About halfway through its journey, the marble is suddenly pushed up the valley wall. Nonetheless, the force is not powerful enough to cause the marble to reach the cusp of the wall, so the homeorhetic properties of the system guide the marble toward its original trajectory. The right-hand panel, in contrast, illustrates a case in which the external force was strong enough to force the marble over the hill and into a new valley. Once crossing the cusp, the marble establishes a new trajectory rather than return-

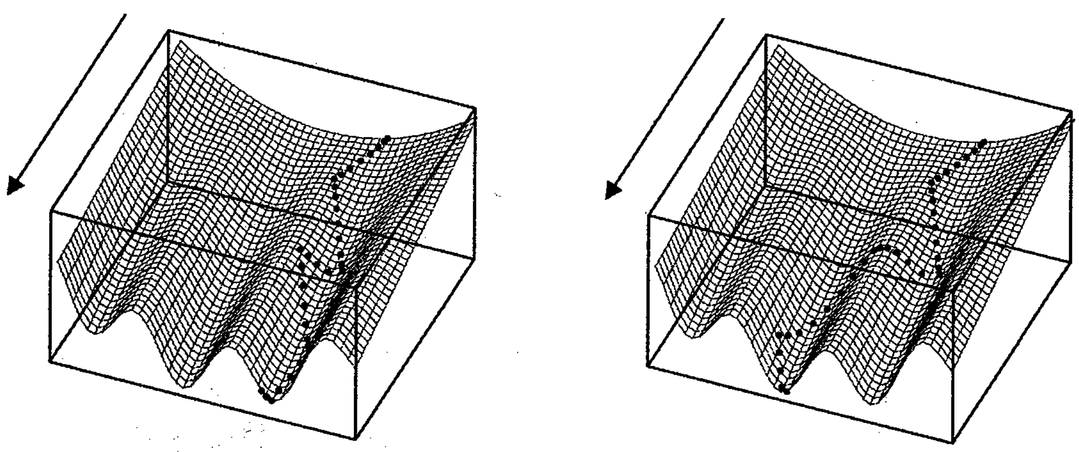

FIGURE 4.4. The effects of external influences on the trajectory of the marble across Waddington's epigenetic landscape. The arrow depicts the flow of time.

ing to its previous one. In Waddington's terms, the marble has established a new end state and, hence, a new developmental trajectory.

It should be clear from this simple illustration that whether homeorhetic processes allow for long-term stability will depend on how many times the marble is pushed around and with what degree of force it is pushed. If the marble is only gently nudged, homeorhetic forces will overcome the disturbance and return the marble to its original pathway. If, however, the marble is subject to the "slings and arrows of outrageous fortune," it may be impossible to determine the marble's fate in the long run.

To explore the impact of external perturbations more systematically, we conducted a simulation similar to the previous one, but this time we included external disturbances. To introduce disturbances to the system, we allowed the marble to be pushed in a random direction with variable force at varying points in time. We did, however, impose certain constraints on the nature of these disturbances. For example, we did not allow the marble to be pushed backward, and we never allowed the marble to be pushed off the epigenetic surface.

In Figure 4.5, we have plotted the Time 1, Time 25, and Time 50 stability functions resulting from a simulation in which the force of the perturbations was fairly strong. As can be seen from the Time 1 stability function, it is easy to determine where a marble will be at Time 2 from the simple knowledge of where it was at Time 1. However, *the further away in time we move from Time 1, the harder it is to predict a marble's fate.* In fact, in this simulation, our ability to predict a marble's final position is no better than chance; the limiting value of the correlation as time increases is 0.00.

It is noteworthy that, in comparison with the Time 25 stability function we observed in the previous simulation, the Time 25 stability function resulting from this simulation is much more symmetric. In this case, we can predict a marble's position from Time 25 with virtually the same degree of accuracy (or inaccuracy) regardless of whether we are looking forward in time (e.g., Time 30) or backward in time (e.g., Time 20).

We have deliberately presented two extreme situations (i.e., one in which there are no disturbances and one in which there are powerful disturbances) as a way of anchoring the range of dynamics exhibited by Waddington's system. As one might deduce, the patterning of the stability functions migrates between the two extremes previously illustrated, as we gradually manipulate the degree of disturbance (see Figure 4.6 for some example stability functions).

Implications of Waddington's Epigenetic Landscape Analogy for Personality Development

We believe that there are two important conclusions to be drawn from these simulations. First, the abstract processes described by Waddington

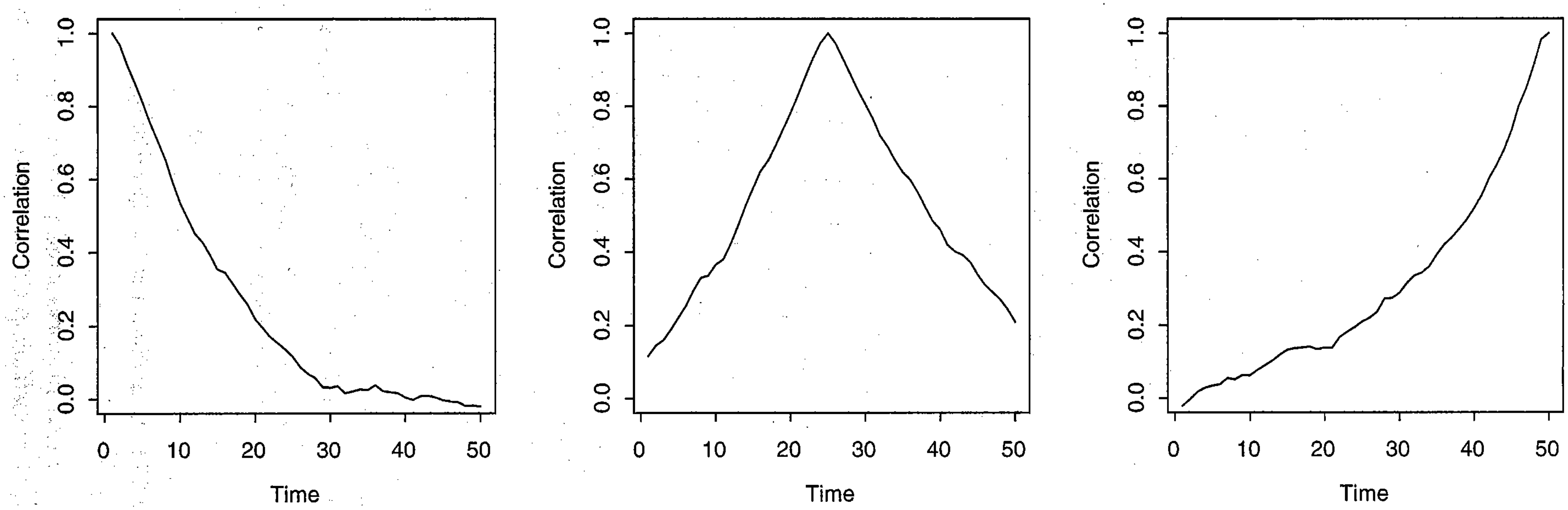

FIGURE 4.5. The effects of large external influences on the stability functions expected in Waddington's analogy. The left-hand panel illustrates the Time 1 stability function; the middle panel illustrates the Time 25 stability function; the right-hand panel illustrates the Time 50 stability function.

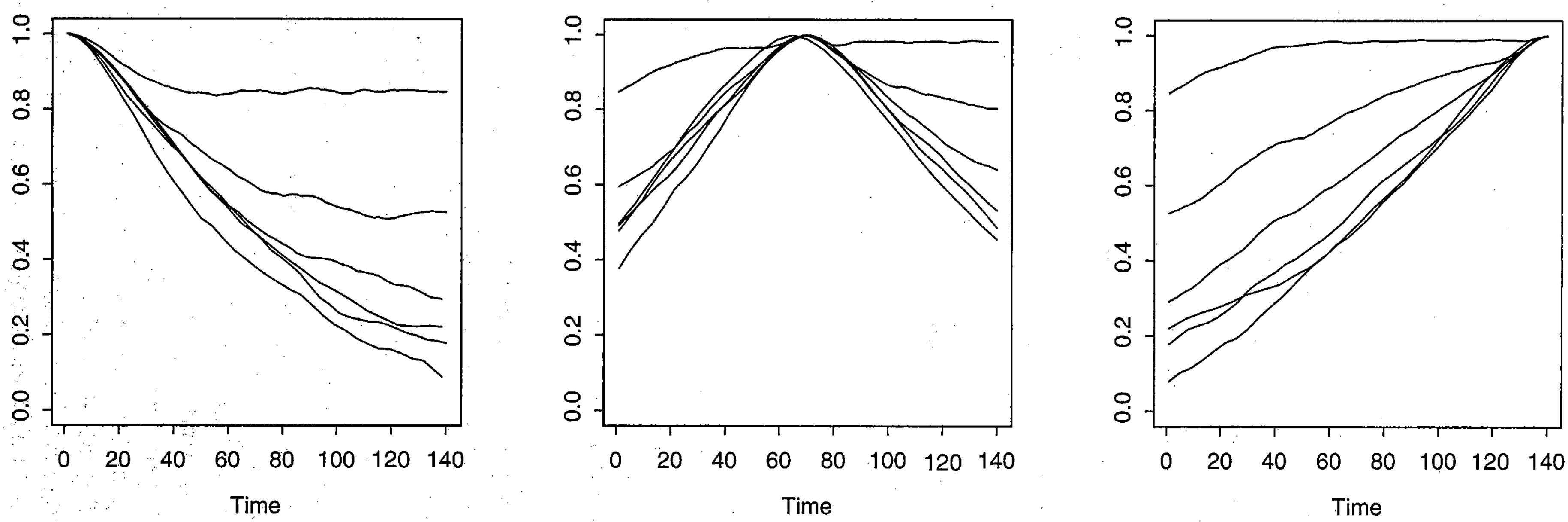

FIGURE 4.6. The effects of external influences of varying magnitude on the stability functions expected in Waddington's analogy. The left-hand panel illustrates the Time 1 stability function; the middle panel illustrates the Time 70 stability function; the right-hand panel illustrates the Time 140 stability function.

have concrete implications for the *pattern* of test–retest correlations that should be observed over time. This discovery is crucial because, if we did not have a way to translate the outcomes of Waddington's dynamics into a form that can be used to quantify stability in a variety of biological systems, the analogy loses its power as a theoretical tool. The fact that we can simulate the system and study the test–retest correlations observed in different conditions allows us to better understand the implications of the analogy for conceptualizing stability and change. Most important, it provides us with a means for determining the extent to which these dynamics manifest themselves in personality development. That is, by comparing empirical data on attachment against the patterns predicted by Waddington's model, we can begin to discern the extent to which homeorhetic processes underlie personality development. We return to this point later in the chapter.

The second key point to take away from these simulations is that, if we are to use the dynamics entailed by Waddington's analogy as a metaphor for those that underlie personality development, we must recognize that, *although these dynamics can give rise to stability, they do not ensure stability.* If we assume that the influence of external forces on the system is nontrivial, then the degree of stability predicted by the system in the long run will be zero. Of course, homeorhetic processes help to maintain the marble's pathway in the face of external influences, but they cannot do so if the force of the external influence is greater than the resistance provided by these processes. Once this theoretical threshold has been crossed, understanding the fate of the marble is more a matter of understanding the history of external influences that the marble has faced rather than of understanding the nature of homeorhetic processes per se.

MODELING HOMEORHETIC PROCESSES IN PERSONALITY DEVELOPMENT

Thus far we have seen that Waddington's analogy—an analogy that has had a critical influence on the way Bowlby and others have conceptualized personality development—is much more complex in its implications than is generally recognized. In the absence of strong external forces, the analogy implies a high degree of stability in a marble's position over time. In the context of strong disturbances, however, the analogy implies not only that the degree of stability will be weaker but also that it will approach zero asymptotically over time. In short, Waddington's dynamics, although capable of providing an explanation for stability, do not necessarily predict a *high* degree of stability.

The next challenge is to take Bowlby's ideas about the specific processes giving rise to stability and change in attachment organization, formalize them, and determine whether they make the same predictions about continuity made by Waddington's analogy. We focus on two key questions: (1) What are the abstracted dynamic mechanisms that contribute to both stability and change in attachment organization? and (2) What are the implications of these dynamic mechanisms for how we understand the stability of attachment patterns over time?

The Mechanisms of Stability and Change in Attachment

Bowlby (1973) discussed three classes of homeorhetic mechanisms: (1) person–environment transactions, (2) the diminishing sensitivity over time of working models to environmental influences, and (3) the establishment of stable representations of attachment experiences (i.e., *prototypes*) early in life—representations that serve as a foundation for subsequent experiences. After briefly discussing each of these mechanisms of stability, we develop a mathematical model for each one and investigate the implications of those theoretical models for the patterns of stability and change that should be observed over time.

Transactional Processes

According to Bowlby, one reason that attachment patterns may be relatively stable over time is that there are reciprocal influences between the representational models constructed by an individual and the quality of his or her caregiving environment. Although working models are constructed on the basis of social experiences, those models eventually come to influence the quality of the social interactions the child has. This general theme—that people and their environments mutually constrain one another—is common to many contemporary perspectives on personality development (for reviews, see Caspi & Roberts, 1999; Fraley & Roberts, in press). The fact that the social environment is constrained by the working models that the individual holds suggests that working models are unlikely to be challenged over the course of development.

Decreasing Sensitivity

A second source of homeorhesis discussed by Bowlby (1973) was epigenetic sensitivity. Drawing on Waddington's ideas about "degrees of canalization," Bowlby argued that the attachment system is more sensitive to environmental influences early in development: "The model proposed postulates that the psychological processes that result in personality structure are endowed with a fair degree of sensitivity to environment, especially to family environment, during the early years of life, but a sensitivity that diminishes throughout childhood and is already very limited by the end of adolescence" (Bowlby, 1973, p. 367). Although Bowlby did not specify the precise mechanisms that may lead sensitivity to diminish (e.g., neural changes, social-cognitive mechanisms, environmental changes), his proposition implies that the social environment is less influential later in life.

Prototype Representations

A third homeorhetic mechanism that Bowlby discussed concerned the enduring nature of representations of early experiences:

> No variables . . . have more far-reaching effects on personality development than have a child's experiences within his family: for, starting during his first months in his relations with his mother figure, and extending through the years of childhood and adolescence in his relations with both parents, he builds up working models of how attachment figures are likely to behave towards him in any of a variety of situations; and on those models are based all his expectations, and therefore all his plans, for the rest of his life. (1973, p. 369)

According to Bowlby, a system of nonlinguistic representations, procedural "rules" of information processing, and behavioral strategies is constructed in early life that serves as an adaptation to the individual's early caregiving environment. As complex cognitive capacities emerge, however, representational models develop that are consciously accessible and more easily updated to reflect ongoing relationship experiences. However, the early representations themselves remain unchanged. These early "prototypes" remain autonomous yet continue to play an ongoing role in shaping the quality of the caregiving environment.

The prototype concept provides a powerful theoretical mechanism for explaining patterns of stability. If children are continuously drawing on patterns of behavior and belief acquired early in life, attachment patterns should be somewhat consistent across different developmental periods (Sroufe, 1979; Sroufe, Egeland, & Kreutzer, 1990). Sroufe and his colleagues (1990, p. 1364), for example, have argued that "earlier patterns may again become manifest in certain contexts, in the face of further environmental change, or in the face of certain critical developmental issues. While perhaps latent, and perhaps never even to become manifest again in some cases, the earlier pattern is not gone." The notion that some aspects of working models may be more primitive or have more priority than other attachment representations is consistent with contemporary perspectives on the organization of working models that emphasize the hierarchical structure of attachment representations (e.g., Collins & Read, 1994). In Collins and Read's (1994) hierarchical model, for example, relationship-specific representations, although influenced by existing representations, may be constructed and updated without affecting representations that have priority in the hierarchy. In short, although there may be a degree of coherence across the kinds of attachment representations that an individual develops, the representations that are constructed early in life may continue to be especially influential in later childhood and early adulthood (for further discussion of the prototype hypothesis, see Fraley, 2002; Owens et al., 1995; Sroufe et al., 1990; van IJzendoorn, 1996).

Modeling the Dynamics of Attachment Stability and Change

In the sections that follow, we explore formal mathematical models of each of these homeorhetic mechanisms. Although these processes could be construed as operating in concert, we begin by modeling and discussing each process separately in order to highlight the specific implications of each mechanism for understanding stability and change in attachment security. To model these dynamic processes, we use difference equations (see Haefner, 1996, and Huckfeldt, Kohfeld, & Likens, 1982, for a clear and concise introduction to the use of difference equations in behavioral science). In a *difference equation,* a variable at one point in time, t, is modeled as a function of itself at an immediately preceding time point, $t - 1$, and of any factors contributing to its change. For example, in the equation $P_t = P_{t-1} + \Delta P_{t-1}$, variable P, a personality trait, is modeled as a function of itself at an immediately preceding point in time ($t - 1$) and of all variables that cause it to change (ΔP_{t-1}). In the following sections, we show how the dynamics of these processes influence the patterns of stability and change that should be observed in attachment. Readers who are interested in the mathematical details of these analyses and simulations can find them in Fraley (2002) and Fraley and Roberts (in press).

Modeling Transactional Processes in Attachment Development

We begin by making explicit four assumptions previously discussed. First, on the basis of attachment theory and research, we assume that there is variability in the security of the working models held by individuals, such that some people are more secure than others (see Fraley & Spieker, 2003; Fraley & Waller, 1998). Although contemporary models of individual differences emphasize the two dimensions that underlie security (Fraley & Shaver, 2000; Griffin & Bartholomew, 1994), for the purposes of this chapter we assume that these dimensions exhibit the same dynamic properties. (Whether that is the case is open for future research and discussion.) Second, we assume that as an individual navigates his or her social environment, his or her working models are influenced by the quality of the social environment (i.e., whether others are sensitive and responsive to one's needs; see Ainsworth, Blehar, Waters, & Wall, 1978). In other words, if someone is treated in a cold or aloof manner, we expect that person's level of security to decrease to some extent. Conversely, if the individual experiences warm and responsive care or support from significant others, we expect his or her security to increase to some degree. Third, we assume that the responses solicited from significant others will tend to be consistent with existing working models. That is, working models not only reflect the quality of the caregiving environment but also play an active role in shaping the quality of the caregiving environment. This process may manifest itself in the way in which working models bias or color the interpretation of relational events (e.g., Collins, 1996) or in the kinds of interaction partners that people select (e.g., Frazier, Byer, Fischer, Wright, & DeBord, 1996). Fourth, we assume, as Lewis (1997) has argued, that there are some stochastic processes in these dynamics. In other words, working models are not 100% predictable from the quality of the caregiving environment, nor is the quality of the caregiving environment 100% predictable from the security of one's working models.

In the transactional model, the theoretical processes are fully interdependent: The person influences his or her relational context, and the relational context influences the person. What do these processes predict about the form and magnitude of stability over time? To explore this question, we studied the stability functions implied by the transactional model under a variety of parameter values. Figure 4.7 shows some typical stability functions implied by the transactional model under different parameter values. As can be seen, the age 1 stability function (left-hand panel) begins high (the correlation of a variable with itself is necessarily 1), decelerates rapidly, and gradually bottoms out at an expected test–retest correlation of zero. The age 30 and age 60 functions are similar; the curves decelerate quickly as the interval between the age in question and other ages increases, approaching zero in both directions for the age 30 function (i.e., going backward or forward in time) and approaching zero going back in time for the age 60 function.

Notice that the values chosen for different parameters in the model affect how rapidly the curves decelerate. When environmental factors are allowed to have a large impact on the person, for example, change occurs more quickly, and the curves decelerate rapidly. When environmental factors are allowed to have only a minor impact on the person, or, alternatively, when working models are allowed to have a powerful influence on the social environment that the person experiences, change in security is much more gradual. In each case, however, notice that the stability functions approach zero as the time interval increases. In other words, if transactional processes—coupled with stochastic forces—are the only processes affecting attachment development, the expected correlation between se-

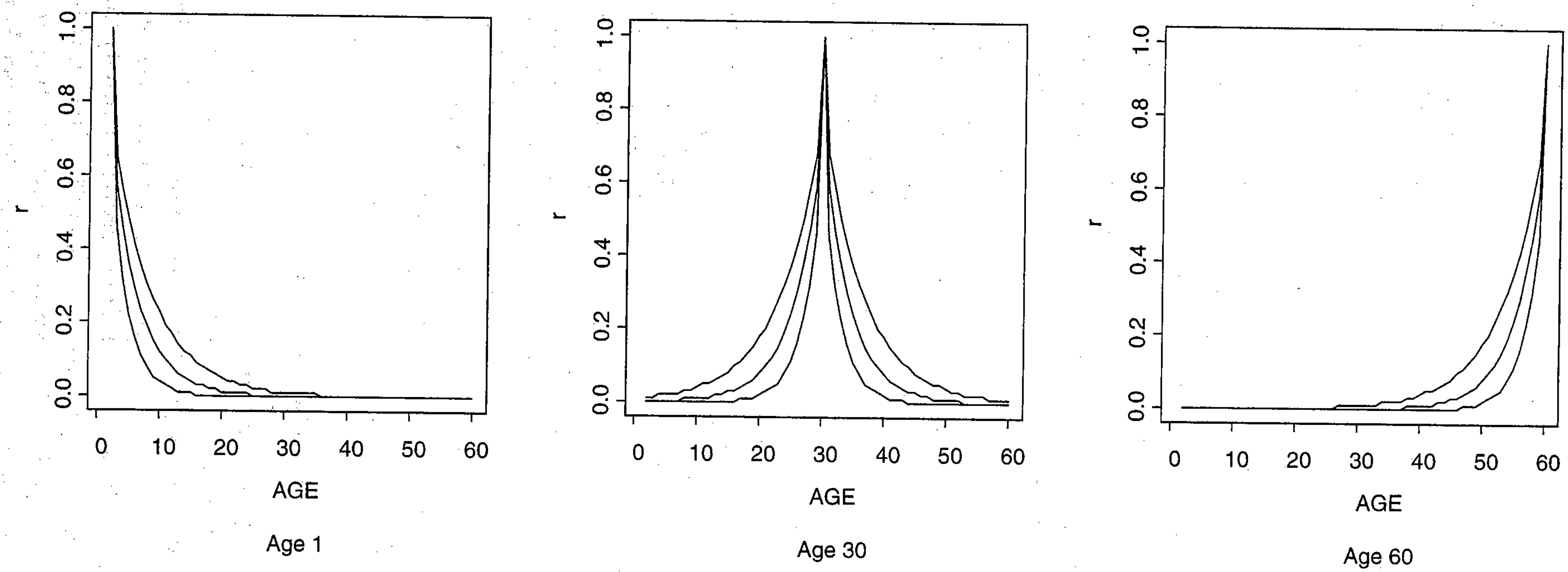

FIGURE 4.7. Stability functions for ages 1, 30, and 60, respectively, predicted by the transactional model. The different curves illustrate the behavior of the model under different parameter values.

curity in childhood and any sufficiently distant age is zero, regardless of how much or how little an effect the environment has on people.

In summary, according to the transactional model, the correlation between initial states of security and subsequent states of security gradually approaches zero. This is a critical finding because it demonstrates that, if transactional processes underlie attachment dynamics, we should not necessarily expect a high degree of stability from infancy to adulthood. Transactional processes promote stability in the sense that they affect the "decay rate" of the stability functions but do not alter the limiting value of those curves. Even if people play an active and powerful role in shaping their social environments, we expect the correlation between security early in life and later in life to approach zero over the long run.

Given that people are playing an active role in shaping their environments, why do transactional dynamics predict stability functions that approach zero over time? The answer to this question lies in the way the residuals affect the dynamics of the model. At each point in time, a portion of random variance contributes to security (see Fraley, 2002). To the extent that these stochastic factors play a role in shaping personality development, a person's developmental trajectory is guaranteed to get bumped around in unpredictable ways. Indeed, the individual developmental trajectories implied by the model could be described as *random walks*; it is nearly impossible to know where each person is going to end up in the long run from simple knowledge of where each person began (cf., our second Waddington simulation, Figure 4.5). The important point here is that nothing in the conjectured dynamics is "grounding" the person; there is no developmental tether, so to speak, keeping the person within a circumscribed region of developmental space. As such, a person's level of security, while influencing his or her environment, will tend to bounce around as random environmental events occur. Transactional dynamics can limit the magnitude of the influence of these random factors but do not remove them completely. If stochastic factors were removed from the model, transactional processes would imply perfect stability (i.e., $r = 1.00$ – measurement error) across all ages.

Modeling Decreasing Environmental Sensitivity

To incorporate Bowlby's ideas about the decreasing sensitivity of working models to environmental factors over time, we relaxed some of the constraints that were present in the previous simulation. Specifically, we allowed environmental factors to have less impact on security over time. Prototypical stability functions for the decreasing sensitivity model are depicted in Figure 4.8. As can be seen, the stability functions predicted by this model are similar to those observed before in that they all approach a zero asymptote. However, there is a noteworthy difference between these

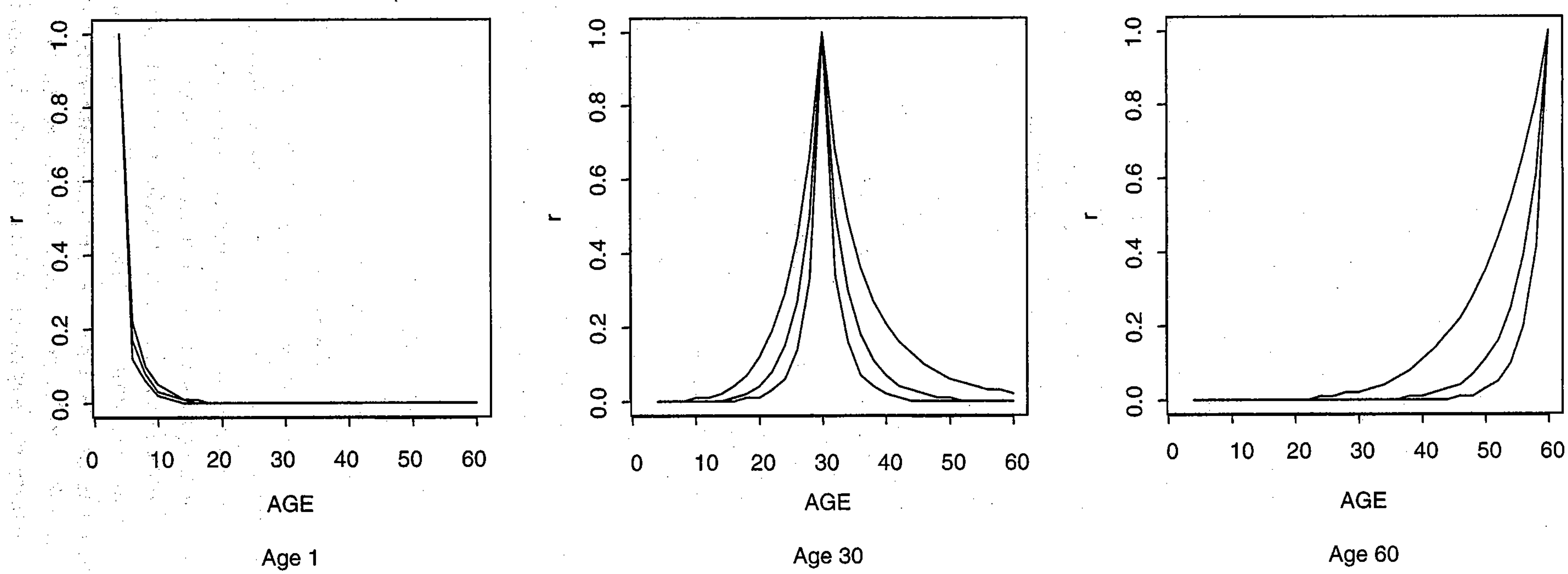

FIGURE 4.8. Stability functions for ages 1, 30, and 60, respectively, predicted by the decreasing-sensitivity model. The different curves illustrate the behavior of the model under different parameter values.

curves and those observed previously. Notice that the curves "decay" much more quickly going forward in time than backward in time. In other words, the rate of change for the age 1 stability function is faster than that of the age 30 stability function, whereas these curves were symmetric in the transactional model we studied previously.

The interesting implication of this finding is that, if one wanted to predict attachment security at any time from measurements taken at age 30, one would do much better making predictions about how people will turn out in the future as opposed to making inferences about what they were like in the past. Notice that the asymmetry in the stability functions is apparent under a variety of parameter values.

It is noteworthy that, despite the fact that environmental sensitivity decreases over time, the curves still approach 0.00 in the limit. Thus, although the decreasing sensitivity of working models may promote the stability of attachment from infancy to adulthood, this mechanism cannot do so in a way that ensures a high degree of stability over time. In other words, even if working models become increasingly resistant to change as people develop, it is still possible that an individual's attachment pattern in adulthood will be unpredictable from his or her attachment pattern in infancy. The exception to this rule occurs when the plasticity of working models is set to zero. In this case, there comes a point at which there is no change in working models, and they are perfectly stable.

In summary, the decreasing-sensitivity model implies that working models of attachment should become less responsive to environmental inputs over the course of development. When formalized, this model predicts an interesting asymmetry in the stability functions that should be observed at different points in the lifespan. For example, according to the model, it should be easier to predict how secure an adult will be across 5 years of adulthood than to predict how secure a child will be across 5 years of childhood.

Modeling the Dynamics of Prototype Processes

According to the prototype hypothesis, a latent factor (i.e., a representational prototype) exerts a consistent influence on attachment dynamics throughout the lifespan. We can represent this idea formally by modifying the transactional model that we discussed previously. Specifically, if we add a variable that represents early or primal representational models and allow it to influence working models at subsequent points in the lifespan, then the prototype will have both direct and indirect effects on the developmental dynamics of attachment (see Fraley, 2002). The mathematical structure of this model is an extension of the trait–state–error models explicated by Kenny and his colleagues (e.g., Kenny & Zautra, 2001; see Lemery, Goldsmith, Klinnert, & Mrazek, 1999, for a similar application).

What patterns of stability does this model imply? To explore this question, we varied the magnitude of the prototype effect and studied the resulting stability functions. Some examples of stability functions are depicted in Figure 4.9. As can be seen, the stability functions predicted by this model are dramatically different from those implied by the other models of development. Specifically, the stability functions have nonzero asymptotes. For example, in this particular simulation, the topmost age 1 stability function has a limiting value of .65. In other words, the predicted correlation between age 1 and age 11 (i.e., a 10-year span) is the same as the predicted correlation between age 1 and age 21 (i.e., a 20-year span). Notice that, as the influence of the prototype increases, the asymptote increases. The only condition in which the curves approach zero is when the influence of the prototype on attachment security is set to zero (see the lowest curve). (Under this parameter condition, however, the model cannot technically be considered a prototype model of development, and it reduces to the simpler transactional model.)

Why does this model predict nonzero asymptotes in the stability functions? The prototype constrains the range of possible security values the person can have. Because the prototype itself does not change, and because it exerts an effect on attachment dynamics over time, an unchanging constraint has been incorporated into the system. This constraint leads to some interesting predictions about the developmental trajectories of individuals. Specifically, changes in security appear to be deviations from a theoretical central tendency determined by the individual's prototype representations (this point is discussed in more depth by Fraley, 2002). In short, these processes give rise to a *dynamic equilibrium* for the individual–a point to which the individual gravitates despite statistical fluctuations in the caregiving environment. This dynamic equilibrium has clear homeorhetic properties because individuals will tend to return to the prototypical pathway even when interpersonal factors temporarily pull them in another direction. We elaborate on the implications of this finding later in the chapter.

In summary, the prototype model predicts a markedly different form of continuity when compared with that predicted by transactional and decreasing-sensitivity processes. Specifically, the predicted stability functions decrease to a nonzero asymptote. An important implication of the model is that stability need not be high when old representations continue to influence development. The key distinction between this model and the others is that this one implies that the degree of stability observed, whether large or small, will be the same over, for example, 10- and 30-year spans.

Notice also that, under certain parameter values, the prototype model predicts a dip in the backward stability functions between ages 1 and 5 (see Figure 4.9). This dip emerges when the initial (i.e., Time 1)

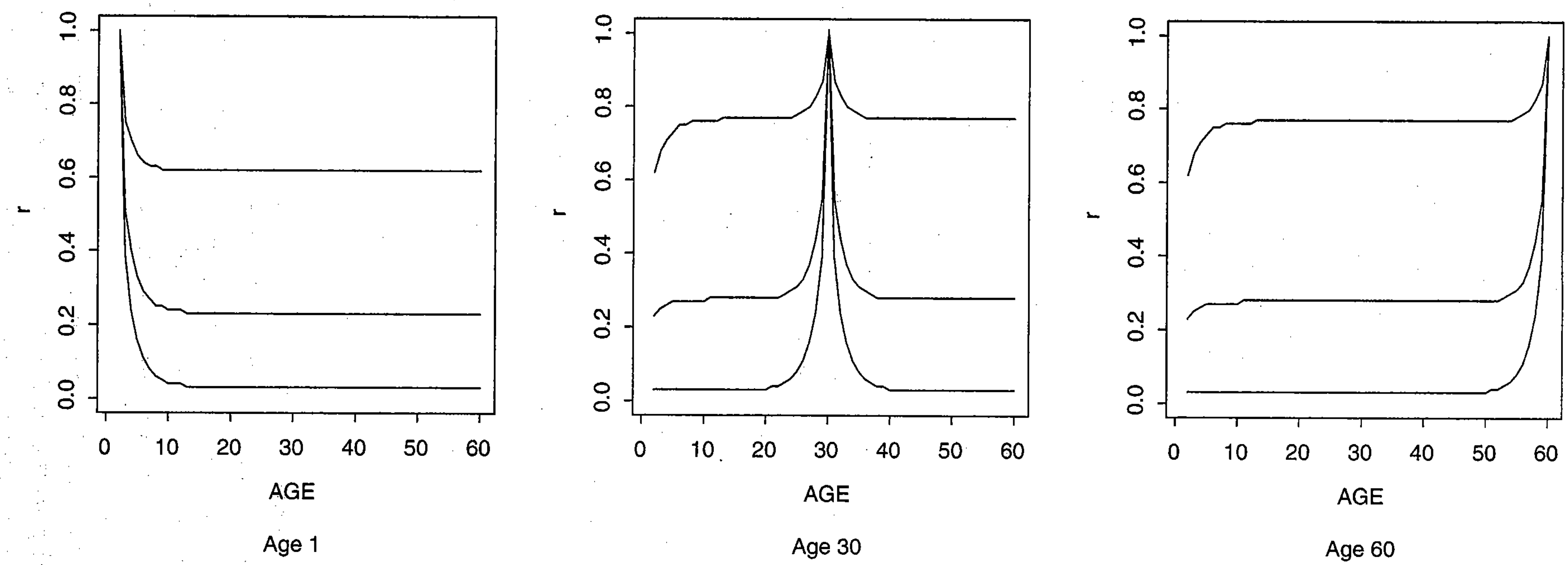

FIGURE 4.9. Stability functions for ages 1, 30, and 60, respectively, predicted by the prototype model. The different curves illustrate the behavior of the model under different parameter values.

covariances between persons, prototypes, and environments is smaller than what the dynamics of the system will naturally produce over time. In these particular simulations, the initial covariances were set to zero, so persons, prototypes, and environments were initially uncorrelated. However, the covariances among these variables increased as person–environment transactions took place because prototypes were affecting people, who were affecting their environments, which were, in turn, affecting people. As these indirect effects accumulate, the covariation among prototypical representations, environments, and security increases.

An interesting consequence of these dynamics is that this model, like the decreasing-sensitivity model, predicts an *asymmetry* in stability functions, such that the limiting value of the age 1 stability function is lower than that of the age 15 stability function. Importantly, the prototype model is capable of making this prediction without an explicit mechanism that increases or decreases plasticity. In the interest of parsimony, we do not explore decreasing-sensitivity mechanisms per se for the remainder of this chapter because such effects flow naturally from a prototype model of attachment dynamics.

Summary

In summary, analyses of the prototype model indicate that prototype-like processes are capable of predicting a nonzero degree of stability between early and later attachment patterns. If prototype processes exist, there should be evidence of stability from infancy to adulthood—even if early prototypes exhibit only a modest effect on social interactions. This prediction contrasts sharply with those made only on the basis of transactional and decreasing-sensitivity mechanisms, which indicated that the stability should always approach zero in the long run.

Although the prototype model does not explicitly suggest that working models should become less sensitive over time, analyses of the model revealed that such a phenomenon emerged naturally from the intrinsic dynamics of the model. This suggests that it may not be necessary to postulate explicit constructs to account for decreasing sensitivity over time. If we assume that the initial correlation between prototypes, environment, and security is low—but that that there is a causal relationship between these variables—prototypes, environment, and security will eventually come to covary positively together. If the initial covariation between these three variables is not as high as that implied by the dynamics between them, the stability of attachment will be weaker in early childhood than in later childhood or adulthood. It appears that resistance to change emerges in this model not because working models per se are becoming less flexible but because there is increased covariation among the variables that shape the expectations that people hold. *The interplay of these dy-*

namic forces causes the person's developmental pathway to become canalized over time.

On the basis of these simulations and analyses, we believe that Bowlby's theoretical ideas regarding the mechanisms that sustain and change attachment patterns *do not* necessarily imply that a high degree of stability will be observed between attachment patterns in infancy and attachment patterns in adulthood. Of the three homeorhetic mechanisms that Bowlby discussed, the first two—transactional dynamics and those that entail decreasing sensitivity over development—predict that degree of stability over long spans of time will be zero. Although these processes *do* serve to boost stability in comparison with situations in which they are not operating, these processes cannot be used to support the conjecture that attachment security will be highly stable across development. The one mechanism that does allow for nonzero degrees of stability in the limit (i.e., the prototype process) is neutral with respect to the *degree* of stability (i.e., high or low) that should be observed. In other words, although this mechanism implies that secure children may tend to grow up to be secure adults, it does not imply that this association must be high in magnitude.

Although each of the three homeorhetic processes discussed by Bowlby leads to higher levels of stability than would be observed in its absence, there is nothing intrinsic in the dynamics of these processes that ensures that an individual's developmental trajectory will be easy to predict on the basis of early caregiving experiences. The homeorhetic dynamics implied by the prototype model, like those implied by Waddington's marbles on epigenetic landscapes, "break down" if the degree of environmental influence is too large. Although the system is still "trying" to maintain a specific developmental pathway, the specific pathway maintained is changing too rapidly to give rise to developmental stability.

EMPIRICAL TESTS OF BOWLBY'S DYNAMIC MECHANISMS

How can Bowlby's ideas about the homeorhetic properties of human development be tested empirically? Although an increasing number of studies have addressed the stability of attachment patterns over time (see Fraley, 2002, for a review), the typical study on stability and change assesses security at only two points in time. Unfortunately, this kind of information does not allow us to evaluate the homeorhetic dynamics thought to underlie attachment development. To understand why, consider a hypothetical study that finds a test–retest correlation of .30 between security levels assessed over a period of 2 years. Do these data support or refute the notion that transactional processes, for example, play a key role in attachment dynamics? The question is difficult to answer for at least two reasons. First, no one writing about transactional dynamics—including Bowlby—has made a *point prediction* (i.e., a quantitative prediction) about the magnitude of test–retest coefficients that should be observed over 2 years if these processes are operating. One might assume that the prediction would be 0.00 based on our previous discussion, but, as can be seen from the decaying nature of the curves in Figure 4.7, that is not the case. Even if transactional dynamics were taking place, the test–retest correlation over 2 years may be quite high. Second, a coefficient of .30 clearly indicates *some* degree of stability, and it is not clear whether this particular value is more consistent with a perspective that emphasizes instability (e.g., Lewis, 1999) over stability (e.g., Waters et al., 2000). In short, simply knowing the magnitude of stability over two points in time is insufficient for determining whether attachment dynamics behave in the homeorhetic manner that Bowlby envisioned.

As our previous simulations illustrate, evaluating the homeorhetic nature of these theoretical mechanisms requires studying the *pattern* or *form* of test–retest coefficients observed over time, not the magnitude of a single test–retest coefficient (as is common in longitudinal research on attachment). In the following sections, we study patterns of stability by piecing together diverse longitudinal findings on the stability of attachment. Specifically, we summarize meta-analytic data originally reported by Fraley (2002) on the stability of attachment from infancy to adulthood. We supplement these data with data on the stability of attachment across adulthood, as culled from the empirical literature on adult attachment in the social–personality research tradition.

Data on Stability from Infancy to Adulthood

How stable are attachment patterns from infancy to adulthood? Although there are now an increasing number of longitudinal studies that are able to address this question, considerable diversity exists in the answers provided by these studies. Some studies suggest that, over the first 19 years of life, there is a strong degree of stability in attachment, such that secure children are highly likely to be secure as adults (see Waters et al., 2000). Other studies, in contrast, indicate that there is virtually no stability over such lengthy spans of time (e.g., Lewis et al., 2000).

Fraley (2002) adopted a meta-analytic approach to resolve the disparate results of alternative studies on stability. In 1999 he identified all studies containing test–retest data on attachment patterns between 12 months of age—as assessed with Ainsworth et al.'s (1978) Strange Situation procedure—and subsequent ages. Twenty-seven samples were obtained through PsycINFO computer searches, consultation with attachment researchers, and cross-referencing of articles as the database developed. Once the studies were identified, the stability results from each were transformed to a common metric. For studies in which attachment classifications, rather than continuous ratings of security, were employed, Fraley (2002) focused on the stability of secure–insecure classifications rather than the stability of three- or four-category classifications (e.g., A, B, C or A, B, C, D). One reason for doing so was that every study allowed an unambiguous secure–insecure distinction to be made across assessment times and methods (e.g., security manifests itself in functionally, if not in phenotypically, similar ways in infancy and adulthood). This distinction can be considered a rough approximation of a latent continuum of security. Also, two-category test–retest effects can be summarized conveniently as Pearson product-moment correlations—phi correlations, to be exact. This allows the stability findings across a variety of studies to be evaluated on the same Pearson correlation metric that we adopted in the simulations reported previously.

Table 4.1 reports the meta-analytic stability results for five temporal intervals: age 1 to age 1 (i.e., immediate test–retest), age 1 to age 2, age 1 to age 4, age 1 to age 6, and age 1 to age 19. Notice that the coefficients start off high (the age 1 test–retest correlation is 1.00) and, despite some variation, appear to decrease rapidly to a nonzero plateau. Because these data only reflect a single empirical stability function (i.e., the age 1 stability function), they cannot be used to evaluate the predicted asymmetrical properties of the stability functions. However, it should be clear from these data that the test–retest correlations do not approach zero in the limit. In fact, the data can be accounted for fairly well by the prototype model. If we use these data to calibrate the prototype model, we find an estimated asymptotic test–retest correlation of .39 (see Fraley, 2002). This suggests that, if the underlying model is correct, the expected correlation between security assessed at age 1 and security assessed at any other point later in the lifespan will be approximately .39.

What does this imply about the stability of attachment from infancy to adulthood? First, these data indicate that there is not a high degree of stability. A test–retest correlation of .39 suggests that, if we had a sample

TABLE 4.1. Meta-Analytic Data on Attachment Continuity from Infancy to Adulthood

Temporal group	r	Total n
Age 1–age 1	1.00	9
Age 1–age 1.5	.32	896
Age 1–age 4	.35	161
Age 1–age 6	.67	131
Age 1–age 19	.27	218

Note. These meta-analytic data were reported by Fraley (2002).

of secure children, approximately 70% of them would grow up to be secure adults, whereas 30% of them would grow up to be insecure as adults. Although this degree of stability is impressive when compared against the degree of stability observed in other personality traits ($r \cong .20$, see Fraley & Roberts, in press), one would not use such data to make the claim that early childhood experiences serve as a powerful foundation for the development of adult attachment patterns.

The second critical implication of these data is that a prototype-like process may underlie empirical patterns of stability and change in attachment. If this view is correct, then early attachment patterns, although not strongly influential in adult development, may exert a broad influence across different life periods. Because the empirical curve reaches its asymptote so quickly (around age 2), the degree to which early experiences shape attachment may be assumed to be the same at age 2 and at age 19. We expound on this implication in more depth later. For now, however, we note that, although early attachment is not a *strong* predictor of later attachment patterns, it is a *far-reaching* predictor of later attachment patterns in the sense that we can use it to predict attachment at age 4 with the same degree of precision as attachment at age 19.

Data on Attachment Stability in Adulthood

To further investigate empirical patterns of stability and change, we examined the ability of the prototype model to account for data on attachment stability among adults. A growing number of social and personality psychologists have conducted longitudinal investigations of attachment in adulthood (e.g., Baldwin & Fehr, 1995; Klohnen & Bera, 1998; Scharfe & Bartholomew, 1994). By collating the empirical data obtained in a diverse number of studies, we can take a small—but significant—step toward reconstructing the broader patterns of stability and change that exist in attachment security.

To identify longitudinal studies that included test–retest data on adult attachment patterns (i.e., those assessed after 18 years of age), we conducted PsycINFO computer searches and cross-referenced articles as the database developed. Twenty-four samples/datapoints were obtained. Many of the studies used categorical measures of attachment rather than continuous ratings. To transform the findings from such studies to a standard Pearson correlation metric, we computed the phi correlation for the test–retest stability of secure–insecure classifications. In cases in which base rate information was not reported and in which only the percent of the sample that retained the same classification was reported, we assumed that the base rate of security was 50% and used this base rate to compute phi. (Alternative assumptions do not have any noteworthy impact on the patterns of data we report.)

We have reproduced these data in Table 4.2. One thing to note about these data is that, for the most part, very few studies have examined the stability of attachment security over a period extending more than 1 year. One noteworthy exception is the study by Klohnen and Bera (1998), which examined the stability of attachment patterns in the Mills College sample at ages 27, 43, and 52.

Overall, the raw magnitude of the test–retest correlations tends to be higher than those observed in childhood. The correlations reported in Fraley (2002) average around .39, whereas the adult correlations average around .54. A second noteworthy feature of the data is that the correlations do not behave as if they are approaching zero in the limit. For example, the Klohnen and Bera (1998) data suggest that the stability of attachment is roughly the same from age 27 to age 43 ($r \cong .58$) as it is from age 27 to age 52 ($r \cong .55$).

In Figure 4.10 we summarize the data for studies that had test–retest intervals of one year or longer in order to illustrate the patterns of stability. We have also superimposed the stability functions implied by the prototype model. There are several noteworthy features of these graphs. First, notice that the prototype model predicts that the asymptotic value of the stability functions in adulthood (e.g., the age 30 stability function) is higher (i.e., $r \cong .50$) than that expected for the age 1 stability function ($r \cong .39$). Second, notice that the adult data points are well approximated by the theoretical curve. Although the data do not fall precisely on the predicted curve, the discrepancy between the theoretical values and the predicted values is remarkably small.

What do these patterns, in conjunction with the childhood data reviewed previously, imply about the mechanisms underlying stability and change? The fact that the correlations estimated over 1-year intervals tend to be somewhat higher in adulthood than in childhood (i.e., they exhibit the property of asymmetry predicted by the prototype model) indicates that some degree of canalization may be taking place. The fact that the correlations do not approach zero in the limit also suggests that prototype-like dynamics may underlie empirical patterns of stability and change.

We also examined, in a separate analysis, the stability of attachment security reported in studies that used test–retest intervals that were shorter than 1 year. We have plotted attachment stability as a function of the test–retest intervals in Figure 4.11. (Among these adult samples, age was uncorrelated with the length of the test–retest interval, so we have not presented these data by age per se. We have also excluded the Baldwin et al., 1993, sample from the figure.) Notice that the test–retest correlations approach their asymptotic values almost immediately (i.e., within a week). Notice also that the asymptote implied by these data is much larger than zero and very close to the asymptote entailed by the other studies that examined stability over periods of 1 year or more.

TABLE 4.2. Longitudinal Studies Including Adult Attachment Test–Retest Data

Study	*n*	Age at first assessment	Test–retest interval (weeks)	*r* (continuous measures)	Percent stable (categorical measures)	Phi (categorical measures)
Baldwin & Fehr (1995)	221	20.5	16.0		67.4	0.35
Baldwin, Fehr, Keedian, Seidel, & Thomson (1993)	16	20.9	16.0		43.7	-0.13
Barnes (1991)[a]	46	18.0	12.0		67.4	0.35
Benoit & Parker (1994)						
Test–retest 1	84	29.2	54.0		77	0.54
Test–retest 2	84	29.2	54.0		90	0.80
Collins & Read (1990)	101	18.8	9.0	0.64		
Cozzarelli, Karafa, Collins, & Tagler (2003)	442	24.1	108.0	0.38		
Davila, Burge, & Hammen (1997)						
Test–retest 1	155	18.0	27.0	0.52		
Test–retest 2	155	18.0	108.0	0.48		
Davila & Cobb (2003)	86	18.0	54.0	0.63		
Davila, Karney, & Bradbury (1999)						
Test–retest 1	344	26.8	27.0	0.68		
Test–retest 2	344	26.8	54.0	0.71		
Test–retest 3	344	26.8	81.0	0.58		
Test–retest 4	210	26.8	108.0	0.61		
Feeney & Noller (1992)	172	17.9	10.0	0.67		
Feeney, Noller, & Callan (1994)	70	23.7	40.5	0.62		
Fuller & Fincham (1995)	44	31.8	108.0	0.62		
Hammond & Fletcher (1991)	102	20.0	18.0	0.47		
Keelan, Dion, & Dion (1994)	101	19.0	18.0		80.2	0.60
Kirkpatrick & Hazan (1994)	172	39.1	216.0		70.0	0.40
Klohnen & Bera (1998)						
Test–retest 1	142	27.0	864.0	0.58		
Test–retest 2	142	27.0	1350.0	0.55		
Test–retest 3	100	43.0	486.0	0.71		
Levy & Davis (1988)	63	20.0	2.0	0.58		
Lopez & Gormley (2002)	207	18.0	31.5		57.0	0.14
Pistole (1989)	67	18.0	1.0		76.1	0.52
Ruvolo, Fabin, & Ruvolo (2001)	322	19.7	22.5	0.49		
Scharfe & Bartholomew (1994)	144	24.5	36.0	0.51		
Senchak & Leonard (1992)	335	23.8	52.0		74.2	0.48
Shaver & Brennan (1992)						
Test–retest 1	127	19.0	36.0	0.60		
Test–retest 2	242	19.0	36.0	0.68		
Smith, Murphy, & Coats (1999)	60	18.0	13.0	0.77		
Tinio (1992)[a]	12	18.0	16.0		83.3	0.67
Wieselquist et al. (1999)	130	32.5	54.0	0.56		

Note. For studies employing only categorical measures of adult attachment, we have reported the percent of the sample that retained the same attachment classification from time 1 to time 2 and a phi coefficient to express that information in a Pearson correlation metric (see text). For studies that included dimensional measures of adult attachment, we have reported the test–retest correlation, *r*. In cases in which the average age of the sample was not reported, we assumed an average value of 18.

[a]Unpublished studies reported by Baldwin and Fehr (1995).

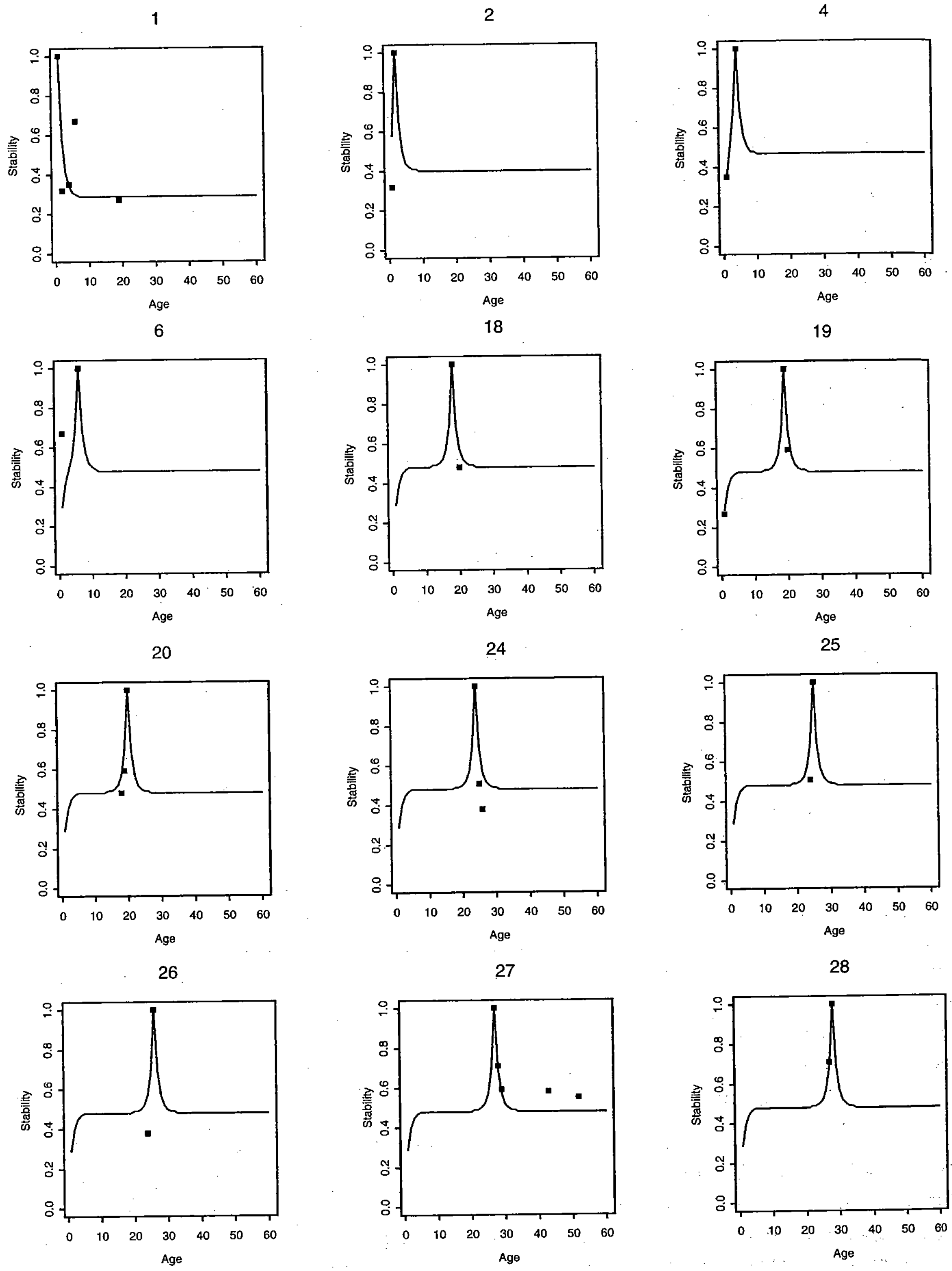

FIGURE 4.10. Stability functions for a variety of ages between 1 and 52. The points represent meta-analytic data points; the curves represent the stability functions predicted by the prototype model.

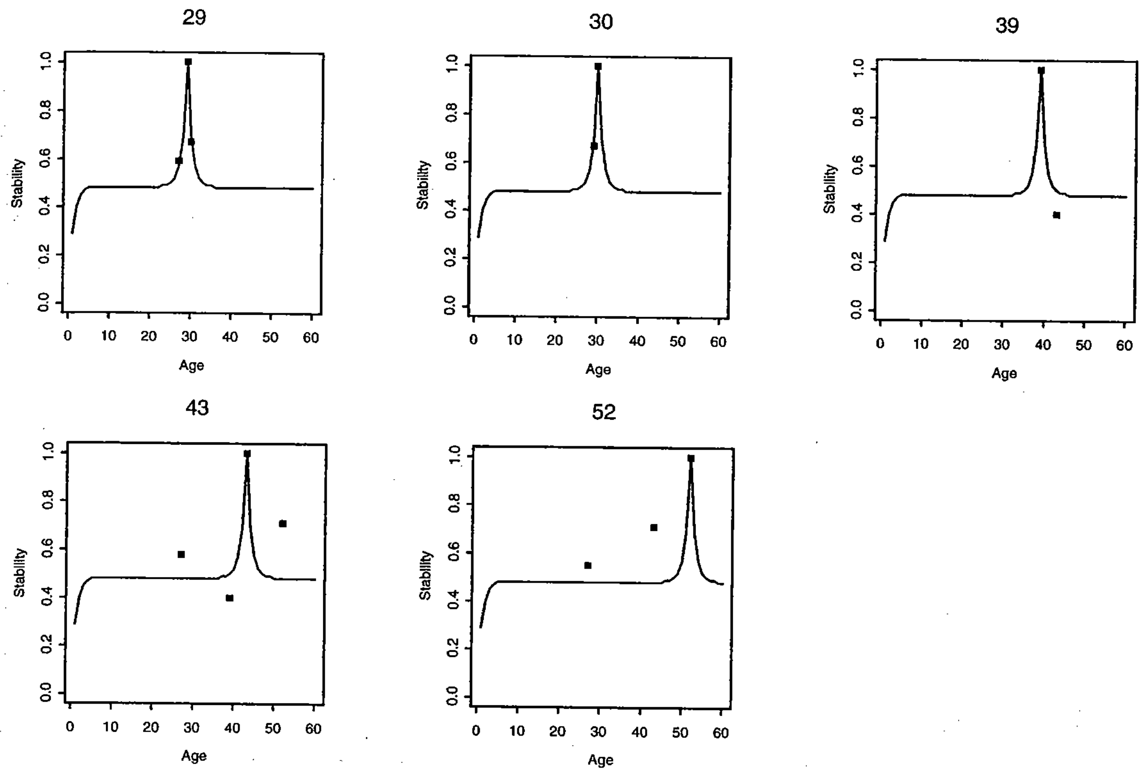

FIGURE 4.10. *(continued)*

CONCLUSIONS

In this chapter, we used dynamic modeling techniques to formalize Bowlby's ideas about the basic processes that may sustain attachment patterns over time. In the sections that follow, we discuss the implications of our simulations and analyses for (1) the assumptions researchers hold about how much stability should exist in attachment over the life course, (2) debates about within-person variation in attachment patterns, and (3) the methods that are used to study the dynamics of stability and change.

Assumptions about Stability

Many researchers are implicitly guided by the view that attachment theory predicts a strong association between early and later attachment patterns (e.g., Duck, 1994; Lewis, 1997; Westen, 1998). Indeed, one of the intriguing implications of attachment theory is that the way a person thinks, feels, and behaves in his or her romantic relationships is a reflection of the way in which that person's attachment system has become organized over the course of development—beginning with his or her earliest attachment relationships. The notion that early caregiving experiences influ-

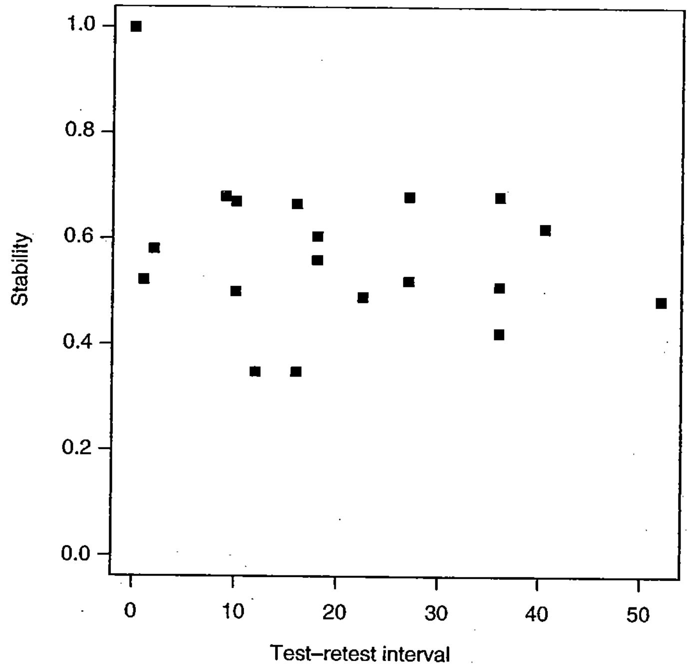

FIGURE 4.11. Stability of adult attachment in studies with test–retest intervals shorter than a year. Notice that the asymptote implied by these data is greater than zero and is reached within a few weeks.

ence the way we relate to others throughout the life course is compelling for a number of reasons. For one, it provides a straightforward explanation for why some people are relatively secure in their relationships, whereas others are more sensitive, defensive, or withdrawn. In addition, it raises the possibility that, if psychologists could intervene at an early stage in a child's life, it might be possible to foster permanent changes for the better in his or her psychological development.

Despite its allure, the assumption that early caregiving experiences foreshadow adult development is quite controversial in contemporary psychology (see Duck, 1994; Kagan, 1996; Lewis, 1997). If a person's style of regulating attachment-related feelings and behaviors in his or her romantic relationships is strongly influenced by his or her early caregiving experiences, it would seem that our relational fates are sealed within the first few years of life. This would appear to leave little room for psychological growth, change, or intervention beyond infancy (Lewis, 1997). In addition to these theoretical concerns, the assumption of stability has been challenged by a growing empirical database on the instability of attachment patterns (e.g., Baldwin & Fehr, 1995). If attachment patterns are only moderately stable across short spans of time, how is it possible for early attachment experiences to provide a solid foundation for subsequent development?

We believe that the model we have developed in this chapter provides a way to understand how early attachment patterns can exhibit continuing effects across the life span yet exhibit only a weak degree of stability over time. The empirical data that we reviewed indicate that there is a weak to moderate degree of stability from infancy to adulthood but that the stability that exists from age 1 to later ages does not decay as the length of the test–retest interval increases. According to our theoretical and empirical analyses, security is just as stable from age 1 to age 2 as it is from age 1 to age 20. Thus it is not the case that early attachment has a *strong* influence on later development but that the influence that exists appears to be *enduring*. According to Bowlby's ideas on the role of prototypical attachment representations and their homeorhetic effects on personality development, early attachment patterns manifest themselves in some shape or form across diverse developmental periods of the life course, even if the degree to which those patterns manifest themselves is minor.

Although Bowlby believed that early attachment patterns serve as the foundation for subsequent attachment relationships, he never made a quantitative prediction about the degree of stability that should be expected over long periods of time. The mechanisms he discussed, like Waddington's, offer an explanation for why stability may be observed, but they do not ensure that stability will be the rule rather than the exception. In light of these considerations, we believe that it may be inappropriate for researchers to predict high degrees of stability based on Bowlby's theory. It is of great theoretical interest, of course, to know how stable attachment patterns are over time, but the actual degree of stability, although it informs and constrains the way we conceptualize attachment dynamics, does not provide a test of the theory. As we explain later, testing the theory requires studying the *patterns* of stability and change across development, not appraising the *raw magnitude* of the stability coefficients.

Within-Person Variation in Attachment Patterns

In recent years an increasing number of researchers have documented substantial within-person variation in attachment patterns (see Baldwin & Fehr, 1995; La Guardia, Ryan, Couchman, & Deci, 2000; Pierce & Lydon, 2001). Baldwin and Fehr (1995), for example, reported that approximately 30% of research participants reported different attachment styles from one point in time to the next. This result raised the question of whether it was appropriate for attachment researchers to conceptualize attachment styles as trait-like properties of people or as phenomena exhibiting a more fluid, context-specific nature. Over the years, researchers have adopted a variety of perspectives on this issue. Fraley and Waller (1998), for example, argued for a trait-like approach and suggested that the instability observed by Baldwin and Fehr might be best explained by the kinds of measurement errors that are introduced when continuous data are categorized. La Guardia and her colleagues (2000) argued that a sizable proportion of the within-person variations in attachment could be attributed to ongoing interpersonal dynamics, such as variation in the extent to which people's basic needs for autonomy, competence, and relatedness are fulfilled. Although empirical and theoretical progress has been made toward exploring the extent to which attachment behaves in a trait-like manner, the field has yet to settle on a consensual interpretation of what this variation means and the implications it has for understanding attachment dynamics.

We believe that the homeorhetic processes discussed in this chapter provide a novel and compelling way to conceptualize both the within-person stability and the change that have been documented in attachment patterns. To illustrate how this may be the case, we explore one of the basic equations thought to underlie attachment dynamics (see Fraley, 2002): $dS/dT = \eta(E_t - S_t)$. According to this equation, the amount of change in working models at any time t is proportional to the discrepancy between security at Time t, S_t, and the quality of the caregiving environment at Time t, E_t. When E_t and S_t are equivalent, security will not change ($dS/dT = 0$). When the caregiving environment is harsher or more rejecting than expected, working models change in the direction of decreased security. Similarly, when the caregiving environment is more responsive than expected given one's working models, security increases. The parameter η controls the lability or plasticity of working models.

This basic equation has two important implications for the within-person dynamics of stability and change. First, if we conceptualize the environment as being a function of a stable representational prototype (P), the individual will tend to gravitate toward a value of security that corresponds to the security of that prototypical representation. To demonstrate this result, we can simply substitute P for E, set the derivative to zero, and solve for S (Huckfeldt et al., 1982). Simple algebraic manipulation shows that the attractor state of the system (i.e., the value toward which the system gravitates) is equal to P. In other words, an individual's security level will adjust itself in such a way that it eventually converges on the quality of the prototype. This is true regardless of how secure the individual is initially (see the left-hand panel of Figure 4.12).

Does this process exhibit the kind of homeorhetic stability discussed by Waddington and Bowlby? The middle panel of Figure 4.12 illustrates the security of an individual over time. At Time 390, the caregiving environment is temporarily disturbed so that it becomes substantially more rejecting than it was initially. (For example, it may be the case that the individual was rebuffed by a loved one.) At Time 391, the perturbation is removed. What happens to the security of the individual over time? The perturbation knocks the individual out of his or her pathway, but he or she quickly returns to the pathway previously established (and guided by his or her representational prototype). If there are a large number of environmental factors affecting the individual, then his or her trajectory will bounce around considerably from day to day, but those changes will tend to fluctuate around the same prototypical value (see the right-hand panel of Figure 4.12).

This very simple equation captures an important feature of the homeorhetic processes discussed by Waddington and Bowlby. Specifically, if we conceptualize the prototype as reflecting a critical component of the epigenetic landscape, we see that the individual will gravitate toward that end state despite disturbances from the external environment. Importantly, it is not the case that the person is unaffected by the environment. However, the effect of those experiences is only temporary, and the individual will eventually reestablish his or her original trajectory.

What does this imply about the nature of within-person variation? It suggests that attachment security can behave both as a trait-like and a contextual variable. In other words, it is not necessary to view trait-like and contextual interpretations of security as being in opposition. Although there may be considerable within-person variation in attachment patterns, that variation can be characterized as temporary deviations from a *dynamically* stable value. Although this conjecture flows naturally from the prototype model that we have discussed in this chapter, we are not aware of any existing empirical data that can be used to provide a rigorous test of this hypothesis. Testing this conjecture will require future research not only to demonstrate principled within-person variation, as La Guardia and colleagues (2000) and Pierce and Lydon (2001) have done, but to determine whether specific relational events, such as an argument with a significant other, lead to temporary, as opposed to enduring, changes in attachment security.

Baldwin and his colleagues (Baldwin & Fehr, 1995; Baldwin, Keelan, Fehr, Enns, & Koh-Rangarajoo, 1996) have made the argument that not only does within-person variation exist in attachment patterns but also one reason this variation exists is that people hold multiple working models of themselves in different relationships, each of which can be activated to varying degrees in any one context. Thus it is possible that people hold multiple prototypes based on different significant others in their lives. When this idea is incorporated into the basic model we have discussed, it has some interesting implications for the way the homeorhetic dynamics of the system manifest themselves. To expand the previous equation to accommodate this possibility, we simply added multiple prototypical states to the dynamic equation: $dS/dT = \eta(P_1 - S)(P_2 - S)(P_3 - S)$. Algebraically, this equation is cubic, and, therefore, it has three attractor states given by

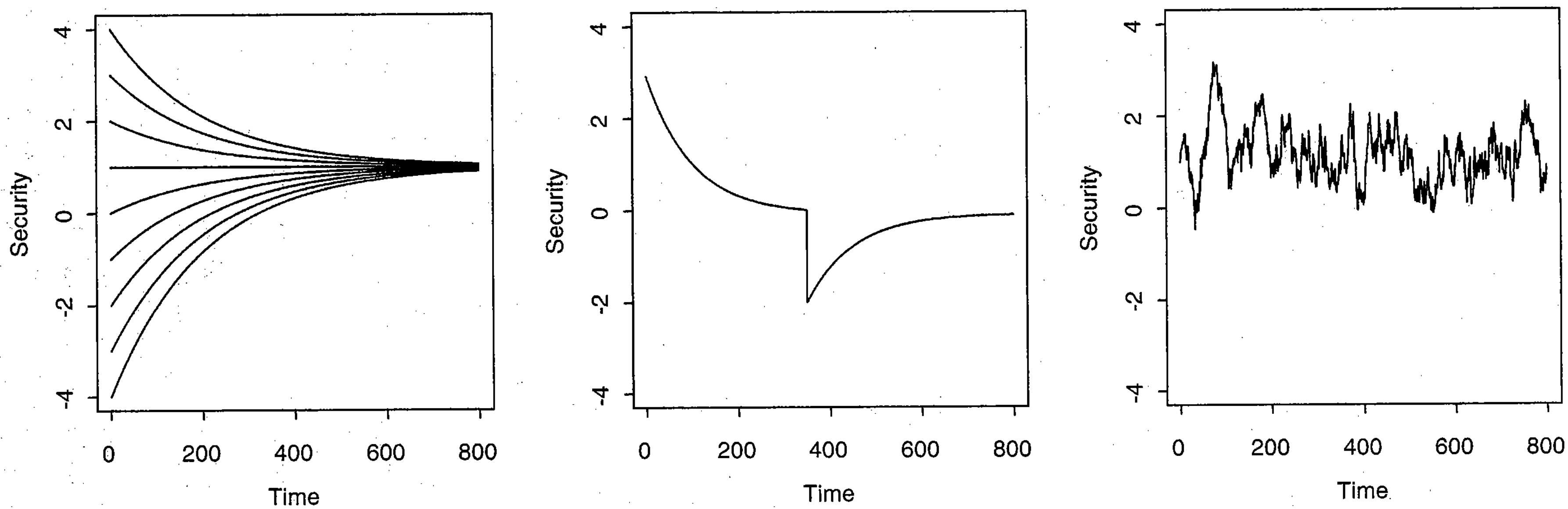

FIGURE 4.12. The dynamics of stability and change from a within-person perspective. The left-hand panel shows how people who begin with different levels of security converge on the same value when they held moderately secure prototypes. The middle panel shows the temporary impact of a disturbance on a person's developmental trajectory. The right-hand panel illustrates the maintenance of the system's dynamic equilibrium despite stochastic disturbances.

the security of the three prototypical representations (see the left-hand panel of Figure 4.13). The first and third attractors are what are called *sinks* (Blanchard, Devaney, & Hall, 1996). Values that begin near a sink tend to converge on that point. Conceptually, a sink is much like the valley floor in Waddington's epigenetic landscape; marbles placed within a certain vicinity of the floor tend to gravitate toward it; they are attracted to it. The second attractor, in contrast, is what is called a *source.* Values that begin near a source tend to move away from that point (Blanchard et al., 1996). A source is much like the cusp between two valley walls in Waddington's analogy. If a marble were to be poised in just the right place on the cusp, it may come to a stop. However, as soon as it moves away from that position–even by a minuscule amount–it will be forced down the hill.

Like the first equation we discussed, this equation exhibits homeorhetic properties. Specifically, if we disrupt an individual's developmental trajectory, he or she will find a way back to his or her original pathway (see the topmost trajectory in the right-hand panel of Figure 4.13). However, the homeorhetic properties of this system are more complex than those discussed previously. If the disturbance is strong enough to push the individual over a cusp point, he or she will change pathways, and a new developmental trajectory will be established. This is illustrated by the bottommost trajectory in the right-hand panel of Figure 4.13. This individual was initially on a trajectory leading her toward extreme insecurity; however, at Time 200, an external force was introduced that temporarily boosted her security. This change brought the person's current level of security over a cusp in the dynamic surface, leading her to establish a new trajectory toward greater security.

If multiple prototypes exist in the mental system, it is possible that they may combine in the way captured by the previous equation to produce multiple attractor points in developmental space (i.e., multiple valleys in the epigenetic landscape). If this is true, then when an individual's current state of security is relatively close to a source point, even a minor environmental disturbance may create a situation in which the individual is pushed off his or her pathway and onto a new one. This suggests that, for some people, minor events may lead to dramatic changes in their personality organization, whereas those same events may lead to nothing more than temporary changes for other people.[3] Regardless of whether we conceptualize the system as having one or more attractor points, this basic conceptualization suggests that the same dynamic mechanisms can lead security to behave as *both* a trait-like variable and a contextual or state-like variable. As such, this model provides a possible resolution to ongoing debate about whether attachment styles represent one kind of variable as opposed to the other.

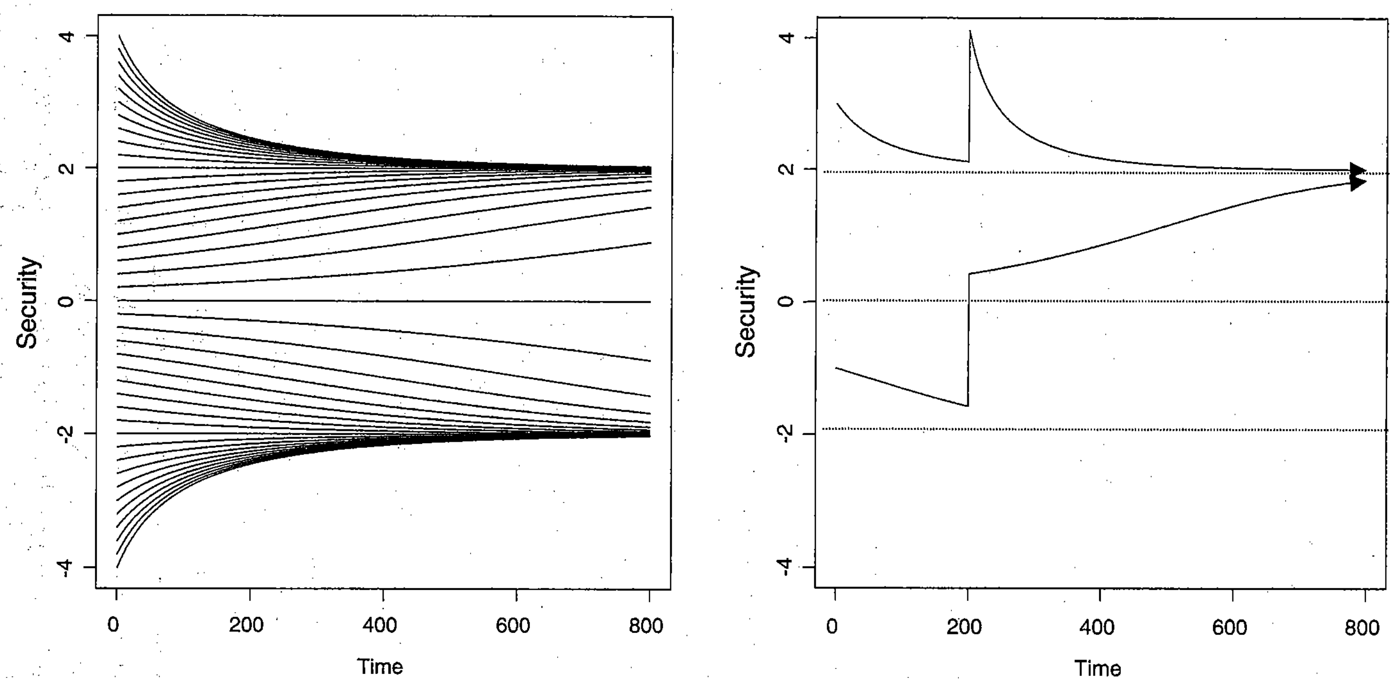

FIGURE 4.13. The dynamics of stability and change in a dynamic system involving multiple prototypes or multiple attractor states. The left-hand panel illustrates alternative developmental trajectories in a multiple attractor system. The right-hand panel demonstrates how the same kind of disturbance can have different effects for people with the same system.

Methods for Studying Change

Our analyses suggest that Bowlby's theory predicts that the degree of stability in attachment can fall anywhere between 0.00 and 1.00. In light of this derivation, one cannot empirically "test" attachment theory by studying the stability of attachment patterns between two points in time, as is often done in contemporary research. Theoretically, any test–retest correlation greater than zero would be consistent with the theory, thereby making such empirical tests extraordinarily weak and ambiguous. The power of Bowlby's theory lies not in the predictions that it makes about the *degree* of stability that should be observed from infancy to adulthood but in the *patterns* of stability that should be observed over time. Specifically, if the dynamics of stability and change can be characterized by homeorhetic, prototype-like processes, then we should expect (1) the correlation between security measured at age 1 and any other age to gradually decay to a nonzero value, (2) the test–retest correlations in childhood to be lower on average than those observed in adulthood, and (3) the stability functions later in the life course to decay to nonzero values.

We believe that a proper empirical test of attachment theory's assumptions about stability and change requires investigating these patterns of continuity. This will require a concerted effort on the part of investigators to develop methodological paradigms that allow individuals to be studied repeatedly over time. For example, it should be possible to test Bowlby's ideas by studying patterns of stability and change over brief periods of time in adulthood using Web-based technologies, diary studies, or event-sampling techniques. It is only through such work that the empirical patterns implied by Bowlby's theory can be documented and evaluated. We have tried to take a first step in uncovering such patterns by bringing together findings from a variety of studies that have examined the test–retest stability of attachment. Although these data seem to corroborate the dynamic processes entailed by Bowlby's theory, they are subject to obvious limitations (i.e., different measures, different samples). We hope future researchers will take advantage of the predictions outlined here in order to further evaluate Bowlby's ideas about human development.

NOTES

1. Although Bowlby (1973) didn't state exactly what he considered the railway destinations to represent in his analogy, it seems safe to assume that he considered them to represent alternative states of security or adjustment. For the purposes of this chapter, we assume that the railway destinations, as well as the valleys in Waddington's (1957) landscape, represent different degrees of security.
2. We use the term "trait" in its broadest sense to refer to any kind of biological or psychological quality, character, or property.

3. Davila and her colleagues have argued that some insecure people may be psychologically vulnerable and, consequently, exhibit less stability in their levels of security over time (Davila, Burge, & Hammen, 1997; Davila & Cobb, Chapter 5, this volume). There are a number of ways in which this observation can be accounted for by the prototype model. First, it is possible that, as Davila and Cobb (Chapter 5, this volume) discuss, highly insecure individuals hold multiple working models of themselves and their relationships. If this is true, insecure people will possess a greater number of potential equilibria in the dynamic space illustrated in Figure 4.13. An individual with a higher degree of such equilibria will be more likely to exhibit change, because minor fluctuations in the environment can easily knock the person out of one trajectory and into another. It is also possible that some people are more reactive to environmental fluctuations than others, and that this reactivity is correlated negatively with security. (See Fraley, Waller, & Brennan, 2000, for a psychometric interpretation of the association between insecurity and instability.)

REFERENCES

Ainsworth, M. D. S., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the Strange Situation.* Hillsdale, NJ: Erlbaum.

Arend, R., Gove, F., & Sroufe, L. A. (1979). Continuity of individual adaptation from infancy to kindergarten: A predictive study of ego resiliency and curiosity in preschoolers. *Child Development, 50,* 950–959.

Baldwin, M. W., & Fehr, B. (1995). On the instability of attachment style ratings. *Personal Relationships, 2,* 247–261.

Baldwin, M. W., Fehr, B., Keedian, E., Seidel, M., & Thomson, D. W. (1993). An exploration of the relational schemata underlying attachment styles: Self-report and lexical decision approaches. *Personality and Social Psychology Bulletin, 19,* 746–754.

Baldwin, M. W., Keelan, J. P. R., Fehr, B., Enns, V., & Koh-Rangarajoo, E. (1996). Social cognitive conceptualization of attachment working models: Availability and accessibility effects. *Journal of Personality and Social Psychology, 71,* 94–104.

Barnes, M. (1991). *"I like your style": Effects of visualization and memory on relationship attachment styles.* Unpublished honors thesis, University of Winnipeg.

Benoit, D., & Parker, K. C. H. (1994). Stability and transmission of attachment across three generations. *Child Development, 65,* 1444–1456.

Blanchard, P., Devaney, R. L., & Hall, G. R. (1996). *Differential equations.* Boston: International Thomson.

Bowlby, J. (1973). *Attachment and loss: Vol. 2. Separation: Anxiety and anger.* New York: Basic Books.

Bowlby, J. (1980). *Attachment and loss: Vol. 3. Loss: Sadness and depression.* New York: Basic Books.

Bowlby, J. (1982). *Attachment and loss: Vol. 1. Attachment* (2nd ed.). New York: Basic Books. (Original work published 1969)

Brumbaugh, C. C., & Fraley, R. C. (2004). *Transference and attachment: How do attachment patterns get carried forward from one relationship to the next?* Manuscript submitted for publication.

Caspi, A., & Roberts, B. W. (1999). Personality continuity and change across the life course. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (2nd ed., pp. 300–326). New York: Guilford Press.

Collins, N. L. (1996). Working models of attachment: Implications for explanation, emotion, and behavior. *Journal of Personality and Social Psychology, 71,* 810–832.

Collins, N. L., & Read, S. J. (1990). Adult attachment, working models, and relationship quality in dating couples. *Journal of Personality and Social Psychology, 58,* 644–663.

Collins, N. L., & Read, S. J. (1994). Cognitive representations of attachment: The structure and function of working models. In K. Bartholomew & D. Perlman (Eds.), *Advances in personal relationships: Vol. 5. Attachment processes in adulthood* (pp. 53–90). London: Kingsley.

Cozzarelli, C., Karafa, J. A., Collins, N. L., & Tagler, M. J. (2003). Stability and change in adult attachment styles: Associations with personal vulnerabilities, life events, and global construals of self and others. *Journal of Social and Consulting Psychology, 22,* 315–346.

Davila, J., Burge, D., & Hammen, C. (1997). Why does attachment style change? *Journal of Personality and Social Psychology, 73,* 826–838.

Davila, J., & Cobb, R. J. (2003). Predicting change in self-reported and interviewer-assessed adult attachment: Tests of the individual difference and life stress models of attachment change. *Personality and Social Psychology Bulletin, 29,* 859–870.

Davila, J., Karney, B. R., & Bradbury, T. N. (1999). Attachment change processes in the early years of marriage. *Journal of Personality and Social Psychology, 76,* 783–802.

Duck, S. (1994). Attaching meaning to attachment. *Psychological Inquiry, 5,* 34–38.

Feeney, J. A., & Noller, P. (1992). Attachment style and romantic love: Relationship dissolution. *Australian Journal of Psychology, 44,* 69–74.

Feeney, J. A., Noller, P., & Callan, V. J. (1994). Attachment style, communication and satisfaction in the early years of marriage. In K. Bartholomew & D. Perlman (Eds.), *Advances in personal relationships: Vol. 5. Attachment processes in adulthood* (pp. 269–308). London: Kingsley.

Fraley, R. C. (2002). Attachment stability from infancy to adulthood: Meta-analysis and dynamic modeling of developmental mechanisms. *Personality and Social Psychology Review, 6,* 123–151.

Fraley, R. C., & Roberts, B. W. (in press). Patterns of continuity: A dynamic model for conceptualizing the stability of individual differences in psychological constructs across the life course. *Psychological Review.*

Fraley, R. C., & Shaver, P. R. (2000). Adult romantic attachment: Theoretical developments, emerging controversies, and unanswered questions. *Review of General Psychology, 4,* 132–154.

Fraley, R. C., & Spieker, S. J. (2003). Are infant attachment patterns continuously or categorically distributed? A taxometric analysis of Strange Situation behavior. *Developmental Psychology, 39,* 387–404.

Fraley, R. C., & Waller, N. G. (1998). Adult attachment patterns: A test of the typological model. In J. A. Simpson & W. S. Rholes (Eds.), *Attachment theory and close relationships* (pp. 77–114). New York: Guilford Press.

Fraley, R. C., Waller, N. G., & Brennan, K. A. (2000). An item response theory analysis of self-report measures of adult attachment. *Journal of Personality and Social Psychology, 78,* 350–365.

Frazier, P. A., Byer, A. L., Fischer, A. R., Wright, D. M., & DeBord, K. A. (1996). Adult attachment style and partner choice: Correlational and experimental findings. *Personal Relationships, 3,* 117–137.

Fuller, T. L., & Fincham, F. D. (1995). Attachment style in married couples: Relation to current marital functioning, stability over time, and method of assessment. *Personal Relationships, 2,* 17–34.

Geary, D. C., & Huffman, K. J. (2002). Brain and cognitive evolution: Forms of modularity and functions of mind. *Psychological Bulletin, 128,* 667–698.

Griffin, D., & Bartholomew, K. (1994). Models of the self and other: Fundamental dimensions underlying measures of adult attachment. *Journal of Personality and Social Psychology, 67,* 430–445.

Haefner, J. W. (1996). *Modeling biological systems: Principles and applications.* New York: International Thomson.

Hammond, J. R., & Fletcher, G. J. O. (1991). Attachment styles and relationship satisfaction in the development of close relationships. *New Zealand Journal of Psychology, 20,* 56–62.

Horowitz, M. J. (1991) (Ed.). *Person schemas and maladaptive interpersonal patterns.* Chicago: University of Chicago Press.

Huckfeldt, R. R., Kohfeld, C. W., & Likens, T. W. (1982). *Dynamic modeling: An introduction.* Newbury Park, CA: Sage.

Kagan, J. (1996). Three pleasing ideas. *American Psychologist, 51,* 901–908.

Keelan, J. P. R., Dion, K. L., & Dion, K. K. (1994). Attachment style and heterosexual relationships among young adults: A short-term panel study. *Journal of Social and Personal Relationships, 11,* 201–214.

Kenny, D. A., & Zautra, A. (2001). Trait–state models for longitudinal data. In L. M. Collins & A. G. Sayer (Eds.), *New methods for the analysis of change: Decade of behavior* (pp. 243–263). Washington, DC: American Psychological Association.

Kirkpatrick, L. A., & Hazan, C. (1994). Attachment styles and close relationships: A four-year prospective study. *Personal Relationships, 1,* 123–142.

Klohnen, E. C., & Bera, S. (1998). Behavioral and experiential patterns of avoidantly and securely attached women across adulthood: A 31-year longitudinal perspective. *Journal of Personality and Social Psychology, 74,* 211–223.

La Guardia, J. G., Ryan, R. M., Couchman, C., & Deci, E. L. (2000). Within-person variation in security of attachment: A self-determination theory perspective on attachment, need fulfillment, and well-being. *Journal of Personality and Social Psychology, 79,* 367–384.

Lemery, K. S., Goldsmith, H. H., Klinnert, M. D., & Mrazek, D. A. (1999). Developmental models of infant and childhood temperament. *Developmental Psychology, 35,* 189–204.

Levy, M. B., & Davis, K. E. (1988). Lovestyles and attachment styles compared: Their relations to each other and to various relationship characteristics. *Journal of Social and Personal Relationships, 5,* 439–471.

Lewis, M. (1997). *Altering fate: Why the past does not predict the future.* New York: Guilford Press.

Lewis, M. (1999). On the development of personality. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (2nd ed., pp. 327–346). New York: Guilford Press.

Lewis, M., Feiring, C., & Rosenthal, S. (2000). Attachment over time. *Child Development, 71,* 707–720.

Lopez, F. G., & Gormley, B. (2002). Stability and change in adult attachment style over the first-year college transition: Relations to self-confidence, coping, and distress patterns. *Journal of Counseling Psychology, 49,* 355–364.

O'Leary, D. D. M., Schlaggar, B. K., & Tuttle, R. (1994). Specification of neocortical areas and thalamocortical connections. *Annual Review of Neuroscience, 17,* 419–439.

Owens, G., Crowell, J. A., Pan, H., Treboux, D., O'Connor, E., & Waters, E. (1995). The prototype hypothesis and the origins of attachment working models: Adult relationships with parents and romantic partners. In E. Waters, B. E. Vaughn, G. Posada, & K. Kondo-Ikemura (Eds.), Caregiving, cultural, and cognitive perspectives on secure-base behavior and working models: New growing points of attachment theory and research. *Monographs of the Society for Research in Child Development, 60*(2–3, Serial No. 244), 216–233.

Pierce, G. R., Sarason, B. R., & Sarason, I. G. (1992). General and specific support expectations and stress as predictors of perceived supportiveness: An experimental study. *Journal of Personality and Social Psychology, 63,* 297–307.

Pierce, T., & Lydon, J. (2001). Global and specific relational models in the experience of social interactions. *Journal of Personality and Social Psychology, 80,* 613–631.

Pietromonaco, P. R., & Carnelley, K. B. (1994). Gender and working models of attachment: Consequences for perceptions of self and romantic relationships. *Personal Relationships, 1,* 63–82.

Pistole, M. C. (1989). Attachment in adult romantic relationships: Style of conflict resolution and relationship satisfaction. *Journal of Social and Personal Relationships, 6,* 505–510.

Rakic, P. (1988, July 8). Specification of cerebral cortical areas. *Science, 241,* 170–176.

Rumelhart, D. E., McClelland, J. L., & the PDP Research Group. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition.* London: MIT Press.

Ruvolo, A. P., Fabin, L. A., & Ruvolo, C. M. (2001). Relationship experiences and change in attachment characteristics of young adults: The role of relationship breakups and conflict avoidance. *Personal Relationships, 8,* 265–281.

Scharfe, E., & Bartholomew, K. (1994). Reliability and stability of adult attachment patterns. *Personal Relationships, 9,* 51–64.

Senchak, M., & Leonard, K. E. (1992). Attachment styles and marital adjustment among newlywed couples. *Journal of Social and Personal Relationships, 9,* 51–64.

Shaver, P. R., & Brennan, K. A. (1992). Attachment styles and the "Big Five" personality traits: Their connections with each other and with romantic relationship outcomes. *Personality and Social Psychology Bulletin, 18,* 536–545.

Smith, E. R., Murphy, J., & Coats, S. (1999). Attachment to groups: Theory and measurement. *Journal of Personality and Social Psychology, 77,* 94–110.

Smith, L. B., & Thelen, E. (Eds.). (1993). *A dynamic systems approach to development: Applications.* Cambridge, MA: MIT Press.

Sroufe, L. A. (1979). The coherence of individual development: Early care, attachment, and subsequent developmental issues. *American Psychologist, 34,* 834–841.

Sroufe, L. A., Egeland, B., & Kreutzer, T. (1990). The fate of early experience following developmental change: Longitudinal approaches to individual adaptation in childhood. *Child Development, 61,* 1363–1373.

Sroufe, L. A., & Jacobvitz, D. (1989). Diverging pathways, developmental transformations, multiple etiologies and the problem of continuity in development. *Human Development, 32,* 196–203.

Tinio, E. J. (1992). *Career and relationship commitment in two university samples: The importance of self-efficacy.* Unpublished honors thesis, University of Winnipeg.

Troy, M., & Sroufe, L. A. (1987). Victimization among preschoolers: Role of attachment relationship history. *Journal of American Academy of Child and Adolescent Psychiatry, 26,* 166–172.

van Geert, P. (1994). *Dynamic systems of development.* New York: Harvester Wheatsheaf.

van Geert, P. (1997). Time and theory in social psychology. *Psychological Inquiry, 8,* 143–151.

van IJzendoorn, M. H. (1996). Commentary. *Human Development, 39,* 224–231.

Waddington, C. H. (1957). *The strategy of the genes: A discussion of some aspects of theoretical biology.* London: Allen & Unwin.

Waters, E., Merrick, S., Treboux, D., Crowell, J., & Albersheim, L. (2000). Attachment security in infancy and early adulthood: A 20-year longitudinal study. *Child Development, 71,* 684–689.

Waters, E., Wippman, J., & Sroufe, L. A. (1979). Attachment, positive affect, and competence in the peer group: Two studies in construct validation. *Child Development, 50,* 821–829.

Westen, D. (1998). The scientific legacy of Sigmund Freud: Toward a psychodynamically informed psychological science. *Psychological Bulletin, 124,* 333–371.

Wieselquist, J., Rusbult, C. E., Foster, C. A., & Agnew, C. (1999). Commitment, pro-relationship behavior, and trust in close relationships. *Journal of Personality and Social Psychology, 77,* 942–966.