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Attachment Stability From Infancy to Adulthood: Meta-Analysis and Dynamic Modeling of Developmental Mechanisms

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A central tenet of attachment theory is that a person's attachment pattern in adulthood is a reflection of his or her attachment history—beginning with the person's earliest attachment relationships. However, the precise way in which early representations might shape adult attachment patterns is ambiguous, and different perspectives on this issue have evolved in the literature. According to the prototype perspective, representations of early experiences are retained over time and continue to play an influential role in attachment behavior throughout the life course. In contrast, the revisionist perspective holds that early representations are subject to modification on the basis of new experiences and therefore may or may not reflect patterns of attachment later in life. In this article, I explore and test mathematical models of each of these theoretical processes on the basis of longitudinal data obtained from meta-analysis. Results indicate that attachment security is moderately stable across the first 19 years of life and that patterns of stability are best accounted for by prototype dynamics.

While working in a child care clinic in Britain during the early 1940s, John Bowlby was struck by the affectionless qualities of the juvenile thieves in his care and sought to uncover features of their early family histories that had influenced their emotional development (Bowlby, 1946). Unbeknownst to him, the task he was about to undertake would occupy him in various ways for the rest of his life. Bowlby's work (1969/1982, 1973, 1980) eventually led to the development of one of the most comprehensive and penetrating theories of personality development and close relationships in modern psychology, one that has had a profound influence on society, childcare policy, and the history of psychiatry (Karen, 1994; Sroufe, 1986).

In brief, Bowlby's (1969/1982, 1973, 1980) theory was designed to explain the nature of a child's tie to his or her primary caregiver and the impact of that bond on subsequent adjustment and behavior throughout the life course. Attachment theory emphasizes the critical role of early experience in shaping the expectations and beliefs a child constructs concerning the responsiveness and trustworthiness of significant others. According to the theory, a child who is exposed to responsive and consistent caregiving develops the expectation that others will be available and supportive when needed (Ainsworth, Blehar, Waters, & Wall, 1978). Such expectations, or internal working models, contribute to the way children subsequently organize their attachment behavior and can have an important impact on shaping and maintaining an individual's interpersonal dynamics.

Not surprisingly, researchers studying adult attachment have increasingly drawn on Bowlby's theory (1969/1982, 1973, 1980) as a way to organize observations about caregiving, pair bonding, and personality processes (Bartholomew & Perlman, 1994; Feeney & Noller, 1996; George, Kaplan, & Main, 1995; George & Solomon, 1999; Hazan & Shaver, 1987, 1994; Main, Kaplan, & Cassidy, 1985; Pottharst, 1990; Simpson & Rholes, 1998; Sperling & Berman, 1994; van IJzendoorn, 1995). Attachment theory has been promising in this respect because it offers a compelling way to explain why some adults are more secure, resilient, or sensitive than others. According to the theory, such psychological qualities are reflections of the way in which an individual's attachment system has become organized over the course of a lifetime, beginning with his or her earliest attachment relationships.

Unfortunately, the degree to which early attachment representations influence adult attachment patterns is unknown. Although several longitudinal studies are now available that have followed individuals from in-

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fancy to adulthood, the results of these studies are inconsistent and have generated a considerable amount of debate and discussion (e.g., Kagan, 1996; Lewis, 1997; Thompson, Lamb, & Estes, 1983; Waters, 1983; Waters, Hamilton, & Weinfield, 2000). It has been difficult to resolve this debate partly because no one has undertaken a systematic examination of the longitudinal literature on attachment stability. Theoretical arguments are often buttressed with selected citations from the literature rather than a thorough examination of the evidence (but see Thompson, 1997). Another reason why this debate has been difficult to resolve is that at least two perspectives on attachment stability have evolved in the literature, each positing a different role for early attachment representations in development and each making different predictions about the degree of long-term stability that should be observed. One perspective, which I refer to as the *revisionist perspective,* holds that early attachment representations are revised and updated in light of ongoing experience and consequently may or may not correspond to attachment representations later in life (e.g., Kagan, 1996; Lewis, 1997, 1999). This view is based on the idea that working models of attachment—including those developed early in life—are subject to change as people enter relationships that are incompatible with their previous expectations. The other perspective, which I refer to as the *prototype perspective,* also assumes that working models are updated and changed as individuals encounter new events but suggests that the representations developed in infancy remain unchanged and continue to shape interpersonal dynamics throughout the life span (e.g., Owens et al., 1995; Sroufe, Egeland, & Kreutzer, 1990). This perspective assumes that early representations are preserved over the course of development and reactivated in the context of new interactions. As such, these prototypes can contribute a constant source of variability to attachment dynamics over the life span, increasing the likelihood that attachment patterns in adulthood will reflect those observed in childhood.

Because these two perspectives have vastly different implications for understanding the role of early attachment in adult life and the degree of stability that should be expected from infancy to adulthood, it is of theoretical importance to determine which developmental process best characterizes stability and change in attachment. My primary objective in this article is to take a first step in this direction by comparing the relative veracity of the revisionist and prototype perspectives on attachment stability. To do so, I use dynamic modeling techniques (i.e., techniques for mathematically modeling stability and change; Haefner, 1996; Huckfeldt, Kohfeld, & Likens, 1982; van Geert, 1994) to reveal the precise implications of each theoretical perspective for understanding attachment stability. The predictions of each model are compared with existing data on attachment stability as culled from a meta-analysis of longitudinal studies on attachment. By comparing observed patterns of stability with the patterns predicted by each theoretical model, it should be possible to begin to uncover the basic structure of the developmental mechanisms giving rise to stability and change in attachment.

I begin by discussing the dynamics of internal working models and elaborate on their unique role in promoting stability and change according to each theoretical perspective.[1] Next, I describe the equations used to model revisionist and prototype processes and report the patterns of stability predicted by each developmental process. These predictions are compared with meta-analytic data on stability to determine which developmental mechanism best accounts for empirical patterns of attachment stability. Finally, I discuss the implications of the findings for attachment theory and personality development more generally. In the process, I hope to advance current knowledge about the degree of stability that exists in attachment security from infancy to adulthood, as well as the developmental mechanisms underlying continuity and change.

Attachment System and Internal Working Models

One of Bowlby's (1969/1982) objectives in the first volume of his *Attachment and Loss* series was to document and explain the intense distress exhibited by children who were separated from their primary caregivers. He and his colleagues (Bowlby, Robertson, & Rosenbluth, 1952; Heinicke & Westheimer, 1965) noticed that separated children frequently expressed intense anxiety and despair, often vigorously trying to regain their missing caregivers by crying, clinging, and searching. To explain these reactions, Bowlby (1969/1982) drew extensively from ethological theory, arguing that such "protest" reactions function to restore and maintain proximity to a primary attachment figure—a strategy that would be adaptive for infants born without the capacity to defend or care for themselves.

[1]It should be noted from the outset that the details of the revisionist and prototype perspectives, as I articulate them here, may or may not map on to any particular researcher's or theorist's view of personality development. Although I credit specific researchers for some of the ideas discussed, this should not be taken to imply that these researchers would agree with every point contained within one of the broader models. My portrayal of these perspectives is designed to distill some of the deeper currents underlying recent thought on attachment, stability, and development while acknowledging that theorists may differ from one another with respect to some of the finer points. By making the broader distinctions between these two classes of theorizing explicit, I hope to highlight the markedly different implications they have for explaining patterns of stability in attachment.

Bowlby (1969/1982) posited that attachment behavior was regulated by an innate motivational system—the *attachment behavioral system*—"designed" by natural selection to promote the safety and survival of infants. According to Bowlby (1969/1982), the internal dynamics of the attachment system are similar to those of a homeostatic control system in which a "set goal" is maintained by the constant monitoring of endogenous or exogenous signals and continuous behavioral adjustment. In the case of the attachment system, the set goal is physical or psychological proximity. When the child perceives the attachment figure to be nearby and responsive, he or she is generally playful, uninhibited, and sociable. However, when he or she perceives a threat to the relationship or his or her well-being, the child seeks the attention and comfort of the primary caregiver. From an ethological perspective, these dynamics facilitate proximity between child and caregiver, which helps to ensure the child's safety and protection and, ultimately, his or her reproductive fitness.

During the early months of life, the degree of security that the infant experiences depends largely on exogenous signals such as the proximate availability and responsiveness of primary caregivers. Over repeated interactions, however, children develop a set of knowledge structures, or *internal working models,* that represent those interactions and contribute to the endogenous regulation of the system (Bretherton, 1985; Bretherton & Munholland, 1999; N. L. Collins & Read, 1994; Main et al., 1985; Reite & Boccia, 1994). Importantly, these structures are thought to reflect the kinds of experiences the child has had over repeated interactions with primary caregivers. If significant others are generally warm, responsive, and consistently available, the child learns that others can be counted on when needed. Consequently, he or she is likely to explore the world confidently, initiate warm and sociable interactions with others, and find solace in the knowledge that the caregiver is potentially available (Ainsworth et al., 1978). In short, the child has developed secure working models of attachment. If significant others are cold, rejecting, unpredictable, frightening, or insensitive, however, the child learns that others cannot be counted on for support and comfort, and this knowledge is embodied in insecure or anxious working models of attachment. The child is likely to regulate his or her behavior accordingly, either by excessively demanding attention and care or by withdrawing from others and attempting to achieve a high degree of self-sufficiency (Main, 1990). (See DeWolff & van IJzendoorn, 1997, and van IJzendoorn, 1995, for meta-analyses of the effect of maternal behavior on child security.)

According to Bowlby (1969/1982) and subsequent theorists, internal working models become the primary mediators of the attachment system as children develop and come to play a substantial role in shaping and maintaining the quality of social environments (Bretherton, 1985; Main et al., 1985; Sroufe & Waters, 1977). 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 in experimental contexts (N. L. Collins, 1996; Pierce, Sarason, & Sarason, 1992; Pietromonaco & Carnelley, 1994). Such dynamics allow working models to shape the kinds of interactions the person experiences and therefore facilitate personality stability (Bartholomew & Horowitz, 1991; Bretherton, 1985; Rothbard & Shaver, 1994).

Mechanisms of Stability: Two Alternative Perspectives

Although attachment theory holds that working models developed early in life have important implications for shaping an individual's subsequent affectional relationships, the theory does not specify exactly how these representations exert their influence over time. As a result, two general perspectives or themes on this issue can be discerned in the literature on attachment. In brief, one perspective, the revisionist perspective, assumes that early attachment representations are revised and updated in light of ongoing experience and consequently may or may not correspond to later attachment representations. The other perspective, the prototype perspective, assumes that early attachment representations are retained throughout development and have an ongoing effect on attachment dynamics throughout the life course. I discuss these differences in more detail in the following section.

Revisionist Perspective

According to the revisionist perspective, working models of early attachment experiences are relatively flexible and may be revised or modified when one's experiences diverge from existing expectations. For example, if an individual expects attachment figures to be responsive to his or her needs based on early experiences, but subsequent experiences challenge this expectation, those initial expectations will be updated to reflect new experiences. In this respect, the revisionist perspective does not necessarily predict stability between infant and adult attachment patterns because the caregiving environment may change substantially over time. As many researchers have noted, factors such as parental loss, serious illness, or moving to a new town or school all have the potential to affect the quality of the caregiving environment in unpredictable ways (Kagan, 1996; Lewis, 1997, 1999; Thompson, Lamb, &

Estes, 1982; Vaughn, Egeland, Sroufe, & Waters, 1979; Waters, 1978).

Despite these opportunities for change, early expectations may persist to some degree because individuals can exert some degree of influence over their caregiving environments. That is, individuals typically select environments that are consistent with their current beliefs and expectations and elicit from others reactions that are congruent with existing working models (Arend et al., 1979; Caspi & Bem, 1990; Collins, 1996; Pierce et al., 1992; Troy & Sroufe, 1987; Waters et al., 1979). Consider an individual who has learned that others are generally unresponsive and insensitive to his needs. These expectations could lead him to interpret the actions of a new relationship partner as being motivated by a lack of care—even if the partner is behaving in a genuinely caring way. If he acts on this inference, he will, perhaps unknowingly, play a role in recreating the same interpersonal dynamics to which he is accustomed. Consequently, his working models will not be altered, or will not be altered to the same degree that they would have been otherwise.

In short, the revisionist perspective suggests that attachment patterns may be stable from infancy to adulthood, but it does not require that this be the case. Changes in maternal employment, maternal loss, or other family dynamics not directly related to a child's existing beliefs will affect the kind of experiences the child has and will produce some degree of change in his or her representations. Because early attachment representations can be revised, there is nothing intrinsically stable about the developmental processes at work (Lewis, 1997).

Prototype Perspective

One of Freud's (1940) most influential propositions was that a child's early relationship with his or her mother serves as a prototype for subsequent relationships throughout the life span. Because attachment theory was built partially on the foundation of psychoanalysis (see Bowlby, 1969/1982), it is not surprising that this theme is present in contemporary thinking about personality stability within the attachment field (Owens et al., 1995; Sroufe et al., 1990). The prototype perspective can be summarized as follows: A system (which I call a *prototype*) of nonlinguistic representations, procedural "rules" of information processing, and behavioral strategies is constructed 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 operate according to the revisionist principles discussed previously (i.e., they are continuously updated to reflect ongoing relationship experiences). However, the early prototype remains unchanged.[2] These early prototypes remain autonomous and play an ongoing role in shaping the quality of the caregiving environment.

Prototype-like dynamics have been advanced in the attachment literature by several authors. For example, N. L. Collins (1996) noted that "representations of self and others continue to evolve as individuals encounter new relationships throughout their lives. Nonetheless, attachment theory suggests that cognitive models that begin their development early in one's personal history are likely to remain influential" (p. 811). Furthermore, it has been assumed by many attachment researchers that attachment patterns should be highly consistent across different developmental periods because children are continuously drawing on patterns of behavior and belief acquired early in life (Sroufe, 1979; Sroufe et al., 1990). For example, Sroufe et al. (1990) 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. (p. 1364)

(See Owens et al., 1995, Sroufe et al., 1990, and van IJzendoorn, 1996, for further discussion of prototype-like ideas.)

Like the revisionist perspective, the prototype perspective implies that there is room for both stability and change in attachment patterns. For example, people will become more or less secure as they encounter situations that are inconsistent with their expectations, thereby leading to instability in attachment patterns. Counteracting this tendency, however, is the propensity of people to create or seek out environments that are consistent with their prototypes, thereby promoting stability. The critical theoretical difference between the revisionist and prototype perspectives lies in the fate they ascribe to representations developed early in life. The prototype perspective assumes that these early representations remain unchanged and can play a direct role in influencing relational experiences later in life. As such, the prototype can contribute a stable (i.e., unchanging) source of variance to attachment dynamics throughout the

[2]According to classical analytic theory, prototypes remain relatively unchanged because of repression. In contrast, according to attachment theory, early prototypes remain relatively unchanged because procedural, nonlinguistic forms of representation are more difficult to modify once sophisticated forms of cognition emerge. This perspective should not be confused with a "sensitive period" view in which plasticity decreases after a certain period of time, a view that I return to later in this article (Main et al., 1985). The sensitive-period-like quality of the attachment perspective is incidental to the fact that cognition becomes increasingly complex with age. The prototype is thought to remain relatively unchanged after infancy because the primary mode of thought has changed.

life span, allowing for the possibility that attachment patterns will be highly stable from infancy to adulthood. The revisionist perspective, in contrast, assumes that both early and concurrent representations are modified over time. Thus, although this perspective is capable of predicting both stability and change, the absence of an intrinsically stable mechanism implies that there is no reason to expect a high degree of stability in attachment patterns over time (Lewis, 1997). As I demonstrate in the following sections, this subtle difference in the way the two perspectives conceptualize the malleability of early representations can lead to dramatically different predictions regarding the stability of security from infancy to adulthood.

Modeling the Dynamics of Stability and Change

To determine whether the prototype or revisionist perspective best captures the developmental processes underlying attachment stability, one needs a better understanding of the unique implications of each framework. Unfortunately, it is difficult to specify the predictions of a theoretical model when it is confined to a verbal form (see van Geert, 1997). Therefore, in the next section, I formalize the assumptions of each theoretical perspective on stability as a system of dynamic linear equations and explore these equations systematically to obtain a more precise understanding of their implications (Haefner, 1996; Huckfeldt et al., 1982; van Geert, 1994). As will be discovered, the two models make unique predictions concerning the patterns of stability that should be observed over time. I exploit this fact to test the veracity of the two models. Specifically, I estimate the parameters of the revisionist and prototype models with data obtained from meta-analysis of longitudinal studies of attachment stability, and determine which model provides the best fit to the data.

Modeling Revisionist Dynamics

Before formalizing the revisionist model, I begin by making explicit three assumptions previously discussed. First, on the basis of attachment theory and research, I assume that there is variability in the security of the working models held by individuals such that some people are more secure than others.[3] Second, I assume that as an individual develops and navigates through his or her social environment, working models are updated and modified in a way that reflects the quality of experience with significant others. Third, I assume that the responses solicited from significant others will tend to be consistent with existing working models. That is, the quality of an individual's caregiving environment will be shaped to some degree by the security of his or her working models. These assumptions can be formalized with the following rudimentary difference equation:

$$S_{t+1} = S_t + \Delta S_t \qquad (1)$$

where the security (S) of an individual's working models (t = time), S_{t+1}, is a function of existing security, S_t, and a change component, ΔS_t. The change component is defined as follows:

$$\Delta S_t = \eta(E_t - S_t) + \varepsilon. \qquad (2)$$

According to this equation, the amount of change in working models is proportional to the difference or discrepancy between security at time t, S_t, and the quality of the caregiving environment (E) at time t, E_t.[4] When E_t and S_t are equivalent, ΔS_t will equal zero and security will not change ($S_{t+1} = S_t + 0 = S_t$). 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. When η is set to zero, working models are impervious to change. However, as η approaches 1.00, working models become increasingly environmentally labile. The residual term, ε, represents unidentified sources of influence on the updating process, variance that is uncorrelated with security or other environmental factors.

As noted previously, the quality of the caregiving environment is not random with respect to an individual's working models. Instead, the quality of an individual's social interactions is determined, in part, by the security of his or her working models. Equation 3, a standard regression model (McClendon, 1994) of the form $Y = \rho X + \varepsilon$, with a zero inter-

[3]Although attachment researchers have typically assumed that individual differences in security are categorically distributed at the latent and manifest levels, Fraley and Spieker (2001) and Fraley and Waller (1998) have recently shown that dimensional models provide a better fit to the data. Thus, throughout this article I work under the assumption that security is a quantitatively distributed variable (see also Cummings, 1990).

[4]It should be noted that the time index or iteration number, t, in these equations corresponds to interpersonal interactions taking place over an arbitrary unit of time. However, it might be useful for the reader to conceptualize t as being equivalent to 1 year because later in the article the model parameters are estimated under the assumption that each unit represents 1 year.

cept,[5] a weight of ρ, and a residual term ε, represents this interdependence:

$$E_t = \rho S_t + \varepsilon. \tag{3}$$

According to this equation, the environment, E_t, is determined to some degree ρ, by concurrent security S_t, and unidentified sources ε. When $\rho = 1$, the environment is completely determined by attachment security. When $\rho = 0$, the environment is unaffected by attachment security. Thus, ρ represents the degree of influence that people have in shaping their caregiving environments (i.e., by eliciting expectation-consistent behaviors from others and selecting environments consistent with existing beliefs).

These equations capture the major processes thought to support stability and change in working models throughout development. They recognize that (a) there is variation in the security of working models, (b) working models are continuously updated to some degree to reflect the responsiveness of significant others, and (c) the responsiveness of significant others is determined, in part, by the concurrent security of the individual. Although these equations simplify relational dynamics considerably, I demonstrate in a subsequent section that these rudimentary equations behave in ways that are similar to more complex models. In the next section, I consider the implications of this model for understanding stability in attachment. Later, the parameters of the model are estimated with meta-analytic data on attachment stability, and the fit of the model is evaluated.

Exploring the Dynamics of the Revisionist Model

What does the revisionist model imply about the stability of security over time? To answer this question, I systematically varied the values of ρ, the causal influence of working models on the quality of the caregiving environment, and η, the plasticity of working models. The correlation between the initial security of working models (i.e., at Time 1) and the security of working models at later time points was examined to explore the implications of the model for developmental stability. The functions mapping the correlations between Time 1 and all times (e.g., Times 1–20) are referred to as *stability functions* throughout the rest of this article. The analytical derivations of the stability functions are presented in Appendix A.

The results of this analysis are summarized in Panels A and B of Figure 1.[6] To illustrate the effects of varying ρ, I plotted in each panel the stability functions observed under five levels of ρ (0.00, 0.25, 0.50, 0.75, and 1.00). To demonstrate the effects of varying plasticity, I plotted these functions with an η value of .20 in Panel A and an η value of .80 in Panel B.

As depicted by the upper curve in each panel, when ρ is set to 1.00 (i.e., when there is a perfect association between the security of working models and the responsiveness of significant others), the stability of attachment security is perfect. However, as ρ is decreased, the stability functions drop substantially. In fact, as time increases and $\rho < 1.00$, the correlation between early security and later security always approaches 0.00. This indicates that even if people have a substantial (but not perfect) degree of influence in shaping their social interactions, there will eventually come a time when existing variability in working models is independent of initial variation.

It is also of interest to compare the functions generated when η is set to low (Panel A) and high (Panel B) values. When plasticity is high, the curves appear to decelerate more rapidly than they do when plasticity is low. Although not illustrated, it should be noted that stability is perfect when η is set to zero. When $\eta = 0$, working models are insensitive to environmental changes (see Equation 2).

Although increasing the value of η appears to make the stability coefficients decrease more slowly, note that the general form of the curves does not change as η is varied. Specifically, the correlation between security at age 1 and any age t can be modeled as α^t—regardless of the values of η and ρ. This suggests that, although η and ρ characterize the behavior of different theoretical components of the revisionist process (i.e., the plasticity of people and the effect that people have on their environments, respectively), these two components have the same effect on the stability functions.

A correlational pattern that can be described in this manner (i.e., α^t) is typically referred to as a *simplex pattern* in the educational and psychometric literatures (e.g., L. M. Collins & Horn, 1991; Kenny & Zautra, 1995, 2001). This pattern is generally thought to emerge from a process in which a variable influences itself over time. This kind of process can be modeled by a first-order autoregressive equation, such as $S_{t+1} = \alpha S_t + \varepsilon$, in which a variable, such as security, at time $t + 1$, is a weighted function of that variable at time t and residual sources of variance. It is noteworthy that the

[5]The intercept is set to zero in Equations 2 and 3 because attachment theory does not assume that people systematically increase or decrease in security over time or that the quality of caregiving environments systematically increases or decreases over time. Although recent data suggest that normative (i.e., mean) levels of security increase with age (e.g., Klohnen & Bera, 1998), the study of the stability of individual differences and mean (i.e., normative) levels of a trait are theoretically and mathematically distinct (see Caspi & Bem, 1990).

[6]All analyses were based on programs written by R. Chris Fraley in S-Plus 2000 (MathSoft, 1999).

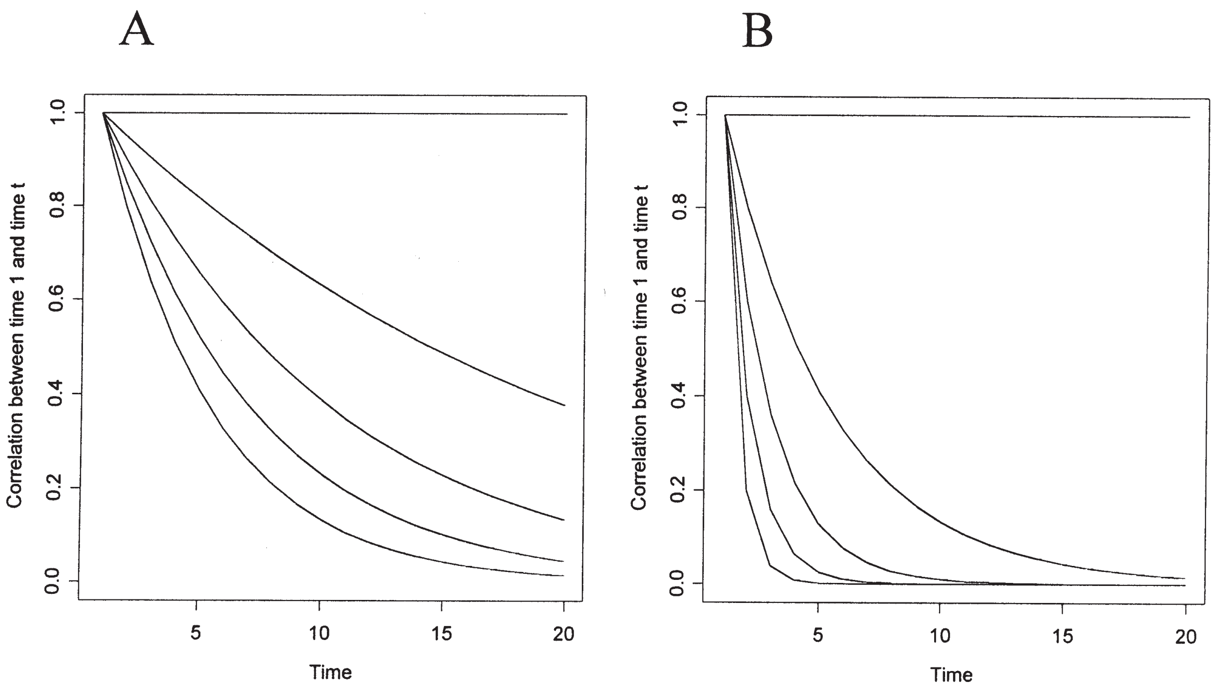

Figure 1. **Panel A presents the stability functions predicted by the revisionist model when $\eta = 0.20$ and ρ equals 0.00, 0.25, 0.50, 0.75, or 1.00 (moving from the lowermost to the uppermost curves, respectively). Panel B presents the stability functions predicted by the revisionist model when $\eta = 0.80$ and ρ equals 0.00, 0.25, 0.50, 0.75, or 1.00 (moving from the lowermost to the uppermost curves, respectively). As can be seen, the functions always approach zero when $\rho < 1.00$.**

parameter α in the first-order autoregressive equation functions in the same way as the combination of η and ρ in the revisionist model. To see why this must be the case, it is useful to rewrite (via substitution and rearrangement of terms) the revisionist equations as $S_{t+1} = (1 - \eta + \eta\rho)S_t + \eta\varepsilon_E + \varepsilon_S$. According to this equation, security is explicitly modified by a combination of η and ρ (specifically, $[1 - \eta + \eta\rho]$). Thus, a revisionist model in which $\eta = .5$ and $\rho = .5$ is identical to a first-order autoregressive equation in which $\alpha = .75$ (i.e., $[1 - .5 + .5 \times .5 = .75]$).

In light of the mathematical similarity between the revisionist model and the traditional first-order autoregressive model, it is convenient to summarize the effects of η and ρ as a single parameter for the remainder of this article. In other words, I replace the parameter $[1 - \eta + \eta\rho]$ from the original revisionist equations with α and state the revisionist model as a first-order autoregressive equation:

$$S_{t+1} = \alpha S_t + \varepsilon, \tag{4}$$

where α corresponds to the effect that security has on itself over time directly or indirectly by influencing factors that, in turn, influence security. As discussed in Appendix B, this equation captures the essential dynamics of the revisionist process, despite its simplicity. To illustrate, I have depicted the effect of α on stability functions in Figure 2. As α decreases (i.e., as the effect that the person has in shaping his or her environment decreases or as the effect that the environment has on shaping the person increases), the stability functions decay more rapidly. In all cases, however, the correlation between security at Time 1 and any time sufficiently distant approaches zero.

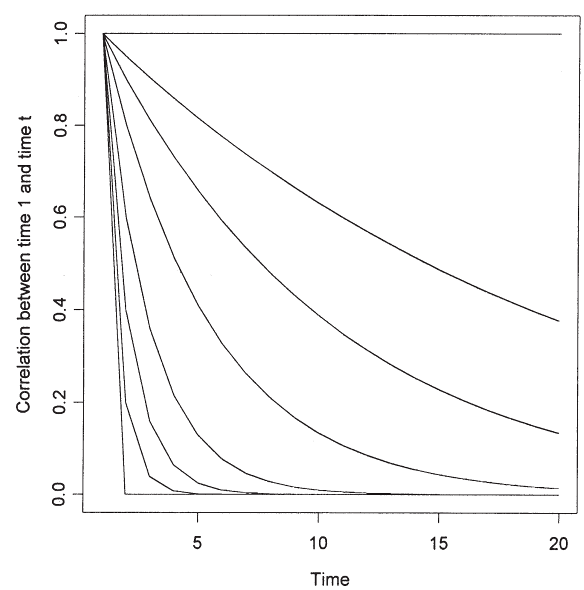

Figure 2. **Stability functions predicted by the simplified revisionist model when α equals 0.00, 0.20, 0.40, 0.60, 0.80, 0.90, 0.95, or 1.00 (moving from the lowermost to the uppermost curves, respectively). As can be seen, the functions always approach zero when $\rho < 1.00$.**

There are a number of advantages to working with a simplified version of the revisionist model. As it becomes evident later in the article when the parameters of each model are estimated, this simplification will enable us to estimate the parameters of the revisionist model uniquely. Without this simplification, one would be faced with the problem that there are many combinations of η and ρ that can produce the same stability function. For example, a revisionist curve generated by $\eta = .5$ and $\rho = .5$ is identical to a curve generated by $\eta = .625$ and $\rho = .6$ (both curves have an α value of .75). The revisionist model when stated as a first-order autoregressive equation, however, requires only one parameter ($\alpha = .75$), and, importantly, there are no other values of α that would produce the same curve. Second, stating the revisionist model in this manner helps to highlight the similarities between the kinds of processes that have been discussed by attachment researchers and processes that have been discussed in other fields (see Campbell & Kenny, 1999, for some examples).

Summary of the revisionist model. On the basis of the revisionist perspective on stability, a formal model was created incorporating the key mechanisms believed to underlie stability and change. According to the model, the correlation between initial states of security and subsequent states of security gradually approaches zero. An important finding resulting from this analysis was that the stability curves approach zero even when people play an active role in shaping their social environments. Increasing ρ delays the time at which the limiting value of zero is approached but does not affect the limiting value itself. Another important observation resulting from this analysis was that the two key parameters of the revisionist model have the same effect on the stability functions (i.e., both parameters affect the rate at which the curves decay). This implies that revisionist processes can be represented more conveniently as a one-parameter, autoregressive model.

Modeling Prototype Dynamics

The prototype model requires three assumptions. The first two overlap with those of the revisionist model: (a) there is variability in the security of the working models held by individuals such that some people are more secure than others and (b) as an individual develops and navigates through his or her social environment, working models will be updated and modified on the basis of the quality of experiences with significant others. In addition to these two assumptions, the prototype model assumes that the responses elicited from significant others will be driven partly by early representations (i.e., one's prototype of relationships). These assumptions can be formalized with some minor modifications to Equation 3:

$$E_t = \rho_1 S_1 + \rho_2 S_t + \varepsilon. \quad (5)$$

According to this equation, the quality of the environment, E_t, is always determined to some degree, ρ_1, by security at Time 1 (i.e., the prototype), S_1, and to some degree, ρ_2, by concurrent security, S_t. As discussed in detail in Appendix B, this equation can be simplified as follows:

$$E_t = \rho S_1 + \varepsilon. \quad (6)$$

This equation behaves in the same way as Equation 5, so I work with this equation for the remainder of the article. Nonetheless, it is important to keep in mind that the prototype model does not formally exclude the role of concurrent security in social dynamics.

As before, Equations 1 and 2 are used to revise working models according to the discrepancy between the environment and concurrent security, S_t. Thus, although security, S_t, continues to be updated and revised over time, the prototype, S_1, is not revised and continues to exert an influence on social interactions.

These simple equations capture the primary mechanisms thought to support stability within the prototype framework. They recognize that (a) there is variation in the security of working models; (b) working models are continuously updated to reflect the responsiveness of significant others; and (c) the responsiveness of significant others is determined, in part, by stable, autonomous representations of early childhood experiences. In the next section, I explore the implications of the prototype model for understanding stability in attachment across time.

Exploring the Dynamics of the Prototype Model

In these analyses, the effect of attachment prototypes on the quality of the caregiving environment, ρ, and the plasticity of working models, η, was varied. The analytic solution for prototype stability functions is described in Appendix A. The results of the analyses are summarized in Panels A and B of Figure 3. To illustrate the effects of varying ρ, I have graphed in both panels stability functions for five levels of ρ (0.00, 0.25, 0.50, 0.75, and 1.00). To demonstrate the effects of varying plasticity, I have graphed these functions with an η value of .20 in Panel A and an η value of .80 in Panel B.

As depicted by the upper curve in each panel, when ρ is set to 1.00 (i.e., when there is a perfect association between prototypes and the responsiveness of significant others), stability of working models is perfect. The sta-

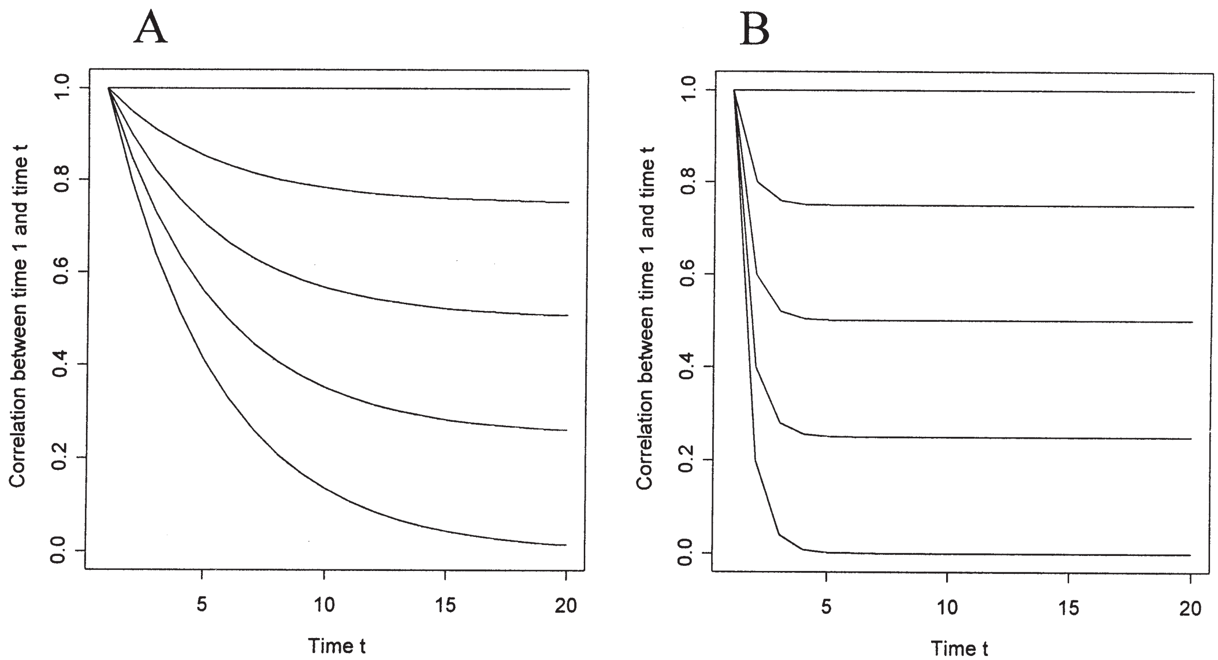

Figure 3. Panel A presents the stability functions predicted by the prototype model when $\eta = 0.20$ and ρ equals 0.00, 0.25, 0.50, 0.75, or 1.00 (moving from the lowermost to the uppermost curves, respectively). Panel B illustrates the stability functions predicted by the prototype model when $\eta = 0.80$ and ρ equals 0.00, 0.25, 0.50, 0.75, or 1.00 (moving from the lowermost to the uppermost curves, respectively). As can be seen, the functions always approach a nonzero value when $\rho > 0.00$.

bility curves systematically drop, however, as this parameter is decreased. Importantly, the form of the stability functions differs substantially from that observed under the revisionist model. The only case in which the stability functions approach zero is when ρ is set to 0.00. In all other cases, the stability functions plateau at values greater than zero. Specifically, the curves approach their corresponding ρ values. For example, when ρ is set at 0.25, the correlation between early security and later security approaches 0.25. When plasticity or η is set to a low value, the curves approach their limiting value more slowly (see Figure 3, Panel A) than they do when η is set to a high value (see Figure 3, Panel B). Although not illustrated, stability is perfect when plasticity is set to zero because working models are unresponsive to environmental change when η equals zero (see Equation 2).

These curves indicate that, if the prototype model is correct, then 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 that made by the revisionist model, which indicated that the stability correlations should always approach zero when α is less than 1.00.

Summary of the prototype model. Based on the prototype perspective, a dynamic model was created that incorporates the key mechanisms responsible for stability and change in working models throughout development. According to the model, early prototypes of attachment relationships are activated in the context of new experiences and contribute to the quality of those interactions. These interactions in turn affect the ongoing dynamics of attachment relationships. Analyses indicate that the prototype model is capable of predicting a nonzero degree of stability between early and later attachment patterns, as long as prototypes have a nonzero causal effect on the quality of social interactions and there is a nonzero degree of plasticity in working models.

Variations of Model Assumptions

Although the present formalizations of the prototype and revisionist processes provide relatively parsimonious ways to model attachment dynamics, it should be noted that these models represent simplifications of the theoretical processes in question. Several assumptions were made in these modeling efforts to keep the modeling as simple as possible. First, in formalizing the prototype model, I explored an equation (Equation 6) that assumed that only early security, rather than early and concurrent security, shapes the caregiving environment. Theoretically, however, I assume that both processes operate simultaneously, as represented in Equation 5. Second, I assumed that plasticity, η, is the same value for all individuals. However, it is possible that plasticity is an individual difference variable such that some people are more resistant to change than others (Davila, Burge, & Hammen, 1997; but see Fraley, Waller, & Brennan, 2000). Third, it may be that plasticity decreases over time such that people become more resistant to change as they get older. Also, it may be the case that there is variability in the degree to which working models interact with the environment over time such that the effects of security on the social environment are stronger at some ages and weaker at others.

I chose to focus on the simplified versions of these theoretical models because mathematical analyses indicate that the simplified versions give rise to patterns of stability that are virtually identical to those resulting from models with more complex assumptions. Hence, in this article I have focused on the most parsimonious formulation of the models for ease of explication. A complete discussion of these issues is presented in Appendix B, but I summarize briefly the key points here. First, a "mixed" model that incorporates both revisionist and prototype processes behaves the same as the simplified prototype model. Second, when plasticity is allowed to vary as an individual difference variable, the same patterns discussed previously emerge. Third, versions of the models that allow plasticity to decrease over time behave the same as the original models unless plasticity is allowed to decrease to zero, at which point both the revisionist and prototype models produce stability functions that asymptote at values greater than zero. Finally, if one assumes that the various parameter values vary across ages, the two models continue to make the same pattern of predictions unless the parameters are set to extreme and unrealistic values at one or more time points (e.g., the effect of security on the social environment is perfect at one or more time points). These results are important because they indicate that the simplifying assumptions of the models will not occlude the ability to elucidate the basic dynamics of each process. The rudimentary models, despite their simplicity, are capable of distilling the essential properties of each process.

It is noteworthy that the statistical behavior of these models is similar to that of other mathematical models of change that have been discussed in literature. For example, the pattern of correlations implied by the revisionist model is comparable to that implied by a variety of autoregressive models that have been studied in education and psychology (see L. M. Collins & Horn, 1991). As noted previously, autoregressive models involve variables that influence themselves over time, and, as a general rule, these models predict that the correlation between a variable and itself measured at different points in time will decrease as the interval between measurements increases.

The pattern of correlations generated by the prototype model is similar to that implied by variants of the "trait-state-error" model discussed by Kenny and Zautra (1995, 2001). The trait-state-error model, like the prototype model, is capable of predicting stability functions that plateau at nonzero values due to the influence of a stable, trait-like factor. As with the prototype model, the plateau emerges in the trait-state-error model because an unchanging source of variance is contributing to the variable in question at each point in time.

The reader may find it useful to conceptualize the two-parameter revisionist model and classic first-order autoregressive models as belonging to a broader class of models with autoregressive properties, whereas the prototype model and specific variants of Kenny's (Kenny & Zautra, 1995, 2001) trait-state-error model that involve the trait component can be viewed as belonging to a broader class of models that contain constant sources of variance. Conceptualizing the models in this manner should help to underscore some of the mathematical similarities between processes that have been described in independent literatures.

Summary of the Model Analyses

Several analyses were conducted to explore, in a systematic manner, the theoretical implications of the revisionist and prototype models of attachment stability. These frameworks have some unique implications when examined formally. Specifically, the revisionist model predicts that the correlation between Time 1 and subsequent times will approach zero even when people have a substantial degree of influence on their social worlds. This discontinuity occurs because representational models are continuously revised and updated to reflect the caregiving environment. To the extent that the caregiving environment contains variance unrelated to existing representations, working models will eventually become saturated with variance that is independent of initial states of security. The prototype model was able to predict nonzero levels of stability between early attachment patterns and adult attachment patterns. Specifically, the analysis indicate that the correlation between early security and security at each subsequent age will reach a nonzero asymptote (when ρ is set to a nonzero value). Thus, the correlation between security at Time 1 and Time 10 can be just as large as the correlation between security at Time 1 and Time 20.

Testing the Revisionist and Prototype Models

To determine which model provides a better approximation to the developmental processes underlying attachment stability, I conducted a meta-analysis of existing longitudinal data on attachment stability and used these data to estimate and evaluate each model. Recall that the revisionist and prototype models make different predictions about the form of the functions mapping security in early life to security in later life. Specifically, the revisionist model predicts that the stability functions always approach zero. The prototype model dictates that the stability functions always plateau at a nonzero value.[7] Thus, by examining patterns of attachment over time, as estimated through meta-analysis, it should be possible to determine which model of personality development provides a better account of stability and change in attachment.

Meta-Analysis of Attachment Stability Data

The meta-analysis proceeded in three major steps. In 1999 I 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 (see Table 1).[8] A discussion of the various assessment techniques and can be found in the reviews by Hesse (1999) and Solomon and George (1999), as well as the original articles themselves. Twenty-seven samples were obtained through PsycINFO (American Psychological Association, 1971–1998) computer searches, consultation with attachment researchers, and cross-referencing of articles as the database developed. I relied extensively on consultation and cross-referencing in an attempt to include all relevant studies, including so-called file drawer studies (i.e., studies that are not published or submitted for publication due to statistically nonsignificant results; Rosenthal, 1979). It should be noted, however, that as of the time of this writing, all but one of the included studies has been published or accepted for publication. In other words, there do not appear to be any file drawer studies on the stability of attachment. There are several reasons why this may be the case. First, the majority of studies on attachment are designed to test hypotheses about the association of attachment patterns with various developmental outcomes. Very few studies focus on the stability of attachment per se, and consequently, there are few reasons to file a study away based on the stability findings alone. Second, as I discuss later, there are a number of studies in the literature that show little to no stability in attachment patterns, as well as a few that show remarkably high levels of stability. In light of these observations, it seems unlikely that a researcher would choose to file a study away based on the results per se because there does not seem to be a bias toward the publication of studies that favor one outcome (e.g., high stability) over another (e.g., low stability). Finally, the financial investment and time required to conduct longitudinal research would seem to deter investigators from filing away stability results. Furthermore, the rarity of such research makes it unlikely that large-scale longitudinal studies on attachment exist that have not been identified.

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, I 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). For the purposes of this article, 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.

It is noteworthy that the Time 2 assessments for the studies reported in Table 1 tend to clump around five temporal intervals. For example, 15 of the studies reassessed attachment security between 18 and 20 months of age (approximately 2 years of age). This temporal clumping is probably due to the fact that there are a limited number of methods for assessing security beyond 18 months of age. The strange situation is not a valid assessment of security after 20 months (Solomon & George, 1999). Furthermore, there are no standard methods for assessing security between late childhood and early adolescence, although Main and her colleagues have developed procedures for assessing security in 6-year-olds (Main & Cassidy, 1988; Main et al., 1985) and adults (George et al., 1995; Main, 1995). Because the Time 2 assessments of security clustered around five rough temporal periods (Ages 1, 2, 4, 6, and 19), each sample was classified as belonging to one of these five temporal groups. The stability coefficient for each of the five reassessment times was estimated by averaging the stability coefficients (with the appropriate Fisher's r-to-z transformations) within each temporal group.

The estimated stability coefficients and various summary statistics within each temporal group are reported in Table 2. Although I have reported estimates that are weighted and unweighted by sample size, for the remainder of this article I focus on the weighted es-

[7]More precisely, the functions will always plateau at a nonzero value when ρ is set to a value greater than zero. Because it is reasonable to assume that working models have a nonzero effect on interpersonal behavior, I do not make this qualification explicit throughout the remainder of the article.

[8]Only studies using the standard strange situation procedure at 12 months of age were employed in the meta-analysis because several investigators (e.g., Sroufe, 1990) have questioned the validity of measurements taken from modified versions of the strange situation procedure. As a result, several studies with informative data were not included in the meta-analysis because they did not employ the standard strange situation procedure at 12 months of age: Bretherton, Ridgeway, and Cassidy (1990); Connell (1976); Easterbrooks (1989); Lewis, Feiring, and Rosenthal (2000); NICHD Early Child Care Research Network (in press); and Takahashi (1990). Readers are referred to these studies for further information. Note that the conclusions drawn in this article are the same regardless of whether these studies are included in the analyses.

Table 1. *Longitudinal Studies Included in the Meta-Analysis of Attachment Stability*

Study	First Assessment	Second Assessment	N	Risk Status	r
Temporal Group: Age 1–Age 1					
Goossens, van IJzendoorn, Tavecchio, & Kroonenberg (1986)	12 months	13 months	9	Low	1.00
Temporal Group: Age 1–Age 1.5					
Belsky, Campbell, Cohn, & Moore (1996)					
Sample 1	12 months	18 months	90	Low	–.03
Sample 2	12 months	18 months	120	High	.04
Egeland & Farber (1984)	12 months	18 months	189	High	.32
Egelund & Sroufe (1981)					
Sample 1	12 months	18 months	25	High	.33
Sample 2	12 months	18 months	32	Low	.67
Frodi, Grolnick, & Bridges (1985)	12 months	20 months	38	Low	.13
Howes & Hamilton (1992a)	12 months	19 months	23	Low	.49
Jacobsen, Huss, Fendrich, Kruesi, & Ziegenhain (1997)	12 months	18 months	32	Low	.31
Lyons-Ruth, Repacholi, McLeod, & Silva (1991)	12 months	18 months	46	High	–.03
Owen, Easterbrooks, Chase-Landsale, & Goldberg (1984)	12 months	20 months	59	Low	.57
Main & Weston (1981)	12 months	18 months	15	Low	.46
Schneider-Rosen, Braunwals, Carlson, & Ciccheti (1985)	12 months	18 months	29	High	.39
Thompson, Lamb, & Estes (1982)	12.5 months	19.5 months	43	Low	–.03
Vaughn, Egeland, Sroufe, & Waters (1979)	12 months	18 months	100	High	.37
Waters (1978)	12 months	18 months	50	Low	.92
Temporal Group: Age 1–Age 4					
Howes & Hamilton (1992b)					
Sample 1	12 months	42 months	72	Low	.22
Sample 2	12 months	48 months	89	Low	.45
Temporal Group: Age 1–Age 6					
Ammaniti, Speranza, & Candelori (1996)	12 months	5 years	20	Low	.56
Jacobsen, Huss, Fendrich, Kruesi, & Ziegenhain (1997)	12 months	6 years	32	Low	.37
Main, Kaplan, & Cassidy (1985)	12 months	6 years	40	Low	.76
Wartner, Grossman, Bombik-Fremmer, & Suess (1994)	12 months	5–6 years	39	Low	.79
Temporal Group: Age 1–Age 19					
Hamilton (2000)	12 months	17–19 years	30	High	.50
Main (in press)	12 months	19 years	38	Low	.50
Waters, Merrick, Treboux, Crowell, & Albersheim (2000)	12 months	21 years	50	Low	.45
Weinfield, Sroufe, & Egeland (2000)	12 months	19 years	57	High	.10
Zimmerman, Fremmer-Bombik, Spangler, & Grossman (1997)	12 months	16 years	43	Low	–.14

Note: The strange situation was used to assess security at 12 months of age. The method for assessing attachment security at the second point in time varied, and readers are referred to the original articles for more information. Risk status refers to whether or not the sample was considered to be at high risk for instability.

timates (Hedges & Olkin, 1985, p. 230–232). These coefficients start off high (the Age 1 test–retest correlation is 1.00) and appear to decrease rapidly to a nonzero plateau. The one exception to this pattern is the Age 6 assessment studies that generally reported exceptionally high stability coefficients.

Table 2. *Summary Statistics for Meta-Analytic Data on Attachment Continuity*

Temporal Group	Weighted *r*	Unweighted *r*	*SD r*	*Mdn n*	*Total n*
Age 1–Age 1	1.00	1.00	.00	9	9
Age 1–Age 1.5	.32	.38	.28	43	896
Age 1–Age 4	.35	.34	.16	81	161
Age 1–Age 6	.67	.65	.20	36	131
Age 1–Age 19	.27	.30	.29	43	218

Note: *Weighted r* is the average test–retest coefficient for each temporal group, with each study's *r* weighted by its sample size.

Estimating and Testing the Revisionist and Prototype Models

To determine which theoretical model provides the best fit to the meta-analytic data, the key parameters of each model were estimated using grid search techniques. Specifically, stability functions were generated for each model by varying the values of each parameter from 0.00 to 1.00 in increments of 0.01. A combination of values was sought that minimized the squared deviation between the predicted values of the model and the meta-analytic data. The best estimate of α for the revisionist model was 0.80. For the prototype model, the best estimates of ρ and η were 0.39 and 1.00, respectively. The best-fitting prototype model was better able to account for the data (mean square error [*MSE*] = .022; R^2 = .78) than the best-fitting revisionist model (*MSE* = .084; R^2 = .17). The corresponding best-fitting curves generated by each model are presented in

Figure 4. Notice that the prototype curve predicts a stability asymptote equivalent to a correlation of .39.

Although the prototype model provides a better fit to the data than the revisionist model, it is worth noting that the fit is far from perfect. The error bars around each data point in Figure 4 illustrate the 95% confidence intervals for each meta-analytic average (Cooper, 1998, p. 140; Hedges & Olkin, 1985, p. 231). Figure 3 also shows 95% confidence intervals representing the upper and lower bounds of the stability functions that would be expected, over the long-run, given the estimated parameters of each model and a sample size of 40 (the median sample size across the studies in the meta-analysis).[9] It is noteworthy that the Age 6 data are outside of the range of values predicted by the estimated prototype model (see Panel B). Thus, either the model is fundamentally flawed because it cannot account for the Age 6 data, or the Age 6 data overestimate the true degree of stability in attachment.[10] If the prototype model is estimated without the Age 6 data, it provides an excellent fit to the data (*MSE* = .002; R^2 = .98) and yields parameter estimates similar to those estimated when the Age 6 data are included ($\rho = 0.29$ and $\eta = 0.96$). Both the Age 2 and Age 6 data fall outside the range of expected values for the revisionist model (see Panel A).[11,12]

Summary of the Findings

A meta-analysis of the existing longitudinal data on attachment stability was conducted to test the relative veracity of the revisionist and prototype models of attachment stability. The prototype model provided the best fit to the data, indicating that a prototype-like process may contribute to attachment stability across the life course. The estimated model indicates that early prototypes exert a moderate influence on subsequent interactions ($\rho = 0.39$) and that these interactions are easily incorporated into concurrent beliefs about the world ($\eta = 1.00$). Furthermore, the prototype model predicts that the continuity between early attachment security and attachment security at any point later in the life course will be equivalent to a correlation of approximately .39. In summary, there is a moderate degree of stability in attachment from infancy to adulthood, and the pattern of stability observed is better accounted for by a prototype-like process than a revisionist one.

General Discussion

One of the major themes of attachment theory is that the way we think, feel, and behave in our adult relationships is a reflection of our attachment history. However, the precise ways in which that history influences our relationship patterns is unknown. In this article I have focused on two hypotheses concerning the mechanisms underlying attachment stability. According to the prototype hypothesis, representations of early experiences are retained and continue to play an influential role in attachment behavior throughout the life course. In contrast, the revisionist hypothesis holds that early representations are subject to revision on the basis of new experience and therefore may or may not reflect patterns of attachment later in adulthood.

[9]These confidence intervals were calculated on the basis of the standard error of the model-implied correlation at each point. In other words, the interval captures the range of data that should be expected 95% of the time, given the estimated parameter values and a sample size of 40.

[10]It is unclear why the stability coefficients for Age 1 to Age 6 are so high, especially in light of the fact that many of the stability coefficients over shorter periods of time (i.e., age 12–18 months) are lower. One possibility is that the Age 6 assessments were conducted with more care and precision than some of the assessments conducted for the other time intervals. Another possibility is that there are fewer factors uncorrelated with attachment (i.e., residuals in the models) influencing attachment at age 6. Unfortunately, there is no way to move beyond cautious speculation at this time. Nonetheless, it is important to draw attention to the magnitude of these coefficients so that future research may be undertaken to uncover their significance.

[11]It is possible that these results could change substantially if a single new study was added. I evaluated this possibility by conducting a series of simulations in which I systematically added a new hypothetical study of $N = 40$ (the median sample size across studies in the meta-analysis) with extreme results (i.e., a stability coefficient of $r = .99$ or $r = .00$) at each of the critical four temporal groups (i.e., Ages 2, 4, 6, and 19). When I did this, the results were practically unchanged, suggesting that the number of studies included in these analyses are sufficient for obtaining stable results. For example, adding a study with a stability coefficient of .00 to the 2-year-old temporal group decreases the meta-analytic estimate from .32 to .31. The changes in the other age groups were also small. By adding a new study with a coefficient of zero, the meta-analytic stability coefficients dropped from .35 to .29 for the Age 4 group, .67 to .55 for the Age 6 group, and .27 to .23 for the Age 19 group. Furthermore, the prototype model continued to outperform the revisionist model even when these extreme simulated findings were added to the database.

[12]As one reviewer noted, the revisionist model predicts a highly constrained pattern of correlations—a pattern that is typically referred to as a *simplex* in the educational and psychometric literatures (see L. M. Collins & Horn, 1991; Kenny & Zautra, 1995, 2001). When measurement errors are added to this kind of model, however, the pattern of correlations is less constrained (*quasi-simplex;* see Campbell & Kenny, 1999). Thus, it is possible that a revisionist model that modeled measurement errors might be possible of accounting for the data just as well as the prototype model. To explore this issue, I studied the behavior of a revisionist model that incorporated measurement errors. Because research on the psychometric properties of the different measures used in this meta-analysis tend to suggest that the ratio of true score to observed score variance is (a) pretty high (about .80) and (b) invariant across tasks (e.g., the strange situation, the Adult Attachment Interview [AAI]; Main, Kaplan, & Cassidy, 1985), I constrained (a) the reliability of the measurements to fall between 0.80 and 1.00 and (b) the reliability of the measurements to be equal across ages. Using these constraints, the best-fitting model ($\alpha = 0.89$, reliability = 0.80, $R^2 = .38$) did not fit the data as well as the prototype model ($R^2 = .78$). In short, even when measurement errors are incorporated into the revisionist model, the model is still not capable of explaining the data as well as the prototype model.

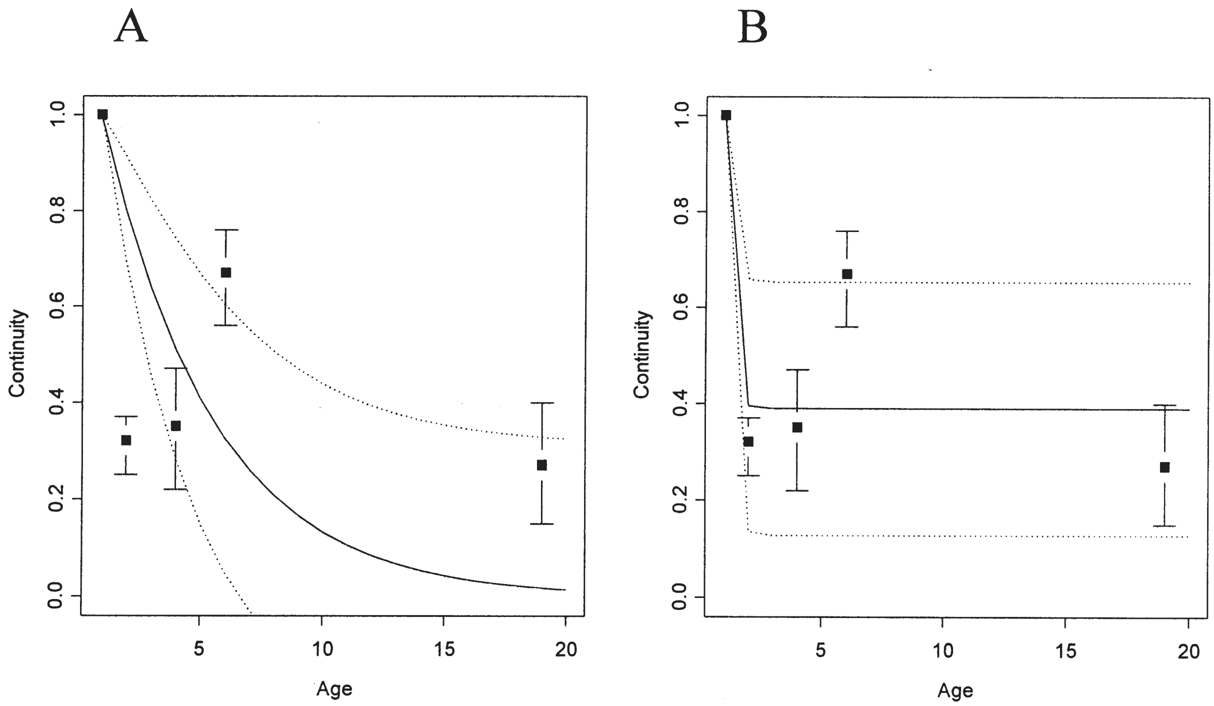

Figure 4. **Meta-analytic correlations between attachment security assessed at Age 1 and Ages 1, 2, 4, 6, and 19, and the best-fitting curves predicted by the revisionist (Panel A) and prototype (Panel B) models. The error bars around each meta-analytic correlation correspond to 95% confidence intervals. The dashed lines correspond to the range of values that would be predicted 95% of the time given the parameter estimates for each model and a sample size of 40. As can be seen, the curve generated by the prototype model ($\rho = 0.39$, $\eta = 1.00$) provided a better fit ($R^2 = .78$) to the data than the curve generated by the revisionist model ($\alpha = .80$, $R^2 = .17$).**

A formal model of each theoretical perspective was developed and the implications of each were systematically examined. It was discovered that the revisionist process is not sufficient to account for long-term stability. Even if working models help to mold the social environment in a way that is consistent with existing beliefs and expectations, the vicissitudes of life guarantee that there will eventually come a point in development when little correlation exists between early and later patterns of security. In contrast, the prototype process was able to predict stability in attachment patterns across long periods of time, thereby providing a viable mechanism for personality stability across the life span.

The unique predictions of each model were compared with empirical data from a meta-analysis of existing longitudinal studies on attachment. The prototype model provided a better fit to the meta-analytic data than the revisionist model, suggesting that a prototype-like process may underlie the dynamics of attachment stability. The estimated prototype model indicates that working models of attachment are remarkably plastic over the course of a year (the estimated value of η was 1.00). However, despite this plasticity, the model indicates that people are unlikely to change substantially because early prototypes continue to play an enduring and powerful role in shaping people's caregiving environments (the estimated value of ρ was 0.39). In fact, the estimated prototype model indicates that the true degree of attachment stability between age 1 and subsequent ages is roughly equivalent to a correlation of .39.

Several questions follow from these findings. First, if one assumes momentarily that a prototype-like process underlies attachment dynamics, how might prototypes develop and how might they exert a stable influence on development in the face of experiential variability? Second, what are the implications of prototype dynamics for understanding continuity and change in attachment? Third, to what extent do early prototypes contribute to stability across different kinds of attachment relationships? In other words, does the relatively high degree of stability observed in child–parent attachment necessarily suggest that high stability will exist between early attachment patterns and adult romantic attachment patterns?

Retention of Early Representational Structures

According to Bowlby (1980) and other attachment theorists (e.g., Sroufe et al., 1990), representations constructed during the first year of life are pre-verbal in nature. They consist of basic emotional reactions (e.g., visceral reactions) and behavioral response tendencies (e.g., unconditioned and conditioned responses) and do not require conscious mediation for their acquisition or execution. As such, the content and organization of these representations may be more difficult to access or modify later in childhood when conscious thought becomes increasingly linguistic. As more complex cognitive processes emerge in development, it is possible that the kinds of representations that are constructed become functionally autonomous from the older representations on which they are built. These consciously accessible models may be activated and updated or revised without substantially affecting the ontogenetically older structures.

Students of learning and memory have long made a similar distinction between procedural and declarative knowledge to account for dissociations in the cognitive performance of individuals without and with amnesia (Squire, 1987). *Procedural knowledge* is a term used to characterize memory for skills, habits, and actions that are relatively implicit and difficult to articulate or describe. *Declarative knowledge* is a term used to characterize memory for episodic and semantic information that is available for conscious retrieval and manipulation. Importantly, evidence indicates that declarative memory develops later than procedural memory (Parkin, 1997), thereby allowing basic emotional and behavioral response patterns to form independently of declarative memory systems. Several authors have suggested that the delayed development of declarative memory is the basis for infantile amnesia—the inability of older children and adults to recall episodic memories from the first few years of life (Mandler, 1984; Nadel & Zola-Morgan, 1984; Perner & Ruffman, 1995; Pillemer, 1998; Schacter & Moscovitch, 1984; but see McDonough & Mandler, 1994, and Nelson, 1994, for evidence of other forms of retention).

Research on the development of procedural and declarative memory is consistent with the idea that early attachment experiences may be represented in a form functionally autonomous from the declarative structures that develop when more complex cognitive capacities emerge. However, is there any evidence that knowledge acquired early in learning can continue to play an influential role in behavior despite changes in one's learning history? Experimental research on behavioral extinction in nonhuman animals indicates that conditioned associations can remain intact after a series of extinction trials in which the conditioned stimulus is repeatedly presented without an aversive consequence. Evidence for this inference comes from the observation that a single presentation of a conditioned stimulus after extinction is sufficient for reinstating the original response at levels comparable to those observed prior to extinction (Bouton & Bolles, 1979; Rescola & Heth, 1975). Importantly, response recovery can occur as long as 1 year after extinction of the response (McAllister & McAllister, 1988). Such findings provide compelling evidence that initial representations or associations remain intact despite changes in learning history.

Research on eyewitness testimony has repeatedly documented the fallibility of human memory in response to misleading information. Early research in this area demonstrated that people often misremember events when they are later exposed to inaccurate information about those events (Loftus & Palmer, 1974). These findings gave rise to a theoretical debate concerning whether false information "overwrites" memory for the original events or impairs the accurate retrieval of memory for the original events (Beli, Windschitl, McCarthy, & Winfrey, 1992; Loftus & Loftus, 1980; McCloskey & Zaragoza, 1985)—a debate that is not all that different from the one discussed here with respect to early attachment representations. Recent evidence suggests that some memory for the original events is retained, at least implicitly, even when explicit recollection of the events is inaccurate (Loftus, Feldman, & Dashiell, 1995). Moreover, contemporary theoretical models of attitude change suggest that explicit attitudes may change easily in the face of conflicting evidence, whereas implicit attitudes remain the same (Wilson, Lindsey, & Schooler, 2000).

In conjunction, these findings lend credence to the idea that early representations of attachment experiences may (a) develop independently of complex (verbal, declarative, or conscious) modes of representation, (b) continue to exert an enduring influence on attachment behavior, and (c) remain resistant to change in the face of environmental variability and modifications to declarative or explicit knowledge structures. Nonetheless, more research is needed to investigate the development and operation of such structures in the context of attachment relationships.

The Dynamics of Stability and Change in Attachment Security

Previous authors (Owens et al., 1995; van IJzendoorn, 1996) have argued that, if the prototype model is correct, then a high degree of stability in attachment patterns should be observed between infancy and adulthood. However, as the simulations reported here indicate, this is not necessarily true. Prototype-like processes can give rise to high or low—but stable—patterns of continuity, depending on how much of an influence people have on their environments (see Figure 3). Such influence is likely to be attenuated under conditions characterized by relational discord, economic hardship, and abuse. Nonetheless, such conditions should not alter the fundamental nature of the developmental processes giving rise to continuity and change. To examine further this possibility in the present data set, each sample was coded for whether it was characterized by risk factors such as family instability, marital discord, and abuse (see Table 1). The point-biserial correlation between risk status and stability was –.23, indicating that samples characterized by such risk factors exhibited less stability than other samples. When the revisionist and prototype models were estimated separately within each kind of sample, the prototype model provided a better fit than the revisionist model in each case.[13] However, as might be expected, the estimated value of ρ for the prototype model was smaller in the at risk sample ($\rho = 0.27$, $\eta = 1.00$) than in the not at risk sample ($\rho = 0.48$, $\eta = 1.00$; see Figure 5). Environmental risks and changes appear to reduce the degree to which people can exert an influence on their environment but do not appear to alter the underlying dynamics of continuity and change.

Given that the prototype model can predict high or low stability, how can researchers best characterize dynamics of stability and change for a single individual? Recall that both the revisionist and prototype models of attachment share some important features. According to both models, change in security is a function of the discrepancy between security at any one time, S_t, the quality of the environment, E_t, and residual variance (see Equations 1 and 2). What differentiates the models are their respective explanations of how early working models shape the caregiving environment. As researchers, we can ask two questions about the dynamics of these basic processes that will help us understand patterns of attachment stability. First, what is the form of the equilibrium solution to the equations? In other words, at what point will an individual's level of security stop changing? Second, is the equilibrium stable? That is, when security levels are temporarily perturbed, will security converge toward or diverge from the equilibrium value?

To address the first question, reconsider Equation 2 from an ideographic perspective. When an individual is in a steady state or equilibrium state, change in security, ΔS_t, will equal zero and security, S_t, will be constant. Thus, Equation 2 can be rewritten as follows:

$$0 = \eta(E_t - S^*), \tag{7}$$

where S^* denotes the equilibrium value of security. (I have removed the residual term, ε, because the expected value of the residual is zero.) To determine the equilibrium value, Equation 7 can be solved for S^*

[13]The meta-analytic correlations for each of the five temporal intervals for the not at risk sample were as follows: $r_{\text{Age 1, Age 1}} = 1.00$, $r_{\text{Age 1, Age 2}} = .40$, $r_{\text{Age 1, Age 4}} = .35$, $r_{\text{Age 1, Age 6}} = .67$, and $r_{\text{Age 1, Age 19}} = .48$. The correlations for the at risk group were as follows: $r_{\text{Age 1, Age 1}} = 1.00$, $r_{\text{Age 1, Age 2}} = .26$, and $r_{\text{Age 1, Age 19}} = .28$. Note that the correlation between Age 1 and Age 1 was assumed to be 1.00 in the at risk sample even though no studies were available to estimate this correlation. Also, because there were relatively few at risk samples, at risk data are available only for three time points. Because of this limitation, analyses of the at risk group should be interpreted with extreme caution.

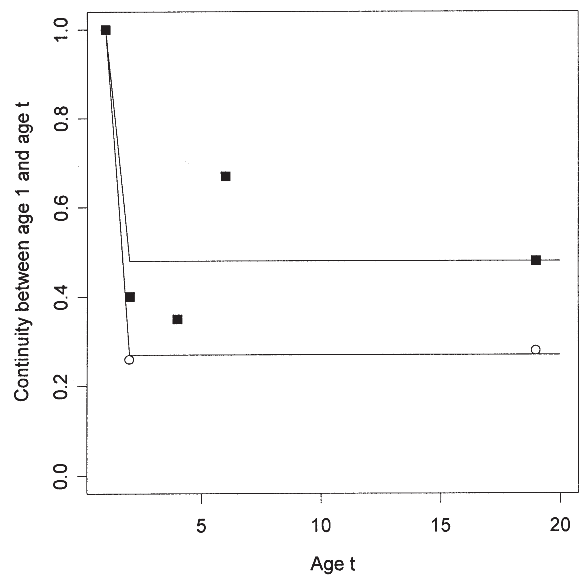

Figure 5. Estimated continuity functions for the prototype model for samples at risk (open circles) and samples not at risk (closed squares). Data from both groups can be accounted for by a prototype-like process, but the estimated value of ρ is smaller for the at risk group ($\rho = 0.27$) than the not at risk group ($\rho = 0.48$).

(Huckfeldt et al., 1982). Simple algebraic manipulation shows that the equilibrium value, S^*, is equal to E_t. In other words, an individual's security level will adjust itself in such a way that it eventually converges on the quality of the corresponding environment. This is true regardless of how secure the individual is initially (Equation 7 does not contain a term representing previous levels of security). As can be seen in Panel A of Figure 6, when individuals with a variety of initial levels of security are exposed to the same environment, E, they eventually converge on the same value of security.

Is this equilibrium stable? Because the equilibrium value is equal to E_t—independently of the security of the individual at any one time—the equilibrium is necessarily stable as long as the environment is stable. To illustrate this point, consider what happens when the caregiving environment is temporarily perturbed. Panel B of Figure 6 illustrates the security of an individual over time. At Time 10, 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 child's parent has temporarily lost his or her job and that this has affected the quality of treatment the child receives.) At Time 11, the perturbation is removed. What happens to the security of the individual over time? The perturbation knocks the individual out of equilibrium briefly, but he or she quickly returns to his or her previous equilibrium state when the original environment is reinstated.

What happens when working models reflect multiple environmental influences rather than a single environmental factor? Adding additional influences to the

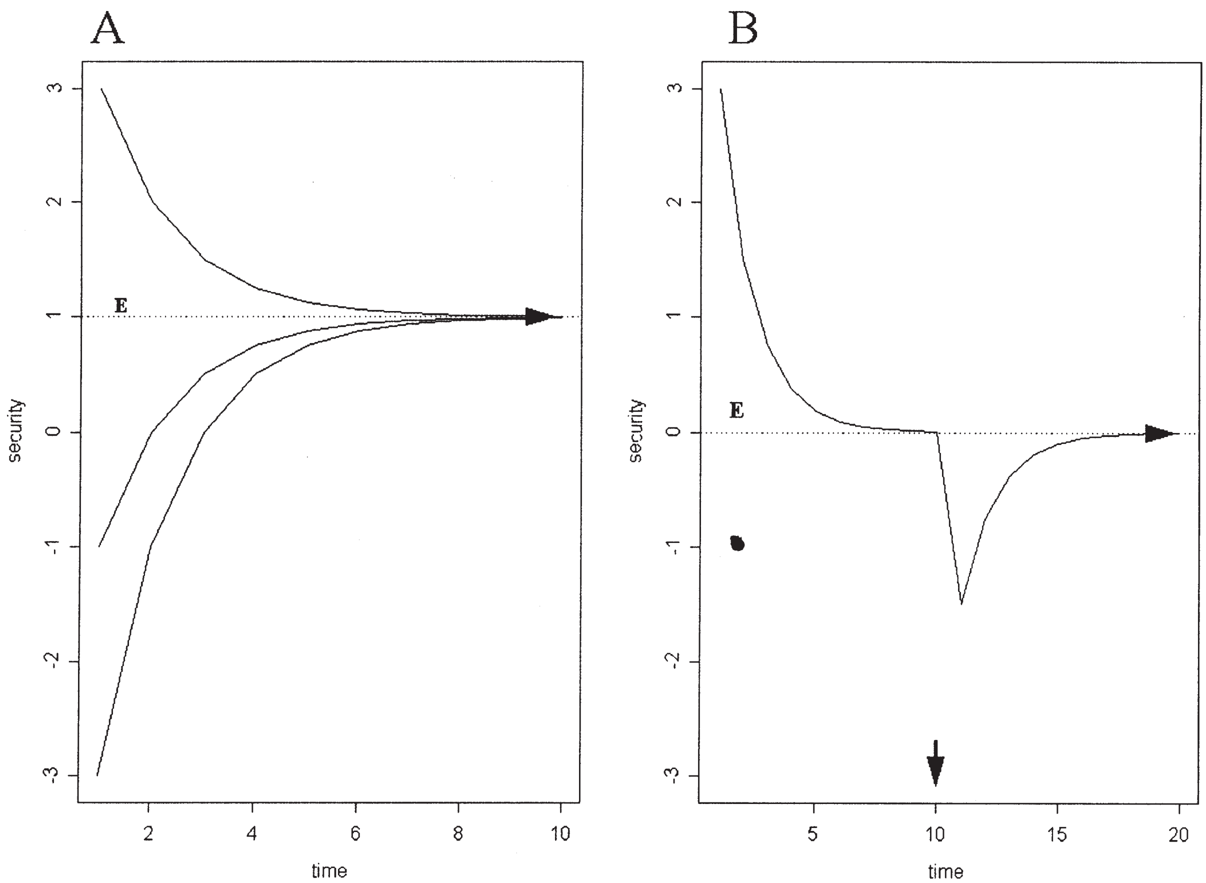

Figure 6. Changes in security over time. Panel A describes the trajectory of security toward equilibrium for three individuals with different initial values of security but similar environments. Panel B describes the trajectory of security for an individual who experiences a transient negative environmental disturbance at Time 10.

caregiving environment, even temporarily, changes the individual's equilibrium value. Consider Equation 8, which represents the dynamic equation for k causal influences on security:

$$\Delta S_t = \eta_1(E1_t - S_t) + \eta_2(E2_t - S_t) + \ldots\ \eta_k(Ek_t - S_t). \quad (8)$$

The equilibrium solution to this equation is

$$S^* = \frac{\eta_1 E1_t + \eta_2 E2_t + \ldots \eta_k Ek_t}{n_1 + n_2 + \ldots \eta_k} \quad (9)$$

or, more compactly

$$S^* = \frac{\sum_{i=1}^{k} \eta_i Ei_t}{\sum_{i=1}^{k} \eta_i}. \quad (10)$$

Thus, the equilibrium value is a weighted combination of the k causal influences.

When environmental influences are changing over time, an individual's equilibrium value will also change over time. Essentially, a new value, E, will be added to or subtracted from Equation 8 at each time step, thereby changing the equilibrium solution at each time step. Thus, an individual can be only as stable as his or her environment. Recall, however, that the revisionist and prototype models have different implications for environmental stability (and hence stability in security). According to the prototype model, there is at least one constant, stable source of influence on the environment—the prototype of early relationships. At any point in development, this representational structure is playing an active role in shaping social interactions. Thus, an individual's equilibrium value will always be a function of the prototype, S_1, and stochastic aspects of the environment, E_k, that are not shaped by the prototype:

$$S^* = \frac{\eta_1 S_1 + \sum_{i=2}^{k} \eta_i Ei_t}{\eta_1 + \sum_{i=2}^{k} \eta_i}. \quad (11)$$

Because the prototype is a constant over time, the individual's security will randomly fluctuate around the prototype or equilibrium value, yielding a dynamic or statistical equilibrium. When the prototype exerts a large influence on the environment (i.e., when ρ is large), the degree of fluctuation will be small. When this influence is small, however, the degree of fluctuation will be large. In a group of individuals (such as those simulated previously), the sample correlation between Time 1 security and subsequent security will vary around a nonzero asymptote when everyone has converged on their respective statistical equilibria. With the revisionist model, there is no constant source of stability over time (see Equation 10). Instead, an individual's trajectory will resemble a "random walk." Of course, an individual can exert some degree of influence over his or her environment, but this influence reflects changing levels of security. Revisionist processes must lead to stability functions that approach zero because there is no intrinsic stability in the revisionist process.

What are the implications of these dynamics for changing an individual's attachment pattern? First, these analyses suggest that for enduring change to take place, an individual's statistical equilibrium must be changed. In other words, a stable external or internal influence must be incorporated into the person's psychological or social world to counterbalance the effects of the existing prototype. As can be inferred from Equation 11, the addition of a second stable source of influence will result in an averaging of the individual's prototype and the second source. If someone has a negative prototype, then a highly positive and persistent source of influence needs to be incorporated into the system if the individual is to become more secure and stay that way. It is noteworthy that therapeutic approaches focused on specific behavior patterns or aimed at altering the "deep structures" of individuals have claimed some success in changing people's security or their parenting behavior (Bowlby, 1988; van IJzendoorn, Juffer, & Duyvesteyn, 1995). Such techniques typically focus on reorganizing the basic response tendencies of the individual or try to induce permanent change in the basic beliefs that people hold about the world. However, when techniques are used that entail short-term or broadband interventions, the effects can be relatively transient (see Lewis, 1997, and Rowe, 1994, for thoughtful discussions of these issues). Family therapists have long argued that individual therapy is of limited value unless the maladaptive dynamics of the family are changed as well (Nichols & Schwartz, 1998).

Importantly, this analysis suggests that factors promoting prototype-like stability need not arise exclusively from intraindividual processes. A stable, constant feature of the social environment, for example, can be sufficient to create prototype-like patterns of stability. Although research suggests that features of the caregiving environment thought to influence security (e.g., maternal sensitivity) are not stable enough to promote such stability (e.g., Crockenberg & McCluskey, 1986; Easterbrooks & Goldberg, 1990; Grossmann, Grossmann, Spangler, Suess, & Unzner, 1985; Pederson et al., 1990), it is possible that alternative factors that have yet to be explored may be capable of doing so.

In summary, analyses of the dynamics of the prototype process reveal several noteworthy features. First, prototype-like processes do not imply that stability between infancy and adulthood will be high, contrary to some assumptions (Owens et al., 1995; van IJzendoorn, 1996). The factor determining the magnitude of cross-time stability is the causal effect of the prototype on the social world, which can be attenuated as the social environment fluctuates. Thus, although the model can account for high patterns of stability, it can also account for what can be called *stable instability.* Second, prototype processes promote stability by producing a dynamic or statistical equilibrium for each individual. A person's level of security may fluctuate quite a bit but will tend to fluctuate around a set value. Finally, although environmental factors can decrease stability (by reducing the effect that people have on their environments), short-term environmental factors do not have long-term effects on stability. The dynamics of the model indicate that people naturally return to equilibrium levels of security when short-term caregiving disturbances are introduced. To induce an enduring change in security, an individual's equilibrium must be modified. Such modification probably requires fundamental and stable alterations in the individual's psychological or social organization.

To What Extent Should Early Attachment Patterns Influence Attachment Patterns in Romantic Relationships?

Perhaps the most provocative and controversial theme of adult attachment theory is that one's pattern of relating in the context of romantic relationships is shaped by one's history with parental attachment figures (Hazan & Shaver, 1987, 1994). Although the idea that parental attachment patterns could have some degree of influence on romantic attachment patterns is relatively uncontroversial, hypotheses about the source and degree of overlap have been controversial (Duck, 1994; Hendrick & Hendrick, 1994; Owens et al., 1995). According to the analyses and models presented here, early attachment prototypes should have some influence on security in the context of romantic relationships. However, it is important to note that the studies on adults examined in this meta-analysis did not assess romantic security per se.[14]

[14]One unpublished study has examined the association between infant strange situation classifications and adult romantic attachment patterns and found a correlation of .17 between the two (J. Steele, personal communication, April 8, 1998). Although this correlation is small, it is within a range compatible with the present findings.

Perhaps the strongest evidence for the influence of early prototypes comes from retrospective studies, although these studies have many problems in their own right. Hazan and Shaver (1987) found that adults who were secure in their romantic relationships were more likely to recall their childhood relationships with their parents as being affectionate, caring, and accepting (also see Feeney & Noller, 1990, and Levy, Blatt, & Shaver, 1998). Other studies reveal an overlap between security in the parental and romantic domains. Again, such evidence is required if the prototype hypothesis is correct but does not constitute direct evidence for the existence of such processes. Owens et al. (1995) assessed romantic relationship security in a sample of 45 engaged couples by administering the Current Relationship Interview (Crowell, 1990), a relatively new instrument modeled after the content and structure of the AAI. Parental attachment security was assessed with the AAI. Owens et al. found that security with parent was correlated approximately .29 with security with partner. In an unpublished study of 215 dating undergraduates, Fraley and Shaver (1999) collected self-report measures of security with a significant parental figure and current romantic partner. The items for each domain were similarly worded and security was scored the same way within each domain. Fraley and Shaver found a correlation of .30 in security across parental and romantic relationships. It is noteworthy that this correlation is virtually identical to that observed by Owens et al. (1995) who employed interview methods to assess parental and romantic security. In a recent study, Shaver, Belsky, and Brennan (2000) examined the association between self-reported relationship security and the various continuous subscales of the AAI (e.g., Coherence of Mind, Mother Loving, Mother Rejecting). They found that each of the AAI subscales could be predicted from linear combinations of the self-reported romantic attachment scales. Interestingly, Coherence of Mind, the hallmark of security in the AAI, was correlated approximately .30 with romantic security (also see Bartholomew & Shaver, 1998).

In summary, research suggests that, in adulthood, there is some degree of overlap between attachment security in the romantic and parental domains. Although such evidence does not provide strong or direct support for the existence of prototype-like processes in stability between these domains, it is a necessary outcome of such processes.[15] Future research on transference processes might be useful in uncovering some of the proximate mechanisms involved in this domain (Andersen & Baum, 1994).

[15]It is also of interest that adult security in the context of romantic relationships has been found to be relatively stable over long periods of time (Baldwin & Fehr, 1995; Klohnen & Bera, 1998; Scharfe & Bartholomew, 1994).

Limitations of This Study

There are several limitations of this study. First, different methods for assessing attachment security were employed within each temporal interval. This undoubtedly introduced a substantial amount of noise to the pattern of estimates. It may be the case that the strange situation is a more sensitive method for assessing variability in the organization of the attachment system than the AAI, or vice versa. Unfortunately, variability in methodological precision is reflected in the data reported here (Hunter & Schmidt, 1990).

Another limitation of this study is that the data available for analysis were not developmentally comprehensive. It would be desirable to have a matrix containing the correlations between security at all possible assessment times. The fact that most studies assessed security only at Age 1 and a single subsequent time point leaves us with only a small piece of this ideal matrix. If data were available to estimate the full correlation matrix, the two developmental models could be tested more rigorously. For example, parameter estimates for each model could be estimated from independent parts of the matrix and their consistency or convergence could be studied. It should be noted that the equations presented in Appendix A can be used to derive predicted correlations based on the prototype model; perhaps these predictions can be tested in the decades to come.

Finally, recall that the theoretical models place great weight on the interplay of the person and his or her caregiving environment. The empirical analyses reported here, however, focused only on the stability of attachment. Although measures of the environment per se are not needed to test the two models of stability discussed in this article, they are clearly necessary if the parameters of more complex and complete models are to be estimated (see Appendix B). It is necessary for future longitudinal research on attachment security to measure systematically the features of the caregiving environment that are thought to matter over time.

Three caveats are in order. First, the models employed in this article were relatively simple characterizations of the developmental processes of interest and were not intended to capture the full richness and complexity of human development. These models were used because they provided the most parsimonious representation of the revisionist and prototype perspectives on stability and because the more realistic and complex elaborations of these basic models did not offer any insight into attachment stability that was not gleaned from the basic models (see Appendix B). Nonetheless, future theoretical investigations into attachment development stand to gain enormously from elaborating the basic processes discussed here.

Second, although the meta-analytic patterns of stability are most consistent with those predicted by the prototype model, alternative interpretations can be given for such patterns. As discussed previously, the observed stability may be due to stable social factors external to the individual rather than internal, prototype-like structures. Alternatively, it may be the case that stable genetic factors correlated with security are exerting a constant source of influence throughout development. In this respect, it is important to note that dynamic models that contain genetic or trait components or both are capable of producing the same kinds of predictions as those generated by the prototype model (see Campbell & Kenny, 1999, pp. 122–126; Fraley & Roberts, 2001). Thus, it may be the case that the factor contributing to attachment stability over time is genetic instead of an invariant representation of early caregiving experiences. Although models of attachment based on heritable factors have had little success in explaining attachment consistently (see Vaughn & Bost, 1999), future research employing research designs that are more rigorous than those characterizing previous work may reveal important interactions between heritable and nonheritable factors in attachment development. In the meantime, researchers should keep in mind that processes not explicitly posited by classical attachment theory are capable of explaining the pattern of stability observed here. The fact that the data are consistent with the prototype model does not mean that the data were, in fact, generated by the mechanisms postulated by the prototype model.

Finally, although the results of these analyses indicate that a prototype-like process might underlie attachment stability, it is important to recognize that future studies could lead to revisions of the parameter estimates or modifications of the theoretical processes underlying stability. Ideally, science should operate in a revisionist manner in which new data are used to update existing theories and existing theories are used to guide the collection of new data. If future studies indicate that alternative models are more appropriate, then theoretical adjustments will need to be made. Hopefully, the theoretical and empirical analyses presented here will help facilitate future investigations and refinements of these issues.

Conclusion

When Bowlby was considering the nature of personality development, he likened it to a railway system that begins with a single main route that forks into a number of distinct lines (Bowlby, 1973, pp. 363–371; Sroufe, 1997; Sroufe & Jacobvitz, 1989). Although these lines initially continue in the same direction as the main route, each junction brings forth a greater chance of divergence. Some of the tracks eventually lead to distant lands, some run in parallel to the main route. Personality development, Bowlby (1975) believed, is an ever-branching process in which critical junctures afford a chance for maintaining or reorganizing the personality. The analyses here suggest that, despite the junctures afforded by life, there is an enduring tendency for people to remain relatively close to their original routes.

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Appendix A
Derivations of the Revisionist and Prototype Stability Equations

In this appendix, I present the derivations of the equations used to model the stability functions for the revisionist and prototype models. Although the basic equations (Equations 2 and 3) characterize the dynamic relations among variables in the form of difference equations, simple difference equations often can be represented within familiar linear regression frameworks (see Huckfeldt et al., 1982). For example, Equations 1 and 2 imply that $S_{t+1} = S_t + \eta(E_t - S_t) + \varepsilon$, which can be rewritten as $S_{t+1} = (1 - \eta)S_t + \eta E_t + \varepsilon$. In other words, the difference equation given by the combination of Equations 1 and 2 is identical to a regression equation in which the weight for S_1 is $(1 - \eta)$.

As Jöreskog and Sörbom (1982) showed, linear structural relations among sets of centered variables can be modeled by the following matrix equations: $Y = \Lambda\eta + \varepsilon$ and $\eta = B\eta + \zeta$. The first equation, sometimes called the *measurement model,* represents the observed scores (contained in the matrix Y) as a weighted (Λ) linear function of latent variables (contained in matrix η) and measurement residuals (contained in matrix ε). The second equation, sometimes called the *structural model,* represents the latent variables (contained in matrix η) as a weighted (B) linear function of one another and residual variances (contained in matrix ζ). These two equations can be combined, via substitution and algebraic rearrangement, to form a single equation:

$$Y = \Lambda(I - B)^{-1}\zeta + \varepsilon, \tag{A.1}$$

where I is an identity matrix (i.e., a matrix with 1s on the diagonal and 0s off the diagonal).

For modeling attachment stability, it is necessary to go beyond modeling the variables themselves and to model the covariances among them. Because the covariance between two variables can be defined as the cross-product of the variables divided by *N,* the covariances of the measured variables can be represented by postmultiplying both sides of Equation A.1 by themselves and dividing by *N.* Doing so yields

$$S = \Lambda(I - B)^{-1}\Psi(I - B')^{-1}\Lambda' + \Theta_\varepsilon, \tag{A.2}$$

where S is a matrix containing the predicted covariances among all measured variables, given the parameter values contained in the various matrices; B is a matrix of causal weights among the latent variables; and Ψ is a concatenated matrix containing the variances and covariances of exogenous latent variables and the variances and covariances of latent residuals. In this article, I was interested in the covariances among the latent variables, not the measured variables per se. The easiest way to express these covariances is by assuming that the latent variables were measured with perfect precision, thereby making Λ an identity matrix and Θ_ε a null matrix (i.e., a matrix containing all zeros). This assumption reduces Equation A.2 to

$$S = (I - B)^{-1}\Psi(I - B')^{-1}. \tag{A.3}$$

Equation A.3 serves as one way to model the covariation among attachment scores over time. (An alternative way that yields quantitatively identical results is discussed later.) In the next section, I describe the patterning of parameter values of the key matrices of Equation A.3, B and Ψ.

Parameter Matrices

The general pattern of the B matrix for the revisionist model is as follows:

$$B = \begin{array}{c} \\ E_0 \\ S_1 \\ E_1 \\ S_2 \\ E_2 \\ S_3 \\ E_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccccccc} E_0 & S_1 & E_1 & S_2 & E_2 & S_3 & E_3 & S_4 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \eta & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\eta) & \eta & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & (1-\eta) & \eta & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (1-\eta) & \eta & 0 \end{bmatrix} \end{array}$$

Because the patterning of parameter values repeats itself over time, the structure is shown for only a subset of possible time points. (Throughout the text, the equations have been written as if security influences the environment within the "same" slice of time. This might seem unusual at first in light of the way researchers typically treat cause and effect; however, note that this way of spacing the variables over time is structurally equivalent to interspersing them such that the rows and columns of the beta matrix are as follows: $E_{0.5}$, S_1, $E_{1.5}$, S_2, $E_{2.5}$, S_3, $E_{3.5}$, S_4. I have focused on the integer-based subscripts for ease of exposition.) In this matrix, the causal flow is vertical such that dependent variables are represented by rows and independent variables are represented by columns. The parameter η represents the causal influence of the social environment on security, ρ represents the casual influence of security on the environment, and $(1 - \eta)$ represents the influence of security on itself over time (i.e., the variance in security that isn't affected by other factors). As noted previously, this latter path is given a weight of $(1 - \eta)$ because rearrangement of Equations 1 and 2 reveals that $S_{t+1} = (1 - \eta)S_t + \eta E_t + \varepsilon$.

The general form of the Ψ matrix for the revisionist model is as follows:

$$\Psi = \begin{array}{c} \\ E_0 \\ \zeta_{S_1} \\ \zeta_{E_1} \\ \zeta_{S_2} \\ \zeta_{E_2} \\ \zeta_{S_3} \\ \zeta_{E_3} \\ \zeta_{S_4} \end{array} \begin{array}{c} \begin{array}{cccccccc} E_0 & \zeta_{S_1} & \zeta_{E_1} & \zeta_{S_2} & \zeta_{E_2} & \zeta_{S_3} & \zeta_{E_3} & \zeta_{S_4} \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \psi_{S_1} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \psi_{E_1} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \psi_{S_2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \psi_{E_2} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \psi_{S_3} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \psi_{E_3} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \psi_{S_4} \end{bmatrix} \end{array}.$$

In this concatenated matrix, the upper left portion represents the variance of the exogenous variable (i.e., E_0); the lower left portion represents the variances and covariances among latent residuals—the portion of variance left over after all casual variables feeding into a variable have been accounted for. The parameter ψ corresponds to the residual variances for the latent variables. The residual for a latent variable was calculated iteratively as 1 minus the sum of the weighted variance–covariance matrix of latent variables affecting that variable (see Cliff, 1987, on the variance of a weighted composite). By calculating the residuals in this manner and by setting the exogenous variance to unity, the latent variables are standardized over time (i.e., the variances of the latent variables were always 1.00). Hence, the covariances can be interpreted as correlations.

The B matrix for the prototype model is patterned as follows:

$$B = \begin{array}{c} \\ E_0 \\ S_1 \\ E_1 \\ S_2 \\ E_2 \\ S_3 \\ E_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccccccc} E_0 & S_1 & E_1 & S_2 & E_2 & S_3 & E_3 & S_4 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \eta & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\eta) & \eta & 0 & 0 & 0 & 0 & 0 \\ 0 & \rho & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & (1-\eta) & \eta & 0 & 0 & 0 \\ 0 & \rho & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (1-\eta) & \eta & 0 \end{bmatrix} \end{array}.$$

The only difference between the structure of this B matrix and the B matrix for the revisionist model is the way in which security influences the environment. In this model, early security, S_1, influences the environment at each step to the degree ρ. The Ψ matrix has the same form for the prototype model as it does for the revisionist model, although the specific values of the residual variances will necessarily differ.

Solving equation A.3 provides the correlation matrix among all variables, including the correlations between security and the environment over time. To obtain the stability functions for attachment, one can simply select the appropriate correlations (i.e., every other correlation in the second column of S).

An Alternative Method

The matrix solution provides a useful way to obtain the predicted stability functions for given parameter values because it can be easily modified to incorporate alternative conceptualizations of the models (see Appendix B). However, it is a bit difficult to experiment with because the easiest way to compute the residual terms (i.e., calculating them iteratively) is still quite cumbersome. An alternative way to derive the stability functions for the two models can be obtained by using covariance algebra. I discuss these solutions following because (a) they are easier to experiment with and (b) they provide an alternative, yet converging way to characterize the mathematics of the models (i.e., given the same parameter values, the matrix equations and the equations derived following will provide identical stability coefficients).

I begin by deriving the covariance between initial levels of security, S_1, and security during the following two time steps, S_2 and S_3. I assume that all scores are in standardized form (M = 0.00, variance [VAR] = 1.00), thereby allowing the covariances to be interpreted as correlations.

According to Equations 1 and 2, security at Time 2 is a function of initial security and the weighted discrepancy between initial levels of security and the quality of the environment

$$S_2 = S_1 + \eta(E_1 - S_1) + \varepsilon,$$

which can be rewritten as follows:

$$S_2 + \eta E_1 - \eta S_1 + \varepsilon.$$

The covariance (*COV*) between S_1 and S_2 can be expressed as the expected value (*E*, with no subscripts) of the cross-product of security at Time 1 and Time 2

$$COV_{S_1,S_2} = E[S_1 S_2]$$
$$COV_{S_1,S_2} = E[S_1(S_1 + \eta E_1 - \eta S_1 + \varepsilon)],$$

which, using the algebra of expectations, can be expanded as follows:

$$COV_{S_1,S_2} = E[S_1S_1 + \eta S_1E_1 - \eta S_1S_1 + S_1\varepsilon]$$
$$COV_{S_1,S_2} = E[S_1S_1] + \eta E[S_1E_1] - \eta E[S_1S_1] + E[S_1\varepsilon].$$

Because the expected value of the product of these variables are covariances, we can rewrite the equation as follows:

$$COV_{S_1,S_2} = COV_{S_1S_1} + \eta COV_{S_1E_1} - \eta COV_{S_1S_1} + COV_{S_1\varepsilon}$$
$$COV_{S_1,S_2} = VAR_{S_1} + \eta COV_{S_1E_1} - \eta VAR_{S_1} + 0$$
$$COV_{S_1,S_2} = (1-\eta)VAR_{S_1} + \eta COV_{S_1E_1}.$$

($COV_{S_1\varepsilon}$ equals zero because the expected covariance between variation in security and residual variation is zero.) Because the variance of S_1 is 1.00 and the covariance between S_1 and E_1 is equal to ρ, the covariance between security at Time 1 and Time 2 can be simplified to $(1 - \eta) + \eta\rho$.

The equation for the covariance between S_1 and S_3 is similar in form to that of the covariance between S_1 and S_2:

$$COV_{S_1,S_3} = E[S_1(S_2 + \eta E_2 - \eta S_2 + \varepsilon)]$$
$$COV_{S_1,S_3} = E[S_1S_2 + \eta S_1E_2 - \eta S_1S_2 + S_1\varepsilon]$$
$$COV_{S_1,S_3} = E[S_1S_2] + \eta E[S_1E_2] - \eta E[S_1S_2] + \mathrm{E}[S_1\varepsilon]$$
$$COV_{S_1,S_3} = COV_{S_1S_2} + \eta COV_{S_1E_2} - \eta COV_{S_1S_2} + COV_{S_1\varepsilon}$$
$$COV_{S_1,S_3} = (1-\eta)COV_{S_1S_2} + \eta COV_{S_1E_2}.$$

If this process is carried out for any time *t* greater than or equal to 2, then

$$COV_{S_1,S_t} = (1-\eta)COV_{S_1S_{t-1}} + \eta COV_{S_1E_{t-1}}, \quad \text{(A.4)}$$

where $COV_{S_1,E_{t-1}}$ is given by

$$COV_{S_1,E_{t-1}} = E[S_1E_{t-1}]$$
$$COV_{S_1,E_{t-1}} = E[S_1(\rho S_{t-1} + \varepsilon)]$$
$$COV_{S_1,E_{t-1}} = \rho COV_{S_1S_{t-1}} + COV_{S_1\varepsilon}$$
$$COV_{S_1,E_{t-1}} = \rho COV_{S_1S_{t-1}}. \quad \text{(A.5)}$$

($E_{t-1} = \rho S_{t-1} + \varepsilon$ via Equation 3.) By substituting $\rho COV_{S_1 S_{t-1}}$ for $COV_{S_1 E_{t-1}}$ in Equation A.4, the general equation for revisionist stability functions for $t \geq 2$ can be stated as

$$COV_{S_1,S_t} = (1-\eta)COV_{S_1S_{t-1}} + \eta\rho COV_{S_1S_{t-1}} \text{ or}$$
$$\left(1-\eta+\eta\rho\right)COV_{S_1S_{t-1}}. \quad \text{(A.6)}$$

The general equation for prototype stability functions is similar to that for the revisionist model. However, recall that according to the prototype model, the quality of the environment is a function of initial, rather than concurrent, levels of security (see Equation 6). Thus, the $COV_{S_1E_{t-1}}$ term from Equation A.4 should be rewritten as follows:

$$COV_{S_1,E_{t-1}} = E[S_1(\rho S_1 + \varepsilon)]$$
$$COV_{S_1,E_{t-1}} = \rho COV_{S_1S_1} + COV_{S_1\varepsilon}$$
$$COV_{S_1,E_{t-1}} = \rho VAR_{S_1}. \quad \text{(A.7)}$$

By substituting ρVAR_{S_1} for $COV_{S_1E_{t-1}}$ in Equation A.4, the general equation for the prototype stability functions for t ≥ 2 can be succinctly expressed as

$$COV_{S_1,S_t} = (1-\eta)COV_{S_1S_{t-1}} + \eta\rho VAR_{S_1}. \quad \text{(A.8)}$$

Appendix B
Variation of Model Assumptions

The models discussed in the text were deliberately simplified for the ease of exposition. My objective for this appendix is to discuss some more complex ways of representing the theoretical dynamics of each model and to demonstrate that these more complex models predict the same patterns of stability as those predicted by their simpler versions.

Revisionist and Prototype Processes

Theoretically, the prototype model is a mixed model, one that suggests that concurrent levels of security and early levels of security shape the course of social interaction. However, in the previous prototype modeling efforts, the influence of concurrent security was removed for mathematical simplicity. To demonstrate that the removal of this term is inconsequential for the overall pattern of predictions made by the prototype model, I explore the pattern of covariances implied by a model that incorporates paths from early and concurrent security. Such a model would have the following pattern of parameters in its B matrix:

$$B = \begin{array}{c} \\ E_0 \\ S_1 \\ E_1 \\ S_2 \\ E_2 \\ S_3 \\ E_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccccccc} E_0 & S_1 & E_1 & S_2 & E_2 & S_3 & E_3 & S_4 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \eta & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ e & \rho & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\eta) & \eta & 0 & 0 & 0 & 0 & 0 \\ 0 & p & e & \rho & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & (1-\eta) & \eta & 0 & 0 & 0 \\ 0 & p & 0 & 0 & e & \rho & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & (1-\eta) & \eta & 0 \end{bmatrix} \end{array}.$$

The parameter p is now used to denote the effect of the prototype on the environment, whereas the parameter ρ is used to denote the effect of concurrent levels of security on the environment. (I discuss the parameter e in the next section.) I explored the implications of this model by systematically varying these two parameters and studying the resulting stability functions (see Equation A.3). Some example functions are presented in Figure B.1.

Figure B.1 demonstrates that the mixed model is capable of producing revisionist or prototype continuity functions, depending on the value of the p parameter. Panel A illustrates the continuity function generated when both p and ρ are set to zero. This function has the same form as those observed previously when security had no effect on the caregiving environment (see Figure 1). When the prototype parameter, p, is set to a positive value, and the concurrent security parameter, ρ, is set to zero, the resulting stability functions, like the prototype functions discussed previously, have a nonzero asymptote (see Panel B). When the concurrent security parameter, ρ, is set to a positive value, and the prototype parameter, p, is set to zero, the stability functions behave exactly like those generated by a pure revisionist model, approaching a limiting value of zero (see Panel C). Importantly, when both the revisionist and prototype security parameters are set to positive values, the form of the resulting stability functions resemble those generated by a pure prototype model (see

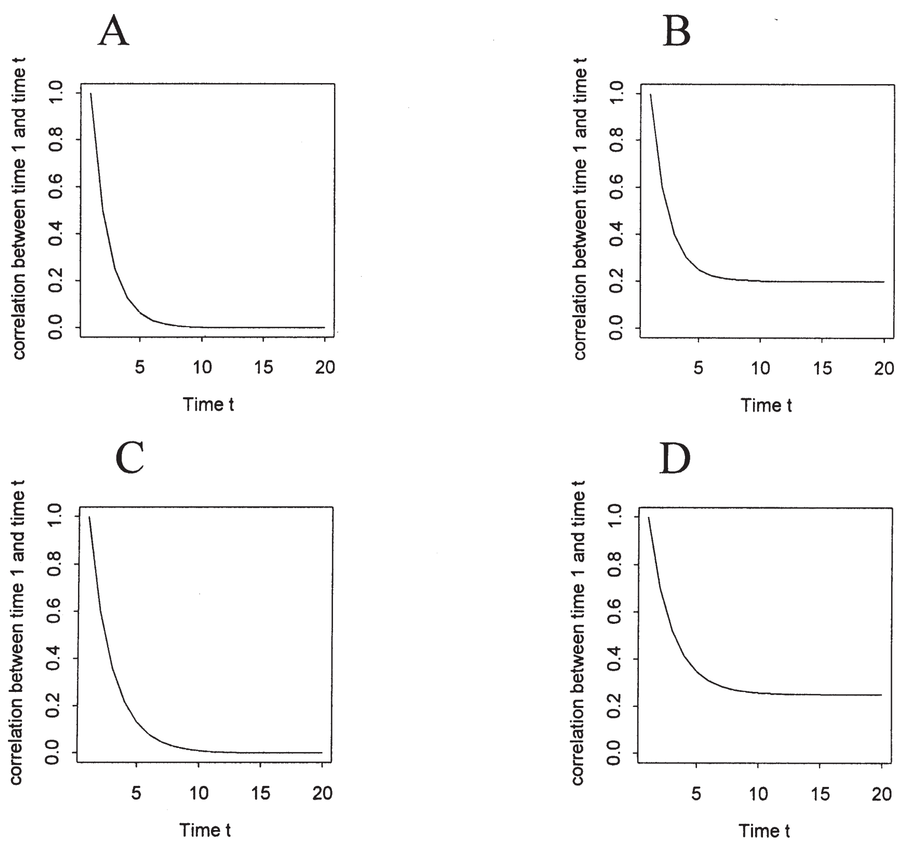

Figure B.1. Stability functions for a mixed model. Panel A depicts the stability function when both the prototype, *p,* and concurrent security, ρ, parameters are set to 0.00. Panel B depicts the continuity function generated when the prototype parameter is set to 0.20 and the concurrent security parameter is set to 0.00. Panel C depicts the function generated when the prototype parameter is set to 0.00 and the concurrent security parameter is set to 0.20. Panel D depicts the continuity function when both the prototype parameter and the concurrent security parameter are set to 0.20 (η was set to 0.50 in each of these simulations).

Panel D). In other words, the simplified prototype model produces the same qualitative predictions about continuity as the more complex model that incorporates both revisionist and prototype dynamics.

Stability of the Environment

For simplicity, the simulations discussed in the text assumed that the environment does not influence itself. In other words, there is no "carryover" of E_{t-1} to E_t that is distinct from the variance contributed by security. Such a carryover effect can be added by including the parameter *e* in the B matrix shown previously. Including this parameter, however, does not change the pattern of predictions made by the revisionist and prototype models: The overall level of stability is elevated when *e* is set to a nonzero value, but the stability functions continue to approach zero over the long run for the revisionist model and a positive value for the prototype model.

Individual Differences in Plasticity

In the simulations it was assumed that people are equally plastic. However, it may be the case that some people are more rigid in their beliefs than others. Is the general form of the continuity functions dependent on whether plasticity is treated as an individual difference variable or a constant? According to Equation 5, one reason why the prototype model yields a nonzero continuity function is that a fraction of the S_1 variance always contributes to subsequent levels of security. Thus, as long as the variance in initial levels of security is not multiplied by zero, the prototype model will produce a nonzero limiting value regardless of whether η is treated as a constant or an individual difference variable.

Decreasing Plasticity Over Time

It is likely that the nervous system is more plastic in early childhood than in later adulthood (see Costa & McCrae, 1994). Thus, it is possible that these models may behave differently if η is allowed to decrease over time rather than being held constant. To examine the consequence of decreasing plasticity, I conducted a series of simulations in which η was allowed to decrease exponentially over time according to the following equation: $\eta_t = \alpha + (1 - \alpha) \times exp(-t)$, where *exp* repre-

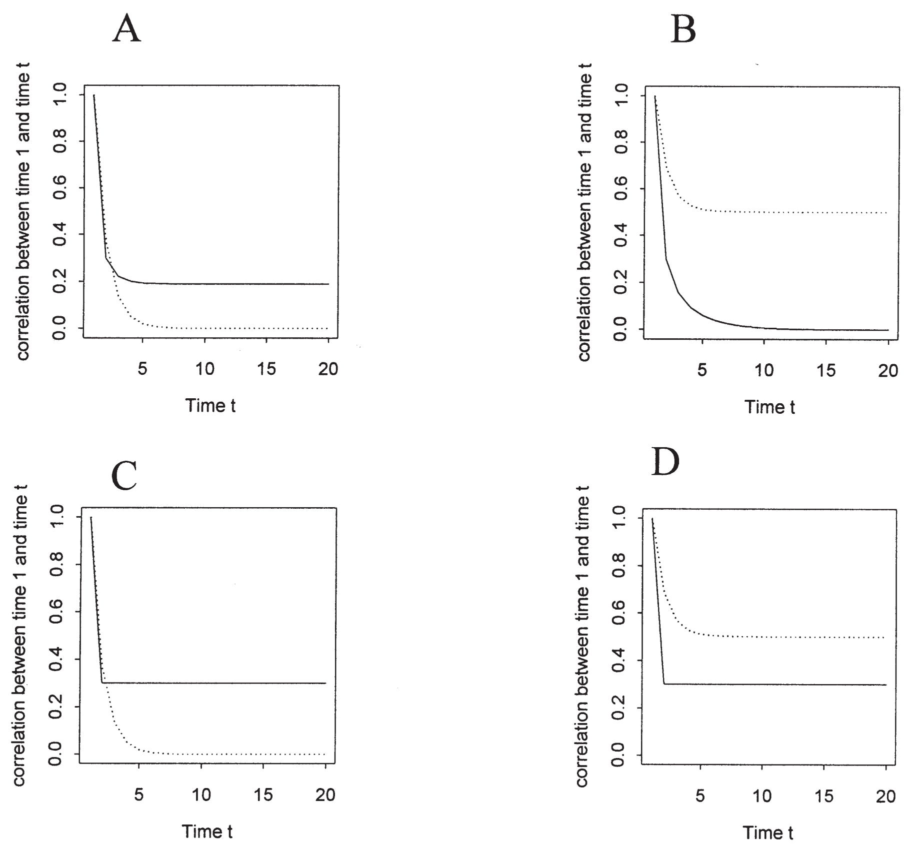

Figure B.2. Stability functions for the revisionist and prototype models when plasticity, η, is allowed to decrease over time. Stability functions are illustrated by solid lines; the values of η over time are illustrated by dotted lines. Panels A and B depict the stability functions generated by the revisionist model when η is allowed to decrease to a zero value (Panel A) or a nonzero value (Panel B). Panels C and D depict the stability functions generated by the prototype model when η is allowed to decrease to zero (Panel C) or a nonzero value (Panel D).

sents the exponential function and α represents the limiting value of plasticity.

Panels A and B of Figure B.2 illustrate the continuity functions generated by the revisionist process when plasticity is allowed to decrease to a zero (Panel A) or a nonzero value (Panel B). It is noteworthy that the revisionist process produces a curve with a nonzero asymptote when plasticity is allowed to decrease to zero (see Panel A). This occurs because the random component of the environment cannot be absorbed by the individual when he or she is incapable of being altered by environmental feedback. When plasticity is allowed to decrease to any value other than zero, however, the revisionist process produces curves with the same form produced in the original simulations (i.e., the stability curves approach zero; see Panel B).

Panels C and D illustrate the continuity functions generated by the prototype process when plasticity is allowed to decrease to a zero (Panel C) or a nonzero value (Panel D). It is noteworthy that the prototype process behaves the same (i.e., it produces a continuity function with a nonzero asymptote) regardless of whether η decreases to zero or a nonzero value.

These findings on decreasing plasticity have two important implications. First, they demonstrate that the prototype and revisionist processes give rise to similar patterns of stability regardless of whether plasticity is allowed to remain constant or decrease over time. Second, they reveal a potentially important indeterminacy in the models. Namely, the revisionist and prototype processes behave exactly alike (i.e., they produce nonzero limiting values) when plasticity is allowed to decrease to zero. It is unlikely, however, that people ever reach a point in life where they are absolutely unresponsive to environmental feedback. Thus, this indeterminacy is unlikely to pose real problems for empirical attempts to tease the two kinds of models apart.

Varying the Effects of ρ Over Time

It is also possible that the effect of security on social interaction is variable over time such that security is more influential at some ages than others. When ρ is allowed to vary over time in the revisionist and prototype models, the stability functions are notably less smooth but do not change their general form. In other words, the prototype model predicts a nonzero asymptote, and the revisionist model predicts a zero asymptote.

Summary of Variations on Model Assumptions

The simplified versions of the revisionist and prototype models give rise to patterns of stability that are virtually identical to those resulting from models with more complex assumptions. This is an important result because it indicates that the simplifying assumptions of the models employed here will not occlude the ability to elucidate the basic dynamics of each process. The rudimentary models, despite their simplicity, distill the essential properties of each process.