

Oxford Handbooks Online

Self-Regulatory Processes in Early Development

Marjorie Beeghly, Bruce D. Perry, and Edward Tronick

The Oxford Handbook of Treatment Processes and Outcomes in Psychology

Edited by Sara Maltzman

Online Publication Date: Feb
2016

Subject: Psychology, Clinical Psychology, Counseling Psychology
DOI: 10.1093/oxfordhb/9780199739134.013.3

[–] Abstract and Keywords

In this chapter, we focus on the emergence of self-regulatory processes during infancy, as framed in biopsychosocial context. We begin with a brief review of the neurobiological underpinnings of early self-regulatory processes and how self-regulatory systems develop in early childhood. Next, given that infants come into the world highly dependent on caregiver support for their survival, we argue that the emergence of self-regulation occurs primarily in a relational context, and that the capacity for self-regulation reflects both self- and parent–infant co-regulatory processes. We also provide evidence to show that variations in these early self- and parent–infant regulatory processes are linked to children’s resilient or maladaptive functioning in later life. We illustrate our arguments with findings from developmental research on self-regulation in at-risk populations and in diverse contextual-cultural settings. After a brief discussion of the implications of this literature for practice, we conclude that the Mutual Regulation Model provides a useful framework for practitioners attending to the quality of the parent–infant relationship.

Keywords: self-regulation, mutual regulation, infancy, biopsychosocial, resilience

Introduction

There is growing consensus among scientists and practitioners that the ability to self-regulate in culturally appropriate ways is foundational for healthy developmental and behavioral functioning across the life span (Charles & Carstensen, 2007; Posner & Rothbart, 2000; Rothbart & Jones, 1998; Thompson, Virmani, Waters, Raikes, & Meyer, 2013; Vohs & Baumeister, 2004). Perhaps for this reason, self-regulation has been intensively studied across disciplines, and there is increasing demand for interventions promoting self-regulation (see Bridgett, Burt, Edwards, & Deater-Deckard, 2015, for a review). Parents, too, acknowledge the importance of self-regulation for positive child outcomes and consistently endorse self-regulation as their most important socialization goal (Kopp, 1982).

Yet self-regulation remains one of the most challenging constructs to define, both theoretically and operationally (Boekaerts, Pintrich, & Zeidner, 2005; Diaz & Eisenberg, 2015), and despite decades of research, a clear, consistent definition remains elusive (Feldman, 2009). Generally speaking, self-regulation (often referred to as “self-control”) is a broad “umbrella” term that encompasses a variety of processes that assist individuals in pursuing and attaining their goals (Fujita, 2011; Mann, Ridder, & Fujita, 2013), including the goal of maintaining self-organization (Tronick, 1989). However, specific conceptualizations of self-regulation and associated research methods to assess it vary markedly across and within disciplines.

In the field of developmental science, many researchers conceptualize self-regulation as a temperament dimension stemming from increasingly differentiated, complex, and hierarchically organized bio-behavioral processes that allow individuals to modulate their arousal, attention, emotions, behavior, and cognition in adaptive ways (Calkins, 2011; Calkins & Fox, 2002; Fox & Calkins, 2003; Posner & Rothbart, 2000). These processes comprise a wide range of “hot” and “cool” psychological functions such as effortful control, executive capacities (e.g., attention), motivational and emotional

processes, and goal-directed behaviors (Holodynski, Seeger, Kortas-Hartmann, & Wormann, 2013; Rothbart, Sheese, & Posner, 2007). More recently, developmental scientists have been adopting an expanded definition of self-regulation that includes more dynamic and complex transactions among multiple levels of influence over time, including genetic, physiological, child, and caregiving/contextual factors (Shiner et al., 2012). Other investigators (e.g., those in the field of affective neuroscience) prefer to focus on the development of core brain systems (e.g., brain stem, limbic, and cortical) and evaluate how transactions among these systems, in conjunction with other intrinsic and extrinsic influences, organize and influence self-regulatory processes and other behavioral outcomes (Perry, 1999, 2008; Tucker, Derryberry, & Liu, 2000), including the development of consciousness (Damasio, 2003). Still others emphasize the role of parent-infant *co-regulatory* processes and parent-child relationships in the emergence of self-regulatory processes, as guided by biopsychosocial models and dynamic systems approaches (e.g., Bronfenbrenner & Morris, 2006; Fogel, 2015; Sameroff, 2010; Sroufe, 2013; Tronick & Beeghly, 2011).

One reason for the conceptual and methodological variations across studies may stem from the fact that the capacity for self-regulation is not fully developed at birth but rather emerges gradually over the course of many years. The extended period of self-regulatory development corresponds to the relatively slow maturation of prefrontal brain areas associated with inhibitory control and their transactions with other brain regions and associated biobehavioral processes. Although even young infants have rudimentary self-regulatory capacities that manifest from the interplay among multiple biopsychosocial somatic and brain systems, these capacities are limited and cannot be sustained without caregiver regulatory support (Tronick, 2005, 2008; Tronick & Beeghly, 2011). Thus, the specific systems that reflect children's primary self-regulatory challenges at different ages (e.g., physiological, emotion regulation, attentional, and social-cognitive) vary (Feldman, 2009).

Despite these variations, a growing body of studies shows that self-regulatory processes (diversely defined) are related to a multitude of positive social, emotional, and cognitive outcomes, including, but not limited to the following: coping with stressors (DiCorcia, Sravish, & Tronick, 2013; DiCorcia & Tronick, 2011), social competence (Eisenberg & Fabes, 1992), empathy and adjustment (Eisenberg, Smith, Sadovsky, & Spinrad, 2004), and academic achievement (Eisenberg, Sadovsky, & Spinrad, 2005; Nota, Soresi, & Zimmerman, 2004). This research also suggests that a *lack* of capacity for adequate self-control (both under- and over-control) predicts a broad array of maladaptive outcomes across the life span, including the development of psychopathology (Bridgett et al., 2015; Calkins & Fox, 2002; Calkins, Propper, & Mills-Koonce, 2013).

What is less well understood is when and how the capacity for self-regulation emerges in early life. In this chapter, we focus on the emergence of self-regulatory processes during infancy, as framed in biopsychosocial context. We begin with a brief review of the neurobiological underpinnings of early self-regulatory processes and how self-regulatory systems develop in early childhood. Next, given that infants come into the world highly dependent on caregiver support for their survival (Easterbrooks, Bartlett, Beeghly, & Thompson, 2013; Fogel, 2015), we argue that the emergence of self-regulation occurs primarily in a relational context, and that the capacity for self-regulation emerges from self- and parent-infant co-regulatory experiences that are repeated over time. We also provide evidence to show that variations in these early self- and parent-infant regulatory processes are linked to children's resilient or maladaptive functioning in later life (Beeghly & Tronick, 2011; DiCorcia et al., 2013; Easterbrooks, Driscoll, & Bartlett, 2008; Tronick, 1989, 2005, 2006, 2008; Tronick & Beeghly, 2011). We illustrate our arguments with findings from developmental research on self-regulation in at-risk and atypical populations and in diverse contextual-cultural settings, and also briefly discuss implications of this literature for practice.

Neurobiological Perspectives on the Development of Self-Regulatory Systems

Research on the developmental neurobiology of early self-regulatory processes has burgeoned in recent years. A large group of studies demonstrates that there are marked individual differences in level of emotion reactivity and capacity for self-regulation during infancy, and that those differences are associated with the coordinated activation of both the sympathetic and parasympathetic nervous systems and related neuroendocrine activity, such as stress hormones (e.g., Calkins & Fox, 2002; Fox & Calkins, 2003; Schore, 2005). This literature also shows that the capacity for self-regulation is linked to the dynamic interplay and coordination among "top down" and "bottom up" neurobiological processes (Thompson et al., 2013).

The capacity for self-regulation is widely thought to emerge in conjunction with the development of slowly maturing

Self-Regulatory Processes in Early Development

regions of the cerebral cortex (i.e., medial and ventral prefrontal cortex (PFC) and anterior cingulate cortex (ACC), which exert increasing levels of inhibitory control over “lower” brain structures, particularly those associated with emotion activation (e.g., amygdala, hypothalamus, brain stem, and central gray; e.g., Calkins & Fox, 2002; Posner & Rothbart, 2000; Thompson et al., 2013; Thompson, Lewis, & Calkins, 2008). In turn, growth in these “top down” processes is associated with the emergence of executive function skills that are thought to support children’s cognitive strategies to self-regulate, such as response inhibition, effortful control, increased working memory, rule switching, and cognitive flexibility (Thompson et al., 2013).

However, there also is evidence that “bottom up” processes play an important role. Findings from animal and human research demonstrate that these processes are coordinated with, and influence, the functioning of higher-order brain systems in both hierarchical and synchronous ways (Feldman, 2009). For instance, several researchers show that activation of limbic areas of the brain (i.e., amygdala) is linked to greater perceptual sensitivity to danger cues and other dimensions of affective learning (Ochsner et al., 2009). Others demonstrate that neural connections among different “lower” brain structures (i.e., limbic structures and the anterior cingulate) are linked to variations in individuals’ ability to appraise emotional information and engage in higher-order self-regulation tasks (Quirk, 2007; Woltering & Lewis, 2009). Moreover, imaging studies show that both lower-level and higher-order brain systems are activated simultaneously during tasks evaluating emotional responding (Kober et al., 2008) and may influence each other in a dynamic, transactional manner (Thompson et al., 2013). Thus, self-regulation is not solely governed by inhibitory control in higher-order cortical areas, but is also influenced by dynamic transactions among widely distributed brain systems. Evidence for interplay among genetic/epigenetic factors, brain, and infant temperament characteristics has also been reported (e.g., Rothbart et al., 2007), and these processes may begin before birth (Conradt et al., 2015).

Feldman (2009) adopted a developmental hierarchical-integrative perspective to evaluate whether the emergence of self-regulatory processes is best described by hierarchical (bottom-up) aspects of self-regulatory development (i.e., the idea that physiological, emotional, attentional, and self-regulatory processes develop “on top of each other”; Edelman, 2004) or by integrative aspects of self-regulatory development (i.e., the notion that brain stem, limbic, and cortical systems synchronize to execute a regulatory goal; Tucker et al., 2000). Feldman hypothesized that different age-salient regulatory “goals” confront infants during early childhood, and that regulatory systems reflecting these goals would change over the course of early childhood. She also expected that there would be substantial continuity in regulatory systems over time, and that regulatory capacities at each level would integrate functioning at lower levels.

To evaluate these hypotheses, Feldman (2009) conducted a longitudinal study following healthy preterm infants from the time of their birth to age five. Four age-salient regulatory systems were operationalized as follows: For newborns, a primary regulatory goal is to maintain physiological homeostasis (Sander, 1975). Feldman indexed this capacity by evaluating vagal tone and sleep-wake cyclicity. For infants later in the first year, a primary regulatory goal is emotion regulation (i.e., the capacity to control negative emotions stemming from internal and external stressors). Emotion regulation was evaluated by examining infants’ response to stress at 3, 6, and 12 months of age. For toddlers in the second year of life, a primary regulatory goal is to regulate attention processes including sustaining attention to tasks and engaging in goal-directed behaviors. This goal was operationalized as toddlers’ ability to focus attention and delay response. For preschoolers, a primary regulatory goal is the ability to internalize social and moral standards for behavior, as reflected in the capacity for integrated, internalized self-regulation, i.e., the ability to integrate concepts of self and executive functions with learning. These skills were assessed using executive function tests, behavior adaptation, and self-restraint tasks.

Among her many results, a few key findings are highlighted here. First, Feldman (2009) provides evidence that there is considerable coherence among the different regulatory systems across the first 5 years of life, suggesting that the construct of “regulation” is relatively stable and continuous across time, measures, and levels of observation. This study also shows that all three levels of regulation cumulatively predicted self-regulation at age 5, a capacity that reflects the consolidation of a sense of self and the ability to use higher-order executive skills (e.g., planning, inhibition) for learning.

Moreover, Feldman’s (2009) findings reveal that there are bidirectional influences in the development of regulatory functions across the first 5 years of life, including the capacity to manage negative affect beginning at birth, and that these skills are associated with the growth of more mature regulatory skills. Interestingly, the presence of a higher level of negative emotionality and associated stress early in life appears to have a long-term negative impact on the formation and integration of later regulatory systems. In contrast, a lower level of negative emotionality early in life is not associated with later regulatory problems. These findings have important implications for the study of risk and resilience in early

childhood (Beeghly & Tronick, 2011; Easterbrooks et al., 2008; Masten & Obradović, 2006).

Although Feldman's longitudinal study of the emergence of multiple regulatory systems in early childhood is unique and important, she omitted measures of the caregiving environment, including parent-infant co-regulatory processes, which limits interpretation of her findings (Feldman, 2009). Caregiving quality and parent-infant co-regulatory processes are critical to evaluate because they can have an important protective (or undermining) effect on infants' self-regulatory development (Beeghly, Fuentes, Liu, Delonis, & Tronick, 2011; Easterbrooks et al., 2013; Tronick, 2006, 2008). These processes may play an especially important role for infants at risk for suboptimal regulatory outcomes, such as those with a biological predisposition for negative emotionality (Calkins et al., 2013). In the next section, we discuss how variations in the caregiving environment transact with neurobiological processes to affect children's self-regulatory and other developmental outcomes.

The Importance of the Caregiving Environment

Taking a probabilistic epigenetic perspective, Gottlieb (2007) posits that development is supported and shaped by a set of hierarchically organized but reciprocally interacting factors and processes ranging from genetic to environmental. Research guided by such a dynamic biopsychosocial model shows that variations in the quality of children's early experiences in the context of biological vulnerability alter emerging neurobiological systems relevant to self-regulation via their impact on higher and lower brain regions and associated neuroendocrine systems (see also Blair, 2002, 2010). For this reason, the evaluation of caregiving quality and parent-infant co-regulatory processes should be an important priority in biopsychosocial research on early self-regulatory processes.

There now are many examples in the literature showing how parenting quality transacts with biological and environmental processes to shape children's outcomes (e.g., Calkins & Mackler, 2011; Calkins, Smith, Gill, & Johnson, 1998; Feldman, 2007; Martinez-Torteya et al., 2014; Propper & Moore, 2006). For instance, children growing up in harsh environmental conditions, who also have unresponsive caregivers, are more likely to exhibit heightened emotional and physiological reactivity and poorer self-regulation during challenge tasks (Boyce & Ellis, 2005). In other research, repeated activation of the fear response in early childhood (either via a biological predisposition toward negative emotionality, poor caregiving quality, or both) is linked to stable increases in negative emotional reactivity in later life (Calkins & Hill, 2007). Calkins and colleagues also show that electroencephalographic (EEG) asymmetry, a marker of behavioral inhibition, moderates the association between maternal sensitivity and infants' responses to frustration (Calkins et al., 1998). A follow-up analysis shows that EEG asymmetry also moderates the association between maternal sensitivity and infants' response to frustration (Swingler, Perry, Calkins, & Bell, 2014).

Most of the studies that evaluate biopsychosocial processes focus on negative child regulatory outcomes. However, there also are many studies highlighting transactions among sensitive parenting and optimal patterns of child behavioral and physiological reactivity and regulation. In a recent longitudinal study, Nicole Perry and colleagues evaluated transactional associations between children's parasympathetic regulatory processes (vagal withdrawal) during challenge tasks and caregiving quality (N. B. Perry, Mackler, Calkins, & Keane, 2014). Vagal withdrawal is considered an index of positive physiological regulation because it supports the capacity for sustained attention, social engagement, and adaptive coping (Porges, 2011). Specifically, Perry et al. demonstrate that greater maternal sensitivity at 2.5 years is linked with greater vagal withdrawal during challenging tasks at 4.5 years, which in turn is associated with greater maternal sensitivity at 5.5 years.

A growing number of studies in the behavioral genetics field evaluate how genetic factors and interactions or correlations between genetic and environment factors transact with parenting quality to predict children's regulatory outcomes (e.g., Kochanska, Philibert, & Barry, 2009; Leve et al., 2010; Montiroso et al., 2015; Propper et al., 2008; Smith et al., 2012). Deater-Deckard and colleagues assessed whether maternal-child mutuality during social interactions was associated with degree of kinship or child behavior problems. In one study, both the degree of kinship and variations in mother-child mutuality were associated with individual differences in children's proneness to anger and soothability (Deater-Deckard & O'Connor, 2000). This suggests that both non-shared environmental influences and evocative gene-environment correlations contribute to the quality of parent-child relationships. However, in other research with adoptive families, where parent-child kinship is zero, greater parent-child mutuality is linked with lower levels of aggression (Deater-Deckard & Petrill, 2004), highlighting the importance of positive parenting and mutual regulatory processes for positive child regulatory outcomes.

Some researchers focus on the effects of extreme variations in the caregiving environment (e.g., trauma and child maltreatment) on early self-regulatory development. These studies are important because they highlight more clearly how environmental factors may influence neurobiological structures and processes relevant to self-regulation. Many of these studies provide compelling evidence that severe or chronic exposure to toxic stressors (e.g., violence, child abuse and neglect, maternal psychopathology) in early childhood is linked to alterations in brain organization and associated somatic and neurologic systems that, in turn, are linked to long-term psychosocial maladaptation and psychopathology (Calkins & Dollar, 2014; Calkins et al., 2013; Cicchetti, 2013; B. Perry, 1999, 2001, 2008; B. Perry & Pollard, 1998; Unger & Perry, 2012; Shonkoff, 2012; Schore, 2005).

For instance, Gunnar and colleagues show that children with a history of maltreatment exhibit alterations in limbic–hypothalamic–pituitary–adrenal (L-HPA) axis functioning, whereas their non-maltreated counterparts do not (Gunnar et al., 2006). Similarly, Pollak and colleagues demonstrated that maltreated children have higher event related potential (ERP) responses to pictures of angry (but not happy or fearful) facial expressions, indicating that these children have a lower attention threshold for detecting anger expressions (Pollak, 2002; Pollak, Klorman, Thatcher, & Cicchetti, 2001). In longitudinal research, Ahlfs-Dunn and Huth-Bocks (2014) show that infants of women exposed to intimate partner violence during the first year postpartum exhibit more socioemotional problems at 12 months than infants of unexposed women, and this association is moderated by mothers' postpartum posttraumatic stress symptoms.

Importantly, positive parenting may be an important protective factor for infants of trauma-exposed women. In a longitudinal study of women with a history of childhood maltreatment and their infants, maternal positive parenting was associated with improved behavioral regulation (i.e., positive affect and social engagement) and decreased cortisol reactivity following exposure to a social stressor (Martinez-Torteya et al., 2014).

Parent-Infant Co-Regulatory Processes and the Mutual Regulation Model

Many investigators who study mother–infant interactive processes use microanalytic techniques to evaluate dyadic coordination and mutual regulatory processes (e.g., Beebe et al., 2008; Beebe et al., 2010; see Fogel, 2015; Tronick, 2007, for reviews). Findings from this research suggest that parent–infant interactions are *co-regulated* at the dyadic level.

Our own work on self- and dyadic co-regulation follows this tradition and is guided by the Mutual Regulation Model (Beeghly & Tronick, 1994; Beeghly et al., 2011; Tronick, 1989, 2002; 2005, 2006, 2007, 2008; Tronick & Beeghly, 2011). According to this model, infant regulatory capacities emerge from within a dyadic mutually-regulating communication system comprised of an infant subsystem, a parental subsystem, and the dynamic interaction between them (Beeghly et al., 2011; Tronick, 1989). This model focuses mainly on the interpersonal nature of infant development; however, it is nested within and consistent with broader theoretical perspectives, including developmental systems/organizational and dynamic systems perspectives (Bronfenbrenner & Morris, 2006; Cicchetti, 1993; Fogel, 2015; Sameroff, 2010; Sroufe, 2013).

The Mutual Regulation Model posits that infants and their parents co-regulate their social interactions by responding moment-to-moment to each other's behavioral and emotional displays. Moreover, the success or failure of their mutual regulation depends on four reciprocal processes: (a) infants' ability to self-organize and control their own physiological states and behavior; (b) the integrity and maturation of sensorimotor, attentional, and socioemotional components of infants' communicative system (e.g., gaze shifting, affective displays, and gestures); (c) parents' ability to perceive and correctly interpret their infant's communicative signals; and (d) parents' motivation and ability to respond to their infant contingently and appropriately, in order to facilitate their infant's regulatory efforts (Beeghly et al., 2011; Tronick & Beeghly, 2011). When self- and parent–infant regulatory processes function well, infants can actively and thoroughly engage the world of people and objects, which is a major developmental task of infancy and toddlerhood (Brazelton, 1992; Sroufe, 1996; Tronick & Beeghly, 2011). Over time, their repeated, active transactions with the social and non-social environment support positive developmental and self-regulatory outcomes (Tronick & Beeghly, 2011).

As described by Kopp (1982, 1989) and detailed in the neurobiological sections of this chapter, older, more mature infants have a larger repertoire of regulatory strategies than newborns and younger infants. Because of their developmental advances in motor, attentional, and communicative skills (e.g., independent locomotion, selective attention, gestural communication, and language), older infants are able to rely less on fussing and self-soothing to regulate their arousal and attentional states (Feldman, 2007, 2009; Planalp & Braungart-Rieker, 2015). Prior to the onset

Self-Regulatory Processes in Early Development

of representational thought, infants' early regulatory processes are procedural or implicit. However, after the first year, toddlers begin to internalize their social experiences and develop rudimentary "working models" or mental representations of how their mother and other caregivers are likely to respond and behave (Bretherton & Munholland, 1999) and, concomitantly, infants begin to gain a sense of their own agency and efficacy in the world of people and objects. These internal working models gradually begin to act as superordinate regulators of biological systems and increasingly influence how infants respond to others, cope with stressful situations, and regulate their emotions and behavior (Feldman, 2007). However, the extent to which they override procedural regulatory processes remains an open question.

Throughout this developmental process, parents and other caregivers play a critical role in scaffolding infants' engagement with people and objects and in repairing disruptions ("mismatches") in parent-infant relationships (Beeghly et al., 2011; Tronick, 2005; Tronick & Beeghly, 2011). Microanalytic research shows that dyadic mismatches occur frequently during typical parent-infant social interactions because of infants' immaturity and the speed of interactive exchanges (i.e., tenths of seconds; Tronick, 1989), and that mismatches are stressful and generate negative affect. Consequently, infants very easily can become dysregulated during even routine activities, which in turn constrains their self-regulatory and communicative capacities.

However, when caregivers and infants engage in mutual regulation and repair mismatches quickly, children's age-possible capacity to engage the social and object worlds in a positive way is supported and restored. Some investigators argue that the repeated experience of successful reparation (i.e., restoration of positive engagement) following a disruption or mismatch promotes the growth of infants' self-regulatory skills in multiple domains and also contributes to their later-emerging mental representations of self-efficacy and basic trust (DiCorcia & Tronick, 2011; Tronick, 1989; Tronick & Beeghly, 2011). One reason for this is that the repeated experience of reparation allows the parent-infant dyadic system to create new "meanings" for each partner which are incorporated into memory, with or without consciousness, increasing each partner's socioaffective complexity (Tronick, 2005, 2008; Tronick & Beeghly, 2011). We believe that developing a successful reparatory history with a specific person via repeated parent-infant interactions (e.g., caretaking routines, playful interactions, or social games) leads to an implicit, preverbal "knowing" by infants that "we can repair mismatches" (Tronick, 2008; Tronick & Beeghly, 2011). This repeated experience of reparation at the dyadic level contributes to a sense of trust, which in turn contributes to the establishment of a secure attachment relationship with that person.

It is notable that dyads' successful reparatory processes are associated with positive affect (Tronick, 1989). Kochanska and colleagues suggest that, for the infant, experiencing repeated successful reparatory processes likely contributes to the formation of a core sense of positive affect that conveys a general sense of well-being (Kochanska, Aksan, Penney, & Doobay, 2007) as well as an emergent sense of mastery and agency (Wang & Barrett, 2013). We contend that the capacity to approach novel or uncertain situations with a sense of trust, secure attachment, positive affective core, a general sense of well-being, and an emergent sense of agency reflects a history of effective self- and parent-infant regulatory processes throughout infancy, and together these capacities may define the robust or resilient infant (Beeghly & Tronick, 2011; Easterbrooks et al., 2008).

Partial empirical support for this notion is provided in several recent longitudinal studies. Guo and colleagues (Guo, Leu, Barnard, Thompson, & Spieker, 2015) assessed the effect of attachment security on dyads' emotion co-regulatory processes before and after a stressful event (maternal separation). Their results show that mother-child dyads with secure attachment have more positive interactions and fewer negative interactions following the stressor than mother-child dyads with insecure attachment. Similar findings are reported by Lindsey and Caldera (2015), who show that parent-toddler dyads with secure attachment have more synchronous social interactions and exhibit more shared positive affect than parent-toddler dyads with insecure attachment.

In other research, Zentall and colleagues investigated associations between the quality of the mother-child relationship, as indexed in attachment security, and children's physiological regulatory processes, as indexed in sleep-wake regulation (Zentall, Braungart-Rieker, Ekas, & Lickenbrock, 2012). Their findings reveal that infants with a secure mother-infant attachment at 12 months decrease their number of night wakings over time, whereas infants with an insecure-ambivalent pattern of attachment continue to wake at night into the second year of life.

In a longitudinal analysis of archival data, Drake and colleagues evaluated whether attachment experiences in early life are associated with children's later development of self-regulation and conscientious behavior (Drake, Belsky, & Pasco

Fearon, 2014). Their results show that attachment quality assessed at 15 and 36 months is related to children's social self-regulation and attentional impulsivity at Grade 1. In turn, social self-control at Grade 1 mediates the effect of attachment on school engagement at Grade 5, even when Grade 1 school engagement is controlled analytically (Drake et al., 2014).

Taken together, these studies suggest that positive parent-child relationships and mutual co-regulatory processes promote positive child regulatory outcomes throughout early childhood. But what happens when dyadic mismatches are not repaired in a timely way and become prolonged? Without the provision of appropriate parental support and scaffolding, infants very likely will become persistently dysregulated or disengaged. Such infants therefore must use much of their energy resources to self-regulate and achieve homeostasis, and as a consequence, spend less time engaging the social and inanimate environment (Tronick, 1989; Tronick & Beeghly, 2011). In turn, chronically dysregulated or disengaged infants may fail to resolve age-salient developmental tasks confronting them, which may eventually lead to maladaptive developmental outcomes (Sroufe, 1996; Tronick & Beeghly, 2011).

Individual Differences in Mutual Regulation: Risk and Resilience

A large literature shows that parents' ability to respond sensitively and appropriately to their infant's cues is altered by the presence of child, parental, and familial risk and resilience factors (see Beeghly et al., 2011, for a review). These factors, in turn, affect the children's ability to self-regulate their internal states, express their emotions outwardly, and achieve their goals. Illustrations from research on premature infants, infants with prenatal substance exposure, and maternal depression are provided below.

Premature birth.

The outcomes of children born prematurely are heterogeneous. However, for infants at higher biological risk (e.g., those born very prematurely, at less than 32 gestational weeks, or with very low birthweight, <1,500 g), nervous system compromise may prevent infants from organizing, integrating, or sustaining positive attentional, behavioral and/or emotional states, particularly in the absence of sensitively attuned parental support. Research by Landry and colleagues shows that preterm infants have more optimal developmental and regulatory outcomes when their mothers maintain their infants' focus of attention during dyadic toy play than when they re-direct it at whim (Landry, Smith, & Swank, 2006). Notably, Landry et al. report that this association is stronger for prematurely born infants with a higher level of bio-developmental risk than for lower-risk infants. Higher-risk preterm infants also benefit more than lower-risk preterm infants from parenting interventions designed to support parental responsiveness and maintain mother-toddler joint attention (Landry et al., 2006).

In other research, prematurity and associated medical conditions are associated with compromised mother-infant interactive processes, including dyadic co-regulation. In a microanalysis of dyadic co-regulation at 12 months infant age, Sansavini and colleagues report that dyads with an infant born extremely preterm (at less than 28 gestational weeks) engage in less frequent symmetric and more frequent unilateral co-regulation patterns than dyads with a full term, healthy infant; these dyads also display less positive and more neutral affective intensity (Sansavini et al., 2015). On a positive note, another study shows that the quality of mutual regulation established between mothers and their toddlers born very preterm (at less than 32 gestational weeks) during social play significantly mediates the negative association between very preterm status and children's later mental developmental outcomes (Delonis & Beeghly, 2015), with implications for parenting interventions.

Prenatal substance exposure.

Infants exposed prenatally to cocaine and other substances are also at heightened risk for self-regulatory problems, but this association is altered by caregiving quality and other factors. In their longitudinal research, Eiden and colleagues demonstrate that prenatal cocaine exposure is *indirectly* associated with children's effortful control at 36 months of age via exposure to negative parenting (i.e., maternal harshness during parent-infant social interactions). In one analysis, Eiden et al. show that prenatal cocaine exposure is indirectly associated with externalizing problems at preschool age via children's exposure to maternal harshness at age 2 and children's own poorer self-regulation at age 3 (Eiden, Coles, Schuetze, & Colder, 2014). In another analysis (Finger, Schuetze, & Eiden, 2014), prenatal cocaine exposure had an indirect association with children's physiological regulatory capacity (i.e., low baseline respiratory sinus arrhythmia [RSA] and low RSA withdrawal) during a negative affect task. In turn, RSA is linked to fewer behavior problems, and this association was moderated by maternal negative affect. In a third analysis, exposure to high maternal harshness among

Self-Regulatory Processes in Early Development

children with poorer autonomic reactivity is associated with lower conscience development at age 3 (Eiden, Godleski, Schuetze, & Colder, 2015).

In other research (Wiebe et al., 2015), direct links between prenatal tobacco exposure and children's motivational self-regulation during a delay of gratification task are reported. However, this association is moderated by child sex, such that prenatally exposed boys have poorer performance. Interestingly, prenatal tobacco exposure is not associated with cognitive aspects of self-regulation (e.g., in tasks requiring children to hold information in mind and inhibit prepotent motor responses; Wiebe et al., 2015).

Maternal psychopathology.

Parental psychological problems such as depression or anxiety can lead to prolonged periods of disorganized parent-infant social interactions, compromising concurrent and long-term infant regulatory outcomes. For instance, high maternal depressive symptoms assessed at 6 weeks postpartum are linked to altered patterns of mother-infant self- and interactive contingency during social interaction at 4 months postpartum (Beebe et al., 2008). Maternal depression is also a robust predictor of infants' later social, emotional, and cognitive problems (see Goodman & Brand, 2009; Murray & Cooper, 1997; Tronick & Reck, 2009, for reviews). This may be because mothers with a high level of depressive symptoms early in the postpartum year are likely to continue experiencing high symptoms over the next several years, and the severity and chronicity of their symptoms are exacerbated by the presence of social risk factors such as poverty or single parenthood (Beeghly et al., 2003). Thus, infants of mothers with chronically high depressive symptoms, compared with infants of non-depressed mothers, are more likely to be exposed to negative maternal mood states and associated compromised social interaction patterns on a relatively stable basis (Beeghly et al., 2003).

Notably, both infant and parental characteristics contribute to the negative child, maternal, and dyadic outcomes associated with maternal depression. In research by Field and colleagues, infants of depressed mothers were less responsive to faces and voices as early as the neonatal period and to their own and other infants' cry sounds (Field, Diego, & Hernandez Reif, 2009), suggesting that maternal depression is linked to a higher level of infant arousal, less attentiveness, and/or slower processing. In turn, depressed mothers exhibit less responsive behavior with their infants, and this effect is strengthened when mothers had co-morbid mood states of anger and anxiety (Field et al., 2009). In our own research with the Still-Face paradigm at 3 months, mothers with a high level of postpartum depressive symptoms had more difficulty repairing the *dyadic* rupture caused by the maternal still-face than their non-depressed counterparts, and this effect was stronger for depressed mother-son dyads (Weinberg, Olson, Beeghly, & Tronick, 2006).

Fortunately, the associations between maternal psychopathology and children's regulatory outcomes may be altered by the quality of dyadic interactive processes, with implications for intervention. Research by Richter and Reck (2013) shows that the links between maternal anxiety and infant regulatory problems in crying and sleeping vary as a function of positive maternal engagement in stressful situations. Interplay among these factors with infants' physiological processes are also reported. For instance, Khoury and colleagues show that infants' emotional self-regulation strategies moderate the association between maternal depression and infants' HPA axis activity (Khoury et al., 2015).

Self-Regulatory Processes in Cultural Context

For both at-risk and typically developing children, the process of infant self-regulation and parent-infant mutual regulation takes place within a cultural framework (Ford & Mauss, 2015; Raver, 2004). Parents' caregiving practices are embedded within the context of their culturally specific beliefs and values, including individualistic versus collectivistic orientation (Levine et al., 2008; Otto & Keller, 2014). Therefore, adopting dynamic biopsychosocial models to study cultural influences on early self-regulatory processes is important (LeCuyer & Zhang, 2014; Raver, 2004).

Although under studied, cultural variations in caregiving behavior affect how distressed infants develop regulatory capacities, which, in turn, affects mothers' caregiving practices. We illustrate this using an example from the Efe, a foraging people in the Congo. Efe mothers typically respond to their infants' cries quite rapidly, within 10 seconds 90% of the time (LeVine et al., 2008). This rapid parental response shapes infants' experience with distress, regulation of arousal and stress, and expectations about their mother's responsiveness. In contrast, in many industrialized Western nations, infants are often left to cry for longer periods of time before parental intervention, suggesting that Western parents place a greater demand on their distressed infants for self-soothing and self-regulation (LeVine et al., 2008).

Conclusion: Implications for Practice

The literature reviewed in this chapter has several implications for practitioners who serve families with infants and young children (Beeghly & Tronick, 2011; Tronick, 2008). The first is that practitioners should be aware that infants' self-regulatory capacities provide the basis for the development of resilience, and that these capacities organize within the context of parent–infant relationships. Practitioners should also understand that brief periods of miscoordination in the parent–infant relationship occur frequently, are normative, and likely reflect the role of everyday routines and activities, as well as the uneven nature of infants' developmental trajectories (Brazelton, 1992). These periods of dyadic disorganization may temporarily disrupt infants' regulatory capacities and the quality of parent–infant relationships. Practitioners who are aware of these findings may be better equipped in helping parents understand normative periods of disorganization as a way to support parent–infant relationships (Brazelton, 1992).

Risk factors such as premature birth, prenatal substance exposure, and maternal depression may undermine early self- and parent–infant co-regulatory processes. These risk conditions may deplete the resources of the infant and the caretaker in ways that compromise their functioning in the present, and if this compromised pattern of parent–child functioning persists, it may presage developmental and behavioral problems in the future. For instance, higher levels of maternal depressive symptomatology (when chronic) may contribute to persistent infant dysregulation and compromised parent–infant relationships, which can lead to maladaptive child self-regulatory and other developmental outcomes. Practitioners should attend to these parental conditions in order to promote positive parent–child relationships and optimal child functioning, as well as to prevent developmental problems. Interventions for maternal problems such as depression have generally proven to be effective (see Cuijpers, Weitz, Karyotaki, Garber, & Andersson, 2015, for a review).

Finally, practitioners should be aware that, although parent–infant co-regulation is a joint activity of both infant and parent, parents play a greater role in providing regulatory input to their immature infants whose own resources are insufficient. Therefore, helping parents recognize and respond appropriately to infants' cues may help prevent prolonged dyadic dysregulation and promote positive parent–child relationships. For example, a parent who feeds a hungry child repairs the child's state of distress, and metabolic homeostasis is returned. But a parent who gives the hungry child an object to play with, or who ignores the distress, fails to repair the child's state. Such distress continues at high energetic cost, precluding the child's engagement with the world and potentially compromising development. Thus the Mutual Regulation Model provides a useful framework for practitioners as they carefully attend to the quality of the parent–infant relationship.

Author Note

Partial support during preparation of this manuscript was provided from the Eunice Kennedy Shriver National Institute for Child Health and Human Development (grants RO1 HD048841 and RO1HD044068 to Marjorie Beeghly, PI; and grant RO1HD050459 to Ed Tronick, PI), the National Institute of Mental Health (grant RO1MH45547 to Ed Tronick, PI), and the National Science Foundation (grant 0819839 to Ed Tronick, PI). We are grateful to Mahya Rahimian Mashhadi for her valuable contributions to this manuscript.

References

- Ahlf-Dunn, S. M., & Huth-Bocks, A. C. (2014). Intimate partner violence and infant socioemotional development: The moderating effect of maternal trauma symptoms. *Infant Mental Health Journal, 35*, 322–335.
- Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., & Andrews, H. (2008). Six-week postpartum maternal depressive symptoms and 4-month mother–infant self- and interactive contingency. *Infant Mental Health Journal, 29*, 442–471.
- Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., ... Feldstein, S. (2010). The origins of 12-month attachment: A microanalysis of 4-month mother–infant interaction. *Attachment and Human Development, 12*, 3–141. doi: 10.1080/14616730903338985
- Beeghly, M., Fuentes, M., Liu, C. H., Delonis, M. S., & Tronick, E. (2011). Maternal sensitivity in dyadic context: Mutual regulation, meaning-making, and reparation. In D. W. Davis & M. C. Logsdon (Eds.), *Maternal sensitivity: A scientific*

Self-Regulatory Processes in Early Development

foundation for practice (pp. 45–69). Hauppauge, NY: Nova Science Publishers.

Beeghly, M., Olson, K. L., Weinberg, M. K., Pierre, S. C., Downey, N., & Tronick, E. Z. (2003). Prevalence, stability, and socio-demographic correlates of depressive symptoms in Black mothers during the first 18 months postpartum. *Maternal & Child Health Journal*, *7*, 157–168.

Beeghly, M., & Tronick, E. (1994). Effects of prenatal exposure to cocaine in early infancy: Toxic effects on the process of mutual regulation. *Infant Mental Health Journal*, *15*, 158–175. doi:10.1002/1097-0355(199422)15:2<158::AID-IMHJ2280150207>3.0.CO;2-7

Beeghly, M., & Tronick, E. (2011). Early resilience in the context of parent-infant relationships: A social developmental perspective. *Current Problems in Pediatric and Adolescent Health Care*, *41*, 197–201. doi 10.1016/j.cppeds.2011.02.005. PMID: 21757137

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist*, *57*, 111–127. doi:10.1037/0003-066x.57.2.111

Blair, C. (2010). Stress and the development of self-regulation in context. *Child Development Perspectives*, *4*, 181–188.

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2005). *Handbook of self-regulation*. Burlington, MA: Elsevier Academic Press.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*, 271–301.

Brazelton, T. B. (1992). *Touchpoints: Your child's emotional and behavioral development*. Reading, MA: Addison-Wesley.

Bretherton, I. & Munholland, K. A. (1999). Internal working models in attachment relationships: A construct revisited. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (pp. 89–111). New York, NY: Guilford.

Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-Deckard, K. (2015). Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological Bulletin*, *141*, 602–624.

Bronfenbrenner, U., & Morris, P. (2006). The bioecological model of development. In R. M. Lerner (Ed.), *Theoretical models of human development Vol 1 of the Handbook of child psychology* (6th ed., pp. 793–828). New York, NY: Wiley.

Calkins, S. D. (2011). Caregiving as co-regulation: Psychobiological processes and child outcomes. In A. Booth, S. McHale, & N. Lansdale (Eds.), *Biosocial research contributions to understanding family processes and problems* (pp. 49–60). New York, NY: Springer.

Calkins, S. D., & Dollar, J. M. (2014). A biopsychosocial perspective on maternal psychopathology and the development of child emotion regulation. *Journal of Personality Disorders*, *28*, 70–77.

Calkins, S. D., & Fox, N. A. (2002). Self-regulatory processes in early personality development: Multilevel approach to the study of childhood social withdrawal and aggression. *Development and Psychopathology*, *14*, 477–498.

Calkins, S. D., & Hill, A. (2007). Caregiver influences on emerging emotion regulation: Biological and environmental transactions in early development. In J. Gross (Ed.), *Handbook of emotion regulation* (pp. 229–248). New York, NY: Guilford.

Calkins, S. D., & Mackler, J. S. (2011). Temperament, emotion regulation, and social development. In M. K. Underwood & L. H. Rosen (Eds.), *Social development: Relationships in infancy, childhood, and adolescence* (pp. 44–70). New York, NY: Guilford.

Calkins, S. D., Propper, C., & Mills-Koonce, W. R. (2013). A biopsychosocial perspective on parenting and developmental psychopathology. *Development and Psychopathology*, *25*, 1399–1414.

Calkins, S. D., Smith, C. L., Gill, K. L., & Johnson, M. C., (1998). Maternal interactive style across contexts: Relations to emotional, behavioral, and physiological regulation during toddlerhood. *Social Development*, *7*, 350–369.

Self-Regulatory Processes in Early Development

- Charles, S., & Carstensen, L. L. (2007). Emotion regulation and aging. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp.307–327). New York, NY: Guilford.
- Cicchetti, D. (1993). Developmental psychopathology: Reactions, reflections, projections. *Developmental Review, 13*, 471–502.
- Cicchetti, D. (2013). Annual research review: Resilient functioning in maltreated children—past, present, and future. *Journal of Child Psychology and Psychiatry, 54*, 402–422.
- Conradt, E., Fei, M., LaGasse, L., Tronick, E., Guerin, D., Gorman, D., Marsit, C. J., & Lester, B. M. (2015). Prenatal predictors of infant self-regulation: The contributions of placental DNA methylation of NR3C1 and neuroendocrine activity. *Frontiers in Behavioral Neuroscience, 9*, 1–9. doi: 10.3389/fnbeh.2015.00130
- Cuijpers, P., Weitz, E., Karyotaki, E., Garber, J., & Andersson, G. (2015). The effects of psychological treatment of maternal depression on children and parental functioning: A meta-analysis. *European Child and Adolescent Psychiatry, 24*, 237–245.
- Damasio, A. R. (2003). *Looking for Spinoza: Joy, sorrow, and the feeling brain*. New York, NY: Harcourt.
- Deater-Deckard, K., & O'Connor, T. G. (2000). Parent-child mutuality in early childhood: Two behavioral genetic studies. *Developmental Psychology, 36*, 561–570.
- Deater-Deckard, K., & Petrill, S. A. (2004). Parent-child dyadic mutuality and child behavior problems: An investigation of gene-environmental processes. *Journal of Child Psychology and Psychiatry, 45*, 1171–1179.
- Delonis, M. S., & Beeghly, M. (2015). Mother-toddler interaction quality as a predictor of developmental and behavioral outcomes in a very preterm sample. Manuscript submitted for publication.
- Diaz, A., & Eisenberg, N. (2015). The process of emotion regulation is different from individual differences in emotion regulation: Conceptual arguments and a focus on individual differences. *Psychological Inquiry, 26*, 37–47.
- DiCorcia, J. A., Sravish, A. V., & Tronick, E. (2013). The everyday stress resilience hypothesis: Unfolding resilience from a perspective of everyday stress and coping. In G. Laviola & S. Macrì (Eds.), *Adaptive and maladaptive aspects of developmental stress* (pp. 67–93). New York, NY: Springer.
- DiCorcia, J. A., & Tronick, E. (2011). Quotidian resilience: Exploring mechanisms that drive resilience from a perspective of everyday stress and coping. *Neuroscience and Biobehavioral Reviews, 35*, 1593–1602.
- Drake, K., Belsky, J., & Pasco Fearon, R. M. (2014). From early attachment to engagement with learning in school: The role of self-regulation and persistence. *Developmental Psychology, 50*, 1350–1361.
- Easterbrooks, M. A., Driscoll, J. R., & Bartlett, J. D. (2008). Resilience in infancy: A relational approach. *Research in Human Development, 5*, 139–152.
- Easterbrooks, A., Bartlett, J. D., Beeghly, M., & Thompson, R. (2013). Social and emotional development in infancy. In I. B. Weiner (Series Ed.), R. M. Lerner, M. A. Easterbrooks, & J. Mistry (Eds.), *Handbook of psychology, Volume 6: Developmental Psychology* (2nd ed., pp. 91–120). New York, NY: Wiley.
- Edelman, G. M. (2004). *Wider than the sky: The phenomenal gift of consciousness*. New Haven, CT: Yale University Press.
- Eiden, R. D., Coles, C. D., Schuetze, P., & Colder, C. R. (2014). Externalizing behavior problems among polydrug cocaine-exposed children: Indirect pathways via maternal harshness and self-regulation in early childhood. *Psychology of Addictive Behaviors, 28*, 139–153.
- Eiden, R. D., Godleski, S., Schuetze, P., & Colder, C. R. (2015). Prenatal substance exposure and child self-regulation: Pathways to risk and protection. *Journal of Experimental Child Psychology, 137*, 12–29.
- Eisenberg, N., & Fabes, R. A. (1992). Emotion, regulation, and the development of social competence. *Review of Personality and Social Psychology, 14*, 119–150.

Self-Regulatory Processes in Early Development

- Eisenberg, N., Sadovsky, A., & Spinrad, T. L. (2005). Associations of emotion-related regulation with language skills, emotion knowledge, and academic outcomes. *New Directions for Child and Adolescent Development*, *109*, 109–118.
- Eisenberg, N., Smith, C. L., Sadovsky, A., & Spinrad, T. L. (2004). Effortful control: Relations with emotion regulation, adjustment, and socialization in childhood. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 259–282). New York, NY: Guilford.
- Feldman, R. (2007). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, *16*, 340–345.
- Feldman, R. (2009). The development of regulatory functions from birth to 5 years: Insights from premature infants. *Child Development*, *80*, 544–561.
- Field, T., Diego, M., & Hernandez-Reif, M. (2009). Depressed mothers' infants are less responsive to faces and voices. *Infant Behavior and Development*, *32*, 239–244.
- Finger, B., Schuetze, P., & Eiden, R. D. (2014). Behavior problems among cocaine exposed children: Role of physiological regulation and parenting. *Neurotoxicology and Teratology*, *42*, 51–59.
- Fogel, A. (2015). *Infant development: A topical approach*. Cornwall-on-Hudson, NY: Sloan Publishing.
- Ford, B. Q., & Mauss, I. B. (2015). Culture and emotion regulation. *Current Opinion in Psychology*, *3*, 1–5.
- Fox, N. A., & Calkins, S. D. (2003). The development of self-control of emotion: Intrinsic and extrinsic influences. *Motivation and Emotion*, *27*, 7–26.
- Fujita, K. (2011). On conceptualizing self-control as more than the effortful inhibition of impulses. *Personality and Social Psychology Review*, *15*, 352–366.
- Goodman, S. H., & Brand, S. R. (2009). Infants of depressed mothers. In C. H. Zeanah (Ed.), *Handbook of infant mental health* (3rd ed., pp. 153–170). New York, NY: Guilford.
- Gottlieb, G. (2007). Probabilistic epigenesis. *Developmental Science*, *10*, 1–11.
- Gunnar, M. R., Fisher, P. A., & The Early Experience, Stress, and Prevention Network. (2006). Bringing basic research on early experience and stress neurobiology to bear on preventive interventions for neglected and maltreated children. *Development and Psychopathology*, *18*, 651–677.
- Guo, Y., Leu, S.-Y., Barnard, K. E., Thompson, E. A., & Spieker, S. J. (2015). An examination of changes in emotion co-regulation among mother and child dyads during the Strange Situation. *Infant and Child Development*, *24*, 256–273.
- Holodyski, M., Seeger, D., Kortas-Hartmann, P., & Wormann, V. (2013). Placing emotion regulation in a developmental framework of self-regulation. In K. C. Barrett, N. A. Fox, G. A. Morgan, D. J. Fidler, & L. A. Daunhauer (Eds.), *Handbook of self-regulatory processes in development: New directions and international perspectives* (pp. 27–59). New York, NY: Psychology Press.
- Khoury, J. E., Gonzalez, A., Levitan, R., Masellis, M., Basile, V., & Atkinson, L. (2015). Infant emotion regulation strategy moderates relations between self-reported maternal depressive symptoms and infant HPA activity. *Infant and Child Development*. Advance online publication. Retrieved from doi: 10.1002/icd.1916
- Kober, H., Barrett, L. F., Joseph, J., Bliss-Moreau, E., Linquist, K., & Wager, T. D. (2008). Functional grouping and cortical-subcortical interactions in emotion: A meta-analysis of neuroimaging studies. *NeuroImage*, *42*, 998–1031.
- Kochanska, G., Aksan, N., Penney, S. J., & Doobay, A. F. (2007). Early positive emotionality as a heterogeneous trait: Implications for children's self-regulation. *Journal of Personality and Social Psychology*, *93*, 1054–1066.
- Kochanska, G., Philibert, R. A., & Barry, A. (2009). Interplay of genes and early mother-child relationship in the development of self-regulation from toddler to preschool age. *Journal of Child Psychology and Psychiatry*, *50*, 1331–1338.

Self-Regulatory Processes in Early Development

- Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology, 18*, 199–214.
- Kopp, C. B. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology, 25*, 343–354.
- Landry, S. H., Smith, K. E., & Swank, P. R. (2006). Responsive parenting: Establishing early foundations for social, communication, and independent problem-solving skills. *Developmental Psychology, 42*, 627–642.
- LeCuyer, E. A., & Zhang, Y. (2014). An integrative review of ethnic and cultural variation in socialization and children's self-regulation. *Journal of Advanced Nursing, 71*, 735–750.
- Leve, L. D., Kerr, D. C. R., Shaw, D., Ge, X., Neiderhiser, J. M., Scaramella, L. V., ... Rose, D. (2010). Infant pathways to externalizing behavior: Evidence of genotype x environment interaction. *Child Development, 81*, 340–356.
- LeVine, R. A., Dixon, S., LeVine, S. E., Richman, A., Keefer, C. H., Leiderman, P. H., & Brazelton, T. B. (2008). The comparative study of parenting. In R. A. LeVine & R. S. New (Eds.), *Anthropology and child development* (pp. 55–65). Malden, MA: Blackwell.
- Lindsey, E. W., & Caldera, Y. M. (2015). Shared affect and dyadic synchrony among secure and insecure parent-toddler dyads. *Infant and Child Development, 24*, 394–413.
- Mann, T., Ridder, D. D., & Fujita, K. (2013). Self-regulation of health behavior: Social psychological approaches to goal setting and goal striving. *Health Psychology, 32*, 487–498.
- Martinez-Torteya, C., Dayton, C. J., Beeghly, M., Seng, J. S., McGinnis, E., Broderick, A., ... Muzik, M. (2014). Maternal parenting predicts infant biobehavioral regulation among women with a history of childhood maltreatment. *Development and Psychopathology, 26*, 379–392.
- Masten, A. S., & Obradović, J. (2006). Competence and resilience in development. In B. M. Lester, A. S. Masten, & B. S. McEwen (Eds.), *Annals of the New York Academy of Sciences Volume 1094: Resilience in children* (pp. 13–27). doi: 10.1196/annals.1376.003
- Montirosso, R., Provenzi, L., Taviani, D., Morandi, F., Bonanomi, A., Missaglia, S., ... Borgatti, R. (2015). Social stress regulation in 4-month-old infants: Contributions of maternal social engagement and infants' 5-HTTLPR genotype. *Early Human Development, 91*, 173–179.
- Murray, L., & Cooper, P. (Eds.). (1997). *Postpartum depression and child development*. New York, NY: Guilford.
- Nota, L., Soresi, S., & Zimmerman, B. J. (2004). Self-regulation and academic achievement and resilience: A longitudinal study. *International Journal of Educational Research, 41*(3), 198–215.
- Ochsner, K. N., Ray, R. R., Hughes, B., McRae, K., Cooper, J. C., & Weber, J. (2009). Bottom-up and top-down processes in emotion regulation: Common and distinct mechanisms. *Psychological Science, 20*, 1322–1331.
- Otto, H., & Keller, H. (Eds.). (2014). *Different faces of attachment: Cultural variations on a universal human need*. Cambridge, England: Cambridge University Press.
- Perry, B. D. (1999). Memories of fear: How the brain stores and retrieves physiologic states, feelings, behaviors and thoughts from traumatic events. In J. M. Goodwin & R. Attias (Eds.), *Images of the body in trauma* (pp. 26–47). New York, NY: Basic Books.
- Perry, B. D. (2001). The neurodevelopmental impact of violence in childhood. In D. Schetky & E. P. Benedik (Eds.), *Textbook of child and adolescent forensic psychiatry* (pp. 221–238). Washington, DC: American Psychiatric Press.
- Perry, B. D. (2008). Child maltreatment: The role of abuse and neglect in developmental psychopathology. In T. P. Beauchaine & S. P. Hinshaw (Eds.), *Textbook of child and adolescent psychopathology* (pp. 93–128). New York, NY: Wiley.
- Perry, B. D., & Pollard, R. (1998). Homeostasis, stress, trauma, and adaptation: A neurodevelopmental view of childhood

Self-Regulatory Processes in Early Development

- trauma. *Child and Adolescent Psychiatric Clinics of North America*, 7, 33–51.
- Perry, N. B., Mackler, J. S., Calkins, S. D., & Keane, S. P. (2014). A transactional analysis of the relation between maternal sensitivity and child vagal response. *Developmental Psychology*, 50, 784–793.
- Planalp, E. M., & Braungart-Rieker, J. M. (2015). Trajectories of regulatory behaviors in early infancy: Determinants of infant self-distraction and self-comforting. *Infancy*, 20, 129–159.
- Pollak, S. D. (2002). Effects of early experience on children's recognition of facial displays of emotion. *Developmental Psychology*, 38, 787–791.
- Pollak, S. D., Klorman, R., Thatcher, J. E., & Cicchetti, D. (2001). P3b predicts maltreated children's reactions to facial displays of emotion. *Psychophysiology*, 38, 267–274.
- Porges, S. W. (2011). *The polyvagal theory: Neurophysiological foundations of emotions, attachment, communication, and self-regulation*. New York, NY: Norton.
- Posner, M. I., & Rothbart, M. K. (2000). Developing mechanisms of self-regulation. *Development and Psychopathology*, 12, 427–441.
- Propper, C., & Moore, G. A. (2006). The influence of parenting on infant emotionality: A multi-level psychobiological perspective. *Developmental Review*, 26, 427–460.
- Propper, C., Moore, G. A., Mills-Koonce, R., Halpern, C., Hill, A., & Calkins, S. D. (2008). Gene-environment contributions to the development of vagal tone. *Child Development*, 79, 1378–1395.
- Quirk, G. J. (2007). Prefrontal-amygdala interactions in the regulation of fear. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 27–46). New York, NY: Guilford.
- Raver, C. C. (2004). Placing emotional self-regulation in sociocultural and socioeconomic contexts. *Child Development*, 75, 346–353.
- Richter, N., & Reck, C. (2013). Positive maternal interaction behavior moderates the relation between maternal anxiety and infant regulatory problems. *Infant Behavior and Development*, 36, 498–506.
- Rothbart, M. K., & Jones, L. B. (1998). Temperament, self-regulation, and education. *School Psychology Review*, 27, 479–491.
- Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, 1, 2–7.
- Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development*, 81, 6–22.
- Sander, L. W. (1975). Infant and caregiving environment: Investigation and conceptualization of adaptive behavior in a system of increasing complexity. In E. J. Anthony (Ed.), *Explorations in child psychiatry* (pp. 129–166). New York, NY: Plenum.
- Sansavini, A., Zavagli, V., Guarini, A., Savini, S., Alessandrini, R., & Faldella, G. (2015). Dyadic co-regulation, affective intensity, and infant's development at 12 months: A comparison among extremely preterm and full-term dyads. *Infant Behavior and Development*, 40, 29–40.
- Schore, A. N. (2005). Attachment, affect regulation, and the developing right brain: Linking developmental neuroscience to pediatrics. *Pediatrics in Review*, 28, 204–217.
- Shiner, R. L., Buss, K. A., McClowry, S. G., Putnam, S. P., Saudino, K. J., & Zentner, M. (2012). What is temperament now? Assessing progress in temperament research on the twenty-fifth anniversary of Goldsmith et al. *Child Development Perspectives*, 6, 436–444.
- Shonkoff, J. P. (2012). Leveraging the biology of adversity to address the roots of disparities in health and development.

Self-Regulatory Processes in Early Development

- Proceedings of the National Academy of Sciences USA*, 109 (Suppl. 2), pp. 17302–17307 doi:10.1073/pnas.1121259109
- Smith, H. J., Shiekh, H. I., Dyson, M. W., Olino, T. M., Lupton, R. S., Durbin, C. E., ... Klein, D. N. (2012). Parenting and child DRD4 genotype interact to predict children's early emerging effortful control. *Child Development*, 83, 1932–1944.
- Sroufe, L. A. (1996). *Emotional development: The organization of emotional life in the early years*. New York, NY: Cambridge University Press.
- Sroufe, L. A. (2013). The promise of developmental psychopathology: Past and present. *Development and Psychopathology*, 25, 1215–1224.
- Swingler, M. M., Perry, N. B., Calkins, S. D., & Bell, M. A. (2014). Maternal sensitivity and infant response to frustration: The moderating role of EEG asymmetry. *Infant Behavior and Development*, 37, 523–535.
- Thompson, R. A., Lewis, M., & Calkins, S. D. (2008). Reassessing emotion regulation. *Child Development Perspectives*, 2, 124–131.
- Thompson, R. A., Virmani, E. A., Waters, S. F., Raikes, A., & Meyer, S. (2013). The development of emotion self-regulation: The whole and the sum of the parts. In K. C. Barrett, N. A. Fox, G. A. Morgan, D. J. Fidler, & L. A. Daunhauer (Eds.), *Handbook of self-regulatory processes in development: New directions and international perspectives* (pp. 5–26). New York, NY: Psychology Press.
- Tronick, E. Z. (1989). Emotions and emotional communication in infants. *American Psychologist*, 44, 112–119.
- Tronick, E. Z. (2002). The increasing differentiation and non-transferability of ways of being together: The primary attachment is specific, not prototypical. *Journal of Infant, Child, and Adolescent Psychotherapy*, 2, 47–60.
- Tronick, E. Z. (2005). Why is connection with others so critical? The formation of dyadic states of consciousness: Coherence-governed selection and the co-creation of meaning out of messy meaning-making. In J. Nadel & D. Muir (Eds.), *Emotional development* (pp. 293–315). New York, NY: Oxford University Press.
- Tronick, E. Z. (2006). The inherent stress of normal daily life and social interaction leads to the development of coping and resilience, and variations in resilience in infants and young children: Comments on the papers of Suomi and Klebanov and Brooks-Gunn. In B. M. Lester, A. S. Masten, & B. S. McEwen (Eds.), *Annals of the New York Academy of Sciences Volume 1094: Resilience in children* (pp. 83–104). doi: 10.1196/annals.1376.008
- Tronick, E. (2007). *The neurobehavioral and social-emotional development of infants and children*. New York, NY: Norton.
- Tronick, E. Z. (2008). Multilevel meaning-making and dyadic expansion of consciousness theory: The emotional and polymorphic-polysemic flow of meaning. In D. Fosha, M. Solomon, & D. Siegel (Eds.), *The healing power of emotion: Affective neuroscience, development, and clinical practice*. New York, NY: Norton.
- Tronick, E., & Beeghly, M. (2011). Infants' meaning-making and the development of mental health problems. *American Psychologist*, 66, 107–119. doi:10.1037/a0021631
- Tronick, E., & Reck, C. (2009). Infants of depressed mothers. *Harvard Review of Psychiatry*, 17, 147–156.
- Tucker, D. M., Derryberry, D., & Liu, P. (2000). Anatomy and physiology of human emotion: Vertical integration of brain stem, limbic, and cortical systems. In J. C. Borod (Ed.), *The neuropsychology of emotion: Series in affective science* (pp. 56–79). New York, NY: Oxford University Press.
- Ungar, M., & Perry, B. D. (2012). Violence, trauma, and resilience. In R. Alaggia & C. Vine (Eds.), *Cruel but not unusual: Violence in Canadian families* (pp. 1–21). Ontario, Canada: Wilfrid Laurier University Press.
- Vohs, K. D., & Baumeister, R. F. (2004). Understanding self-regulation: An introduction. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 1–9). New York, NY: Guilford.
- Wang, J., & Barrett, K. C. (2013). Mastery motivation and self-regulation during early childhood. In K. C. Barrett, N. A. Fox, G. A. Morgan, D. J. Fidler, & L. A. Daunhauer (Eds.), *Handbook of self-regulatory processes in development: New*

Self-Regulatory Processes in Early Development

directions and international perspectives (pp. 337–380). New York: Psychology Press/Taylor and Francis.

Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*, 670–683.

Wiebe, S. A., Clark, C. A., DeJong, D. M., Chevalier, N., Espy, K. A., & Wakschlag, L. (2015). Prenatal tobacco exposure and self-regulation in early childhood: Implications for developmental psychopathology. *Development and Psychopathology*, *27*, 397–409.

Woltering, S., & Lewis, M. D. (2009). Developmental pathways of emotion regulation in childhood: A neuropsychological perspective. *Mind, Brain, and Education*, *3*, 160–169.

Zentall, S. R., Braungart-Rieker, J. M., Ekas, N. V., & Lickenbrock, D. M. (2012). Longitudinal assessment of sleep-wake regulation and attachment security with parents. *Infant and Child Development*, *21*, 443–457.

Marjorie Beeghly

Department of Psychology, Wayne State University, Detroit MI Boston Children's Hospital, Boston, MA

Bruce D. Perry

The ChildTrauma Academy, Houston, TX Feinberg School of Medicine, Northwestern University, Chicago, IL

Edward Tronick

Distinguished University Professor of Psychology, College of Liberal Arts Director, Child Development Unit, University of Massachusetts, Boston

