Emotion Regulation as a Scientific Construct: Methodological Challenges and Directions for Child Development Research

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Emotion regulation has emerged as a popular topic, but there is doubt about its viability as a scientific construct. This article identifies conceptual and methodological challenges in this area of study and describes exemplar studies that provide a substantive basis for inferring emotion regulation. On the basis of those studies, 4 methods are described that provide compelling evidence for emotion regulation: independent measurement of activated emotion and purported regulatory processes; analysis of temporal relations; measurement across contrasting conditions; and multiple, convergent measures. By offering this perspective, this article aims to engage thoughtful debate and critical analysis, with the goal of increasing methodological rigor and advancing an understanding of emotion regulation as a scientific construct.

The concept of emotion regulation has become popular in the psychological literature. In the study of child development, for example, the topic has been the subject of several books (Bradley, 2000; Eisenberg & Fabes, 1992; Fox, 1994; Garber & Dodge, 1991; Schore, 1994) and special sections of journals (Dodge, 1989; Eisenberg & Moore, 1997; Stifter, 2002). Searches of the general literature reveal hundreds of diverse studies that either used the term directly (i.e., referred to emotion regulation or related terms such as emotional control, affect regulation, emotion management) or indirectly (e.g., interpreted findings in terms of emotion regulation). These studies vary in a broad range of ways. Some focus on how emotions regulate other psychological processes (e.g., degrade a cognitive operation) and others focus on individual differences in emotional self-regulation. Some treat emotion regulation as a trait (e.g., the well-regulated person); others treat it as a transitory state change (e.g., moment-to-moment adjustments in emotion). The literature also examines emotion regulation in diverse contexts, from the intimacies of close relationships (e.g., Field, 1994; Gottman, 1994) to public behavior in the athletic arena and workplace (Fisher & Ashkanasy, 2000; Grandey, 2000; Hanin, 2000). In the developmental literature, studies of emotion regulation span infancy and toddlerhood (e.g., Field, 1994; Grolnick, Bridges, & Connell, 1996), childhood (Eisenberg, 2001; Shields & Cicchetti, 1997), adolescence (e.g., Kobak, Cole, Fennig-Gillies, & Fleming, 1993; Zimmerman, 1999), and adulthood (e.g., Carstensen & Charles, 1998; Magai & Cohen, 1998).

The broad popularity of the concept of emotion regulation, however, co-exists with concern about its status as a scientific construct. The concept has been applied to such a range of diverse phenomena that its utility as a construct has been questioned (e.g., Cicchetti, Ackerman, & Izard, 1995; Gross, 1998; Kagan, 1994; Rutter, 1991; Stansbury & Gunnar, 1994; Underwood, 1997). Thus, there is enthusiastic pursuit of a construct called emotion regulation but cautious concern about whether it is a viable construct. Researchers interested in the development of emotion regulation, then, are at an important crossroads: Pursue the idea despite the cautions and challenges or abandon it as a diffuse, overinclusive, poorly defined notion.

So why pursue the study of emotion regulation? What does it offer that cannot be achieved through studying other aspects of children’s emotional development? It offers a unique perspective that differs from those offered by studies of emotion expression, emotion language, and emotion understanding. The construct of emotion regulation proposes to account for how and why emotions organize or facilitate other psychological processes (e.g., focus attention, promote problem solving, support relationships) and yet why they can have detrimental effects (e.g.,...
disrupt attention, interfere with problem solving, harm relationships). The concept of emotion regulation has appeal in child development research because of its role in integrating an understanding of typical and atypical development (Cole, Michel, & Teti, 1994; Denham, 1998; Eisenberg, 2001; Keenan, 2000; Saarni, 1999).

Unfortunately, the child development literature might lead a new reader to conclude that the valence of an emotion is the sufficient ingredient for predicting outcomes. Negative emotions could be construed as culprits that disorganize functioning. Conversely, positive emotions could be construed as singularly important to successful developmental outcomes. This is an overly simplistic view. The value of the concept of emotion regulation is as a tool to understand how emotions organize attention and activity and facilitate strategic, persistent, or powerful actions to overcome obstacles, solve problems, and maintain well-being at the same time as they may impair reasoning and planning, complicate and compromise interpersonal interactions and relationships, and endanger health (Cole, Michel, et al., 1994; Gross & Munoz, 1995). It is not the valence of an emotion but the complex processes by which emotions relate to cognition and behavior and ultimately developmental outcomes that must be conceptualized and studied. The concept of emotion regulation serves this purpose.

In stating the importance of emotion regulation, we do not intend to convey that it takes priority over other domains of psychological development, such as cognition, perception, or social relations. Rather, any psychological account of child development is incomplete without understanding the importance of emotions as motivators. They infuse experience with meaning. Certain aspects of cognition allow us to calculate the distance between the chair and the door. Emotion allows us to evaluate steadily and quickly whether it is in our interest to stay in the chair and to act instantly if we need to escape through the door. Emotion regulation helps us stay in the chair even when we feel compelled to escape.

Enthusiastic popularity does not address doubts and concerns about the value of emotion regulation as a scientific construct. Instead, such enthusiasm only increases the need for the highest scientific standards in the research enterprise. Despite the germinal works on the topic (e.g., Fox, 1994), research designs in emotion regulation have been limited in their scientific rigor and clarity. Our reading of the current child development literature generated three major concerns. First, most studies of emotion regulation use the term without definition. Second, most studies employ methods that fail to distinguish between emotion and emotion regulation. Third, most studies interpret relations between the valence of emotion (positive or negative) and a factor of interest (e.g., adjustment) as providing information about emotion regulation without supplying evidence of any regulatory process. Future studies must pay careful attention to definition and method to provide substantive evidence for the regulating and regulated aspects of emotions.

In this article we address some of the challenges researchers face in distinguishing emotion regulation from emotion. We draw on works on emotion theory and emotion regulation to state the working definitions that we have adopted to guide our research. We then present selected examples, from the child development literature, of studies that produced substantial inferential evidence of emotion regulation. Based on these works, we summarize four methods that these studies used to provide such compelling evidence. We have not solved all the thorny issues involved in this enterprise, nor do we intend to convey that our approaches are the only methods that can be used to study emotion regulation. Our presentation is intended to highlight some of the salient problems in this area of study and to demonstrate that they can be overcome despite significant challenges to the study of emotion regulation.

First Things First—Definitional Challenges

To distinguish the construct of emotion regulation from that of emotion, one must define emotion. Some have argued that emotions are inherently regulatory and that the two concepts cannot be distinguished (e.g., Stansbury & Gunnar, 1994) or that our understanding of emotion is so limited it cannot be distinguished from emotion regulation (Kagan, 1994). To advance research in emotion regulation, the researcher must articulate a position in relation to these conceptual and definitional challenges and attempt to define the constructs.

What Is Emotion?

Unfortunately, there is no consensus on the nature of emotion. There are many theories of emotion, and each contemporary emotion theory offers a different definition. Consequently, there is no “gold standard” for methods of studying emotion. In our view, it is crucial for each emotion regulation researcher to articulate a conceptual approach and define the
constructs invoked if work in this area is to be scientifically viable and rigorous. We approach the definitional challenge by adopting assumptions shared by the emotion theories most often cited in the literature on emotion regulation in early childhood (Barrett & Campos, 1987; Frijda, 1986; Izard, 1977; Lazarus, 1991; Sroufe, 1996; Tomkins, 1962, 1991). Despite substantial differences among them, they share a neo-Darwinian influence, viewing emotions as biologically prepared capabilities that evolved and endured in humans because of their extraordinary value for survival. Emotions are a kind of radar and rapid response system, constructing and carrying meaning across the flow of experience. Emotions are the tools by which we appraise experience and prepare to act on situations.

We have extracted several assumptions about the nature of emotion from our reading of these various theories that influence our empirical efforts. We assume that emotions are biologically endowed processes that permit extremely quick appraisals of situations and equally rapid preparedness to act to sustain favorable conditions and deal with unfavorable conditions. The term appraisal, introduced by Arnold (1960), refers to the process of appreciating the specific significance of a situation (or perception or representation of a situation) for individual well-being (Barrett & Campos, 1987; Frijda, 1986; Lazarus, 1991; Scherer, Schorr, & Johnstone, 2001). Thus, emotions are partly defined as a means of evaluating experience. The process of appraising is linked to readiness to interact in certain ways with the environment (Arnold, 1960; Frijda, 1986). That is, appraisals are accompanied by tendencies to be ready to respond in a particular way. Whether appraisals cause emotions, whether emotions are appraisals, whether appraisals precede or co-occur with action-readiness tendencies, whether specific discrete emotions are associated with specific discrete action tendencies—all these matters are unresolved in the literature. Therefore, we prefer the view, eloquently stated by Campos, Mumme, Kermoian, and Campos (1994), that appraisal and action readiness are the “warp and woof” that constitute the fabric of emotion. In thus describing these assumptions, there is a risk of treating emotions as things. But emotion is a process, a constant, vigilant process (Izard, 1977; Walden & Smith, 1997), which periodically reaches a level of detection for the person (i.e., a feeling) or an observer (a friend, a parent, or even a developmental scientist).

These assumptions about the nature of emotion lead our work in the direction of trying to detect the ebb and flow of a child’s emotions by observing the child in particular circumstances, which are known to afford particular appraisals and action tendencies, and measuring the child’s emotional reaction in those circumstances. A focus on emotions as appraisal and action readiness directs methods away from reliance on the assessment of conscious experience and to observations of the relation between the person and the environment (Barrett & Campos, 1987; Witherington, Campos, & Hertenstein, 2001). Because emotions are so rapid and fluid, often involving micromomentary changes beyond the level of detection that current technology allows, they elude concrete or simple assessment. Observational methods only approximate such dynamic processes in children, but as we show, measures derived from observations can provide an adequate basis for inferring that emotion was activated and that regulation occurred.

What Is Emotion Regulation?

The construct of emotion regulation has been difficult to segregate from the construct of emotion (Campos et al., 1994; Kagan, 1994; Stansbury & Gunnar, 1994). One reason, of course, is the historical lack of consensus on the definition of emotion. Moreover, because the process of appraisal and action readiness alters the experience and behavior of the self and others, emotions are inherently regulatory (Campos et al., 1994; Haviland-Jones & Kahlbaugh, 2000; Izard & Ackerman, 2000). If emotions are inherently regulatory, how then are emotion and emotion regulation distinct? We think it is possible to distinguish elements of appraising and readying to act, which has regulatory effects on action and social interaction, because emotions have different effects depending on how they are regulated. Thus, we suggest that one must attempt to infer specific emotions have been activated and independently infer regulatory processes.

A second, related complication is that emotions can be construed as having regulatory influences on domains of functioning that are intimately related to emotions. Emotions affect and are affected by physiological activity, including cardiovascular (Porges, Doussard-Roosevelt, & Maiti, 1994), cortical (Fox, 1994), and neuroendocrine (Stansbury & Gunnar, 1994) systems. These systems are not clearly distinct from emotions themselves. Garber and Dodge (1991) suggested that researchers distinguish intradomain regulatory processes (aspects of emotional responses influencing theoretically related components, such as physiological activity, attributions about the situation) from interdomain processes (aspects of
emotional responses influencing theoretically distinct, separate systems, such as social interaction.

A third definitional complication is that the term emotion regulation is not only applied when emotion processes are thought to influence other processes; it is also applied to convey that emotions have the capacity to be regulated. Many studies have examined how individuals modify their emotional reactions, eliminating, minimizing, switching, amplifying, or redirecting them. Emotion regulation thus conceptualized provides a way of considering why one sad person seeks the solace of friends and another turns to mood-altering substances. A dynamic view of emotion regulation requires an appreciation that emotions are regulated even as they are regulating.

A fourth definitional issue concerns confusion about whether the term emotion regulation refers only to optimal functioning or includes maladaptive emotion regulation (Casey, 1996; Cicchetti, Ganiban, & Barrett, 1991; Cole, Michel, et al., 1994; Garber & Dodge, 1991; Keenan, 2000). To restrict the term for optimal functioning confounds emotion regulation with psychological health, overlooking the regulatory features of emotion in disturbed and at-risk individuals. That is, emotion regulation in a person with clinical problems, or at risk for them, is helping that person deal with present situations even as those very efforts may create risk for later or different problems (Cole, Michel, et al., 1994; Thompson & Calkins, 1996). This confusion contributes to equating positive emotion with “goodness” and negative emotions with “badness.”

A final issue that complicates our understanding of emotion regulation is related to the fact that emotions must be understood in context. Consider a preschool boy’s apparent joy during an interaction with his mother. How do we determine whether this appearance of joy (smiling, laughing, lilting voice) is joy? We use context. Depending on other features of the interaction, we may conclude that the joy reflects the goal of maintaining interpersonal harmony or that it is rude and disrespectful, serving the goal of maintaining dominance in the interaction. Thus, not all joys are the same joy, although all may serve to maintain a desired goal (Barrett & Campos, 1987; Kagan, 1994). But another set of contextual cues might lead us to say that the boy’s expression of joy masks a different emotion, for example, that he is actually angry with his mother but is covering that over with apparent happiness. The joy is part of an effort to regulate the anger. Emotions are fluid and complex. The use of contextual variations and multiple cues is needed to converge on the correct inferences in any study.

In sum, research in emotion regulation has been plagued by a lack of clarity and definition. With this in mind, we describe the working definitions that help us navigate empirically through the difficult challenges of research in this area. They are the tools we have adopted, derived from the work of others, to guide research methods.

**Working Definitions of Emotion and Emotion Regulation**

Despite lack of consensus about what emotions are, ambiguities in the use of the term emotion regulation, and the technical challenges inherent in studying phenomena that are most surely micromomentary in nature, researchers must have working definitions to guide and advance research. Those definitions should lead to methods that provide strong inference (a) that an emotional state was activated and (b) that regulatory processes occurred independently. In following our own advice, we summarize the working definitions we use. As we have said, they are derived from the works described previously. Emotions are appraisal-action readiness stances, a fluid and complex progression of orienting toward the ongoing stream of experience. Emotions are moving targets that are usually unseen (and unfelt). Emotions must be inferred from evidence of the individual’s relation to surrounding events. We use the word stance to imply, as others have, that emotions involve being poised, oriented, ready, or inclined toward a course of action. The term stance connotes that the individual is evaluating a situation (appraising) and inclining toward a particular class of actions (action readiness).

Emotion regulation refers to changes associated with activated emotions. These include changes in the emotion itself (e.g., changes in intensity, duration; Thompson, 1994) or in other psychological processes (e.g., memory, social interaction). Emotion regulation is not defined by which emotions are activated but by systematic changes associated with activated emotions. Thus, evidence that one person is angrier than another does not by itself show that the first person is regulating anger differently from the second.

The term emotion regulation can denote two types of regulatory phenomena: emotion as regulating and emotion as regulated. In each case, the regulatory aspects must be conceptualized independently of which emotion is activated initially. Emotion as regulating refers to changes that appear to result from the activated emotion. Again, the distinction between intradomain and interdomain changes bears repeating (Garber & Dodge, 1991). An independence of emotion and regulation, applied to intradomain changes, must be carefully considered and justified theoretically.
Intradomain changes (e.g., relations between fear, as judged by facial expression and behavior, on an emotion-related system such as cardiovascular activity) may reflect the systemic nature of emotion rather than an independent emotion regulating a separate system (Stansbury & Gunnar, 1994).

Emotion as regulating also refers to interdomain changes (e.g., a child’s sadness altering a caregiver’s discipline strategy). In the latter case, the researcher momentarily segregates emotion process and social process, much as a snapshot captures a moment, while appreciating that the two are inextricably related. Systematic evidence that one’s own, or another’s, activity changes the valence, intensity, or duration of an activated emotion constitutes evidence of emotion as regulating.

Emotion as regulated refers to changes in the activated emotion. These include changes in emotion valence, intensity, or time course (Thompson, 1990, 1994) and may occur within the individual (e.g., reducing stress through self-soothing) or between individuals (e.g., a child makes an unhappy parent smile). Interdomain changes are closely related to the regulation of emotion. For example, a day care worker changes his or her discipline strategy in response to a youngster’s sadness and the youngster’s sadness is modified by the new caregiver behavior and then, it is hoped, both feel better than they had. Emotion as regulated is not limited to such positive scenarios, however, and can include examples of strategies that may be judged by other criteria as maladaptive (e.g., Cole, Michel, et al., 1994).

Until advances in research methods afford new and improved definitions, emotion regulation researchers must provide working definitions of their constructs to increase clarity. Furthermore, there is a need for operational strategies that provide a strong empirical basis for inferring emotion regulation. Methods that demonstrate change promise to contribute to the understanding of emotion regulation more than methods that focus solely on emotion valence. If change cannot be captured as an index of regulatory processes, creative uses of contrasting conditions and multiple, converging measures offer promise for increasing the level of inferential interpretation. We next illustrate these points by describing studies that have provided compelling evidence with which to infer emotion regulation in early childhood.

Developmental Evidence for Emotion Regulation

At present, research in emotion regulation faces technical limits in distinguishing emotion regulation from emotion itself. It is difficult to distinguish the initial intensity of an emotional reaction from regulation of that emotion (Kagan, 1994). At the physical level, emotional reactions emerge from neural activity that occurs in milliseconds (see Davidson, Jackson, & Kalin, 2000). Traditional emotion measures (e.g., facial expression, subjective report, physiological markers) are as likely to reflect regulatory influences as they are emotional reactions per se. Although technical advances may some day permit the capturing of an emotion in progress, at present we need consensus on how best to use existing methods to provide the strongest inference that emotion regulation is being studied (Fox, 1994).

In this section we provide examples of studies from the child development literature that provide evidence for the construct of emotion regulation. Our criteria for selecting a study were that it (a) attempted to assess emotion independently of purported regulatory phenomena and (b) assessed either outcomes that were related to activation of an emotion (emotion as regulating) or factors that caused changes in emotion (emotion as regulated). Our goal was not an exhaustive review of the broad and amorphous emotion regulation literature, but an illustration that a substantive basis for inferring emotion regulation can be achieved. For conciseness, we focus on three areas of research, each of which addresses the complexities of emotion regulation as a scientific construct: infant temperament, mother–child face-to-face interaction, and early childhood emotional self-regulation. They suggest a developmental sequence in which infants first have a basic self-regulatory capacity for managing emotion of varying and limited effectiveness, then engage in mutually regulatory interactions with their mothers, and finally develop an array of additional self-regulatory strategies over the toddler and preschool years.

Evidence From the Study of Infant Temperament

The concept of temperament refers to innate individual differences in infants. The specific nature of those differences has been debated, but researchers have come to agree that temperament involves, in part, individual differences in emotion (Goldsmith et al., 1987). That is, individual differences in infant temperament reflect biologically based biases toward the experience and expression of certain emotions. Two approaches to the study of infant temperament have yielded evidence that emotions are regulated.

The first approach defines temperament as individual differences in (a) reactivity, that is, the speed and intensity of the initial activation of an
emotion, and (b) self-regulation, that is, the capacity to modify the intensity and duration of that initial emotion by engaging in behavioral strategies such as gaze aversion, self-sucking, or proximity seeking to a caregiver (Rothbart & Bates, 1998; Rothbart & Derryberry, 1981). Empirical evidence derived from this model has yielded two types of findings that contribute to the inferential basis for emotion regulation: (a) purported self-regulatory behaviors were more likely to occur during experimental emotion-activating conditions in contrast to conditions that were not designed to activate a specific emotion and (b) purported strategies were likely to occur when infants appeared distressed (facial grimaces, distress vocalizations) and not during periods of neutral or positive infant emotion expression (e.g., Buss & Goldsmith, 1998; Calkins & Johnson, 1998; Rothbart, 1998).

A few temperament studies further contributed to the evidence of regulation by testing whether enactment of putative regulatory behaviors, after a specific emotion was activated, altered infant emotion expression, behavior, or physiology. Buss and Goldsmith (1998) examined regulatory strategies in relation to fearful and angry distress expressions of 6-, 12-, and 18-month-olds during emotion-activating procedures. Emotions were activated using a barrier to an attractive toy and arm restraint (anger activation) and during exposure to two novel toys, a remote-controlled spider and an unpredictable mechanical dog (fear activation). Infants' emotions and regulatory behaviors were coded independently in 5- to 10-s intervals. Contingency analyses indicated that some, but not all, purported regulatory strategies were followed temporally by a reduction in anger intensity but rarely in fear intensity. Their findings provide a basis for inferring that infants regulate emotions to a limited degree.

Similarly, Stifter and Braungart (1995) observed 5- and 10-month-old infants during conditions designed to activate anger: arm restraint and toy removal. During each procedure, infant negative emotion was scored in 10-s intervals, and regulatory behaviors (e.g., gaze aversion) were coded continuously. Consecutive intervals in which reactivity increased, decreased, or remained constant provided an operational definition of change in negative emotion. Results indicated that two purported strategies (self-soothing and orienting) were more likely to occur in intervals of decreasing negativity than in intervals of stable or increasing negativity. In sum, these two studies provide strong evidence that emotions are regulated by capitalizing on time-based, microanalytic techniques for linking change in activated emotions with putative regulatory strategies. Strengths of their methods were: (a) using experimental procedures to activate target emotions, (b) assessing infant emotion independently of purported regulatory behaviors, (c) assessing infant emotion and regulatory behavior over time, and (d) establishing predicted temporal relations between regulatory efforts and changes in activated emotions.

Arguably, observations of change in emotion as a function of regulatory behavior provide the clearest evidence on which to base inferences that emotions are regulated (cf. Harman, Rothbart, & Posner, 1997). Other research methods have also been used. Stifter, Spinrad, and Braungart-Rieker (1999) employed multiple measures to infer regulatory processes by adding physiological assessment of cardiac activity (i.e., vagal tone, an index of parasympathetic regulation of heart rate) to independently derived ratings of emotion and behavioral strategies. Building on their previous work using temporal analyses (Stifter & Braungart, 1995), they demonstrated predicted differences in patterns of convergence among measures to add to the evidence that children of different temperaments regulate emotions differently.

A second approach to temperament research involves studies of behavioral inhibition (Kagan, 1999; Kagan, Snidman, & Arcus, 1993). The trait is defined by the degree to which an infant or young child is shy and fearful and withdraws in novel, uncertain situations. In the standard paradigm, experimental fear-activating procedures (novel conditions) are employed and measures of emotion (fear intensity), behavior (e.g., withdrawal, which is hypothesized to accompany fear), and physiological activity are collected. Predicted relations among the measures are shown for toddlers who were judged independently to be significantly above average in fearfulness and wariness. Fox (1994) extended the conceptualization of behavioral inhibition to include emotion regulation. He proposed that individual differences in inhibition are explained by two factors: (a) a propensity to react fearfully to novelty and (b) difficulty in effectively modulating fear. Thus, it is not just the proclivity to react with fear but difficulty in regulating fear that leads to highly inhibited behavior.

Evidence for this argument has relied on demonstration of hypothesized relations among multiple measures. Because patients with certain areas of frontal lobe damage have self-regulatory deficits, it has been deduced that patterns of frontal area activation during fear-activating conditions reflect difficulties in emotion regulation in temperamentally inhibited children (Davidson, 1985; Fox, 1994;
Kinsbourne, 1982). Briefly, predominant activation of the left frontal cortex (left frontal asymmetry) should be associated with approach behaviors (positive emotion expression, sociability), whereas hypoactivation of the area should be associated with deficits in approach tendencies (absence of positive emotion). Predominant activation of the right frontal cortex (right frontal asymmetry) should be associated with withdrawal tendencies (negative emotion expression, active withdrawal) and hypoactivation with deficits in withdrawal (inability to inhibit approach). Thus, if temperamentally inhibited children have emotion regulatory difficulty, they should manifest hypoactivation of the left frontal area or activation of the right frontal area.

Evidence for emotion regulation in this approach to temperament has relied on observations of children in context but has not employed temporal analyses of change. Rather, it has relied on demonstrating predicted patterns among multiple measures as convergent evidence of emotion regulation. Behaviorally inhibited toddlers differ in predicted ways from noninhibited toddlers: in their emotional reactions to novel stimuli, in their use of purported emotion regulatory strategies, and in concomitant patterns of EEG frontal activity, as shown in a series of studies from different research programs (e.g., Fox, 1994; Mangelsdorf, Shapiro, & Marzolf, 1995). For example, 6-, 12-, and 18-month-olds classified as wary or fearful by their mothers engaged in different regulatory behaviors from their bolder peers; they averted gaze and avoided a stranger more than children described as bold (Mangelsdorf et al., 1995). Evidence that these patterns are associated with cortical activity, known to be associated with regulatory processes, strengthens the inference that emotions are being regulated. Four-month-olds who were judged to be irritable showed the predicted convergence of right frontal asymmetry when they were 9 months old and more inhibited behavior (an aggregate of being slow to touch and vocalize and of seeking proximity to mother) in the presence of novel stimuli when they were 14 months old in contrast to infants who were judged to be exuberant (Calkins, Fox, & Marshall, 1996). A similar pattern emerges in studies of older children (Fox et al., 1995; Schmidt, Fox, Schulkin, & Gold, 1999).

The temperament studies described thus far focused on reactivity in the fear system, but a similar approach to emotion regulation has been taken in studies of temperamental anger. For example, Calkins, Dedmon, Gill, Lomax, and Johnson (2002) classified 6-month-old infants as easily or less easily frustrated on the basis of parent report and laboratory assessment and then compared them on a set of coherent measures of regulatory capacity. The latter measures included independent assessments of regulation of anger, attention, and activity, as well as cardiac activity (respiratory sinus arrhythmia [RSA]). Easily frustrated infants exhibited the predicted cluster of characteristics: They engaged in less distraction and more physical acting out, they were less attentive, they were more active, and they had lower RSA suppression than less easily frustrated infants. In a study of 2-year-olds, Calkins and Dedmon (2000) showed that higher risk (as defined by externalizing symptoms) toddlers were more emotionally negative than lower risk toddlers during laboratory tasks. Convergent evidence that frustration was poorly regulated by high-risk toddlers was inferred on the basis that they were more behaviorally disruptive (e.g., noncompliant, distractible, inattentive), and therefore poorly regulated behaviorally, and showed lower RSA suppression than the low-risk toddlers.

Evidence From the Study of Mother–Child Interaction

Broadly speaking, psychologists have focused on emotion regulation as a process that occurs within the person. The interpersonal nature of emotion regulation has been established in research on mother–child interaction. In this framework, the emphasis moves from a focus on infant self-regulation to the complex ways in which emotions are both regulated and regulating in social interaction. Work in this area conceptualizes one partner’s emotions as systematically influencing the other partner’s emotions and behavior. In recursive discourse, each partner’s emotions regulate the other and are regulated by the other. The quality of such exchanges is hypothesized to be a crucial predicate of a variety of developmental outcomes, including the child’s growing ability to self-regulate emotion. Thus, emotion as regulating social interaction is intricately tied to the development of the capacity to regulate one’s own emotions.

Early work observed moment-to-moment interactions between infants and mothers, predicting spontaneous and mutual contingency between partners and reciprocal regulation of dyadic emotional communication (e.g., Cohn & Tronick, 1988; Field & Fogel, 1982; Fogel, 1993; Gianino & Tronick, 1988; Stern, 1985; Trevarthen, 1984; Tronick, 1989). Observations of maternal and infant expressive behavior were recorded and coded continuously and independently, then were analyzed to examine the timing and sequencing of changes in each partner of
the dyad. For example, Field (1994) demonstrated synchrony between mother and infant expressive behavior (facial and vocal activity) and their physiological responses. The findings were interpreted as evidence that typical mothers and infants are sensitive to each other’s emotional signals, reciprocate by matching emotion or modifying behavior to amplify or modulate the other’s emotion, and sustain an ebb and flow of emotional interaction that maintains the relationship in a sensitive, optimal way. Mothers regulate infant emotional states by reading infant emotional signals, providing appropriate stimulation, modulating levels of infant arousal, and reciprocating and reinforcing infant reactions. Infants regulate their mothers’ emotions through their receptivity to mothers’ initiations and stimulation, approaching and withdrawing from stimulation, and responding contingently to maternal emotion.

The quality of these emotion exchanges is conceptualized as an important precursor of the developing child’s ability to regulate his or her own emotions. For example, sophisticated analyses of mother–infant synchrony, using statistical procedures that control for the naturally occurring autocorrelations in the individual’s own stream of emotion, indicate that the quality of dyadic emotion regulation in infancy predicts toddler self-control (Feldman, Greenbaum, & Yirmiya, 1999). Moreover, interpersonal or mutual regulation of emotion is not a phenomenon of infancy only. It has also been observed in studies of parent interaction with toddlers and with preschoolers (e.g., Cole, Teti, & Zahn-Waxler, 2003; Denham, 1993; Dumas, LaFreniere, & Serketich, 1995). These studies use laboratory procedures to tax the dyad by simulating ordinary challenges that young children face in their lives. In most cases, the procedures attempt to stimulate a child’s desire for an activity or object and then block access to it. Typical procedures of this sort, designed to activate frustration and anger, include requiring a young child to clean up toys, to wait for mother to finish work to get a desirable object, to resist touching prohibited toys, or to persist at a difficult task. Such studies also include tasks that support positive emotional exchanges (e.g., snacks, free play, receiving the toy).

The procedures elicit social interactions, which are then coded for emotional cues. Mother and child emotion, as inferred on the basis of facial and vocal cues, are coded independently but are time synchronized to permit demonstration of contingent relations between each partner’s reactions (Cole et al., 2003; Denham, 1993). For instance, using continuous recording of the onset and offset of mother and child emotion displays, Denham (1993) examined mother–toddler “emotional dialogues” across a situation that afforded positive emotions (eating lunch) and one that afforded negative emotions (being measured by a doctor). Analyses revealed contingencies in mother–child emotion displays, with results suggesting that mothers and children responded emotionally to each other in predictable, systematic, and temporally contingent ways.

Research on the dynamics of early parent–child emotional interactions provides evidence for emotion regulation by demonstrating reliable, contingent changes in mother and child emotionally expressive behavior. Those changes are contingent on the partner’s emotional communication and are not a function of the cycling of individual expressivity (e.g., Cohn & Tronick, 1988). These changes involve co-constructed coordination, including matching of positive emotions and repairing of negative or mismatched emotions (Field, Healy, Goldstein, & Guthertz, 1990; Stern, 1977; Trevarthen, 1984; Tronick & Cohn, 1989). Moreover, changes in emotion expression and behavior are associated with contingent changes in physiological activity in each partner (Field, 1994). The time-based methods employed to capture these processes are well suited to inferring that one partner’s emotions are regulated and regulatory. The inference is further strengthened by the inclusion of multiple and synchronized measurement strategies (e.g., time-linked facial and cardiovascular recordings).

Another approach to examining emotion regulation capitalizes on the effects of perturbations of the expected course of social interaction. The still-face paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) reliably demonstrates systematic changes in children’s emotion as a function of changes in maternal affect, thereby offering another avenue for inferring emotion regulation. In the standard three-period procedure, mother and infant first engage in spontaneous interaction. Next, the mother is instructed to be emotionally unresponsive for a short period, keeping her face still and neutral. Finally, the mother is asked to resume her spontaneity.

Findings generated with this method show that when the mother is still, most infants (a) change emotionally, specifically decrease smiling and increase signals of distress; (b) behave as if they are trying to re-engage the mother by vocalizing and gesturing at her; and (c) avert gaze from the mother as efforts to re-engage her fail. During the final relief phase of the procedure, infants resume looking at the
mother with increased positive emotion expressions. These emotional and behavioral changes across episodes are also accompanied by changes in autonomic activity (Weinberg & Tronick, 1996). Moreover, research using the still-face procedure has demonstrated changes, not only in infants' emotion, behavior, and physiology but also in the coordination of dyadic interaction. Weinberg, Tronick, Cohn, and Olson (1999) used second-by-second coding to demonstrate that the disruption of the interaction when maternal emotion is constrained interferes with the mutual regulation of the dyad. Examining the reunion phase, they showed a carryover of negative emotion from the still-face phase as well as changes in mother–infant coordination compared with previous phases.

Changes in the timing and sequencing of dyadic communication suggest that emotion regulates social interaction. In addition, manipulations of specific elements of the still-face procedure provide contrasts that further illuminate the presence of emotion regulation. That is, contrasting conditions afford ways to demonstrate that a mother’s emotions are regulating an infant’s emotions or that an infant is attempting to engage in self-regulatory behavior (Stack & Muir, 1990, 1992). As in the temperament area, researchers who have established evidence of change often add to the body of evidence by measuring multiple domains to provide convergent evidence of regulatory phenomena (Weinberg & Tronick, 1996).

Across studies using the still-face procedure, it has been shown that infants actively engage in behaviors that should regulate the social interaction (vocalizing, gesturing, and communicating distress) and initiate self-regulatory strategies when other regulatory strategies fail (e.g., avert gaze, self-sooth). Furthermore, several studies identified specific associations between infant expressive behavior and purported strategies, thereby strengthening the inference that observed changes were reflective of a regulatory process. For example, Braungart-Rieker, Garwood, Powers, and Notaro (1998) found correlations between ratings of 4-month-old infants’ positive and negative expressions and purported regulatory behaviors. Compared with infants who exhibited more positive emotion during the still-face procedure, infants who exhibited more negative emotion engaged in less self-comforting and less orienting toward an object or the parent. Weinberg and Tronick (1994) also reported associations between certain emotional states and behaviors that are hypothesized to be regulatory strategies. Contingency analyses revealed that infant facial anger during the still-face procedure co-occurred with pick-me-up gestures, attempts to escape or distance from the situation, distress vocalizing, and signs of autonomic distress (e.g., spitting up). Anger did not co-occur, however, with other behaviors purported to be self-regulatory strategies, such as self-distraction; these occurred in synchrony with neutral or positive expressions.

Evidence of emotion regulation based on the use of contrasting conditions is not limited to face-to-face interactions in laboratory conditions. Lamb and Malkin (1986) conducted a longitudinal design of infants from 1 to 7 months old in their homes. They focused on distress relief when infants cried, contrasting conditions of the mother or a female research assistant responding to the infant. They also varied the delay between infant cry and adult relief (immediate or after a 60-s delay). Comparisons across conditions revealed that the arrival of the adult was associated with anticipatory calming (i.e., quieting before being picked up) and that the delay was associated with infant protest, especially when the mother arrived but did not respond. Again, the method used to infer social expectation suggests early infant emotion regulation (initiation of behaviors that regulate mother, i.e., protest) and inchoate self-regulation (calming in anticipation) with the added value of being done in nonlaboratory conditions.

Evidence From the Study of Emotional Self-Regulation

The third area of study that provides evidence of emotion regulation is the study of the early emergence of self-initiated attempts to modulate negative emotion. Advances in cognitive, motor, and language development occur during the second through fifth years of life, which permit children to apply a broader range of abilities to the regulation of their own emotions than they could in infancy (Kopp, 1989; Kopp & Neufeld, 2003; Thompson, 1990, 1994). For example, during the second through fourth years, there is evidence of a decrease in the use of self-soothing and the emergence of new and more complex use of objects and interactions to regulate emotional state (Diener & Mangelsdorf, 1999).

Studies that provide a substantive basis for inferring that young children regulate emotions also rely on observations of children under challenging conditions that afford negative emotions. For example, separation from a parent arguably activates the fear system and obstacles to getting a desired object activate emotions from the anger family. During these procedures, children’s emotionally...
expressive behavior is coded, continuously or in brief epochs, to provide evidence that target emotions were activated. A variety of strategies have been employed to then argue that young children in these emotional situations are regulating their emotional states. Studies based on such methods have shown that (a) young children engage in a variety of putative self-regulatory attempts when faced with challenging situations and (b) enactment of those behaviors is associated with negative emotion.

For example, Grolnick et al. (1996) examined regulatory strategies in toddlers who experienced a separation from mother and a delay in receiving a desirable object. Several social condition manipulations—observing the child’s handling of distress when alone, with the experimenter, with the mother when she was passive, and with the mother when she was active—provided more context for inferring emotional self-regulation attempts. Toddler emotionally expressive behavior was coded every 5 s to create variables that indexed level of intensity and temporal changes in emotional expression for each condition and situation. A principal components analysis revealed that these intensive and temporal variables were highly related and they were aggregated into a single composite score. Independently, self-regulation strategies were coded for the same intervals; these included self-distraction, self-soothing, and bidding for parental attention. Under these emotion-activating conditions, the more a toddler engaged with his or her surroundings, the less negative emotion was seen, but the more a toddler focused on the person or object withheld, the more negative emotion was observed. Toddler self-distraction occurred more frequently if an adult was present and behaving freely than when the child was alone or the adult was passive. This pattern of results was interpreted as evidence that a toddler can engage in a presumably effective self-regulation strategy when social support is present even if that support is not directed at helping the child cope.

Thus, the study hinted that self-distraction was an effective strategy for toddler regulation of fear and frustration. Although this interpretation is consistent with a hypothesis that reallocation of attention can regulate distress, Grolnick et al. (1996) cautioned that the method did not demonstrate that distraction actually changed toddlers’ emotional states. Purported regulatory efforts may coincide with different emotion expression without necessarily modifying them. For example, toddlers who actively engaged in their surroundings may have shown less negative emotion because they were less distressed. That is, the co-occurrence or correlation between two sets of independent codes—emotion and regulatory efforts—is insufficient to conclude that the efforts regulated the emotion.

Diener and Mangelsdorf (1999) addressed the issue in a different manner. Toddlers’ putative regulatory attempts were observed during fear- and anger-activating laboratory procedures. Specifically, 18- and 24-month-olds and their mothers were observed during six emotion-activating tasks. They included a manipulation of maternal involvement to examine toddlers’ self-initiated regulatory efforts by instructing mothers to refrain from initiating interaction with the child for the first half of each task. Toddlers’ efforts and emotional expressions were coded independently in 15-s intervals. Contingency analyses were used to link regulatory efforts to changes in emotion. That is, they examined whether changes in emotional expression temporally followed regulatory attempts. Certain self-initiated behaviors were followed by reduced negative emotion. The effectiveness of self-regulatory efforts varied as a function of which emotion was activated. Furthermore, some purported regulatory behaviors (e.g., distraction) were not associated with reductions in anger or fear.

A similar approach was adopted in a study of anger regulation in preschool boys (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002). Children were observed during a frustration-activating task (i.e., having to wait to get a cookie). Purported regulatory efforts and peak intensity of anger expressions were coded independently in 10-s epochs. Temporal contingency analyses were then used to assess if and how anger changed following a regulatory effort. Some regulatory efforts (e.g., focusing on the desired object) were associated with increased anger expression. However, other regulatory efforts were presumed to improve behavioral self-control in as much as certain strategies, and the frequency and diversity of regulatory strategy use, were associated with self-control when the boys were 6 years old. Thus, the methods in these studies provide useful evidence that young children can engage in emotional self-regulation and that the manner of such efforts is predictive of later outcomes. The evidence is bolstered by methods that contrast task elements (e.g., constraining maternal behavior), inclusion of multiple factors conceptually related to the prediction of emotional self-regulation in children (e.g., temperament, quality of parent–child interaction), and longitudinal evidence of the predictive validity of earlier self-regulatory efforts.

Manipulations of social context, such as constraining an adult’s efforts to help a child, have been
Methodological Directions for Research on Emotion Regulation

Future research in emotion regulation, whether it attempts to demonstrate that emotions are regulatory or regulated, bears a greater burden for demonstrating regulatory processes than studies of the last two decades have borne. Challenging as that burden is, and given the technical limits on capturing an emergent, dynamic process such as emotion, the studies reviewed constitute an impressive body of literature that provides strong inferential evidence for the construct of emotion regulation. Four useful methods have been used across different subsets of these studies. The most compelling evidence for emotion regulation has emerged from studies, or series of studies, that have used combinations of these tools. They do not necessarily exhaust the creative possibilities but they are exemplars that can guide and foster new methods in emotion regulation research. These methods are:

1. independent assessment of activated emotion and purported regulatory strategies,
2. analysis of temporal relations between emotion and regulatory phenomena,
3. comparison of emotion and regulatory phenomena in contrasting conditions, and
4. use of multiple, converging measures to demonstrated predicted organization of emotion regulatory responses.

Independent Measurement of Activated Emotion and Purported Regulatory Strategies

Most studies in the early child development literature rely on observational methods in large part because very young children have considerable difficulty reflecting on and reporting their emotional experiences. Acknowledging that emotions are momentary, dynamic processes, aspects of which are difficult to capture scientifically, it is nonetheless important to emotion regulation research that investigators avoid confounding emotional valence with emotion regulation. Interpreting the level at which a child manifests negative emotion with poor regulation compromises the studying of both the regulatory and regulated aspects of emotion (Cole, Zahn Waxler, et al., 1994; Maughan & Cicchetti, 2002; Thompson, 1994).

In addition, many of the studies that provide strong inference make their observations under controlled or quasinaturalistic conditions that are designed to afford, and therefore heighten, the probability of activating particular emotions. This
increases the level of inference that can be drawn and attempts to control, to a degree, contextual factors that are integral to inferences about emotion. As emotion theories predict, and research has shown, novel stimuli and separation from mother afford emotions related to fear; blocked goals, violated expectancies, and injustices afford emotions related to anger; and positive adult attention and desirable objects afford emotions related to happiness. The laboratory methods used in the studies reviewed therefore provide a means of inferring that certain emotions were likely to be activated.

It appears that laboratory studies have also been effective at assessing emotion and regulatory features independently. Although there have been clever uses of home observations to infer regulatory processes (Lamb & Malkin, 1986), most of the strong evidence for emotion regulation has occurred under laboratory control. It is not that naturalistic studies should be avoided; to the contrary, it is just that thus far controlled studies have been able to distinguish emotion activation from regulatory effects or efforts. They provide the evidence that other researchers can rely on when such controlled conditions are not possible or even desirable to study a particular question. The distinction is crucial to be able to argue that emotions regulate behavior (e.g., a preschooler’s anger can organize problem solving; Wiggins, Cohen, Gitter, Zalewski, & Cole, 2003) or that emotions can be regulated (a toddler’s averting gaze minimizes fear; Buss & Goldsmith, 1998; Diener & Mangelsdorf, 1999). Most studies using such procedures infer emotions were activated on the basis of a set of expressive behaviors (facial, vocal, and sometimes gestural). The evidence is even more compelling when additional measures (e.g., heart rate, vagal tone) or child self-report, offer convergent evidence. No single source of data provides unequivocal evidence that an emotion was activated for each or all children, because of the micromomentary nature of appraisal and action readiness, and the highly dynamic, contextually bound nature of emotion processes. In combination, however, multiple measures can be used to infer that an emotion was activated.

Temporal Relations Between Emotions and Regulatory Phenomena

One of the most compelling ways of demonstrating change is the examination of temporal relations between variables. This has long been a strategy in developmental psychology, in which longitudinal data increase the ability to study and infer change. Just as development is constantly in motion, emotions, too, are ongoing and constantly changing dynamic processes. Time-synchronized assessment and temporal analyses are tools that can be used to infer emotion regulation. In studies of temperament and of the early development of emotional self-regulation, there have been successful efforts to demonstrate that young children deploy behavioral strategies that regulate their emotional states. For example, a reduction in the initial intensity of a fearful reaction when a child averts gaze from a novel stimulus that affords fear constitutes a form of evidence that the gaze shifting altered the intensity or the presence of fear.

In parent–child interaction research, temporal analyses have been used to demonstrate the mutual regulation involved in social interactions—emotions regulate and are regulated in these dyadic exchanges. These studies synchronize independent assessments of emotion and regulatory phenomena in time and employ a variety of methods for analyzing relations among variables. Some studies have used sophisticated strategies such as time-series analyses and sequential analyses, controlling for autocorrelations within individuals to demonstrate coregulatory processes. Others simply use contingency analyses or create variables that incorporate the contingency and subject those to statistical tests. Moreover, a variety of statistical approaches can be employed when needed to capture emotion regulation as a process, including a variety of sequential and time-series techniques (e.g., Bakeman, 1997; Giardino, Lehrer, & Feldman, 2000; Sackett, 1987).

Empirical studies are needed to examine whether emotions can change in the absence of regulation or whether, for example, the dynamics of emotion (e.g., latency to return to a baseline state) reflect allostasis, or stability, in response to internal and external changes (see McEwen & Seeman, 1999, for an example from stress research). Investigators who study temporal relations among measures of inferred emotion and measures of regulatory phenomena must temper their interpretations. They can nonetheless yield substantive evidence of emotion regulation by demonstrating change. Regulation is fundamentally change; demonstration of change over time is one tool that can be used to advance research on emotion regulation.

Contrasting Conditions

A third tool used to examine emotion regulation is the use of contrasting conditions. Two types of contrasting conditions are used in the studies reviewed:
contrasts of social context and contrasts of situational context. In contrasts of social context, a particular pattern of emotional regulation is predicted in a context that affords a certain class of emotional reaction (e.g., toy removal affords frustration or anger, separation from mother affords fear or anxiety). In most of the studies we have cited, the contrasting conditions are two or more manipulations of the social circumstances. Variations include manipulating the presence an adult (mother or research assistant present and absent), the nature of the prior relationship between the attending person and the child (parent, stranger), and the behavior of the adult (adult behavior constrained, unconstrained).

For example, observing a child alone may afford the opportunity to observe and evaluate self-regulatory efforts that might not occur when a parent is present, the logic being that the child relies on the parent rather than manages independently. In other cases, observing the child alone affords assessing emotions that are masked in the presence of another (e.g., an experimenter), as in the case of children masking disappointment. Contrasting conditions help the researcher around the problem of inferring emotion when there is barely a detectable sign of it. These are but a few examples that illustrate how contrasts of social conditions can further our efforts to disentangle evidence of emotions being activated and evidence of regulatory processes.

Another approach to the use of contrasting conditions involves the comparison of situations that afford different emotional reactions, that is, situational context. In the literature we have reviewed, several studies contrasted anger- and fear-activating conditions. Others contrasted nonchallenging (e.g., snack time, free play) with emotionally challenging conditions or contrasted variations in elements of a challenging situation. In most of these studies, a range of emotions was measured to verify that the particular emotions afforded by the challenging context were activated, and in some cases the emotions exhibited in the challenging context were compared with contexts that are less likely to afford those emotions (e.g., a blocked goal task in contrast with a novel, uncontrolled object exposure or a free play). These various approaches to contrasting situational context provide valuable ways to infer emotion and to demonstrate that different emotions may be regulated in different ways.

Multiple, Converging Measures

A final strategy involves using a set of converging measures to demonstrate predicted relations among elements of the larger construct of emotion regulation. There has been a tradition in emotion research to use the convergence of self-report, expressive behavior, and physiological change as definitive evidence of an emotion. The problem of course is that requiring such convergence limits research to only one aspect of emotion processes. For example, an emotion can be activated without its being a conscious phenomenon available to self-report. In several studies of emotion regulation, independent measures of emotion expression, behaviors that are purported to be self-regulatory, and physiological indexes associated with regulation (e.g., vagal tone, frontal asymmetry) were assessed. This multiple-measure strategy can also include using self-report of child or mother, observations of emotion and behavior under contrasting conditions, and manipulations of conditions to heighten inference. Each of the three topical areas we described include studies that used this approach, but it has been employed most convincingly in programs that also used temporal analyses. The risk in studies that rely only on converging measurement is that they alone do not demonstrate change. That inference requires more strategies, such as temporal analyses or contrasting conditions. Findings that children who are characteristically fearful or inhibited also (a) react to novel stimuli with intense fearfulness, (b) do not avert gaze from the threatening situation, and (c) show low levels of vagal tone or frontal asymmetry, offer converging evidence that emotion organizes vigilance for dangerous stimuli but do not demonstrate that uninhibited children are actually regulating their fear by averting gaze. Nonetheless, research programs in the development of emotion regulation that fail to use multiple, converging measurement omit a compelling strategy for heightening inference.

Summary and Conclusions

In this article we identify methodological challenges in the study of children’s emotion regulation and summarize a series of studies that appeared to address these challenges well, and on the basis of those studies, we suggest guidelines for future empirical work. Our purpose was to stimulate discussion and debate, hoping that the process would provide a context for improved research in the development of emotion regulation. We summarize previous work on conceptualizing emotion and emotion regulation, noting several challenges in each of these domains, and provide exemplars from the study of emotion regulation in early childhood that provide sub-
stantial evidence for inferring emotion regulatory processes. In addition to studies of the development of emotional experience, expression, and understanding, child development research can be enriched by studies of how children’s emotions organize their thinking, learning, action, and relationships, and how their thinking, learning, action, and relationships help them acquire the ability to regulate their own emotions.

There is as yet no gold standard by which to evaluate the scientific rigor of studies of emotion regulation. The field has struggled in its effort to move forward because of poorly designed studies and overinterpretation of findings. Because the assessment of emotion, and of emotion regulation, is necessarily inferential in nature, it is important to conceptualize carefully and measure rigorously these phenomena, building the strongest possible case for inferring these processes. Our review of the literature in early childhood emotional development focuses on studies of temperament, studies of parent–child interaction, and studies of the early development of emotional self-regulation. In these studies we find implicit and explicit definitions of emotion regulation and methods for distinguishing inferred emotion from inferred emotion regulation. These studies used a variety of methods that seemed fruitful for inferring emotion regulation, including temporal analyses of relations between emotion and regulatory phenomena, use of contrasting conditions, and differential patterns of converging multiple measures. Although temporal analyses provided the clearest evidence of emotion regulation, interpretations cannot assume a linear relation between emotion and emotion regulation.

Emotions are powerful, elusive, dynamic processes. They have the capacity to regulate other processes and to be regulated. These qualities present both great scientific challenges and the essence of what makes emotion regulation an exciting lens through which to study development. For emotion regulation research to achieve its goals, future studies need to frame their efforts conceptually and use methods that provide compelling inferential evidence. In this article we do not exhaust all the methods that can be used. We anticipate other developmental scientists will join in the effort to increase the rigor with which emotion regulation is studied. All of our research will benefit from such efforts. Ultimately, it is not the mere fact that humans are capable of emotion but how emotions are harnessed in the service of goals that will enlighten our understanding of developmental pathways.

References


Reactive and effortful processes in the organization of temperament

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Abstract
Self-organization can be approached in terms of developmental processes occurring within and between component systems of temperament. Within-system organization involves progressive shaping of cortical representations by subcortical motivational systems. As cortical representations develop, they feed back to provide motivational systems with enhanced detection and guidance capabilities. These reciprocal influences may amplify the underlying motivational functions and promote excessive impulsivity or anxiety. However, these processes also depend upon interactions arising between motivational and attentional systems. We discuss these between-system effects by considering the regulation of approach motivation by reactive attentional processes related to fear and by more voluntary processes related to effortful control. It is suggested that anxious and impulsive psychopathology may reflect limitations in these dual means of control, which can take the form of overregulation as well as underregulation.

Recent models of temperament are based on the assumption that personality differences arise in part from the reactivity of underlying neural systems. Although many systems are involved, among the most important are those serving regulatory functions related to motivation and attention. These systems respond to significant inputs by regulating other neural pathways involved in perceptual and response processing. Given a threatening input, for example, systems related to defensive motivation regulate motor and autonomic circuits to support avoidant behavior and also modulate perceptual pathways to enhance incoming information relevant to the threat and to safety (Derryberry & Rothbart, 1984; Derryberry & Tucker, 1992; Gray, 1982). By regulating the brain’s input and output systems, these motivational circuits promote a temporary neural organization that is adaptive given the organism’s current needs.

Although this organization is clearly important to ongoing survival, it takes on added significance when viewed in terms of the development of self-regulation. As the child develops, initially reactive forms of regulation are supplemented by an increasing capacity for voluntary or effortful forms of control (Rothbart, Posner, & Boylan, 1990; Rothbart & Bates, in press). Across time, we expect common patterns of regulation to promote a progressive stabilization of synapses within the brain, contributing to the structural organizations central to personality (Derryberry & Reed, 1994b; Derryberry & Reed, 1996). Thus, the child’s cognitive representations of events in the world (as potentially rewarding or dangerous) and of the self (as efficacious or vulnerable) can be seen to be closely related to his or her underlying motivational tendencies. By relating these representations to the child’s reactive and effortful forms of regulation, we can better appreciate the extent to which personality development is a self-organizing process.
In the following pages, we examine this process of self-organization and discuss some of the factors contributing to later personality development and to adaptive and maladaptive outcomes. We begin at a physiological level, discussing individual differences in neural systems related to different types of motivational and attentional processes. In the second section, we adopt a cognitive framework and consider the differentiation that occurs within these systems as the child develops. In the final section, we discuss integrative processes that may arise from interactions among these systems. We focus first on reactive approach tendencies and consider their regulation by fear and by effortful forms of control. We conclude by considering the role of effortful control in the regulation of fear.

**Systems of Temperament**

Taking a developmental view of personality, the first sources of individual variability are biologically based temperamental characteristics. Not all of the temperament systems are functional at birth, but follow a developmental time course (Rothbart & Bates, in press). A general goal of temperament approaches is to relate specific neural systems to the major dimensions of personality and ultimately to understand how personality develops. In discussing these relations, we focus on those involving motivational and attentional processes. Although our descriptions are limited in physiological detail, we attempt to discuss a variety of systems involved in different aspects of motivation and attention.

**Motivational systems**

Motivational systems are based within limbic circuits (e.g., amygdala, hypothalamus) that have evolved to serve appetitive, defensive, and nurturant needs. The limbic circuits receive simple perceptual inputs from the thalamus, as well as more complex perceptual and conceptual information from the cortex. If they detect a significant (i.e., need-related) input, the limbic systems regulate brainstem mechanisms that serve motor, autonomic, and attentional functions, and thereby promote an adaptive response (Derryberry & Tucker, 1992; Rothbart, Derryberry, & Posner, 1994).

**Appetitive and approach behavior.** Perhaps the most basic of these is an appetitive system that mobilizes approach behavior to stimuli that predict positive events. The underlying circuitry has been discussed in terms of a “behavioral activation system” (Gray, 1987a, 1987b), a “behavioral facilitation system” (Depue & Iacono, 1989), and an “expectancy–foraging system” (Panksepp, 1992a). Although formulations vary, the basic idea is that the circuits within the basolateral amygdala respond to reward-related inputs by activating dopaminergic neurons within the brainstem’s ventral tegmental area. The dopaminergic neurons in turn project to the nucleus accumbens, where they facilitate approach responses directed toward the rewarding input. In Gray’s (1987b) model, such response facilitation can be elicited by signals predicting reward to produce approach behavior and the emotion of hope, and by signals predicting nonpunishment to produce active avoidance and the emotion of relief. Depue and Iacono (1989) suggest that in addition to facilitating approach and active avoidance, the appetitive system also promotes irritative aggression when goals are blocked. Panksepp (1986a) proposes that the system can also be engaged by regulatory imbalances (e.g., hunger) to facilitate search behavior and a state of desire.

Individual differences in the reactivity of the appetitive system are often related to a general dimension of Extraversion or Positive Emotionality (Larsen & Ketelaar, 1989; Watson & Clark, 1992). In addition, the system has been related to a dimension of impulsivity that is strongest in neurotic extraverts (Gray, 1987b). Relevant individual differences appear by 6 months of age, with infants showing early differences in smiling and laughter that are related to short latencies in approaching objects (Rothbart, 1988). In our parent-report studies of 6- to 7-year-olds, we have found a general “Surgency” factor defined by scales of approach, sensation seeking, activity level, and shyness (with a negative loading) (Ahadi, Rothbart, & Ye, 1993). These characteristics are similar to those found in extraverted
adults, as reported in both three-factor (Eysenck, 1981) and five-factor (McCrae & Costa, 1985) models of personality. Some stability appears early in life, with approach tendencies and positive affect during infancy predicting approach tendencies at 6–7 years (Rothbart, Derryberry, & Hershey, 1995). In addition, Caspi and Silva (1995) have found that preschool children high on approach or confidence tend to be more impulsive and socially potent at the age of 18. Although environmental influences should not be overlooked, these findings are consistent with the development of a constitutionally based appetitive or approach system. As discussed in subsequent sections, this system will motivate not only the child’s approach behaviors, but also his or her representation of potential rewards in the environment. The regulation of this appetitive system, through which approach behavior is limited to appropriate contexts, forms one of the major themes of socialization, and problems in regulation can leave the child vulnerable to psychopathology.

**Fearful behavior.** Complementing the appetitive or approach system, many authors have discussed neural mechanisms related to defensive or fear-related motivation. Examples include Gray’s (1982) “behavioral inhibition system,” Panksepp’s (1982, 1986a) “fear system,” and Gilbert and Trower’s (1990) “defense system.” Gray’s model emphasizes circuitry centered upon the hippocampus that responds to novel signals, biologically prepared fear signals, signals predicting punishment, and signals predicting nonreward (Gray, 1982, 1987b, 1994). Upon detecting this input, the behavioral inhibition system inhibits ongoing motor behavior to promote passive avoidance, increases arousal, and directs attention toward relevant information in the environment. In addition, the behavioral inhibition system functions to regulate approach behavior via inhibitory projections to the appetitive system. In emotional terms, these multiple outputs set up a state of “anxiety” (given novelty or anticipated punishment) or “frustration” (given anticipated non-reward).

While Gray’s model focuses on the hippocampus, other researchers have suggested that the hippocampus is involved primarily in processing contextual information relevant to fear, whereas circuitry within the amygdala processes fear-related object information (Davis, 1992; LeDoux, 1995, 1996). The amygdala’s lateral nucleus receives conditioned fear signals from the hippocampus, thalamus, and cortex, and projects to the central nucleus via pathways through the basolateral and basal accessory nuclei. The central nucleus then projects to multiple areas of the brainstem, where it regulates specific components of fearful behavior, including freezing, reflex potentiation, facial and vocal expressions, and heart rate changes. In addition, the amygdaloid nuclei have extensive connections to reticular and cortical circuits through which they can enhance attention to threatening inputs.

In adult studies of personality, fearful motivation is often related to a general dimension of Neuroticism or Negative Emotionality (Larsen & Ketelaar, 1989; Watson & Clark, 1992), although some have argued for a more specific Anxiety dimension that is strongest in neurotic introverts (e.g., Gray, 1982, 1987b). Individual differences in fearful, inhibited behavior appear later than approach tendencies, but can be seen by the last quarter of the 1st year of life (Rothbart, 1988). Late in the 1st year, some infants begin to show inhibited approach to unfamiliar and intense stimuli, and subsequent fearful behavior accompanied by enhanced sympathetic and adrenal reactivity. Fear and inhibition at 21 months can be predicted by a measure of combined crying and motor reactivity taken at 4 months (Kagan, Snidman, & Arcus, 1992). Additional longitudinal research suggests stability of fearful inhibition from the 2nd to the 8th year of life (Kagan, Reznick, & Snidman, 1988) and from preschool to the age of 18 (Caspi & Silva, 1995). In our studies of 6- to 7-year-olds, fear loads on a factor of Negative Affectivity, along with scales assessing discomfort, anger/frustration, sadness, and loading negatively, soothability (Ahadi et al., 1993). For children assessed in infancy and at the age of 7, a composite measure of the infant’s fear predicted
both fear and sadness at 6–7 years, and was negatively related to later activity, impulsivity, and approach (Rothbart et al., 1995). These developmental findings are consistent with physiological evidence suggesting that fear plays an important role in regulating approach behavior. As discussed in later sections, additional evidence suggests that problems in fear-related regulation, which can arise from deficient as well as excessive fear, are a central factor in several forms of psychopathology.

_Frustrative and aggressive behavior._ In addition to regulating appetitive approach, fear may also play a role in constraining aggressive forms of behavior. Unfortunately, the neural systems related to aggression are not well understood, perhaps because such behavior can be called upon to serve several different motives. As mentioned above, Depue and Iacono (1989) suggest that when a goal is blocked, the appetitive system promotes a form of irritative aggression aimed at removing the obstacle. In the case of predatory or instrumental aggression, Gray (1987b) and Panksepp (1982) suggest that this is also a function of the appetitive system, and thus another form of approach behavior. While the above forms of aggression arise from the appetitive system, Gray (1982) has also proposed that a state of frustration involving inhibited approach arises when the behavioral inhibition system is activated by a signal predicting nonreward. In contrast, unconditioned nonreward or punishment is thought to promote defensive aggression and the emotion of anger. The pathways relevant to defensive aggression involve connections from the amygdala and ventromedial hypothalamus to the periaqueductal gray region of the brainstem and have been described in terms of a fight–flight system (Gray, 1987b) and a rage system (Panksepp, 1982).

Given these different types of aggressive behavior, it is not surprising that adult models relate aggression to several personality dimensions. In five-factor models of personality, antagonism defines one pole of the Agreeableness–hostility dimension, but aggressive elements also can be seen in the dimensions of Extraversion (dominance and assertiveness) and Neuroticism (irritability and anger) (Costa & McCrae, 1985). During infancy, it is possible to distinguish irritable distress involving frustration and anger from fearful distress (Rothbart & Bates, in press). In addition, developmental studies suggest that frustration is related to strong approach motivation. For example, Fox (1989) has found that frustration to arm restraint at 5 months is positively related to approach of strangers and novel events at 14 months. Although fear and frustration are related in our studies of 6- to 7-year-olds, frustration tends to be positively related to measures of positive emotionality, whereas fear is negatively related to positive emotionality (Ahadi, Rothbart, & Ye, 1993). While high infant fear predicts lower approach at the age of 6–7 years, high infant anger/frustration predicts higher 6–7 year approach, and anger/frustration, but not fear, is positively related to activity level at every age we have measured it via parent reports, beginning at 6 months (Rothbart et al., 1995). Finally, aggression in 6- to 7-year-olds is negatively related to fear during infancy, but positively related to activity, smiling, and anger/frustration (Rothbart, Ahadi, & Hershey, 1994). These findings are important in differentiating two forms of negative emotionality, fear and frustration/anger. They also suggest that frustration, anger, and aggression may be more closely related to appetitive, approach motivation than to fear.

_Affiliative and nurturant behavior._ A fourth set of circuits important to temperament regulates social behaviors serving affiliative and nurturant needs. These circuits may prove important in differentiating a second type of reward motivation, related to affiliateness, from the outgoing social behavior that can result from a strong approach system. Knowledge of the underlying systems remains limited, although Panksepp has discussed several possibilities. A key mechanism involved in Panksepp’s (1986b) model involves inhibitory connections through which the ventromedial hypothalamus suppresses defensive aggression within the periaqueductal gray. This inhibition is thought to be enabled by social play, allowing for friendly, trusting, and helpful behaviors that promote social bonding between
members of a species. In addition, Panksepp (1986b) suggests that social cohesion is supported by a “separation distress–panic system.” This system responds to the loss of social support by mobilizing separation distress vocalizations and other agitated behaviors. When the caregiver returns, opiate neurons provide rewarding comfort to the child. Most recently, Panksepp (1992b) has suggested another mechanism, based on the limbic peptide oxytocin, that promotes social bonds. When released during caregiving situations, oxytocin is thought to evoke warm feelings of nurturance and acceptance, and thereby attraction between caregivers and receivers.

A related approach can be found in MacDonald’s (1992) discussion of an “affectional system.” This is thought to be a specialized social reward system that evolved to facilitate close family relationships by promoting feelings of warmth. MacDonald suggests that warmth is not only reciprocally rewarding for parents and child, but also supports feelings of empathy in the child, identification with the parents, and the adoption of parental values. Kochanska’s recent research supports this model. She has found that measures of shared positive affect between the mother and toddler predict measures of internalization of conscience and committed compliance at both toddler and preschool ages (Kochanska & Aksan, 1995; Kochanska, Aksan, & Koenig, 1995). Kochanska (1995) has also found non-fearful children’s internalization of conscience to be related to their security of attachment.

These types of affectionate, affiliative, and nurturant behaviors appear to be related to the dimension of Agreeableness in five-factor models, which includes facets such as trust, altruism, and tender-mindedness (Costa, McCrae, & Dye, 1991). It is interesting that Panksepp’s emphasis upon the role of hypothalamic inhibition of aggression in prosocial behaviors fits well with the two poles (agreeableness vs. hostility) of this dimension. Also relevant is Cloninger’s (1987) dimension of Reward Dependence, which ranges from being socially detached, tough-minded, and independent to being sentimental, warmly sympathetic, and emotionally dependent. Unfortunately, agreeableness has been a relatively neglected individual difference variable in the developmental literature, although Graziano’s (1994) recent work, MacDonald’s (1992) theoretical synthesis, and Kochanska and her associates’ research (Kochanska & Aksan, 1995; Kochanska et al., 1995) may be changing this situation. In the future it will be important to determine the relative importance of shared positive affect and sentimental regard in the prediction of empathy, altruism, and conscience. It will also be important to consider the role of nurturant motives in regulating appetitive and aggressive behavior.

As summarized in Table 1, temperament approaches are based upon physiologically defined motivational systems that contribute, either alone or in combination, to the major personality dimensions. Although the motivational systems are most often viewed as organizing behavioral and emotional components of personality, they also play an adaptive role in attentional regulation and perceptual processing. For example, a key function of the defensive system is to help the individual cope with threat by directing attention to relevant environmental information (Gray, 1982; Derryberry & Tucker, 1992). Similarly, MacDonald’s (1992) affectional system may promote family cohesiveness by directing the child’s attention to parental beliefs and values. Thus, the effectiveness of the motivational systems in carrying out their functions may depend greatly upon their capacity to regulate attention. As discussed in subsequent sections, this attentional regulation will not only influence ongoing behavior, but also the storage of information in memory. By attending to threatening information, for example, the anxious person can store a representation of relevant sources of threat and safety that will help him or her cope with similar dangerous situations in the future. In addition, the child’s attention to parental values and beliefs will provide them with representations for guiding his or her own behavior in a way that preserves cohesiveness within the family.

**Attentional systems**

Given the importance of attention in motivated behavior, researchers have also focused on individual differences in attentional sys-
Table 1. Simplified summary of major motivational systems, their associated emotions and personality dimensions, and some major neural structures

<table>
<thead>
<tr>
<th>Motivational Systems</th>
<th>Emotional States</th>
<th>Related Neural Structures</th>
<th>Personality Dimensions</th>
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<tr>
<td>Appetitive</td>
<td>Hope</td>
<td>Basolateral amygdala</td>
<td>Extraversion</td>
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<tr>
<td></td>
<td>Relief</td>
<td>Ventral tegmental area</td>
<td>Impulsivity</td>
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<tr>
<td></td>
<td>Desire</td>
<td>Nucleus accumbens</td>
<td></td>
</tr>
<tr>
<td>Defensive</td>
<td>Fear</td>
<td>Lateral amygdala</td>
<td>Neuroticism</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>Central amygdala</td>
<td>Anxiety</td>
</tr>
<tr>
<td></td>
<td>Frustration</td>
<td>Hippocampus</td>
<td></td>
</tr>
<tr>
<td>Aggressive</td>
<td>Irritation</td>
<td>Appetitive circuits</td>
<td>Hostility</td>
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<td></td>
<td>Anger</td>
<td>Defensive circuits</td>
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<tr>
<td></td>
<td>Rage</td>
<td>Ventromedial hypothalamus</td>
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<tr>
<td>Nurturant</td>
<td>Warmth</td>
<td>Amygdala</td>
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<td></td>
<td>Affection</td>
<td>Ventromedial hypothalamus</td>
<td>Reward dependence</td>
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</table>

tems. Some of these mechanisms are components of the “reticular activating system” ascending from the brainstem to the cortex. Posner has discussed a “vigilance” system involving norepinephrine projections from the locus coeruleus to the cortex (Posner & Raichle, 1994; Posner & Rothbart, 1992). This system is thought to be involved in the tonic maintenance and phasic adjustments in general alertness. Tucker has described a “tonic activation” system involving dopamine projections from the ventral tegmental area to object processing pathways in the left hemisphere (Tucker & Derryberry, 1992; Tucker & Williamson, 1984). This mechanism is thought to facilitate defensive behavior by focusing attention on important stimuli and preventing distraction.

A second set of attentional circuits is involved in orienting attention from one location to another and in adjusting the scale or breadth of attention. This “posterior attentional system” is distributed across the midbrain’s superior colliculus, the pulvinar nucleus of the thalamus, and the parietal lobe within the cortex. Its functioning can be best understood in terms of component operations that allow attention to “disengage” from one location, “move” to a new location, and “engage” or enhance that location. When engaged at a particular location, the breadth of attention can also be focused to provide more detail of local features or expanded to provide a broader coverage of global information (Posner & Raichle, 1994; Posner & Rothbart, 1992; Rothbart, Posner, & Rosicky, 1994).

A third attentional system is located within the frontal cortex with its pivotal circuitry focused on the anterior cingulate region. This “anterior attentional system” is viewed as an executive system responsible for regulating the posterior attentional system and controlling attention to semantic information (Posner & Raichle, 1994; Rothbart, Derryberry, & Posner, 1994). Vogt, Finch, and Olson (1992) have proposed that the anterior cingulate cortex, with close connections to motor cortex, may provide a site for interaction between motivational and cognitive processes, especially as they affect motor output. Moreover, Posner and Rothbart (1992) suggest that the anterior system underlies the conscious, “effortful control” of behavior through which the individual can regulate more reactive motivational functions. This capacity depends upon sophisticated attentional and inhibitory processes which can be regulated in a planful way in light of representations of the self and future.

Individual differences in these attentional systems are likely related to a variety of attentional biases evident during different motivational states. For example, individuals high in trait anxiety tend to show a narrow attentional focus along with delays in disengaging from threatening inputs (Derryberry & Tucker,
1993). The extent of such involuntary biases may reflect variability in functioning of the posterior attentional system as well as the fear-related motivational system. At a more general level, the anterior attentional system (i.e., effortful control) appears related to the variability in “attentional flexibility” (Derryberry & Rothbart, 1988; Keele & Hawkins, 1982) and “attentional efficiency” (Wells & Matthews, 1994) evident in adults. This variability may contribute to several personality dimensions. For example, individuals high in effortful control may show high levels of Conscientiousness and low Neuroticism (Ahadi & Rothbart, 1994). In recent studies with college students, we have employed a Stroop-like “spatial compatibility” task that requires subjects to make a response given conflicting spatial information (e.g., to respond with the left hand given a stimulus on the right side of the screen). Subjects who perform well on this task are apparently able to suppress the conflicting spatial information and thus inhibit the dominant tendency to respond with the hand corresponding to the location of the stimulus. Self-report measures indicate that subjects who perform well on the conflict task tend to be high in trait anxiety and attentional control, whereas those who perform poorly are high in anxiety and low in attentional control (Derryberry & Reed, 1997).

The anterior system is a relatively late-developing system, although aspects of intentional control can be seen late in the 1st year. In our research, major development of this system occurs during the toddler period. We have recently used a marker task for anterior cingulate function, a spatial conflict task very similar to that described above. Considerable development of the ability to use a rule to inhibit a dominant response occurs between the ages of 27 and 36 months. Children who perform well on this task are described on a parent-report measure of temperament as more skilled at attentional shifting and focusing, less impulsive, and less prone to frustration reactions (Gerardi, Rothbart, Posner, & Kepler, 1996). By 6 or 7 years of age, the construct of effortful control is represented by a factor defined by scales measuring attentional focusing, inhibitory control, perceptual sensitivity, and pleasure from low intensity stimulation (Ahadi et al., 1993). The stability of effortful control has received little investigation, but is suggested by findings that children who are better able to delay gratification in a conflict situation in preschool are more attentive and resistant to stress as teenagers (Shoda, Mischel, & Peake, 1990). As discussed in more detail below, effortful control contributes to a number of important developmental processes, including the ability to delay gratification, the regulation of fear, and the development of conscience (Eisenberg & Fabes, 1992; Kochanska, 1993; Rothbart, Ahadi, & Hershey, 1994).

**Organization Within Temperament Systems**

So far we have considered relevant neural systems and their possible general relations to personality dimensions. To better understand these relations, however, it is necessary to consider developmental processes both within and between these systems. In this section, we focus on development within the motivational systems, viewing their development as a process of self-organization. The basic idea is that as the child develops, cortical synapses are progressively stabilized to form representations that provide input to subcortical motivational systems. These cognitive representations provide motivational circuits with more detailed information that enhances their ability to evaluate complex situations and to regulate behavior accordingly. Although cortical representations depend in large part upon environmental inputs, their stabilization also depends upon activity within the underlying motivational systems. In a sense, the motivational circuits can function as specialized learning mechanisms, guiding the development of cortical representations in light of underlying appetitive and defensive needs. This leads to a progressive differentiation of representational and response processes, but in a manner that is integrated or organized in terms of the central motivational functions.

**Motivation and representational organization**

By representational development we refer to the progressive stabilization of connections...
D. Derryberry and M. K. Rothbart

within cortical regions that process perceptual and conceptual information. These representations are concerned not only with information from the external environment, but also with interoceptive hedonic and energetic information involved in ongoing emotional states, and with complex conceptual information involved in beliefs about the self, others, and the world. As they develop, these cortical structures deliver detailed input to the limbic regions, providing motivational systems with an increased capacity to predict and evaluate potentially significant events (Derryberry & Reed, 1994b, 1996). They also allow motivational processes to be influenced by the belief systems and values of the child’s culture.

Representational inputs have been studied in most detail for the defensive circuits of the amygdala (LeDoux, 1995, 1996). The lateral amygdala receives a direct sensory input from the thalamus, which allows a very rapid (less than 20 ms) fear response based on low-level sensory features. Additional thalamic pathways deliver the sensory information to the cortex, where it undergoes extensive processing across sensory and association areas. Importantly, the cortical areas possess a more detailed cellular and connectional architecture compared to that of the thalamus and amygdala, allowing for more specific and elaborate processing. A number of these cortical regions convey highly processed information to the amygdala, including object information from unimodal association areas and conceptual information from polymodal areas, and also contextual information from the hippocampus (LeDoux, 1995). As they converge upon the lateral amygdala, these cortical inputs allow fear circuitry to respond based on finer distinctions between events (e.g., different facial expressions), to anticipate events in the future (e.g., a specific facial expression may be followed by a specific action), and to relate these events to the surrounding context (e.g., a specific action is more likely to occur in a specific environment). Although the functions of different cortical areas are not yet clear, it is reasonable to assume that they also contribute to more abstract sources of human fear, such as those arising from our concepts of the self and other people. In a sense, cortical representations can be viewed as part of an elaborate appraisal mechanism concerned with detecting and predicting relatively subtle forms of threat.

The development of cortical representations involves considerable plasticity. Rather than being prespecified, connections within the cortex are initially extremely diverse, with extensive interconnectivity between cell groups. Upon exposure to the environment, the more active synapses tend to be strengthened and stabilized, whereas the vast majority appear to regress. It is important to emphasize that the resulting representational networks are not shaped through passive “instruction” by the environment. Instead, internal selective processes arise from the child’s motivational systems to constrain the impact of environmental events (Cicchetti & Tucker, 1994; Derryberry & Reed, 1994b; Tucker, 1992). As discussed below, these selective processes can influence which synapses are most likely to be activated by the environment, and once they are activated, which synapses are most likely to be stabilized.

One general type of motivational selection arises from a child’s response tendencies, regulating the child’s exposure to specific types of information. For example, a child with strong approach tendencies may often seek out novel and stimulating environments, whereas a more fearful child may avoid such stimulation in favor of more familiar and calm environments (Scarr & McCartney, 1983). In addition, children will differ in the types of information they are likely to evoke from the others. While the approach-oriented child may elicit intense social stimulation from others, the fearful child may be treated in a more gentle or protective way. Children will also differ in their exposure to interoceptive emotional information, with approach-oriented children more often experiencing positive affect and fearful children more prone to negative affect (Derryberry & Reed, 1994b; Rothbart, 1989). As a result of these influences, children with different temperaments will be exposed to different types of information, leading to different content within their developing representations.

While the above examples illustrate influ-
ences arising from the child’s response tendencies, a more specific form of motivational selection involves attention. Because the underlying motivational systems regulate attention, temperamental variability in these systems would be expected to lead to attentional differences. Our adult research has investigated these differences in visual tasks that present positive and negative cues prior to targets requiring a simple detection response. When the cues signal an opportunity to gain or lose points, individuals with strong approach tendencies (i.e., neurotic extraverts) are slow to disengage attention from the positive cues, whereas anxious individuals (e.g., neurotic introverts) are slow to shift from negative cues (Derryberry & Reed, 1994a). In addition, when attention is drawn to the location of a negative trait adjective, anxious subjects are slow to disengage and shift to targets in another location (Reed & Derryberry, 1995; Derryberry & Reed, 1996). Similar negative attentional biases have been found in studies of trait anxious and clinically anxious subjects (Eysenck, 1992; Vasey, Daleiden, Williams, & Brown, 1995; Wells & Matthews, 1994). These studies provide support for the idea that trait anxiety biases attention in favor of negative information, though evidence of positive attentional biases, such as noted above for neurotic extraverts, remains limited.

Moreover, much evidence from neuroscience (e.g., Singer, 1990) and developmental psychology (Ruff & Rothbart, 1996) suggests that attention plays a central role in enabling cortical plasticity and explicit forms of learning. This in turn suggests that because individuals with different temperaments attend to different types of information, they will tend to selectively store different information. Consistent with this proposal, anxious individuals form stronger short-term memory representations for attended negative words (Reed & Derryberry, 1995), and a number of studies have demonstrated that trait anxious individuals show enhanced recall of negative information (e.g., Eysenck & Byrne, 1994; Eysenck & Mogg, 1992; Kennedy & Craighead, 1988; for reviews, see Eysenck, 1992; Wells & Matthews, 1994). These types of attentional effects on memory appear to make good adaptive sense, for they allow the motivational system to promote the storage of information that may prove useful to its future functioning.

When viewed developmentally, these findings suggest that motivated attentional biases may progressively shape the child’s cognitive representations in a manner that reflects their underlying temperament (Derryberry & Reed, 1996). Across time, the cortical appraisal mechanism can be fine tuned in light of the child’s needs and concerns. This representational sculpting should depend not only upon the more reactive attentional processes related to subcortical motivational systems, but also upon the effortful processes arising from the anterior attentional system. For example, an anxious child may construct representations that emphasize potential dangers in the world, and perhaps also the sources of safety and relief that can help them cope with these threats. Many fearful children also represent the self as vulnerable and ineffective. In contrast, the approach oriented child may develop representations that emphasize the rewards in the world, other people as sources of pleasant stimulation, and the self as active and efficacious. The child with a strong affectional system may form representations emphasizing the nurturant potential of others, developing views of the self as lovable and accepted or unlovable and rejected. As suggested by MacDonald (1992), the affectional system may be important in directing the child’s attention to the values of the parent and can thus facilitate the transmission of a wide range of cultural values. In addition, it can facilitate development of a rich representation of information about others, including their needs and requirements, as well as strategies for protecting and serving others.

Organizational processes

These representational developments can also be viewed as allowing differentiation of the underlying motivational processes. Because it depends on both environmental and temperamental processes, differentiation will proceed in varied ways across different children. To focus on defensive motivation, for example,
some anxious childrens’ fearful representations may emphasize physical threats in the environment. In severe cases, these children may become vulnerable to physical phobias related to animals, heights, contamination, and so on. Other children’s fear may differentiate primarily within the social domain, leading to possible representations of others as critical and the self as vulnerable and inferior. These children may become susceptible to social anxieties related to avoidant disorder and school phobia. Still others may represent threats across a wide range of physical and social situations, and may thus become vulnerable to the more generalized type of fear evident in overanxious disorder. Although much of this differentiation depends upon information from the environment, it is worth noting that these different types of fear appear particularly adaptive in terms of evolutionary environments (Marks & Neese, 1994).

From a physiological perspective, cortical representations can be viewed as developing extensions of limbic motivational processes (Panksepp, 1992a). In a sense, motivational systems organize cortical connectivity so as to enhance the storage and future processing of important information. As they project back upon the limbic systems, these cortical representations can then provide the motivational processes with enhanced detection and guidance capabilities (Derryberry & Reed, 1996). They allow for more detailed anticipation and evaluation of potential threats and rewards, and provide images and maps that can guide response selection. Such reciprocal effects can give rise to positive feedback interactions between limbic and cortical processes, a type of interaction often considered central to self-organization (Lewis, 1995). Unfortunately, such positive feedback loops may form a vicious cycle leading to progressive problems for some children. A fearful temperament may facilitate representations involved in detecting and avoiding threat, which may in turn exacerbate the child’s fear. Similarly, an approach-oriented temperament may promote reward-related representations that feed back to enhance the child’s impulsivity. Given the tight coupling between cognitive and motivational processes, such accelerating forms of self-organization may be a common feature of many childhood disorders.

However, several additional regulatory processes may protect against such accelerating interactions. First, we have suggested that motivational systems may promote relatively balanced representations that provide negative as well as positive influences. For example, defensive motivation may facilitate information related to threat, but it should also promote attention to information relevant to safety, relief, and coping with the threat (Derryberry & Reed, 1996). By facilitating relieving as well as threatening information, the defensive system can more adaptively guide the individual’s responses (i.e., away from the threat and toward safety). The resulting representational content can be called upon in the future to help the child cope with a threatening situation, and should guard against an accelerating potential for anxiety. Similarly, appetitive forms of motivation should function most effectively when potentially frustrating as well as rewarding information is attended. The stored representations can help the child circumvent frustration while approaching rewards, thereby constraining his or her impulsivity. From this perspective, the motivational systems can be viewed as incorporating negative as well as positive feedback mechanisms, allowing them to function as more balanced regulatory systems, especially when combined with attentional control allowing flexible shifting from one mental content to another, as we indicate below. A similar approach can be found in Higgins’ (1996) discussion of “outcome-focused” regulatory systems.

Second, it is necessary to consider regulatory processes arising from other motivational and attentional systems. As mentioned earlier, physiological and developmental evidence suggests that fear motivation may provide important, but relatively involuntary, controls over appetitive motivation. While such fear regulation may be primarily reactive, additional cortical development increases the child’s capacity for voluntary or effortful forms of control. More specifically, the developing representations allow the child to anticipate futures states of the self and world, to evaluate the consequences of potential ac-
tions, and thus to access informational content necessary for strategic voluntary control (LeDoux, 1994). But to effectively utilize this information, the processing capacity of the frontal and cingulate regions is necessary. In particular, the anterior attentional system can regulate the more reactive posterior system, and can modulate the reactivity or automaticity inherent in activated representations. These executive attentional functions allow the child to rely on an increasing range of conscious representational content, to more flexibly coordinate this content, and to generate behaviors aimed at future states of affairs (Posner & Rothbart, 1992). As discussed in the next section, these effortful processes can be viewed as providing an additional capacity for self-regulation, beyond that provided by reactive motivational influences.

**Organization Between Temperament Systems**

In this section, we move beyond organizational processes within a single motivational system to consider processes arising from interactions between temperament systems. These interactions are likely to be highly complex, involving both reactive and regulatory processes at subcortical and cortical levels. To provide a beginning framework, we approach these interactions in terms of regulatory effects upon more reactive systems. We begin by considering the role of fear in regulating approach, followed by a discussion of effortful control and approach. We conclude by considering the regulatory influence of effortful control on fear.

**Regulatory influences of fear**

Many models of motivation propose that circuits related to fear possess inhibitory connections to those involved in appetitive approach behavior (Fowles, 1994; Gray, 1987b). These inhibitory connections allow anticipatory activity within the fear system to suppress approach responses that might lead the organism into a harmful situation. In human social situations, for example, many types of reward-seeking and approach behaviors are considered inappropriate and can evoke aggression or rejection from others.

Consider a relatively fearless child with strong approach tendencies. In general, such a child should show many approach behaviors directed toward environmental sources of reward. Although they may be subject to frustration (Depue & Iacono, 1989), their emotional tone, at least initially, should be generally hopeful and enthusiastic. At a cognitive level, their representations should emphasize rewarding aspects of the world and other people, and they may develop views of themselves as worthwhile and effective.

However, their relative lack of fear at times may lead them to respond with too much impulsivity. Newman and his colleagues have provided evidence that individuals with strong approach tendencies do not always stop and reflect upon punishment. As a result, their representations may include weak associations between punishment and incorrect behavior (Newman, 1987; Wallace, Newman, & Bachorowski, 1991). If a child’s representations emphasize rewards at the expense of punishments, it will be easy to anticipate the positive consequences of approach behavior but more difficult to predict the negative outcomes that might occur. In severe cases, such children may be vulnerable to externalizing or “disinhibitory” problems such as those involved in conduct disorder.

In contrast, the children with strong approach who are also fearful should be better able to inhibit impulsive approach tendencies. Given findings that anxious individuals show enhanced attention to threats (Derryberry & Reed, 1994a, 1996; Vasey et al., 1995), such children should be more responsive to negative events that arise within a situation. Also, their representations should be fairly balanced in covering the positive and negative aspects of the world, allowing them to anticipate potential problems that might result from their appetitive behavior. However, these children may also be vulnerable to conflicts and indecisiveness in ambiguous situations. If problems arise, children high in fear and approach may demonstrate comorbid externalizing and internalizing symptoms. For example, such a child may develop problems related to con-
duct disorder or attentional deficit hyperactivity disorder (ADHD), but in contrast to the child above, may still feel anxious and guilty about their inappropriate behavior. In addition, given the regulatory influence of fear, the externalizing behavior should be somewhat attenuated. Children with coexistent ADHD and anxiety show reduced impulsivity relative to those with ADHD alone (Pliszka, 1989).

Fear may also play a role in controlling aggressive as well as reward-oriented approach. For example, aggressiveness appears to decrease between kindergarten and first grade in children who show internalizing patterns (Bates, Pettit, & Dodge, 1995). Quay (1993) has reviewed studies of children with under-socialized aggressive conduct disorder, who appear to be characterized by predatory or instrumental forms of aggression (e.g., bullying, threatening). Quay suggests that aggressive acts reflect disinhibited approach motivation, resulting in part from diminished activity within the fear system (which normally inhibits approach). Consistent with this perspective are findings that when conduct disorder is accompanied by anxious symptoms, children show fewer peer nominations as fighting the most or being the meanest (Walker et al., 1991).

These examples point out the adaptive value of fear motivation in regulating approach behaviors (Rothbart & Bates, in press). It is worth noting, however, that strong fear can also result in an overregulation of approach motivation, particularly for children with relatively weak approach tendencies. For example, a socially anxious child may tend to avoid social situations where threat is anticipated, regardless of the potential rewards that are available. Such avoidance can lead the child to miss opportunities for positive and novel experiences. In addition, the child may fail to gain experience that could help him or her cope with social situations in the future. He or she may fail to develop representations that help him or her to anticipate how threatening and relieving events develop within the situation, and to prepare responses appropriate to these events. Even if the child possesses such representations and manages to approach the threatening situation, his or her ongoing behavior may still be overregulated by fear. The negative attentional bias and strong behavioral inhibition may make it difficult to initiate spontaneous actions and to keep up with ongoing events, and he or she may become overly cautious and self-conscious (Gilbert & Trower, 1990; Leary & Kowalski, 1995).

Another example of overregulated approach motivation involves depression. Some models suggest that depressive symptoms result in part from anxiety-related inhibition of appetitive motivation (e.g., Fowles, 1994; Gray, 1994). If exposed to prolonged stress, the resulting inhibition may attenuate the child’s reward sensitivity. This could contribute to the decreased positive affect often seen in depression and perhaps to feelings of hopelessness and pessimism about the future. In addition, the inhibition may suppress the dopaminergic systems responsible for response facilitation. Such an inability to mobilize responses could promote the psychomotor retardation, lack of initiative, and feelings of low energy common in depression. Combined with decreased reward sensitivity, the perception of low energy may lead the child to view themselves as ineffective and helpless. Our prediction of sadness at the age of 7 from infant fearfulness may be related to these processes (Rothbart et al., 1995).

It can be seen that although fear can provide beneficial regulation of undercontrolled approach behavior, it can also lead to problems involving overcontrol. This distinction has been basic to Block and Block’s (1980) theorizing, which emphasizes a dimension of ego control ranging from a lack of control to constricted, inflexible behavior. The question of how much control is optimal is a difficult one, and is well summarized in Block and Kremen’s (1996) comment that “the human goal is to be as undercontrolled as possible and as overcontrolled as necessary.” One of the advantages of a temperament approach is its ability to view the issue of undercontrol versus overcontrol in light of several interacting systems. As discussed above, whether fear leads to too little or too much control depends not only upon the strength of fear motivation,
but also on the strength of the regulated approach motivation. As discussed in the next section, it will also depend on a second type of regulatory influence, that arising from effortful control.

Regulatory influences of effortful control

As mentioned earlier, effortful control reflects individual differences in the anterior attentional system, a set of circuits crucial in controlling attention to spatial and semantic information. Given its extensive access to representational content within the cortex, and its ability to coordinate spatial and semantic attention, effortful control provides a more flexible means of regulation compared to that afforded by fear. One way of conceptualizing these two types of control focuses on differences between passive and active attentional processes. Fear regulation can be highly reflexive, enhancing attention to immediate sources of threat in the environment, and thereby making it difficult for the child to approach certain situations. Effortful control may allow the child to voluntarily decrease attention to threatening inputs, and perhaps to increase attention to relieving inputs. By flexibly distributing attention between these inputs, a more effective coping strategy can be implemented. For example, a child with high, unregulated fear may anxiously watch other children playing roughly on a preschool play-yard. Another child, also fearful, may busily play in the sandbox, taking occasional breaks to observe other children’s activities.

These children may differ in ways related to Block and Block’s (1980) constructs of ego control and ego resiliency. Ego control refers to an emotion-related (fear) system that is associated with categorical, restrictive control of behavior. The child who is anxiously watching may be locked into this system and unable to flexibly construct a strategy to reduce anxiety. In contrast, ego resiliency refers to flexible adaptation to changing circumstances, very much like the effortful control dimension of temperament. The child in the sandbox is structuring the situation to meet her needs, and thereby modulating an otherwise inflexible fear control. This child can switch attention from threatening information (“If I play I might get hurt”) to alternative strategies (“So I’ll play in the sandbox instead”).

It seems likely that limitations in effortful control may contribute to a variety of childhood problems. In the case of externalizing or disinhibitory psychopathologies, we have described models that emphasize strong approach tendencies alone or as a result of weak fear regulation (e.g., Newman, 1987; Quay, 1993). In addition, however, effortful control is also likely to play a role. In children with ADHD, for example, there is evidence of impulsive response to rewards and proneness to frustration (Parry & Douglas, 1983). It is important to keep in mind, however, that many children show these characteristics. Some are nevertheless able to voluntarily constrain their impulsivity, perhaps by limiting attention to potential rewards, by enhancing attention to potential punishments, or simply by following the rules. Those who lack these effortful controls who may be most vulnerable to ADHD (Ruff & Rothbart, 1996).

Aggressive problems also appear to be related to strong approach and weak fear motivation (Quay, 1993), along with deficits in effortful control. Adult psychopaths have been found to be slow to disengage attention when it is focused on a rewarding goal, which may make it difficult for them to access the negative consequences of their actions (Kosson & Newman, 1989). In 4- to 6-year-old children, boys with good attentional control tend to deal with anger by using nonhostile, verbal methods rather than more overt aggressive methods (Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994). In our studies of 6- to 7-year-olds, aggression was positively related to an approach factor (Surgency) and to a Negative Affectivity factor (especially anger) (Rothbart et al., 1994). Effortful control was negatively correlated with aggression but made no unique contribution. Since effortful control was negatively related to surgency and negative affectivity, effortful control may regulate aggression indirectly by controlling reactive tendencies underlying surgency and negative affectivity. For example, children high in attentional control may be able to direct attention away from the rewarding as-
pects of aggression. Similarly, they may be able to decrease the influence of negative affectivity by shifting attention away from the negative cues related to anger.

To better understand aggression and other impulsive problems, it is helpful to consider the relationship between effortful control and additional emotional processes related to empathy and guilt. Adult research suggests that anxious individuals tend to be high in empathy (Dias & Pickering, 1993). Empathy in 6- to 7-year-olds is positively related to negative affectivity (but negatively related to anger), and can be predicted by high levels of fear during infancy (Rothbart et al., 1994). In addition, however, a stronger correlation was found between empathy and effortful control, with children high in effortful control showing greater empathy. In a self-report study of elderly hospital volunteers, Eisenberg and Okun (1996) assessed empathy-related components of sympathy, perspective taking, and personal distress. Negative emotional intensity was positively related to sympathy and personal distress, while attentional control was positively related to sympathy and perspective taking, and negatively related to personal distress. These studies suggest that effortful control may support empathy by allowing the individual to attend to the thoughts and feelings of another without becoming distracted by their own distress.

Adult studies indicate that empathy is also related to guilt (Tangney, Burggraf, & Wagner, 1995). Hoffman (1988) has suggested that guilt is a special case of empathy, involving feelings of concern for the other coupled with a sense of personal responsibility. Like empathy, guilt in 6- to 7-year-olds is positively related to Negative Affectivity and Effortful Control (Rothbart et al., 1994). Following Dienstbier (1984), negative affectivity may contribute to guilt by providing the individual with strong internal cues of discomfort, thereby increasing the probability that the cause of these feelings is attributed to an internal rather than external cause. Effortful control may contribute further by providing the attentional flexibility needed to relate these negative feelings of responsibility to one’s own specific actions and to the negative consequences for another. Adult studies suggest that guilt involves a rather complex attentional pattern focusing on a specific deficient behavior, its effects upon others, and the means of making amends (Tangney et al., 1995). Developing representations of possibilities for prosocial actions are also important in developing outcomes for empathy and guilt. Attentional flexibility can facilitate accessing these representations and information relevant to dealing with the situation. Without adequate attentional control, the child may link the deficiency to general aspects of his or her character, and may thus experience global, debilitating feelings of shame. It is also possible that attentional limitations may lead the child to attribute blame externally, and to the experience of anger directed toward another.

Kochanska’s (1991, 1993, 1995) recent work nicely ties together temperamental and environmental influences on the development of conscience. Fearful preschool-aged children were found to show better internalization of moral principles, with this relationship heightened when mothers used gentle, non-power-oriented discipline. This supports Hoffman’s (1988) proposal that too much power assertion may interfere with internalization by directing the child’s attention away from the consequences of his or her act. In contrast, nonfearful children’s internalized control was associated with security of attachment (Kochanska, 1995), a finding consistent with MacDonald’s (1992) suggestion that feelings of warmth may facilitate the child’s adoption of the parent’s values. Finally, Kochanska has found a main effect involving effortful control in the development of conscience (Kochanska, Murray, Jacques, Koenig, & Vandengeest, 1996). This is consistent with the notion that children with greater attentional flexibility may be better able to resist distraction and to attend to the appropriate information for linking negative feelings, the consequences of their actions, and moral principles. It also supports the notion that effortful control can allow the child to act in situations where he or she might otherwise be paralyzed by distress.

While these examples emphasize the regulation of approach behavior, effortful control
can also be important in regulating fear. If we first consider the fearful child with low effortful control, such a child’s attention may be frequently controlled by the more reactive influences of fear. Our adult studies suggest that these reactive influences include tendencies to narrowly focus attention under threatening situations, and to be slow to shift attention away from threatening and relieving signals (Derryberry & Reed, in press). If an anxious child focuses too narrowly or has difficulty disengaging from a threatening stimulus, their feelings of anxiety are likely to increase, and they may be limited in their ability to process additional information relevant to safety and relief. Even if their representations possess information relevant to relief and coping, their attentional inflexibility may limit their ability to take advantage of this information by using strategies involving action. Many threatening situations require that attention shift fluidly among potential sources of threat and relief, and strategies for achieving the latter, and the anxious child may have trouble in coordinating such information.

In contrast, the fearful child with greater effortful control may be able to voluntarily regulate attention in a way that attenuates these reactive influences and reduces their anxiety. Our adult studies have found that individuals reporting efficient attentional control tend to show low levels of anxiety and frustration (Derryberry & Rothbart, 1988). Even during infancy, babies who can easily disengage attention from an arousing stimulus are reported to be more soothable and less subject to negative affect by their mothers (Rothbart, Ziaie, & O’Boyle, 1992). More specifically, the child with good attentional control may be able to disengage from environmental threats, from internal feelings of anxiety, or from negative self-concepts such as those involving failure and vulnerability. Clinical research indicates that such forms of attentional distraction can prove effective in reducing ongoing anxiety, as in children undergoing dental treatment (Wells & Matthews, 1994).

In addition to limiting the impact of threatening information, effortful control may allow the child to enhance positive information, including situational sources of relief and safety, internal feelings of confidence and energy, and self-concepts related to success and efficacy. In short, effortful control may be crucial in coordinating the various sources of threatening and relieving information required in defensive contexts, and in allowing for adaptive action in situations where children would otherwise be subject to inhibition and a focus on their own distress. Even given high levels of effortful control, however, this kind of coordination may not come easily. The reactive aspects of fear, including the attentional restrictions and potentially distracting autonomic arousal, may make it difficult to accomplish.

As a result of these difficulties, children may come to rely upon a variety of attentional strategies to regulate their anxiety. Because these strategies differ in the deployment of attention, they may also differ in their long-term adaptiveness. As mentioned above, some children may be able to attend in some detail to threatening information, while at the same time flexibly disengaging in order to process and act upon information relevant to safety and coping. However, other children may come to rely upon primarily avoidant strategies, disengaging attention from the threatening situation without attending to sources of relief and available coping options. This may temporarily reduce the child’s anxiety, but it is also likely to limit his or her ability to learn about the threatening situation and the various ways of coping with it (Cortez & Bugental, 1995; Wells & Matthews, 1994). The child may fail to learn that he or she can actively cope with certain situations, and may thus continue to represent the self as vulnerable rather than efficacious. Similarly, some children may be able to reduce the experience of fear by directing attention away from their anxious bodily sensations. This may improve their affective state and help them stay engaged in an ongoing task. But if this strategy were used too extensively, the child may fail to benefit from the more positive aspects of felt anxiety. As noted above, negative feelings play important roles in impulsive control, empathy, and conscience. In addition, adult research has identified a group of
“repressive” individuals who report low anxiety but demonstrate strong physiological signs of stress. Although the attentional mechanisms remain unclear, evidence suggests that individuals who suppress emotional feelings are prone to a variety of health problems (Schwartz, 1990).

Related avoidant strategies may involve enhanced attention to sources of relief and safety in the environment. In these instances, the anxious child may cope with threat by actively seeking assistance or comfort from another person, employing strategies that may require good attentional control. If the other is supportive, the child may come to represent threatening situations in such a way that feelings of relief are primarily associated with other people rather than with his or her own actions. As a result, the child may continue to represent him- or herself as vulnerable, especially in situations where the other is unavailable. In extreme cases, these types of strategies and representations may give rise to problems involving dependent behavior, as in separation anxiety disorder and school phobia (Derryberry & Reed, 1996). Problems involving dependency may also vary with the child’s social reward motivation, becoming most likely in families with affectionate and warm relationships (McDonald, 1992).

While these examples illustrate effortful control based on a reduction of attention to sources of fear, some children may attempt to control fear by increasing attention to threatening information. This may prove to be an attractive strategy for an anxious child, because the effortful component is compatible with the reactive influence of fear (i.e., enhanced attention to threat). In many cases, the extra attention may also provide them with additional information that facilitates coping. Again, however, such strategies can cause problems. For example, some children may adopt effortful strategies focusing attention on small details of their behavior, noting very slight discrepancies between their performance and a standard. This may be useful in helping them make fine adjustments in their behavior, but it may also contribute to the perfectionism that often accompanies anxiety and depression (Lundh & Ost, 1996; Terry–Short, Owens, Slade, & Dewey, 1995). Along similar lines, some children may prepare for a threatening event by attempting to anticipate everything that might go wrong, and intentionally focusing upon a set of behaviors (e.g., being highly planful or organized) that have proven effective in the past. These behaviors appear highly conscientious and may allow the child to develop effective strategies for avoiding anxiety. However, such excessive planning can also take the form of extended worry, and can lead to an overly deliberate and compulsive coping style that limits spontaneity and flexibility (Tucker & Derryberry, 1992). Although these examples are speculative, they point out that self-regulation is a matter of degree, and that the effects of over-control as well as undercontrol need to be considered.

Conclusions
In this paper we have approached personality in terms of the self-organizing processes related to motivational and attentional systems. This self-organization can be viewed in terms of specific motivational processes that regulate and stabilize the child’s representations of self and world. In a sense, the subcortical systems can be viewed as extending into the cortex, where they organize cortical representations in terms of underlying motivational tendencies. At the same time, these cortical representations feed back upon the motivational circuits, providing new means of anticipatory control and guidance. By investigating interactions between the cognitive and motivational components, we can better understand emotional problems in terms of the child’s experience, and to relate such thoughts and feelings to the problematic behaviors.

In addition, the organization within temperament systems is influenced by his or her interactions with other systems. Although many such interactions are possible, we focused on the regulatory effects exerted by fear and effortful control upon approach behavior. To understand impulsive disorders, it may not be enough to consider only the child’s approach motivation, though this is clearly important. We also need to consider the impact
of fear in regulating approach, as well as the more voluntary influences of effortful control. Similarly, to understand anxious disorders, we need to move beyond fear to consider the child’s capacity for self-regulation through effortful control. Finally, we have tried to point out that problems may arise not only from an underregulated system, but also from motivational tendencies subjected to overregulation. It is possible that many of the symptoms related to anxious disorders arise from overcontrol.

Although temperament approaches have gained increasing influence in recent years, it should be clear that we are only beginning to understand the underlying processes. In particular, we need clarification concerning the set of motivational systems that are actually basic to personality, as well as a better understanding of how they interact with attentional mechanisms. In addition, more research is needed concerning interactions between reactive and effortful forms of attention. Nevertheless, we feel that this general approach is promising. When applied to psychopathology, it provides an improved understanding of symptoms, an appreciation of their continuity with normal personality, and a functional view of the links between the affective and cognitive components of these disorders. In these ways, a temperament perspective provides a broad approach to prevention and treatment.

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Emotion-Related Regulation: Sharpening the Definition

Nancy Eisenberg and Tracy L. Spinrad

Cole, Martin, and Dennis (this issue) considered many important conceptual and methodological issues in their discussion of emotion regulation. Although it may be necessary to develop an integrated definition of the construct of emotion regulation, the definition provided in the Cole et al. article is too encompassing. It is important to differentiate emotion regulation from the effects of emotions on others and to differentiate among (a) regulation that stems from individuals external to the child versus behavior that is accomplished by the child, (b) behavior that is goal oriented versus unintentional, and (c) regulation that is voluntary versus behavior that is less voluntarily controlled. An alternate definition of emotion-related self-regulation is provided.

Cole, Martin, and Dennis (this issue) touched on many interesting and important issues in their provocative and well-argued article, some conceptual and some methodological. Our comments pertain primarily to conceptual issues. The points that we argue in this commentary mostly reflect our view that Cole et al.'s definition of emotion regulation is too encompassing and that greater conceptual differentiation will foster both our understanding of emotion-related regulation and the communication of relevant findings and their conceptual significance.

As defined by Cole et al. (this issue):

Emotion regulation refers to changes associated with activated emotions. These include changes in the emotion itself (e.g., changes in intensity, duration; Thompson, 1994) or in other psychological processes (e.g., memory, social interaction). . . . The term emotion regulation can denote two types of regulatory phenomena: emotion as regulating and emotion as regulated. . . . Emotion as regulating refers to changes that appear to result from the activated emotion. . . . Emotion as regulated refers to changes in the activated emotion. These include changes in emotion valence, intensity, or time course (Thompson, 1990, 1994) and may occur within the individual (e.g., reducing stress through self-soothing) or between individuals (e.g., a child makes an unhappy parent smile). (p. 317–333)

We thoroughly agree that all of the processes involved in Cole et al.'s definition of emotion regulation are critical to the study of emotion and relevant to an understanding of emotion regulation. However, we believe that their definition is too broad and that it is heuristically useful to differentiate emotion regulation from other related processes.

Consider the following example. A 16-month-old girl's mother leaves the room. The toddler cries, cannot divert her attention from the door, and moves slightly toward the door. She softly cries in a pitiful manner throughout the time her mother is gone until a stranger enters the room and holds and soothes the child. Then the girl stops crying but continues to whimper and still has her eyes glued to the door. Because the toddler's crying is so pitiful, it affected the stranger's mood and motivated the stranger's efforts to soothe the child.

According to Cole et al.'s (this issue) definition, there is a lot of emotion regulation occurring in this sequence of events. The toddler's upset affects her own behavior (e.g., staring at the door rather than engaging in other activities) and the stranger's mood and attempts to soothe her. The toddler's movement toward the door and perhaps even her continued crying (i.e., the behavior, as differentiated from the experience of upset or sadness) also would be viewed as aspects of emotion regulation because they are “changes that appear to result from the activated emotion.”

Contrast this child with a boy who, in the same situation, cries angrily and approaches the door and tries to get it open to pursue his mother. When the
stranger enters, he screams even more angrily and tries to get her to retrieve his mother. The stranger gets so concerned by his anger that he calls the mother back to the room. In this situation, the boy purposefully attempted to recall his mother by screaming and tried to get the stranger to assist in obtaining this goal by using his anger to mobilize the stranger’s behavior.

In our view, it is important to differentiate emotion as a regulator of change from attempts to regulate emotion. It is also useful to differentiate among (a) regulation that stems from actors external to the child and regulation that is initiated and or mostly accomplished by the child, (b) regulation-relevant behavior based on goals versus behavior that is unintentional; and (c) regulation that is voluntary versus other behavior that is less voluntarily controlled. In thinking about these distinctions, we believe the notions of rudimentary intention and goals are critical. Although achieving goals was not a part of Cole et al.’s (this issue) definition of emotion, the authors did discuss the importance of goals. For example, the closing sentence of their article was: “Ultimately, it is not the mere fact that humans are capable of emotion but how emotions are harnessed in the service of goals that will enlighten our understanding of developmental pathways” (p. 317–333).

Emotion as a Regulator Versus the Target of Regulation

In regard to the first point, although it is true that emotion organizes and affects one’s own and others’ behavior, and may even regulate such behavior, behavior that simply stems from emotional experience is different (at least at a conceptual level) from attempts to modulate emotion and emotion-related behavior based on an attempt to achieve goals. Moreover, labeling emotion as a regulator and emotion as regulating as part of the same construct results in a construct that is so broad that its usefulness is reduced. For example, in the scenarios for the girl and boy presented previously, nearly all behavior—crying, looking at the door, approaching the door, the stranger feeling emotion and soothing the child or recalling the mother—can be considered emotion regulation. Moreover, with such a definition, all effects of a person expressing emotion on others or the environment, even those they are totally unaware of or that occur far in the future, are emotion regulation. Thus, if a girl is angry at her mother and tries not to show it, and unknown to the girl her mother views this anger and gets angry in return and even hits another sibling, the girl’s anger, which she tried to hide, is viewed as emotion regulation because it affected the mother’s emotion and behavior. Although we agree that the girl’s anger affected the mother’s behavior, given the girl’s intent was to hide the anger and the consequences were unintended, we are reluctant to label the girl’s behavior as emotion regulation. Furthermore, in social interactions, much of what occurs is due either to the actors’ emotions and their consequences in that situation (especially when emotion is as broadly defined as in recent definitions and by Cole et al., this issue) or to attempts to regulate one’s own or the other’s emotions and emotion-related behavior. Therefore, most social interactions might be labeled as reflecting emotion regulation.

Thus, if the definition of emotion regulation includes all the effects of one person’s emotions on others, it is very difficult to differentiate emotion regulation from many aspects of the social interaction or for researchers to code it in a meaningful way. Moreover, given the many unintentional and broad effects of an individual’s expression of emotion, it seems important to differentiate between effects of emotional expression that are tied to the expressor’s goals or attempts to adapt (physiologically or socially) and those that are not. Granted, in some situations the effects of emotion may be difficult to distinguish from attempts to regulate emotion. Nonetheless, we believe that the effects of emotion, unless they are used as a means to regulate emotion or emotion-related behavior (e.g., behavioral expressions of emotion or attempts to change the emotion-elicitng context), should be labeled something besides emotion regulation. We suggest that the term emotion regulation be confined to Cole et al.’s (this issue) notion of emotion as regulated, broadly defined.

Self-Regulation Versus Externally Imposed Regulation

As Cole et al. (this issue) discussed, children’s regulation of emotion often is accomplished through the efforts of other people rather than the child, especially at a young age (see also Eisenberg & Morris, 2002; Kopp & Neufeld, 2003; Walden & Smith, 1997). With age, children become increasingly able to participate in the process of managing emotions and their expression. We agree that both processes are part of the larger process of regulating emotion, broadly defined, although the difference between the two is fundamental for an understanding of the growth of self-regulation. In our view, it would be heuristically useful to label these processes differ-
ently, for example, as emotion-related self-regulation (for regulation involving primarily intraorganismic processes and behavior) and external emotion regulation (for regulation mostly implemented by an external agent). Whichever terms are chosen is less important than the recognition of the fundamental difference between being able to regulate emotion oneself and modulating emotion primarily through the efforts of others. In many cases, external emotion regulation is not sought or intended by the child and is not elicited by the child in an attempt to adapt or to achieve a goal. In those instances when the child (or adult) seeks external intervention, the process of emotion regulation could be viewed as involving both external regulation and self-regulation.

**Goal-Oriented Versus Unintentional Behavior**

The notion of intent or goals is fundamental to some distinctions we wish to make. First, although we will not pursue this point in depth, it probably would be useful to consider intentions and goals when examining the diverse effects of emotions. As already noted, because many consequences of emotions are totally unintended and are unknown to the person expressing the emotion, we hesitate to use the word regulation to refer to all consequences of emotion.

Now, consider our scenarios about the two toddlers, and let us confine ourselves from this point onward to the notion of emotion regulation as pertaining to the regulation of emotion (and related behavior) rather than emotion as a regulator. In the first scenario, the girl cried pitifully and was drawn to the door, yet she did not try to open it. The situation appeared to elicit a sad and distressed reaction from her, and her attention was riveted to the door. However, there was no evidence that her emotion was intended to evoke a response from others that would reduce her distress (e.g., it was too soft to be heard by mother outside of the room), nor is there reason to believe that her attention to the door was in some way a part of a pattern of behavior with a goal of bringing mother back (because she did not try to open the door). Her reactions seemed to be merely evoked by the situation, and she did little that could be considered goal-oriented behavior rather than part of a distress reaction. Similarly, if a child freezes up when the mother leaves the room or in response to a novel stimulus, this behavior may merely be a biologically based (i.e., temperamental) response to the stimulus or to the novelty of being left alone and not a response in service of a specific goal in that context (such as bringing the mother back or avoiding the tear-inducing toy).

In contrast, the boy's anger, although it was evoked by the situation, also seemed to be expressed with the goal of bringing his mother back. He approached the door and tried to open it, screamed so loudly that his mother might hear him, and communicated to the stranger his desire for her to assist in finding his mother. Thus, the boy appeared to enact behaviors that were oriented toward the goal of retrieving his mother and thereby reducing his distress. Although it is difficult to ascertain goals and motivations in such situations, we would argue that, for the most part, the girl's behavior was due to the effects of her emotion whereas the boy's behavior was due to both the effects of his emotion and his attempts to modify the situation in a manner that would change or regulate his emotion.

Thus, similar behaviors can, in one situation, be merely behavior that is part of the expression and experience of emotion whereas, in another situation, the behavior can involve more explicit emotion regulation, depending on the individual's intent or goals when enacting the behavior. If a child in the same situation described earlier (mother leaving) clearly was upset but then self-soothed or tried to engage in play with a distracting toy, we would be on even firmer ground in concluding that emotion regulation had occurred than in our example of the boy who was angered. However, if a child played with a toy when his or her mother left, such behavior is not emotion regulation (through distraction) if the child was not upset in the first place. Thus, many behaviors coded as markers of emotion regulation may not serve that purpose if the child is not actually emotionally aroused (or motivated to heighten emotional arousal).

As discussed by Cole et al. (this issue), in some studies of early emotion regulation, many reactions displayed by infants or toddlers in an evocative context are considered instances of emotion regulation (e.g., playing with another toy, interacting with an adult, self-soothing, continuing to attend to the upsetting object). We agree with Cole et al. (and others) that the success of the behavior is not the defining feature of attempts at emotion regulation and that some forms of regulation may even be maladaptive in either the short or long term. However, some behaviors that are coded likely are simply expressions of the emotion or behaviors that are linked to the emotion and do not involve an intent to change the emotional state, the behavior associated with it, or the situation causing the emotion. For example, the child who continues to stare at a forbidden toy may simply be drawn to it and be unable to divert his or her attention. Is such behavior emotion
regulation or the consequence of desire and the inability to modulate either the emotion or related atten
tional behavior? If the toy is obstructed by a barrier, the continued attention might be a means to
find a way to obtain the toy, in which case such behavior might be considered an attempt at emotion
regulation. However, if staring at the toy does not serve the goal of obtaining the toy or reducing
emotion, we would argue that the behavior is not emotion regulation. In brief, we are arguing that goal
orientation and intent should be a part of the definition of emotion self-regulation and that not all re-
actions in emotional situations should be considered as types of emotion regulation. We understand that
emotions are viewed as linked to basic goals, but often the expression of emotion does not serve any
clear goal.

Effortful Versus Reactive Control: Their Role in
Emotion Regulation

In the remainder of this commentary, we discuss the distinction between voluntary and less voluntary
control and the importance of this distinction for the construct of emotion-related self-regulation. How-
ever, before going into this issue in depth, we want to note that our view of emotion regulation may be
broader than that of Cole et al. (this issue) in their discussion of emotion as regulated (rather than emotion
as a regulator). We include in the notion of emotion self-regulation (or what Cole et al. discussed as
the "emotion as regulated") not only the modulation of the experience of emotion and related
physiological states but also the regulation of overt behaviors that are associated with the experience of
emotion (e.g., facial expressions of emotion, reactive aggression) and behaviors that are intended to
modulate emotion through affecting the social context. We were unclear if Cole et al. would include
such behavior under the rubric of "changes in activated emotion," although they most likely would
consider it emotion regulation given that such behavior is a consequence of emotion (i.e., would be
included in the "changes associated with activated emotion" that we have argued should be a separate
construct). Because of the heuristic advantages of differentiating the regulation of internal emotion-
related processes from external behaviors associated with emotion, we sometimes have labeled these
processes emotion regulation and emotion-related behavioral regulation, respectively. We acknowledge
that these two processes are intricately related and sometimes impossible to differentiate (at a concep-
tual or empirical level); thus, we make this dis-
tinction purely because of its heuristic value when thinking about and measuring various aspects of
emotion regulation.

Recently we argued that emotion (self-) regulation involves voluntary or effortful responding. This does
not mean that regulation involves a highly conscious intention to change emotion or behavior; it means
that the cognitions, attention, or behavior involved are voluntarily controlled by the individual and are
not merely automatic or reflexive. Consider the construct of control, often defined in the dictionary
as inhibition. Behavior can be inhibited voluntary or it can be inhibited because of processes over which
the individual has little control, as with the highly inhibited children discussed by Cole et al. (this issue)
who seem to have difficulty modulating their inhibition to novel (and perhaps frightening) stimuli
and situations (see also Nigg, 2000). Similarly, behavior can be voluntarily activated and used to
achieve goals or it can be pulled in a less voluntary manner. For example, impulsive people may be
pulled toward rewarding or positive situations with little ability to inhibit themselves. This notion of
voluntary control is part of Rothbart's concept of effortful control (a major dimension of tempera-
ment), which is defined as "the ability to inhibit a dominant response to perform a subdominant re-
sponse" (Rothbart & Bates, 1998, p. 137) or "effi-
ciency of executive attention, including the ability to
inhibit a dominant response and/or to activate a
subdominant response, to plan, and to detect errors"
(M. K. Rothbart, personal communication, January
26, 2002). Effortful control is reflected in effortful
attentional regulation—the abilities to voluntarily
focus or shift attention as needed in a given situa-
tion—as well as in inhibitory and activational con-
trol—the abilities to effortfully inhibit behavior or
activate behavior as needed, even if the person does
not really desire to do it (e.g., when children must
comply with a command or do a task they do not
want to do). Effortful control is believed to involve
executive functioning in the prefrontal cortex
(Mirsky, 1996) and the anterior cingulate gyrus in the
paleocortex, which appears to be directly related to
awareness of one's planned behavior, correction of
errors, and the control of thoughts and feelings (e.g.,
Posner & DiGirolamo, 2000; Posner & Rothbart,
1998). Although effortful control improves dramati-
cally with age (Diamond, 1990; Kochanska, Murray,
& Harlan, 2000; Posner & Rothbart, 1998), rudimen-
tary aspects of it emerge even in the first year or two
of life.

The biological or temperamental systems related
to less voluntary approach or inhibition have some-
times been labeled as reactive systems (Derryberry & Rothbart, 1997). They include impulsivity and sur- 
gent approach behavior (perhaps based on reward 
dominance; Gray, 1987) or, at the other extreme, very 
low impulsivity and high inhibition. Pickering and 
Gray (1999) and others (Cacioppo, Gardner, & 
Berntson, 1999) have argued that approach–avoidance 
motivational systems related to impulsive (un- 
dercontrolled) and overly inhibited behaviors are 
associated with subcortical systems such as Gray’s 
Behavioral Inhibition System (BIS; which is activated 
in situations involving novelty and stimuli signaling 
punishment or frustrative nonreward) and Gray’s 
Behavioral Activation System (BAS; which involves 
sensitivity to cues of reward or cessation of punish- 
ment). Moreover, these systems appear to be associ- 
ated with biases in people’s attention, for example, 
if they are more likely or quicker to attend to threat- 
ening stimuli (Derryberry & Reed, 2002). Although 
some investigators (Fowles, 1987; Patterson & New- 
man, 1993) have proposed variations of Gray’s sys-
tems, the notion of separate (albeit related) social 
withdrawal and social facilitation (or approach) 
systems appears to be well accepted.

The critical point here is that approach and inhibi-
tion processes, as well as attentional processes, 
may be due to more voluntary, higher level effortful 
control processes or to less voluntary, more auto-
matic processes. Initial research suggests that these 
two types of processes tend to load on different 
later constructs, can be differentiated with factor 
analyses (see Kindlon, Mezzacappa, & Earls, 1995; 
Olson, Schilling, & Bates, 1999), may be associated 
with different aspects of autonomic nervous system 
responding (Mezzacappa, Kindlon, Saul, & Earls, 
1998; see Eisenberg, 2002), and provide some unique 
prediction of adjustment and social competence (e.g., 
Cumberland, Eisenberg, & Reiser, 2004; Eisenberg 
et al., in press; Eisenberg et al., 2003). We (Eisenberg, 
2002) have argued that the construct of emotion 
regulation should be applied only when the relevant 
internal processes (e.g., allocation of attention) or 
volt behaviors are effortfully controlled. When re- 
active processes are involved, the behavior is pulled 
by the situation and is not, we suggest, an attempt to 
modulate the situation. This distinction is similar to 
that made by Compa, Connor, Saltzman, Thomsen, 
and Wadsworth (2001), who defined coping as “con- 
scious volitional efforts to regulate emotion, 
cognition, behavior, physiology, and the environ- 
ment in response to stressful events or circum- 
cstances” (p. 89); however, we view self-regulation 
as volitional but not necessarily very conscious. 
Because effortful control increases with age (see
Eisenberg & Morris, 2002; Posner & Rothbart, 1998), 
we expect it to play an increasing role in children’s 
functioning with age and to increasingly modulate 
the overt expression of experienced reactive pro-
cesses and urges. Some initial findings (Eisenberg 
et al., 2004; Valiente et al., 2003), albeit not all 
(Eisenberg et al., 2003), support this hypothesis.

Another Working Definition

Before providing a working definition of emotion 
self-regulation, we need clarify that we believe that 
equating regulation with change in an ongoing pro-
cess or behavior is too narrow a definition. For ex-
ample, antecedent emotion regulation (Gross, 1999) 
or proactive coping (Aspinwall & Taylor, 1997) fre-
quently involves a priori preventing the occurrence 
of a situation (i.e., preventing change) or preventing 
certain types of cognitions if doing so avoids an 
emotion-eliciting event. For instance, a shy person 
can avoid attending a large party or any new anxiety-
 or fear-provoking activity to regulate his or her 
emotion. Thus, emotion self-regulation can occur by 
preventing the occurrence of an emotion as well as 
by creating circumstances that foster a different (of-
ten, but not always, more positive) emotional ex-
sperience. Moreover, as is recognized by Cole et al. 
(this issue), although most researchers have studied 
 attempts to reduce negative emotions, emotion regu-
lation also can involve heightening of both positive 
and negative emotions.

Thus, based on the considerations we have dis-
cussed and the ideas of others (e.g., Cole, Michel, 
& Tett, 1994; Kopp & Neufeld, 2003; Thompson, 
1994), we define emotion-related self-regulation as the 
process of initiating, avoiding, inhibiting, maintain-
ing, or modulating the occurrence, form, intensity, or 
duration of internal feeling states, emotion-related 
physiological, attentional processes, motivational 
states, and/or the behavioral concomitants of emo-
tion in the service of accomplishing affect-related 
bio-behavioral or social adaptation or achieving indi-
vidual goals. This definition is a work in progress, but 
we hope it will stimulate further conceptual refine-
ments.

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Disambiguating the Components of Emotion Regulation

H. H. Goldsmith and Richard J. Davidson

Affective neuroscience and cognitive science approaches are useful for understanding the components of emotion regulation; several examples from current research are provided. Individual differences in emotion regulation and a focus on the context of emotion experience and expression provide additional tools to study emotion regulation, and its development, from a biobehavioral perspective.

As a point of departure, we provisionally accept the definition of emotion offered in the lead article by Cole, Martin, and Dennis (this issue). We suggest that emotion regulation (ER) can be approached profitably from three complementary perspectives, which are compatible with many of Cole et al.’s points. First, we acknowledge that ER is a difficult topic because it taps into one of the enduring problems in developmental psychology: the conceptualization and measurement of change. Regulation implies change, and in this domain the change is likely to be dynamic and dependent on complex processes. We also note the conceptual and methodological conundrum of separating emotion from ER processes. Emotion processes and ER processes overlap temporally, which presents challenges for studying ER and might even lead some to question whether they are separable. However, we believe that the distinction between emotion and ER, even if it artificially divides processes that lie along a continuum, is heuristicly useful and might require developmental psychologists to augment their typical methods. The three perspectives that we wish to highlight are the affective neuroscience approach, the cognitive science perspective, and the interplay of individual differences and context.

Endophenotypes From Affective Neuroscience

Fully distinguishing emotion from ER with behavioral methodology alone might border on the impossible, which is a stronger assertion than Cole et al.’s (this issue) call for multiple, converging measures to predict the organization of ER. We think that the evidence for neural substrates of ER is stronger than Cole et al. mentioned, but the relevant human evidence is mostly recent and from adults. The evidence from rodents and nonhuman primates is more substantial although harder to assimilate to the child development literature.

Investigation of genetic factors is a salient issue when endophenotypes are implicated. Despite assumptions in the literature that the roots of ER lie only in learning, Goldsmith and colleagues have demonstrated that ER is a partially heritable characteristic. Using samples of young twins, Goldsmith, Buss, and Lemery (1997) demonstrated, and later replicated (Goldsmith, Lemery, & Essex, in press), that identical twins were more similar than fraternal twins on parentally reported ER measures. These ER reports have antecedents in earlier temperament and later correlates in symptoms similar to attention deficit hyperactivity disorder (Nigg, Goldsmith, & Sachek, 2004).

Especially in the fear, anxiety, internalizing domain, multiple endophenotypes of emotion can be viewed as intermediate between the levels of the gene and the behavior. These endophenotypes can be viewed as reflecting either the “regulated” or the “regulatory” aspect of emotion (in the terminology of Cole et al., this issue), and still other endophenotypic measures might reflect the product of reactive and regulatory processes. Some of these endophenotypes can be measured on a second-by-second basis (e.g., electrophysiological response, response to startling probes, cardiovascular measures), and others summarize changes occurring over longer intervals (e.g., fMRI measures of neural activation, cortisol reactivity). With the caveat that a modern neuroscience approach to ER is in its early stages (Davidson, Jackson, & Kalin, 2000; Ochsner, Bunge, 2004 by the Society for Research in Child Development, Inc. All rights reserved. 0009-3920/2004/7502-0007
Gross, & Gabrieli, 2002; Schaefer et al., 2002), we mention some examples of this approach from our own research.

It is first important to distinguish between voluntary and automatic ER (Davidson, Jackson, et al., 2000). Many regulatory processes are presumably invoked automatically as soon as emotion itself is elicited (or even before a punctate emotion is elicited). Other regulatory processes are more voluntary. Davidson and his colleagues have developed experimental paradigms to probe both voluntary and automatic ER. For example, Jackson, Malmstadt, Larson, and Davidson (2000) instructed participants to voluntarily enhance, suppress, or maintain the emotion they were experiencing in response to unpleasant and neutral pictures and found that when participants were voluntarily suppressing their emotion, there was a reliable diminution in the magnitude of eyeblink startle to an acoustic probe delivered after the instruction was presented.

Using a variant of this paradigm in the MRI scanner, Davidson and colleagues demonstrated that reliable changes in amygdala activation occur in response to instructions to voluntarily regulate emotion (Schaefer et al., 2002). Ochsner et al. (2002) also used a variant of this voluntary ER paradigm and replicated the amygdala findings, finding that activation in the ventral prefrontal region varied inversely with activation in the amygdala.

**Chronometric Approaches Inspired by Cognitive Science**

Investigation of ER within contemporary affective science can benefit from cognitive science methods. For example, chronometric paradigms can distinguish between inhibition and decay in memory processes and language comprehension. Because parallel issues exist for ER (e.g., does fear decrease because it is dampened by regulatory processes or does it simply decay in strength without regulatory processes being invoked?), we need similar chronometric paradigms in the emotion field. If our interests were in the comprehension of emotion, the differential reaction-time measures of cognitive psychology would be applicable for studying processes that inhibit the activation of emotion concepts (Gernsbacher, Goldsmith, & Robertson, 1992). However, developmental psychologists' more central interests lie in the experience and expression of emotion. That is, how do the experience and expression of emotion diminish? Does dampening of, say, the experience of fear always reflect ER processes, or can fear simply decay? Such questions require chronometric approaches, with measures other than reaction time. As Cole et al. (this issue) and others (Gross, 2001) emphasize, the temporal patterning of emotion behaviors, affective endophenotypes, and regulatory behaviors is crucial. Our earlier study (Buss & Goldsmith, 1998), which was reviewed by Cole et al., used a temporal analysis of behavioral contingencies, but we now believe that such analyses should be even more fine-grained and should interrogate the biological processes involved.

Among other salient questions about ER that can be approached from a cognitive science perspective are these:

1. Are ER processes continuous or punctuated?
2. Are ER processes anticipatory or reactive?
3. Do different ER strategies compete?
4. Does ER involve automatic or conscious, voluntary, or strategic processing (as mentioned earlier)?

The general answers to these questions are probably both, both, yes, and both. Thus, the questions are more usefully framed about specific ER processes, such as, "Is the dampening of negative affect after the introduction of a strange person into the social context automatic or strategic?" The questions are also more usefully framed from a developmental perspective, such as, "Can voluntary ER processes become relatively automatic as a child matures and gains experience with the relevant incentive contexts?" This question about automatic versus strategic inhibitory processes has been approached empirically in cognitive psychology using proportionality manipulations and dual-task procedures with adult participants. The field has not extended such techniques to the affective domain or to children on a large scale.

However, we have begun to approach this issue in studies with adults. For example, Jackson et al. (2003) developed a paradigm to study automatic ER by examining the chronometry of affective reactivity. This was operationalized as the rapidity of recovery of startle magnitude following the offset of a negative emotion elicitor. We felt comfortable classifying the recovery following a negative event as a component of regulation rather than natural decay because studies with animals reveal that lesions to particular territories of prefrontal cortex (PFC) result in a prolongation of negative reactivity in certain paradigms (see Davidson, Jackson, et al., 2000, for review). This implies that there is a descending regulatory signal from PFC to certain limbic structures, particularly the amygdala, that attenuate or regulate responsivity. Jackson et al. found large
individual differences in recovery speed; measures of prefrontal activation asymmetry obtained prior to the startle experiment predicted this recovery speed. Increased left prefrontal activation predicted more rapid recovery of startle magnitude. This effect was demonstrated following the removal of variance associated with startle magnitude during the stimulus itself, thus operationally disentangling the impact of emotion from the presumed regulatory component (in this case, the poststimulus offset recovery). These examples illustrate the potential of chronometric approaches to elucidate the components of ER when coupled with biological measures.

**Individual Differences and Context**

Individual differences in ER are salient and significant. The typical individual differences questions about ER—concerning its structure or organization, its biological substrates, its stability and consistency, its antecedents in experience, and its adaptive function—all require more investigation, although our knowledge is accumulating at an accelerating pace (see Kopp & Neufield, 2003, for a developmentally oriented review). We think that these individual differences interact strongly with context to affect behavior.

Cole et al. (this issue) emphasized the need to study contrasting conditions as an aid to inferring ER, and they provided various examples of successful use of that strategy. Of course, contrasting conditions vary the context; thus, we strongly agree with Cole et al. However, we wish to highlight the interplay of individual differences in ER with the situational context of emotion and to do so in ways that incorporate endophenotypes from affective neuroscience. The boundary between typical and disordered, the nature of ER, and the importance of context in determining the significance of affective responding are three highly interrelated issues. Dysfunction in ER can be conceptualized as expression of emotion outside its typical incentive contexts. To the extent that typical incentive contexts can be specified, varying incentives can be a powerful method for studying ER, especially when combined with endophenotypic measures (Kalin & Shelton, 2000). Concretely, this perspective claims that high fear under threatening incentives has a different meaning, and thus has different correlates, than high fear in nonthreatening contexts. The same claim would hold for other emotions and their typical contexts.

We recently demonstrated that parentally reported out-of-context fear in 540 young children was a better predictor of later internalizing symptoms than was the strength of in-context (i.e., temperamental) fearful reactions (Lemery & Goldsmith, 2003). Other recent research from our laboratory concerning the frequencies and correlates of out-of-context fearful reactions is based on second-by-second coding of videotaped reactions of infants (Locke & Goldsmith, 2003). Depending on the exact criteria used, 5% to 15% of infants showed consistent negative affect in two highly standardized contexts that typically elicit pleasure. The patterns of correlates in other behavior for out-of-context anger and out-of-context fear differed, suggesting that ER processes may differ according to discrete affect categories.

An affective neuroscience approach to the study of context is now feasible. Ample evidence suggests that contextual processing depends on specific neural substrates, particularly in the PFC and hippocampus (see Davidson, Pizzagalli, Nitschke, & Kalin, 2003, for review). For example, studies of rodents implicate the hippocampus in contextual fear conditioning. Lesions of the hippocampus abolish contextual fear conditioning while preserving fear cue conditioning. The hippocampus and PFC are the brain regions exhibiting the highest densities of glucocorticoid (GC) receptors (see Davidson et al., 2003, for review). Chronic exposure to stressful life events that results in elevated cortisol may, over time, result in neurotoxicity in the regions with high densities of GC receptors (Sapolsky, 2000). This process would impair functional activity in these regions, including emotion-relevant contextual processing. Future developmental work on this topic should include behavioral measures of context-appropriate and context-inappropriate emotional behavior; measures of hypothalamic-pituitary-adrenocortical (HPA) function, particularly cortisol; and morphometric or functional measures of PFC and hippocampus. Because the PFC in particular is late to mature and does not reach its adult functional status until at least puberty, developmental changes in particular regions of PFC may play an important role in developmental changes in context-dependent emotional responses. In developmental studies in rhesus monkeys, Kalin, Shelton, and Takahashi (1991) found systematic changes in context-sensitive affective reactions to standardized emotion elicitors. Although that study did not simultaneously track changes in PFC function, such studies are now possible using noninvasive imaging methods.

The PFC also plays an important role in modulating activation in the amygdala (Davidson, Putnam, & Larson, 2000). Some aspects of behavioral inhibition may be conceptualized as reflecting difficulty in the
regulation of negative affect and anxiety. The under-regulation of negative affect may be reflected in accentuated activation of the amygdala in response to unfamiliar stimuli. In a recent report, Schwartz, Wright, Shin, Kagan, and Rauch (2003) studied a group of individuals in their 20s who had been classified as behaviorally inhibited or uninhibited when they were toddlers. They found significantly greater activation of the amygdala in response to unfamiliar faces in participants previously classified as inhibited compared with those previously classified as uninhibited. These examples illustrate the potential utility of applying concepts and methods from the emerging area of affective neuroscience to the study of developmental issues in ER.

Critical Considerations to Advance the Study of ER

In concluding, we offer three questions and observations—ones consistent with the suggestions of Cole et al. (this issue)—that developmental researchers who wish to study ER might take into consideration in the design of studies and interpretation of results.

First, can ER accounts be empirically confirmed against plausible alternative accounts for the same behavioral phenomena? For example, an alternative to an ER explanation might be a multiple-activation account, in which different emotion systems with mutually inhibitory influences might be activated in close temporal proximity under the influence of complex incentive stimuli. More generally, hypotheses about ER should be posed so that the presence of ER is not the only plausible outcome of studies. Thoroughly testing such hypotheses is likely to require endophenotypes from affective neuroscience.

Second, and more generally, developmental research on ER must make use of modern concepts from affective and cognitive neuroscience to dissect the subcomponents of emotion and ER in a way that honors the distinctions made by the brain. Theoretical accounts of ER must be consistent with known biological constraints. Combining psychophysiological, neuroendocrine, and neuroimaging methods promises to yield considerable new information on this important topic.

Finally, a truly developmental approach to ER should eventually explain why affective states are apparently so labile during childhood and so resistant to modification during some psychopathological states. This may well be related to developmental changes in neural circuitry underlying ER.

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