CHAPTER 22

Attentional Control and Emotion Regulation in Early Development

Martha Ann Bell and Susan D. Calkins

The construct of self-regulation has been used to describe the variation in how children adapt to their environments. Fundamental to individual differences in behavioral adjustment and development in general, self-regulatory processes can be examined at different levels and have many different definitions (Bell & Deater-Deckard, 2007). We view self-regulation as a system of adaptive control that can be observed at the level of physiological, attentional, emotional, behavioral, and cognitive processes (Calkins & Fox, 2002). In this chapter we focus specifically on the attentional, emotional, and physiological regulatory processes of infancy and early childhood. We begin with brief descriptions of the development of each of these three regulatory processes. Then we describe some of our own research on individual differences in attentional processing and self-regulation, including processes associated with the risk for early developing problem behaviors. We end with a note about the challenges of studying early regulatory processes.

Development of Attentional Regulatory Behaviors

We consider temperament-based attentional control to be associated with the executive attention system as critical for development of self-regulation (Posner & Rothbart, 2000). Temperament is generally considered to be biologically based differences in emotional reactivity among individuals and the emergence of regulation of that reactivity beginning late in the first year of life (Rothbart & Bates, 2006). There is evidence that early regulation of temperamental distress may be facilitated by the development of the executive attention system and resultant improvements in attentional control (Ruff & Rothbart,
1996). Children who are emotionally or behaviorally reactive, such as children who are behaviorally inhibited or aggressive, may have a delay or impairment in this development (Calkins & Fox, 2002).

The basic brain architecture of the executive attention system may be in place in early infancy (Gao et al., 2009); one of the earliest measures of this architecture occurs during error detection at 7 months (Berger, Tzur, & Posner, 2006). Much of the developmental literature, however, focuses on fundamental changes in the executive attention system around 10 months of age (Ruff & Rothbart, 1996). This is also the same time frame for initial developmental changes in emotion control or regulation strategies (e.g., self-comforting or self-distraction; Calkins, Dedmon, Gill, Lomax, & Johnson, 2002). This close temporal association is likely why the proposal that attentional control may be associated with emotion regulation is so prominent in the developmental literature. After initial developmental change around 10 months, attentional control then increases rapidly during the toddler and preschool years and is the basis of the temperament construct that Rothbart calls effortful control (Posner & Rothbart, 2000). Effortful control refers to the child's volitional use of executive attentional abilities that include inhibitory control, detection of errors, and planfulness. For example, effortful control is involved when a child must wait before touching an attractive toy. As such, effortful control reflects the influence of temperament on behavior. There appears to be much improvement in effortful control of behavior between 3 and 4 years of age, with continued improvements through age 7 (Rueda, Posner, & Rothbart, 2004). At the same time, stable individual differences emerge. For instance, by middle childhood, it is possible to predict a quarter of the variance in attentional regulation from prior attentional regulation, even when the data are based on different observers at each assessment (Deater-Deckard, Petrill, & Thompson, 2006). Because of its stability and its involvement in the selection, coordination, and storage of information, attentional control may play a prominent role in the development of a broad range of behaviors, including a number of psychopathologies (Posner & Rothbart, 2000).

**Development of Emotion Regulatory Behaviors**

The regulation of emotion is considered to be strongly associated with attentional control and includes the behaviors, skills, and strategies, whether conscious or unconscious, automatic or effortful, that serve to modulate, inhibit, and enhance emotional experiences and expressions (Calkins, 2004; Thompson, Lewis, & Calkins, 2008). The construct of effortful control, noted above, represents a behavioral system that emerges in the second year and allocates resources for the voluntary control of arousal and emotion. Rothbart suggests that the development of executive attention might underlie the effortful control or regulation of emotion. This notion is based on the finding that children who show more effortful control also tend to show less anger, fear, and discomfort (Rothbart, Ellis, & Posner, 2004).

Emotion regulation, just like attentional control, displays dramatic developments during infancy and early childhood (Calkins, 2004; Kopp & Neufeld, 2003). Developmental changes in emotion regulation are demonstrated as the infant develops from needing almost total dependence on caregivers for regulation of emotional states to acquiring independent ability to self-regulate emotions. Thus, early emotion regulation is influenced
mainly by innate physiological mechanisms (Kopp, 2002). Beginning around 3 months of age, some voluntary control of arousal is evident, with more purposeful control evident by 12 months, when developing motor and communication skills allow for deliberate interactions with caregivers. During the second year, toddlers begin to develop greater language skills and better impulse control, thus promoting the transition from passive to active methods of emotion regulation (Calkins, 2004). Kopp (1989) considers emotion self-control to emerge fully between 3 and 4 years of age. Rothbart and colleagues (2004) have suggested that the changes in self-control occurring between ages 3 and 4 years are related to the executive attention system. Attentional and emotional control processes both involve physiological regulation.

Physiological Regulation

Cardiac measures allow physiological assessment of attentional control via the parasympathetic and sympathetic branches of the autonomic nervous system. The parasympathetic branch is critical to attentional regulation (Porges, 1991) via distinct patterns of cardiac activity. Attending to a nonstartling stimulus typically results in a decrease in heart rate (the orienting reflex), whereas heart rate usually increases during a stressor, such as a challenging mental task. Likewise, changes in the variability of the heart rate are associated with sustained attention as well as effortful cognitive processing (Reynolds & Richards, 2008).

According to Porges's polyvagal theory (1991), vagal tone is an aspect of parasympathetic control that can be used as an index of physiological self-regulation associated with attention. Vagal tone can be quantified in different ways, and we consider two of those here: as the standard deviation of heart rate (heart rate variability, HRV) or as Porges's specific measure of vagal efferents from the nucleus ambiguus in the medulla, measured as the variability in heart rate that occurs at the frequency of spontaneous respiration (respiratory sinus arrhythmia, RSA). The vagus nerve to the heart from the nucleus ambiguus serves an inhibitory function of slowing heart rate and modulating the effects on the heart of the sympathetic branch of the autonomic nervous system. When the environment places an external demand on the child's information-processing system, the vagal efferents quickly withdraw or suppress RSA (termed withdrawal of the "vagal brake" by Porges, 1995) and allow the sympathetic nervous system to increase heart rate, which is essential for cognitive or emotional responding (Bornstein & Suess, 2000). As such, RSA or HRV can be conceptualized as a measure of the efficiency of central and autonomic neural feedback mechanisms (Thayer & Lane, 2000). Indeed, higher resting baseline measures of RSA are associated with more efficient attentional processing (Suess, Porges, & Plude, 1994) and with more reactive emotional responding (Calkins, 1997).

Cardiac measures of autonomic nervous system activity during cognitive processing are widely used in developmental studies. Infants who exhibit decreases in RSA during stimulus presentation will habituate more quickly than infants who do not show decreases in vagal tone during information processing (Bornstein & Suess, 2000). Changes in heart rate from baseline to task are associated with better performance on attentional and memory tasks in both infants and young children (Bell, in press; Richards, 1987).
RSA has also been linked to emotional reactivity and regulation. Infants with higher RSA are more emotionally expressive and reactive (Calkins, 1997; Stifter & Corey, 2001). As emotion regulation abilities develop, the reactivity can lead to concentration when attention is critical to the situation or to more expressive reactivity when other circumstances take precedence (Porges, Doussard-Roosevelt, &Maiti, 1994). Thus, RSA or HRV may be associated with coping behaviors involving attentional control during both infancy and early childhood.

As noted at the beginning of this chapter, we consider attentional, emotional, and physiological regulation as part of a larger system of self-regulatory processes (Bell & Deater-Deckard, 2007; Calkins, 2010; Calkins & Fox, 2002). One must consider whether a conceptual framework involving attention, emotion, and physiology is critical, in contrast to a more parsimonious notion of global self-regulation. As previously noted, children demonstrate great improvement in their regulation of attention and emotion from infancy through early childhood. Furthermore, although individual differences are noticeable, these tend to become fairly stable by the end of early childhood (Calkins, Graziano, & Keane, 2007). Thus, it may be possible to describe children as generally well or poorly regulated. Although this approach to conceptualizing self-regulation may be useful, its value is largely descriptive. In our view, it is through the measurement of dynamic biobehavioral mechanisms that we will eventually identify precise mechanisms—mechanisms that probably differ in very important ways for different children, different outcomes, and at different points in development (Bell & Deater-Deckard, 2007; Thompson et al., 2008). We are attempting to identify those mechanisms in our individual research programs.

**Individual Differences in Information Processing and Self-Regulation**

Recently, we have shown associations between attentional processing measures of looking time, emotion regulation skills during distress, and physiological regulation (Diaz & Bell, 2011; Morasch & Bell, 2011). For example, 5-month-old infants who process information quickly (meaning, they require shorter looking time during familiarization of a stimulus, as opposed to longer looking time; Colombo, Mitchell, Coldren, & Freaseman, 1991), appear less distressed during the arm restraint task (Diaz & Bell, in press). Arm restraint is a classic lab procedure designed to induce negative affect; it involves the mother holding her infant’s arms down while the infant is seated facing her (Calkins et al., 2002). During arm restraint, the mother maintains a still face and is nonresponsive to her infant for a period of 2 minutes or until her infant exhibits 10 seconds of hard crying. We have found that the infants who process information quickly in an attentional task prior to the restraint task are more likely than infants who require longer processing time to employ a regulatory strategy where they focus on something other than the source of their distress (i.e., mother) during this arm restraint task.

But what happens to attentional behaviors and physiology as a result of distress? Do infants who have difficulty regulating their negative affect show a different pattern of pre- and postdistress attentional control than infants who appear to self-regulate more easily and exhibit low levels of negative affect after distress? To answer these questions,
we used two distress tasks with a group of 10-month-old infants: the toy removal task followed by the arm restraint task (Morasch & Bell, in press). The toy removal task involves mother and infant playing together with a colorful toy and then the mother holds the toy out of reach while being nonresponsive to the infant’s overtures for 2 minutes or until her infant exhibits 10 seconds of hard crying. Our goal was to stress the infants and then observe how their information-processing skills and attentional control (measured both behaviorally and electrophysiologically via heart rate and HRV) change from predistress to postdistress. The predistress task was the first half of a dynamic Sesame Street video clip, and the postdistress task was the second half of that video clip. We coded the amount of time infants looked at the predistress and postdistress videos, as well as measuring their heart rates and HRV during each video. We also coded the intensity of negative affect during the postdistress video to observe the results of the infants’ emotion regulation skills. Finally, we asked mothers to complete Rothbart’s Infant Behavior Questionnaire—Revised (IBQ-R; Gartstein & Rothbart, 2003) and calculated scores on the orienting/regulation factor, thought to reflect attention-mediated regulation.

We found that less negative affect (i.e., greater self-regulation) after the distress tasks was associated with increases in the amount of time spent looking at the video clip and decreased heart rate and decreased HRV during the postdistress phase. Task-related changes in physiology and visual attention, as well as parent-reported infant orienting/regulation, accounted for 50% of the variance in negative affect during the postdistress video (Morasch & Bell, 2011). Thus, the self-regulation of negative affect (i.e., emotion regulation) was a complex combination of attention-related behaviors and physiology for the infants in these two studies.

In the infant studies noted above, the predistress to postdistress changes in behavior and cardiac activity are examples of beginning self-regulatory skills. Findings for older children’s regulation during emotion-eliciting tasks are more complex. For example, 2- and 3-year-old children exhibited RSA suppression (relative to baseline RSA) during negative (attractive toy locked in clear box) as well as positive (peek-a-boo with a puppet) tasks. After controlling for baseline RSA, the differences between baseline and task RSA (i.e., RSA suppression) were distinguished by the valence of the task (Calkins, 1997). Specifically, orienting toward the puppet during the positive task may have been an effective strategy for increasing the likelihood of positive affect. This behavioral strategy was associated with RSA suppression. Different effects were seen with the negative task, in that orienting toward the forbidden toy was associated with less RSA suppression, whereas orienting toward the experimenter was associated with greater RSA suppression. Orienting to the forbidden toy appears to have been less adaptive, perhaps similar to ruminating, whereas orienting to the experimenter may have invoked a solution to obtaining the denied object (Calkins, 1997). Thus, the associations between physiological and behavioral regulation may reflect the child’s ability regarding attentional control associated with successful task completion.

The infants and young children noted above were from non-selected community samples. Thus, the variations in self-regulation associated with attentional control and emotion regulation can be considered to be those of normally developing infants employing typical variations in self-regulation strategies. However, we have reported that children selected for parent report of potential behavior problems exhibit poor self-regulatory behaviors.
Risk for Early Behavior Problems

The construct of self-regulation and its components of attentional control, emotion regulation, and physiological regulation have been examined extensively during early childhood (Calkins, 2010). As noted previously, self-control over the expression of negative emotion is critical for adaptive social functioning, and the lack of such skills may be a precursor to the development of psychopathology (Calkins & Keane, 2004). One of us (Calkins) has focused on a community sample of toddlers and preschoolers selected for having high, but nonclinical, scores, as well as children having low scores on the Child Behavior Checklist (CBCL) externalizing scale. This scale measures children’s acting-out behaviors, including aggressive and destructive behavior. Children scoring in the high range on the scale are at risk for more significant conduct problems as they grow older.

Our focus on the early childhood period and on children at borderline nonclinical risk for behavior problems has been motivated by the research literature noting considerable development in emotion regulation during this period and by the findings that behavior problems are becoming relatively stable during this time. Lack of behavioral and emotional regulation is thus considered a core deficit for young children with externalizing-spectrum behavior problems (Keenan & Shaw, 2003).

In our selected sample, there is a consistent pattern of findings from 2 to 5 years of age. At age 2, high-risk children and low-risk children do not differ in resting measures of heart rate (HR); however, children in the high-risk group display consistently lower RSA suppression (lower physiological regulation) during emotionally and behaviorally challenging situations than children in the low-risk group (Calkins & Dedmon, 2000). The high-risk children also display consistently more negative affect and dysregulated emotion regulation behaviors than low-risk children during fear, problem-solving, empathy, and frustration challenges. Furthermore, these patterns are stable from ages 2 to 4.5 years (Calkins & Keane, 2004). Perhaps more importantly, children who displayed a pattern of physiological regulation (i.e., stable and high RSA suppression) across a variety of challenges were less emotionally negative, had fewer behavior problems, and had better social skills than other children.

To this point we have focused on children who are at risk for behavior problems due to high ratings in externalizing behaviors during early childhood. We have also examined children whose parents rate them high on a combination of externalizing and internalizing (anxiety, depression) problems on the CBCL. These children are also at risk for later behavior problems either because of the tendency to overcontrol emotions or because of the emotional lability associated with anxiety (Calkins et al., 2007). As in our previous work, we presented the children with a series of emotion regulation challenges designed to assess their effortful control of behavior, attentional persistence, frustration, and positive reactions. Throughout the battery of challenge tasks, we measured HR and RSA to assess physiological regulation.

Results were consistent with our previous work. The high-risk and low-risk groups of children did not differ in resting HR or RSA. However, there were important group differences in how RSA changed with respect to the challenge tasks, with the addition of the mixed externalizing/internalizing group adding important results to our previously reported findings. At age 5, the mixed group displayed significantly greater decreases in RSA (i.e., RSA suppression) across tasks than did children in the externalizing only
group. Thus, children at risk for different patterns of behavior problems (lack of control of emotion and aggression vs. anxious symptoms) displayed distinct patterns of physiological regulation during challenging situations. One of the important tasks for future research is to determine whether the physiological processes precede the behavioral pattern or whether they are a consequence of the behavior (Calkins et al., 2007).

The work that each of us is doing is based on the developmental patterns of early self-regulation. Control of physiological arousal, which is achieved during early infancy, eventually becomes integrated into the processes of attentional control and emotion regulation, as well as the cognitive and behavioral control processes of early childhood (Thompson et al., 2008).

**Challenges for the Study of Early Regulatory Processes**

We have reviewed research showing that attentional, emotional, and physiological regulatory processes are related in complex ways in early development. Although our work shows what appears to be a recognizable pattern of interrelations among these regulatory processes, we must keep in mind that attentional, emotional, and physiological regulation are dynamic processes that are difficult to disentangle (Calkins, 2010). Thus, we cannot know at this point whether physiological processes are the antecedent or the consequence of attention or emotion regulatory behaviors, especially with respect to individual differences in these interrelations.

In addition to being interrelated, attentional and emotion-based processes, along with the physiological regulation associated with each, are part of a multilevel process of self-regulation (Calkins, 2010; Calkins & Fox, 2002). Each aspect of self-regulation has a developmental pattern and each depends on the maturation of some different and some overlapping neural systems (Bell & Deater-Deckard, 2007). This dependency means that the mastery of earlier regulatory skills lays the foundation for later competencies. Likewise, the level of mastery of early skills can restrict the development of later, higher-level skills (Calkins, 2010). Thus, it is imperative to appreciate the developmental progression of each component of self-regulation.

Finally, although we did not review the work here, self-regulation occurs in context. This means that for infants and young children, regulation is a dyadic process (Calkins, 2010) with maternal behaviors contributing to variability in the child’s development of self-regulation (e.g., Smith, Calkins, Keane, Anastopoulos, & Shelton, 2004). The consideration of parent–child interactions in the development of attentional, emotional, and physiological regulatory processes is critical to an informed view of the development.

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REFERENCES


