# Commonalities and Differences in the Research on Children's Effortful Control and Executive Function: A Call for an Integrated Model of Self-Regulation

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ABSTRACT—***Effortful control (EC) and executive function (EF) are 2 constructs related to children's self-regulation that have historically been the subject of research in separate fields, with EC primarily the focus of temperament research and EF the focus of cognitive neuroscience and clinical psychology. This article selectively reviews and compares the EC and EF literature. The review indicates considerable similarities and overlaps in the definitions, core components, and measurement of EC and EF. Differences between the 2 literatures seem to primarily reflect differences in research focus as influenced by each field's "tradition" rather than "real" differences in EC and EF as developmental constructs. Thus, developing an integrated theory of self-regulation encompassing the EC and EF perspectives is critical for reducing overlap and confusion in future research. The article provides a number of recommendations on how to integrate the theory and methodology of EC and EF in future research for (a) the components and organization of self-regulation, (b) the relation of self-regulation to children's adaptive functions, (c) the neurological basis of self-regulation and its development, and (d) the development and evaluation of interventions targeting children's self-regulation.***

KEYWORDS—*effortful control; executive function; self-regulation*

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Self-regulation refers to internal or transactional processes that enable an individual to guide his or her goal-directed activities over time and across changing contexts (Karoly, 1993). Effortful control (EC) and executive function (EF) are two frameworks for studying self-regulation in childhood and adolescence that have received considerable attention in child development research across fields. Historically, these two constructs were the subjects of separate fields, with EC the focus of socioemotional development and temperament research and EF the topic of cognitive neuroscience and clinical psychology. Recent research including both constructs has indicated some clear conceptual and measurement overlap between EC and EF (Blair & Razza, 2007; Bull & Scerif, 2001; Espy et al., 2004). However, dedicated exploration of the relations between EC and EF is rare. This review has two aims: to identify the commonalities and differences in the definitions, core components and structure, and measures of EC and EF, and to call for an integrated model of self-regulation that encompasses both EC and EF. We believe that combining the theory and methodology of EC and EF can benefit multiple areas of research on children's self-regulation.

## DEFINITIONS

### Effortful Control

EC is a multidimensional construct consisting of "the efficiency of executive attention, including the ability to inhibit a dominant response, to activate a subdominant response, to plan, and to detect errors" (Rothbart & Bates, 2006, p. 129). Executive attention, or "mechanisms for monitoring and resolving conflict among thoughts, feelings, and responses" (Rothbart & Posner, 2006, p. 11) is theorized to underlie EC. The construct of EC emerged from research on temperament, which Rothbart and Bates (2006) define as "constitutionally-based individual differences in emotional, motor, and attentional reactivity and self-regulation" (p. 100). In factor analyses of temperament dimensions using parent ratings, three factors emerged: extraversion and surgency, negative affectivity, and EC (Rothbart, Ahadi, Hersey, & Fisher, 2001). Because the ability to use attentional processes to regulate one's emotional arousal, motivation, and behavior plays a key role in emotion regulation, EC is conceptualized as a critical component or correlate of emotion regulation (Eisenberg, Smith, Sadovsky, & Spinrad, 2004).

### Executive Function

In contrast to EC, which has primarily been the focus of research on temperament, EF has been of interest to different areas and fields, resulting in a variety of definitions and labels. Indeed, our review reveals an assortment of labels related to EF, including executive control (Pessoa, 2009), cognitive control (Casey, Tottenham, & Fossella, 2002; Miller & Cohen, 2001), and supervisory attention (Shallice, 1988). Despite the variations in nomenclature, there are some key points of consensus in defining EF. First, EF is a multidimensional construct involving a set of subcomponents and processes that exert control over one's attention, cognition, and behavioral tendencies (Blair, Zelazo, & Greenberg, 2005). Second, EF processes are generally characterized as "top-down," "higher order" (Carlson, 2005; Nelson, de Haan, & Thomas, 2006), or goal directed (Fuster, 2002), and involve control and regulation over automatic or prepotent processes (Barkley, 1996; Diamond, 2006).

Thus, at least in their definitions, the similarities between EC and EF seem to overshadow their differences. Both constructs imply self-control in the face of conflicting or competing demands and are consistent with the broader definition of self-regulation (Karoly, 1993). Some authors have even suggested that the terms are relatively interchangeable (Diamond, 2006; Nelson et al., 2006). As we review below, EC and EF also share some common components and measures.

## COMPONENTS AND MEASURES

### Effortful Control

Based on Rothbart and Bates's (2006) psychobiological theory of temperament, EC includes several interrelated components: (a) inhibitory control (the ability to suppress inappropriate responses), (b) voluntarily focusing and shifting attention, (c) conflict resolution (the ability to make decisions at the presence of discrepant or conflict stimuli), and (d) the ability to detect and correct errors and plan actions.

The most commonly studied component of EC is inhibitory control, which often uses parent or teacher questionnaires and behavioral tasks for measurement (see Table 1 for a detailed list of instruments). Behavioral and questionnaire measures of inhibitory control or EC in general show small to moderate correlations (Eisenberg et al., 2005b; Ponitz, McClelland, Matthews, & Morrison, 2009). Researchers have also used physiological measures (such as vagal tone suppression) to assess constructs and processes that are conceptually linked to inhibitory control (see Table 1).

Questionnaire and behavioral measures are also used to assess executive attention—a core process theorized to underlie EC (Rothbart & Bates, 2006). Tasks that assess executive attention usually involve resolving conflict presented by competing stimuli (see Table 1). Although some scholars view the ability to detect and correct errors and plan actions as components of EC, there has been no extensive research on these processes in the EC literature.

### Executive Function

Researchers have proposed various theoretical models to characterize EF. These models can be broadly grouped into three types: EF as a unitary construct, EF as multiple components, and EF as a unitary construct with dissociable components.

The first model views EF as a single, unitary construct. For example, EF is characterized as a centralized executive system regulating other cognitive systems and subprocesses (Baddeley, 1986; Shallice, 1988). Theories focusing on the processes involved in EF also reflect the unitary view. For example, Zelazo, Müller, Frye, and Marcovitch (2003) conceptualize EF as a functional outcome of a series of problem-solving processes including problem representation, planning, evaluation, and execution. Children's ability to formulate, maintain, and flexibly use rules of increasing complexity reflects the development of EF (Zelazo et al., 2003).

The second view conceptualizes EF as consisting of dissociable components. Miyake, Friedman, Emerson, Witzki, and Howerter (2000) proposed three related EF components: shifting, working memory, and inhibition. The three-factor model was consistent with the results of a confirmatory factor analysis of adults' performance on measures selected to reflect these components (Miyake et al., 2000). Davidson, Amso, Anderson, and Diamond (2006) proposed a similar three-factor model for EF in children. Factor analyses of EF tasks yielded some support for the multifactorial model in school-age and adolescent samples (e.g., Huizinga, Dolan, & van der Molen, 2006; Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003). However, Wiebe, Espy, and Charak (2008) found the single-factor model to be a better fit in a preschool sample.

The third view characterizes EF as a unitary construct with dissociable components (Garon, Bryson, & Smith, 2008). This model views voluntary and selective attention as the common factor that enables and underlies the development of EF components (Garon et al., 2008). This model views the central attention system as a mediator of the associations among various EF components (Garon et al., 2008). Another integrated model of EF

**Table 1**

***A Comparison Between the Effortful Control (EC) and Executive Functions (EF) Literature: A Selected Review***

| | Effortful control | Executive functions |
|---|---|---|
| Definition | "The efficiency of executive attention, including the ability to inhibit a dominant response, to activate a subdominant response, to plan, and to detect errors" (Rothbart & Bates, 2006, p. 129) | "Higher order, self-regulatory, cognitive processes that aid in the monitoring and control of thought and action [which] include inhibitory control, planning, attentional flexibility, error correction and detection, and resistance to interference" (Carlson, 2005, p. 595) |
| Key components | (1) Inhibitory control (Rothbart et al., 2001; Eisenberg et al., 2004)<br>(2) Voluntary focusing and shifting of attention (Eisenberg et al., 2004) or executive attention (Rothbart et al., 2007)<br>(3) Conflict detection and resolution (Rothbart & Bates, 2006)<br>(4) Planning and error detection and correction (Rothbart & Bates, 2006) | (1) Inhibition (e.g., Davidson et al., 2006; Kirkham, Cruess, & Diamond, 2003; Miyake et al., 2000)<br>(2) Cognitive flexibility/shifting/task switching (e.g., Davidson et al., 2006; Kirkham et al., 2003; Miyake et al., 2000)<br>(3) Working memory/updating (e.g., Davidson et al., 2006; Kirkham et al., 2003; Miyake et al., 2000) |
| Measures | (1) Questionnaire measures<br>Toddler Behavior Assessment Questionnaire (Goldsmith, 1996)<br>Child Behavior Questionnaire (Rothbart et al., 2001)<br>Early Adolescent Temperament Questionnaire (Capaldi & Rothbart, 1992)<br>Effortful Control Scale (ECS; Lonigan & Phillips, 2001) | (1) Questionnaire measures<br>Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Retzlaff, & Espy, 2002) |
| | (2) Behavioral measures<br>Go/No Go (requires responding to one type of stimuli and inhibiting a response to another; e.g., Bush, Luu, & Posner, 2000; Bush et al., 1998; Kochanska & Knaack, 2003; Lengua et al., 2007; Lonigan & Phillips, 2001)<br>Head-Toes-Knees-Shoulders (requires the child to perform the opposite of a dominant response to four different oral commands; Ponitz et al., 2008)<br>Stroop (requires ignoring a dominant perceptual feature of a stimulus in favor of a subdominant feature; e.g., Gonzalez, Fuentes, Carranza, & Estevez, 2001; Lengua, Bush, Long, Kovacs, & Trancik, 2008; Lengua et al., 2007; Rothbart, Ellis, & Posner, 2004)<br>Kochanska's multitask battery (e.g., Walk a Line, Turtle's House, Telephone Poles, Circle, Star, and lowering voice; Kochanska & Knaack, 2003; Kochanska, Murray, & Harlan, 2000; Murray & Kochanska, 2002)<br>Puzzle box task (which requires the child to assemble a puzzle in a wooden box without looking, but the child can cheat by lifting the cloth covering the front or looking through the sleeves, an index of behavioral persistence/effortful control is calculated as the portion of time persisting on the task without cheating; Eisenberg et al., 2001; Zhou et al., 2007)<br>Attention Network Task (Rothbart et al., 2007) | (2) Behavioral measures<br>Go/No Go tasks (e.g., Simon Says, Hand Game, Carlson, 2005; Tapping Hands, Diamond & Taylor, 1996)<br>Stroop tasks (e.g., Shape Stroop, Day/Night Stroop, Carlson, 2005; Gerstadt, Hong, & Diamond, 1994)<br>Delay tasks (e.g., Delay of Gratification, Gift Delay, Carlson, 2005; Delayed Response Task, Hunter, 1913; Delayed Matching to Sample Task, Weinstein, 1941)<br>Shifting or conflict resolution tasks (e.g., flanker tasks, Bunge, Dudukovic., Thomason, Vaidya, & Gabrieli, 2002; Spatial conflict, Carlson, 2005)<br>Complex EF tasks (e.g., Dimensional Change Card Sort, Zelazo et al., 2003)<br>False Belief tasks (Wimmer & Perner, 1983)<br>Antisaccade tasks (Munoz, Broughton, Goldring, & Armstrong, 1998)<br>Working memory tasks (e.g., Backward Digit Span, Count and Label, Carlson, 2005) |
| | (3) Physiological measures<br>Vagal tone or respiratory sinus arrhythmia suppression in response to evocative stimuli/events (Calkins & Keane, 2004; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996) | (3) Physiological measures<br>Pupillometric responses during the AX Continuous Performance Task (Chatham, Frank, & Munakata, 2009) |

**Table 1**
***Continued.***

| | Effortful control | Executive functions |
|---|---|---|
| Neural substrates | Efficiency of executive attention is linked to activities in the anterior cingulated gyrus and lateral prefrontal cortex (Fan et al., 2002; Fan et al., 2005) | Orbitofrontal cortex is linked to simple rule representation, whereas ventrolateral prefrontal cortex and dorsolateral prefrontal cortex are linked to representation of sets of conditional rules and rule switching (Bunge & Zelazo, 2006; Crone, Wendelken, Donohue, & Bunge, 2006)<br>Orbitofrontal cortex is theorized to underlie “hot” EF (or EF in emotion-laden situations), whereas dorsolateral prefrontal cortex are theorized to underlie “cool” EF (or EF in decontextualized problem-solving situations; Zelazo & Cunningham, 2007)<br>Improvements in children’s visuospatial working memory over time may result from increasing connectivity strength between brain regions (Bunge & Wright, 2007)<br>Effective recruitment of the right ventrolateral prefrontal cortex for response selection/inhibition tasks increases with age (Bunge et al., 2002) |
| Relations to adaptive functions | EC has been negatively related to externalizing and internalizing problems (Eisenberg et al., 2001; Eisenberg, Sadovsky, et al., 2005; Eisenberg, Zhou, et al., 2005; Eisenberg et al., 2009; Valiente et al., 2003; Valiente et al., 2006; Zhou et al., 2007; Zhou et al., 2008)<br>EC has been positively related to sympathy/empathy and prosocial behavior (Eisenberg et al., 2007; Valiente et al., 2004), and conscience and moral development (Kochanska et al., 2000; Kochanska & Knaack, 2003)<br>EC has been positively related to social competence (Eisenberg et al., 2003; Fabes et al., 1999, Liew, Eisenberg, & Reiser, 2004; Spinrad et al., 2006; Spinrad et al., 2007; Zhou, Eisenberg, Wang, & Reiser, 2004)<br>EC has been positively related to math and phonemic awareness batteries (Blair & Razza, 2007), school competence (Fabes, Martin, Hanish, Anders, & Madden-Derdich, 2003; Valiente, Lemery-Chalfant, & Castro, 2007; Valiente, Lemery-Chalfant, Swanson, & Reiser, 2008), and grade point average (Liew, McTigue, Barrois, & Hughes, 2008; Zhou et al., 2010) | Deficits in EFs were found in populations with ADHD (e.g., Pennington & Ozonoff, 1996; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) and autism spectrum disorders (e.g., Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Hill, 2004; Ozonoff, Strayer, McMahon, & Filloux, 1998)<br>EF has been positively related to social competence (Hughes, 1998; Hughes, Dunn, & White, 1998; Razza & Blair, 2009)<br>EF deficits may undermine children’s ability to understand the theory of mind, and some degree of EF (e.g., inhibition) may be necessary for reflection on others’ mental states (e.g., Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Hughes, 1998; Moses, 2001)<br>EF has been positively related to academic achievement and school readiness (e.g., Blair, 2002; Blair, Granger, & Razza, 2005; Blair & Razza, 2007; Bull & Scerif, 2001; Espy et al., 2004) |
| Developmental trajectories | The orienting system of attention develops during 1st year of life, followed by improvements in selective/executive attention over 2nd and 3rd years of life (Jones, Rothbart, & Posner, 2003; Rothbart & Posner, 2006)<br>Adult-rated attention focusing shows stability from 5 to 10 years of age, whereas the observed attention and behavioral persistence (related to inhibitory control) continued to show changes during this period (Zhou et al., 2007)<br>Ability to resolve conflict between stimuli shows rapid improvement from age 2 to 5 years, and continues to improve until age 7 when they reach adult levels (Rueda et al., 2005) | Inhibitory control is difficult for children at 4 years old; by age 10, working memory is more difficult than inhibitory control (Davidson et al., 2006)<br>There is improvement in complex response inhibition tasks (e.g., maintaining arbitrary rule and inhibiting a prepotent response) during the 3rd year (Carlson, 2005)<br>Cognitive flexibility and inhibition show improvement between 3 and 5 years of age. Task switching/cognitive flexibility continue to show development at age 13 (Diamond, 2006; Davidson et al., 2006)<br>There are improvements in rule use, rule switching, and representation of complex rule sets between ages 3 and 4 years (Zelazo et al., 2003) |

(Jacques & Marcovitch, 2010) sees working memory as the underlying process supporting other EF functions (e.g., response inhibition and set shifting).

In our view, the unitary and multiple-component models share more commonalities than differences. Both models view EF as a multidimensional construct including multiple lower order skills or processes. Whereas the multiple-component models focus on the core skills involved in EF, the unitary or process-oriented models focus on how various skills or components are organized and work together in complex problem-solving situations. Thus, these two approaches can and should be reconciled, and integrated models of EF (Garon et al., 2008; Jacques & Marcovitch, 2010) provide means of integration. However, when evaluating and comparing models, it is important to consider the developmental period during which EF is studied. It is possible that the unitary and integrated representations of EF fit better with younger children than with older children or adolescents (Wiebe et al., 2008). Further research with samples at varying points in development is necessary in order to better understand the applicability of these models.

### Commonalities and Differences Between EC and EF

#### *Commonalities*

We see at least two commonalities in the conceptualization of EC and EF. First, they share a common component: inhibition. Some researchers have used similar measures of inhibition (such as Go/No Go and Stroop) to assess EC (Kochanska & Knaack, 2003; Lengua, Honorado, & Bush, 2007), and others have used them to assess EF (Carlson, 2005). However, whereas the study of EC tends to focus on inhibition of motivation- or emotion-driven behavioral responses (e.g., those tapped by delay of gratification and frustration tasks, or adults' ratings of inhibitory control), the study of EF tends to focus on the inhibition of cognitive responses (such as those tapped by Stroop-like tasks; Nigg, 2000).

Second, EC and EF share a common process: executive attention, a central process underlying EC (Rothbart, Sheese, & Posner, 2007). Similarly, the executive attention network is also named as a key system underlying the development of EF components (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Garon et al., 2008). Kaplan and Berman (2010) also highlight directed attention as a common resource for both EF and self-regulation.

#### *Differences*

One difference we see between the two fields is that EC and EF researchers seem to focus on self-regulation in somewhat different contexts, with EC researchers focusing more on emotion-laden contexts and EF researchers focusing more on emotionally neutral contexts. Mischel, Ayduk, and Mendoza-Denton (2003) distinguished between an emotional, *hot* system and a cognitive, *cool* system of self-regulation. The hot system specializes in quick emotional processing and reflexive approach–avoidance reactions to emotion-laden stimuli, whereas the cool system specializes in complex cognitive processing and reflective planning in response to emotionally neutral stimuli. Similarly, Zelazo and Cunningham (2007) distinguished between "hot" and "cool" EF. Problems involving regulation of emotions (such as tasks that involve rewards or losses) elicit hot EF, whereas abstract and decontextualized problems elicit cool EF. Because hot and cool EF are simultaneously involved in most problem-solving situations, it is best to view them as two ends of a continuum in a single coordinated system rather than two separate systems (Zelazo & Cunningham, 2007). Alternatively, the distinction between hot and cool self-regulation might reflect differences in the context in which researchers generally study self-regulatory skills. The concept of EC comes from temperament research, which has traditionally focused on socioemotional and adaptive functioning. Thus, with the exception of the research on executive attention (e.g., Simonds, Kieras, Rueda, & Rothbart, 2007), the study of EC (especially the inhibition component as measured by observations or ratings of behaviors in naturalistic settings or by tasks involving reward or punishment) has primarily focused on emotion-laden contexts. In contrast, in the EF field, there has been more advancement in research on cool EF than hot EF (Zelazo & Cunningham, 2007).

Recently, some researchers have included both EF and EC or both hot and cool EF in the same study and investigated their relations. For example, Blair and Razza (2007) found moderate relations between EF (inhibitory control and attention shifting on conflict resolution tasks) and EC (parent and teacher report) in preschool and kindergarten children. Similarly, Hongwanishkul, Happaney, Lee, and Zelazo (2005) found small to moderate relations between cool EF (working memory and flexible rule use) and parent-reported EC, although they failed to find relations between hot EF (measured by gambling and delay tasks) and parent-reported EC among 3- to 5-year-olds. However, to date, most researchers have focused on either EC or EF, but not both.

A second difference between EC and EF research concerns working memory. Working memory is considered a core component of EF, but most EC research does not concentrate on it. However, we think that this difference likely reflects researchers' arbitrary decisions in selecting components or measures rather than real differences between EC and EF as developmental constructs. In fact, work by Wolfe and Bell (2004, 2007) indicates similarities and connections in the conceptualization of working memory and EC, and shows medium positive associations between measures of working memory and parent ratings of EC (especially in early development). Therefore, although working memory has not been a focus of EC research, it is likely a component of or related construct to EC.

## A CALL FOR AN INTEGRATED MODEL OF SELF-REGULATION

Although EC and EF come from different theoretical frameworks and are the subjects of research in traditionally separate fields, our review indicates considerable similarities in definition, core components, and measurement. Moreover, differences between the two fields seem to primarily reflect differences in research focuses influenced by the field's "tradition" rather than actual differences in EC and EF as developmental constructs. Thus, an integrative framework of self-regulation encompassing EC and EF perspectives is critical for reducing overlap and confusion in concepts, terminologies, and measures in future research. We offer some recommendations below on how to integrate EC and EF in future research on children's self-regulation. Because the study of EC and EF requires the expertise of researchers across multiple disciplines, we believe that interdisciplinary collaboration is essential for developing an integrated framework of self-regulation.

### The Components and Organization of Self-Regulation

As global constructs, EC and EF are difficult to distinguish. However, it is possible to identify commonalities and distinctions among their individual components, processes, and measures. Thus, a first step in developing an integrated model should be to identify common and unique components of EC and EF and develop a framework for organizing these components. Specifically, we encourage researchers to incorporate components and measures of EC and EF in the same studies and systematically examine their interrelations. For example, studies can use the latent variable approach to "extract" common components of self-regulation among multiple measures of EC and EF (Miyake et al., 2000) and to test the hypothesized role of executive attention as a mediator of the associations among self-regulation components (Garon et al., 2008). Further understanding is needed on how various components are organized and work together in typical situations involving self-regulation. For example, when a child takes away a peer's toy, how do various components of self-regulation (such as working memory, inhibition, and executive attention) work together to (a) resist the temptation to fight back and (b) generate alternative coping strategies such as calling for help or self-distraction? The process-oriented models of EF (e.g., Zelazo et al., 2003) provide an excellent example of how to untangle the complex process of goal-directed problem solving in situations involving complex rules. Using experimental paradigms, Mischel et al. (2003) examined the interaction between hot and cool self-regulatory strategies in affecting children's sustaining delay of gratification. It is possible to apply these approaches to study self-regulatory processes in other contexts.

### The Relations of Self-Regulation to Children's Adaptive Functions

Once researchers identify the common and unique components of EC and EF and establish an integrated model for self-regulation, it will be possible to apply this model to investigate the relations of self-regulation to children's adaptive functions. As Table 1 outlines, there has been extensive research on the links of EC and EF to children's adaptive functions. However, most research on EC has focused on socioemotional competence and mental health (although there has been recent interest in the role of EC in children's academic development). In contrast, research on EF has primarily focused on cognitive and academic development or clinical diagnoses and symptoms.

Thus, a future direction is to examine the common and unique contributions of different components of self-regulation to multiple domains of adaptive functions. We especially encourage researchers to examine the role of EC in children's cognitive and academic development and the role of EF in socioemotional development and mental health. Studies can employ normative, at-risk, and clinical samples to shed light on the role of self-regulation in typical and atypical development.

More research is also necessary to understand the mediating and moderating mechanisms underlying the links of self-regulation to adaptive functions. For example, research on EC has consistently suggested that negative emotionality may interact with EC in predicting behavioral problems and social competence (e.g., Eisenberg et al., 2004). In regard to mediation, Zhou, Main, and Wang (2010) found that social competence and externalizing problems mediate the link between EC and academic achievement, whereas Brock, Rimm-Kaufman, Nathanson, and Grimm (2009) found that the link between cool EF and math achievement was direct and not mediated by classroom behaviors.

### The Neurological Basis of Self-Regulation

The third direction in integrating the research on EC and EF is to further understand the neural mechanisms underlying self-regulatory functions. Research on the neural basis of EF has indicated that different regions of the prefrontal cortex are associated with different EF functions. For example, the orbitofrontal cortex is linked to the representation of simple stimulus–reward associations, whereas the ventrolateral and dorsolateral prefrontal cortex is linked to the representation of sets of conditional rules and rule switching (Bunge & Zelazo, 2006; Crone, Wendelken, Donohue, & Bunge, 2006). From childhood to adulthood, different regions of prefrontal cortex show different maturation patterns, which are associated with distinct developmental trajectories of rule representation and rule switching (Crone et al., 2006).

Research on the neurological basis of EC has primarily focused on the executive attention network. For example, executive attention as measured by the Attention Network Task is associated with activities in the anterior cingulate gyrus and lateral prefrontal cortex (Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). However, the research on EC has generally not used neurobiological methods. Thus, there has been little knowledge of neurobiological indicators of EC components and associations between neurobiological and behavioral indicators of EC.

With an integrated model of self-regulation, researchers can use neurobiological techniques to explore whether behavioral measures previously thought to reflect EC or EF as separate constructs are in fact tapping functions of common neural mechanisms. Meanwhile, integrating EC and EF can greatly facilitate the research on neurological basis of temperament (which includes regulation and emotional reactivity) and its development.

**Psychological Interventions Targeting Self-Regulation**

Integrating the research on EC and EF will have implications for the development and evaluation of psychological interventions targeting children's self-regulation. Because of the critical roles of EC and EF in adaptive functions, there has been a surge of interest in intervention programs aimed at improving EC and EF in young children. For example, Tools of the Mind, a classroom-based EF-training curriculum spanning 1–2 years, improved preschoolers' EF measured by cognitive tasks in a randomized controlled trial (Diamond, Barnett, Thomas, & Munro, 2007). A 5-day computerized attention training improved 3- to 7-year-olds' executive attention measured by performance and Event-Related Potential activities on the Attention Network Task (Rueda, Posner, & Rothbart, 2005). A computerized working memory training improved visuospatial and verbal working memory, response inhibition, and complex reasoning in children with attention deficit hyperactivity disorder (Klingberg, Forssberg, & Westerberg, 2002; Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009).

An important question for future intervention research is whether intervention-induced improvements in self-regulatory skills demonstrated in cognitive tasks are generalizable to real-life situations such as peer conflict or academic challenges. Moreover, few intervention studies have targeted EC. With the integration of EC and EF, interventions targeting self-regulation could consider multiple aspects or components of self-regulation (such as hot and cool regulation). Furthermore, outcome evaluations of intervention effects should simultaneously study multiple domains of adaptive functions, including socioemotional, behavioral, cognitive, and academic development.

Given space constraints and the breadth of the EC and EF literature, our review is necessarily selective. However, we hope we have made a convincing argument for an integrated account of self-regulation encompassing EC and EF perspectives. This integration would benefit not only research but also educational and clinical practices serving typically developing children and children with deficits in self-regulation development.

## REFERENCES


Baddeley, A. (1986). *Working memory*. New York: Oxford University Press.

Barkley, R. A. (1996). Linkages between attention and executive functions. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 307–325). Baltimore: Paul H. Brookes.

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of child functioning at school entry. *American Psychologist*, *57*, 111–127.

Blair, C., Granger, D., & Razza, R. P. (2005). Cortisol reactivity is positively related to executive function in preschool children attending Head Start. *Child Development*, *76*, 554–567.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*, 647–663.

Blair, C., Zelazo, P., & Greenberg, M. (2005). The measurement of executive function in early childhood. *Developmental Neuropsychology*, *28*, 561–571.

Brock, L. L., Rimm-Kaufman, S. E., Nathanson, L., & Grimm, K. J. (2009). The contributions of "hot" and "cool" executive function to children's academic achievement, learning-related behaviors, and engagement in kindergarten. *Early Childhood Research Quarterly*, *24*, 337–349.

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Shifting, inhibition, and working memory. *Developmental Neuropsychology*, *19*, 273–293.

Bunge, S. A., Dudukovic., N. M., Thomason, M. E., Vaidya, C. J., & Gabrieli, J. D. E. (2002). Immature frontal lobe contributions to cognitive control in children: Evidence from fMRI. *Neuron*, *33*, 301–311.

Bunge, S. A., & Wright, S. B. (2007). Neurodevelopmental changes in working memory and cognitive control. *Current Opinion in Neurobiology*, *17*, 243–250.

Bunge, S., & Zelazo, P. D. (2006). A brain-based account of the development of rule use in childhood. *Current Directions in Psychological Science*, *15*, 118–121.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Science*, *4*, 215–222.

Bush, G., Whalen, P. J., Rosen, B. R., Jenike, M. A., McInerney, S. C., & Rauch, S. L. (1998). The counting Stroop: An interference task specialized for functional neuroimaging—Validation study with functional MRI. *Human Brain Mapping*, *6*, 270–282.

Calkins, S. D., & Keane, S. P. (2004). Cardiac vagal regulation across the preschool period: Stability, continuity, and implications for childhood adjustment. *Developmental Psychobiology*, *45*, 101–112.

Capaldi, D. M., & Rothbart, M. K. (1992). Development and validation of an early adolescent temperament measure. *Journal of Early Adolescence*, *12*, 153–173.

Carlson, S. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, *28*, 595–616.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*, 1032–1053.

Carlson, S. M., Moses, L. J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development*, *11*, 73–92.

Casey, B. J., Tottenham, N., & Fossella, J. (2002). Clinical, imaging, lesion, and genetic approaches toward a model of cognitive control. *Developmental Psychobiology*, *40*, 237–254.

Chatham, C. H., Frank, M. J., & Munakata, Y. (2009). Pupillometric and behavioral markers of a developmental shift in the temporal dynamics of cognitive control. *Proceedings of the National Academy of Sciences*, *106*, 5529–5533.

Crone, E. A., Wendelken, C., Donohue, S. E., & Bunge, S. A. (2006). Evidence for separable neural processes underlying flexible rule use. *Cerebral Cortex*, *16*, 475–486.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*, 2037–2078.

Diamond, A. (2006). The early development of executive functions. In E. Bialystok & F. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). New York: Oxford University Press.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science*, *318*, 1387–1388.

Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "Do as I say, not as I do." *Developmental Psychobiology*, *29*, 315–334.

Eisenberg, N., Cumberland, A. J., Spinrad, T. L., Fabes, R. A., Shepard, S., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development*, *72*, 1112–1134.

Eisenberg, N., Michalik, N., Spinrad, T. L., Hofer, C., Kupfer, A., Valiente, C., et al. (2007). The relations of effortful control and impulsivity to children's sympathy: A longitudinal study. *Cognitive Development*, *22*, 544–567.

Eisenberg, N., Sadovsky, A., Spinrad, T. L., Fabes, R. A., Losoya, S. H., Valiente, C., et al. (2005). The relations of problem behavior status to children's negative emotionality, effortful control, and impulsivity: Concurrent relations and prediction of change. *Developmental Psychology*, *41*, 193–211.

Eisenberg, N., Smith, C. L., Sadovsky, A., & Spinrad, T. L. (2004). Effortful control: Relations with emotion regulation, adjustment, and socialization in childhood. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 259–282). New York: Guilford.

Eisenberg, N., Valiente, C., Fabes, R. A., Smith, C. L., Reiser, M., Shepard, S. A., et al. (2003). The relations of effortful control and ego control to children's resiliency and social functioning. *Developmental Psychology*, *39*, 761–776.

Eisenberg, N., Valiente, C., Spinrad, T. L., Cumberland, A. J., Liew, J., Reiser, M., et al. (2009). Longitudinal relations of children's effortful control, impulsivity, and negative emotionality to their externalizing, internalizing, and co-occurring behavior problems. *Developmental Psychology*, *45*, 988–1008.

Eisenberg, N., Zhou, Q., Spinrad, T. L., Valiente, C., Fabes, R. A., & Liew, J. (2005). Relations among positive parenting, children's effortful control, and externalizing problems: A three-wave longitudinal study. *Child Development*, *76*, 1055–1071.

Espy, K. A., McDiarmid, M. M., Cwik, M. F., Stalets, M. M., Hamby, A., & Senn, T. E. (2004). The contribution of executive functions to emergent mathematics skills in preschool children. *Developmental Neuropsychology*, *26*, 465–486.

Fabes, R. A., Eisenberg, N., Jones, S., Smith, M., Guthrie, I. K., Poulin, R., et al. (1999). Regulation, emotionality, and preschoolers' socially competent peer interactions. *Child Development*, *70*, 432–442.

Fabes, R. A., Martin, C. L., Hanish, L. D., Anders, M. C., & Madden-Derdich, D. A. (2003). Early school competence: The roles of sex-segregated play and effortful control. *Developmental Psychology*, *39*, 848–858.

Fan, J., Flombaum, J. I., McCandliss, B. D., Thomas, K. M., & Posner, M. I. (2003). Cognitive and brain consequences of conflict. *Neuroimage*, *18*, 42–57.

Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *Neuroimage*, *26*, 471–479.

Fan, J., McCandliss, B. D., Sommer, T., Raz, M., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*, 340–347.

Fuster, J. M. (2002). Physiology of executive functions: The perception-action cycle. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 96–108). New York: Oxford University Press.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, *134*, 31–60.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3.5–7 years old on a Stroop-like day-night test. *Cognition*, *53*, 129–153.

Geurts, H. M., Verté, S., Oosterlaan, J., Roeyers, H., & Sergeant, J. A. (2004). How specific are executive functioning deficits in attention deficit hyperactivity disorder and autism? *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *45*, 836–854.

Gioia, G., Isquith, P. K., Retzlaff, P., & Espy, K. (2002). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function (BRIEF) in a clinical sample. *Child Neuropsychology*, *4*, 249–257.

Goldsmith, H. H. (1996). Studying temperament via construction of the Toddler Behavior Assessment Questionnaire. *Child Development*, *67*, 218–235.

Gonzalez, C., Fuentes, L. J., Carranza, J. A., & Estevez, A. F. (2001). Temperament and attention in the self-regulation of 7-year-old children. *Personality and Individual Differences*, *30*, 931–946.

Hill, E. L. (2004). Evaluating the theory of EF deficits in autism. *Developmental Review*, *24*, 189–233.

Hongwanishkul, D., Happaney, K. R., Lee, W., & Zelazo, P. D. (2005). Hot and cool executive function: Age-related changes and individual differences. *Developmental Neuropsychology*, *28*, 617–644.

Hughes, C. (1998). Executive function in preschoolers: Links with theory of mind and verbal ability. *British Journal of Developmental Psychology*, *16*, 233–253.

Hughes, C., Dunn, J., & White, A. (1998). Trick or treat? Uneven understanding of mind and emotion and executive dysfunction in "hard-to-manage" preschoolers. *Journal of Child Psychology and Psychiatry*, *39*, 981–994.

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia*, *44*, 2017–2036.

Hunter, W. S. (1913). The delayed reaction in animals and children. *Animal Behavior Monographs*, *2*, 86.

Jacques, S., & Marcovitch, S. (2010). Development of executive function across the lifespan. In W. F. Overton (Ed.), *Handbook of life-span development: Vol. 1. Cognition, biology, and methods across the lifespan* (pp. 431–466). Hoboken, NJ: Wiley.

Jones, L. B., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental Science*, *6*, 498–504.

Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on Psychological Science*, *5*, 43–57.

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. *Annual Review of Psychology*, *44*, 23–52.

Kirkham, N., Cruess, L., & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science*, *6*, 449–476.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology*, *24*, 781–791.

Kochanska, G., & Knaack, A. (2003). Effortful control as a personality characteristic of young children: Antecedents, correlates, and consequences. *Journal of Personality*, *71*, 1087–1112.

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology*, *36*, 220–232.

Lehto, J., Juujarvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology*, *21*, 59–80.

Lengua, L. J., Bush, N. R., Long, A. C., Kovacs, E. A., & Trancik, A. M. (2008). Effortful control as a moderator of the relation between contextual risk factors and growth in adjustment problems. *Development and Psychopathology*, *2*, 509–528.

Lengua, L. J., Honorado, E., & Bush, N. R. (2007). Contextual risk and parenting as predictors of effortful control and social competence in preschool children. *Journal of Applied Developmental Psychology*, *28*, 40–55.

Liew, J., Eisenberg, N., & Reiser, M. (2004). Preschoolers' effortful control and negative emotionality, immediate reactions to disappointment, and quality of social functioning. *Journal of Experimental Child Psychology*, *89*, 298–319.

Liew, J., McTigue, E. M., Barrois, L., & Hughes, J. N. (2008). Adaptive and effortful control and academic self-efficacy beliefs on achievement: A longitudinal study of 1st through 3rd graders. *Early Childhood Research Quarterly*, *23*, 515–526.

Lonigan, C. J., & Phillips, B. M. (2001). Temperamental influences on the development of anxiety disorders. In M. W. Vasey & M. R. Dadds (Eds.), *The developmental psychopathology of anxiety* (pp. 60–91). New York: Oxford University Press.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Mischel, W., Ayduk, O., & Mendoza-Denton, R. (2003). Sustaining delay of gratification over time: A hot-cool systems perspective. In G. Loewenstein, D. Read, & R. Baumeister (Eds.), *Time and decision: Economic and psychological perspectives on intertemporal choice* (pp. 175–200). New York: Russell Sage Foundation.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100.

Moses, L. J. (2001). Executive accounts of theory-of-mind development. *Child Development*, *72*, 688–690.

Munoz, D. P., Broughton, J. R., Goldring, J. E., & Armstrong, I. T. (1998). Age-related performance of human subjects on saccadic eye movement tasks. *Experimental Brain Research*, *121*, 391–400.

Murray, K. T., & Kochanska, G. (2002). Effortful control: Relation to externalizing and internalizing behaviors and factor structure. *Journal of Abnormal Child Psychology*, *30*, 503–514.

Nelson, C. A., de Haan, M., & Thomas, K. M. (2006). *Neuroscience of cognitive development: The role of experience and the developing brain*. Hoboken, NJ: Wiley.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin*, *126*, 220–246.

Ozonoff, S., Strayer, D. L., McMahon, W. M., & Filloux, F. (1998). Inhibitory deficits in Tourette syndrome: A function of comorbidity and symptom severity. *Journal of Child Psychiatry*, *39*, 1109–1118.

Pennington, B. F., & Ozonoff, S. (1996). Executive function and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*, 51–87.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Science*, *13*, 160–166.

Ponitz, C. C., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly*, *23*, 141–158.

Ponitz, C. C., McClelland, M. M., Matthews, J. S., & Morrison, F. J. (2009). A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. *Developmental Psychology*, *45*, 605–619.

Porges, S. W., Doussard-Roosevelt, J. A., Portales, A. L., & Greenspan, S. I. (1996). Infant regulation of the vagal "brake" predicts child behavior problems: A psychobiological model of social behavior. *Developmental Psychobiology*, *29*, 697–712.

Razza, R. A., & Blair, C. (2009). Associations among false-belief understanding, executive function, and social competence: A longitudinal analysis. *Journal of Applied Developmental Psychology*, *30*, 332–343.

Rothbart, M. K., Ahadi, S. A., Hersey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*, 1394–1408.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In N. Eisenberg, W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 99–166). Hoboken, NJ: Wiley.

Rothbart, M. K., Ellis, L. K., & Posner, M. I. (2004). Temperament and self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 357–370). New York: Guilford.

Rothbart, M. K., & Posner, M. I. (2006). Temperament, attention, and developmental psychopathology. In D. Cicchetti & D. J. Cohen (Eds.), *Developmental psychopathology: Vol. 2. Developmental neuroscience* (2nd ed., pp. 465–501). Hoboken, NJ: Wiley.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, *1*, 2–7.

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology*, *28*, 573–594.

Shallice, T. (1988). *From neuropsychology to mental structure*. Cambridge, UK: Cambridge University Press.

Simonds, J., Kieras, J. E., Rueda, M. R., & Rothbart, M. K. (2007). Effortful control, executive attention, and emotional regulation in 7-10-year-old children. *Cognitive Development*, *22*, 474–488.

Spinrad, T., Eisenberg, N., Cumberland, A. J., Fabes, R., Valiente, C., Shepard, S., et al. (2006). The relation of emotion-related regulation to children's social competence: A longitudinal study. *Emotion*, *6*, 498–510.

Spinrad, T. L., Eisenberg, N., Gaertner, B., Popp, T., Smith, C. L., Kupfer, A., et al. (2007). Relations of maternal socialization and toddler's effortful control to children's adjustment and social competence. *Developmental Psychology*, *43*, 1170–1186.

Thorell, L. B., Lindqvist, S., Nutley, S. B., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science*, *12*, 106–113.

Valiente, C., Eisenberg, N., Fabes, R. A., Shepard, S. A., Cumberland, A. J., & Losoya, S. H. (2004). Prediction of children's empathy-related responding from their effortful control and parents' expressivity. *Developmental Psychology*, *40*, 911–926.

Valiente, C., Eisenberg, N., Smith, C. L., Reiser, M., Fabes, R. A., Losoya, S., et al. (2003). The relations of effortful control and reactive control to children's externalizing problems: A longitudinal assessment. *Journal of Personality*, *71*, 1171–1196.

Valiente, C., Eisenberg, N., Spinrad, T. L., Reiser, M., Cumberland, A. J., Losoya, S. H., et al. (2006). Relations among mothers' expressivity, children's effortful control, and their problem behaviors: A four-year longitudinal study. *Emotion*, *6*, 459–472.

Valiente, C., Lemery-Chalfant, K., & Castro, K. S. (2007). Children's effortful control and academic competence. Mediation through school liking. *Merrill-Palmer Quarterly*, *53*, 1–25.

Valiente, C., Lemery-Chalfant, K., Swanson, J., & Reiser, M. (2008). Prediction of children's academic competence from their effortful control, relationships, and classroom participation. *Journal of Educational Psychology*, *100*, 67–77.

Weinstein, B. (1941). Matching-from-sample by rhesus monkeys and by children. *Journal of Comparative Psychology*, *31*, 195–213.

Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, *44*, 575–587.

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit-hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*, 1336–1346.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*, 103–128.

Wolfe, C. D., & Bell, M. A. (2004). Working memory and inhibitory control in early childhood: Contributions from physiology, temperament, and language. *Developmental Psychobiology*, *44*, 68–83.

Wolfe, C. D., & Bell, M. A. (2007). Sources of variability in working memory in early childhood: A consideration of age, temperament, language, and brain electrical activity. *Cognitive Development*, *22*, 431–455.

Zelazo, P. D., & Cunningham, W. (2007). Executive function: Mechanisms underlying emotion regulation. In J. Gross (Ed.), *Handbook of emotion regulation* (pp. 135–158). New York: Guilford.

Zelazo, P. D., Müller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs for the Society for Research on Child Development*, *68*(Serial No. 27), 11–119.

Zhou, Q., Eisenberg, N., Wang, Y., & Reiser, M. (2004). Chinese children's effortful control and dispositional anger/frustration: Relations to parenting styles and children's social functioning. *Developmental Psychology*, *40*, 352–366.

Zhou, Q., Hofer, C., Eisenberg, N., Reiser, M., Spinrad, T., & Fabes, R. (2007). The developmental trajectories of attention focusing, attentional and behavioral persistence, and externalizing problems during school-age years. *Developmental Psychology*, *43*, 369–385.

Zhou, Q., Main, A., & Wang, Y. (2010). Temperament effortful control and anger/frustration to Chinese children's academic achievement and social adjustment: A longitudinal study. *Journal of Educational Psychology*, *102*, 180–196.

Zhou, Q., Wang, Y., Deng, X., Eisenberg, N., Wolchik, S. A., & Tein, J. (2008). Relations of parenting and temperament to Chinese children's experience of negative life events, coping efficacy, and externalizing problems. *Child Development*, *79*, 493–513.