CHAPTER 7

Emerging Executive Functions in Early Childhood

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Executive functions (EF) are cognitive skills that are essential for engaging in complex goal-directed behavior. Multiple skills comprise the broad construct of EF. Primary among them are the skills of *working memory* (the ability to maintain and manipulate information in support of goal driven behavior), *response inhibition/inhibitory control* (initiating purposeful action and restraining impulsive behavior) and *attention shifting/cognitive flexibility* (adaptively adjusting behavior to meet situational demands) (Davidson, Amso, Anderson, & Diamond, 2006). Across development children improve in the overall efficiency of EF skills and are better able to effectively engage and integrate these skills across contexts. Various assessments in childhood indicate that EF skills play a major role in children's social–emotional function (Hughes & Ensor, 2011) and are predictive of academic success by supporting early learning and behavioral regulation in the school setting (Blair, 2002; Blair & Razza, 2007; Mischel, Shoda, & Rodriguez, 1989). Moreover, children with stronger EF skills are better able to learn from training and practice, and show greater gains in subject mastery across childhood (Benson, Sabbagh, Carlson, & Zelazo, 2013; Hassinger-Das, Jordan, Glutting, Irwin, & Dyson, 2014; Welsh, Nix, Blair, Bierman, & Nelson, 2010).

With the continued expansion of EF research in young children, there is increasing interest in the role of environmental influence on the development of these skills, within both normative and atypical caregiving circumstances. In turn, this focus on the environment, along with promising results suggesting that intervention may boost EF skills (see Diamond, 2012, for review), has pushed researchers to consider how best to conceptualize and identify antecedents and early indices of EF skills. This chapter synthesizes current theoretical models relevant to EF development and reviews potential antecedents of EF in infancy and toddlerhood. These antecedents include child attention processes, as well as specific dimensions of parenting, which influence both cognitive and stress regulation systems in the developing child. Additional emphasis is placed on the unique ways in which typical and atypical early caregiving environments can shape the growth of EF in young children. Future areas of exploration in the field of EF research are also highlighted.

Theoretical Models of EF Development

One challenging aspect of EF research in young children is the lack of a definitive unifying framework. Such a framework would help to ground EF findings that emerge across methods (behavioral, parent-report, psychophysiological) and also inform construction of new tasks (Garon, Bryson, & Smith, 2008; see Table 7.1 for examples of EF tasks in young children). A cohesive developmental framework would also allow researchers to hone in more effectively on specific EF skills and identify antecedents in order to better track these components from infancy through the formative preschool years that encompass a rapid period of EF growth in children.

Initially the main model of EF focused on adult work (Miyake et al., 2000), and proposed three primary facets of EF: working memory, inhibitory control, and attention shifting. This theory proposed both unity and diversity in EF processes such that specific EF components could be correlated yet dissociable. As EF research in children become increasingly prominent, Garon and colleagues (2008) proposed an integrative framework in which EF in early childhood was conceptualized as a unitary construct that was grounded in a central atten-

TABLE 7.1. EF Tasks in Young Children

Construct	Exemplar tasks for 3- to 5-year-olds
Cognitive flexibility: *Adaptive adjustment of behavior to meet situational demands*	Dimensional change card sort (DCCS): Children sort bivalent cards according to one dimension (e.g., color) and are then asked to shift and sort the cards on the alternative dimension (e.g., shape).
	Flexible item selection task: Children are presented with three picture cards and are asked to show two pictures that match in one way (e.g., same type of object). Next, children are asked to pick two cards that match in a different way (e.g., same color).
Working memory (WM): *Maintenance and manipulation of information for goal-driven behavior*	Digit span: Children are read a list of numbers and asked to repeat them back to the experimenter. In a modified version (the backward digit span), children are asked to repeat the list of numbers backward.
	Hearts and flowers: Children are asked to remember two rules. For one stimulus (e.g., hearts), they must press a button that corresponds to the same side of the computer screen on which that stimulus appears. For the other stimulus (e.g., flowers), they must press the button that corresponds to the opposite of the screen on which that object appears.
Inhibitory control (IC): *Withholding purposeful action and restraining impulsive behavior*	Delay of gratification task: Children are presented with a desirable item, such as a box of new crayons or a marshmallow, and are asked to wait a set amount of time before touching the item.
	Go/no-go task: Children are asked to press a button for all "go" stimuli presented on a computer screen and withhold responding for a specific "no-go" stimulus (e.g., press a button each time an animal appears on the screen except when the animal is a monkey). A noncomputerized version of this type of task is the game Simon Says, in which the phrase "Simon says" signifies a response and the absence of this prompt indicates that the child should withhold responding.
	Stroop task: Children are presented with a rule for responding (e.g., say the opposite), along with stimuli that make that rule difficult to follow. For example, in the day/night Stroop, children are asked to say "day" when they are shown a picture of the moon and "night" when shown a picture of the sun. A nonverbal version is the grass/snow pointing Stroop, in which children point to a green card when they hear the word *snow* and a white card when they hear the word *grass.*
	Flanker task: Children respond to a central stimulus in a row of stimuli. The flanking stimuli can indicate the same response as the central stimulus, or the opposite response. In the fish flanker, the central fish can be facing the same, or the opposite, direction as the flanking fish. Children are asked to press the right or left button to indicate the direction in which the central fish is swimming.

tion system. This central attention system was postulated to be a functional part of core dissociable EF processes including working memory, response inhibition, and set shifting. This model sought to delineate how EF components could evolve within a core process (i.e., simple vs. complex inhibition) and emphasized the increasing coordination of these process as children went through the preschool years. Based on a hierarchical structure, this model further posits that attention is a foundational ability to EF, such that more complex EF skills (i.e., shifting and planning) build on basic attention abilities. Indeed, work demonstrating age sensitivity in EF tasks provides some support for this notion (Garon, Smith, & Bryson, 2014). Thus, within this integrative framework, infancy and toddlerhood constitute a salient developmental period in which early perturbations in basic attentional skills could significantly impact later emerging EF skills (Garon et al., 2008).

Research by Munakata and colleagues (2011) has focused primarily on the development of inhibitory control in childhood. This framework specifies that inhibition of cortical areas results from the activation of prefrontal cortex (PFC), which is heavily engaged in EF (i.e., cortical areas that are not needed for a particular EF skill can be competitively inhibited in order to engage a different component of EF). In this manner, inhibitory control serves as a "common" EF process, involved in all EF, whereas working memory and attention shifting have more dissociable roles. Similarly, Miyake and Friedman (2012) have updated their theory on EF in adults to underscore the process of inhibitory control as uniquely subsumed within a construct reflecting a common EF factor. As such, inhibitory control is said to have a significant role in directing lower-level cognitive processing to achieve task-relevant goals.

Another developmentally grounded theory of EF, the iterative reprocessing (IR) model, also accentuates the interplay between reactive (bottom-up) and reflective (top-down) cognitive functions in self-regulation (Cunningham & Zelazo, 2010). The IR model focuses on progressive improvement in a child's ability to reflect in the service of problem solving. Specifically, reflection is postulated to support control of attention and hence the emergence of cognitive flexibility. Maintaining this attentional control for a period of time is supported by working memory, and inhibitory control allows for application of sustained attentional control (i.e., cognitive flexibility) in a selective manner across contexts (see Zelazo, 2015, for review).

Currently, research on EF skills in children cuts across these theoretical perspectives. Among preschool-age children, findings are mixed in terms of support for a unitary EF construct (Wiebe et al., 2011) versus a two-factor model distinguishing working memory and inhibitory control as separable factors (Miller, Giesbrecht, Muller, McInerney, & Kerns, 2012). However, details on how the development of EF unfolds and which environmental factors are most relevant, particularly prior to and across major growth periods of EF, are still being explored.

The following sections highlight foundational attentional processes appearing in infancy and toddlerhood that are implicated in the emergence of EF. Although some attentional antecedents have a pronounced initial impact, others may have more enduring influence due to continued differentiation of EF processes over childhood. Importantly, most developmentally oriented models of EF emphasize increasing differentiation as these skills get stronger. Additionally, research that assesses the role of caregiving provides support for the notion that positive parenting practices promote better growth of EF skills. Given the pivotal role of EF in self-regulation, earlier mastery of these skills may better position a child to pursue and achieve adaptive outcomes. The functional implications of attentional and caregiving factors in the formative shaping and refinement of EF are discussed below.

Antecedents to the Development of EF

Assessing EF prior to the preschool years has not been extensively studied due in large part to measurement difficulties. Since assessment of EF frequently involves significant verbal instructions or child responses, the verbal comprehension load can induce misunderstanding of task requirements and highly tax a toddler's cognitive skills (see, e.g., Hendry, Jones, & Charman, 2016, for a review). Nonetheless, there has been some recent success examining a mix of new and old EF-related paradigms in toddlers. This work has relied heavily on batteries of tasks that are examined in aggregate (e.g., Hughes & Ensor, 2005) or modeled to extract observed or latent factors (e.g., Blakey, Visser & Carroll, 2016; Garon et al., 2014; Mulder, Hoofs, Verhagen, van der Veen, & Leseman, 2014). Collectively, this work indicates that (1) multiple aspects of EF factors can be identified in children as young as 2 years of age, (2) individual differences in these EF skills are related to family socioeconomic status (SES), and (3) several new EF paradigms reveal promising avenues for elucidating early interrelations between EF skills. Future longitudinal work using these paradigms will be useful in tracking EF growth from toddlerhood through the preschool years and may provide insight into earlier periods of intervention for EF-related skills.

Attention

Both information-processing speed and attentional control can contribute to the foundations of higher-order EF skills. For example, a longitudinal study assessing processing speed, attention, and memory in infancy and through age 36 months demonstrated that these abilities predict the later emergence of multiple EF skills—working memory, inhibitory control, and attention shifting—in middle childhood (Rose, Feldman, & Jankowski, 2012). In another study, Sigman, Cohen, and Beckwith (1997) measured attentional control in the form of fixation patterns in infancy and found this attentional control to predict the planning component of EF in young adulthood. Although some of this work includes both term and preterm infants, together the findings provide compelling support for the notion that measures of attention and processing speed assessed in infancy or toddlerhood are associated with later higher-order cognition as reflected in a range of EF skills.

It has also been proposed that specific aspects of early attention and information processing may drive individual differences and age-related changes in EF performance across childhood (Rose, Feldman, Jankowski, & Van Rossem, 2005; Rose et al., 2012). However, support for these connections is sparse. Research on individual differences in attention control through age 2 has thus far only been able to indicate moderate stability, which underscores methodological difficulties and highlights the need to account for other factors that may influence patterns of attention in toddlerhood (see Hendry et al., 2016). Nonetheless, emerging evidence suggests that continued pursuit of unpacking specific connections between these markers of attention in infancy and EF may be especially promising to inform early intervention efforts. For instance, Ballieux and colleagues (2016) found that training improved attentional control in 12-month-old infants from low-income families. Given that the development of attention is thought to have greater potential for plasticity at younger ages (Wass, Scerif, & Johnson, 2012), interventions aimed at influencing early attention skills may have beneficial outcomes for the emergence of more sophisticated EF skills.

Another form of early attention that has been linked to later cognitive function and regulatory abilities is *joint attention*. In contrast to assessing attention patterns within an individual, the measurement of joint attention reflects an individual's coordinated attention to objects or events with a social partner (Nichols, Fox, & Mundy, 2005). Joint attention has multiple facets, including *initiating joint attention* (IJA) in order to engage in coordinated attention with a partner, as well as *responding to joint attention* (RJA) via appropriate and controlled gaze following. This latter skill is postulated to be supported by the posterior or *orienting attention network,* which becomes fully functional between ages 3 and 6 months, and directs choice of sensory inputs by guiding engagement and disengagement from stimuli (Mundy, Card, & Fox, 2000; Redcay et al., 2010; Rothbart & Posner, 2001). It is localized primarily in the parietal lobes with both the superior colliculus and frontal eye fields serving as key regions for the network (Cuevas & Bell, 2014; Posner & Peterson, 1990).

The *executive attention network* begins to emerge somewhat later than the orienting network, at around 12 months. It continues to develop across the next 3 years and ultimately obtains top-down control over other attention networks. This network is pivotally involved in processing conflict among competing response choices and is served by multiple neural regions including the PFC, the anterior cingulate cortex, and basal ganglia (Posner, Rothbart, Sheese, & Voelker, 2012). With respect to social interaction and joint attention, the executive attention system is most commonly linked to IJA behaviors, with volitional control serving as a major distinguishing feature of IJA compared to RJA (Mundy & Jarrold, 2010). However, it is important to note evidence of functional overlap and connectivity between the orienting and executive attention networks early in development (e.g., Gao et al., 2009; Posner et al., 2012), as well as longitudinal associations between attentional markers related to these networks in infancy and EF skills assessed at 2, 3, and 4 years (Cuevas & Bell, 2014).

Additional work supports the notion that the ability to engage in joint attention is a significant indicator of emerging self-regulatory processes in infancy and toddlerhood. Indeed, longitudinal work links RJA at 12 months to more effective attention strategies employed during a delay of gratification task at 36 months (Vaughan Van Hecke et al., 2012). Similarly, greater frequencies of IJA behaviors, including pointing and showing, have been linked to more successful completion of EF tasks at 18 months (Miller & Marcovitch, 2015). These findings align with models implicating representational abilities as foundational cognitive skills underlying the emergence of EF (e.g., Marchovitch & Zelazo, 2009), as well as the conceptualization of key aspects of joint attention reflecting *social executive functions* (Mundy, 2003). Although distinctions between EF occurring in limited versus extensive social contexts has yet to be fully explored, strong evidence suggests that social interactions, and in particular caregiving behaviors, are quite important in shaping the development of EF skills in children.

Caregiving

It has long been proposed that caregiving is formative to children's emerging self-regulation; however, only more recently has attention focused on mapping out the paths between parenting and EF skills. Evidence suggests that parenting may influence brain development through both nurturing and the explicit teaching of regulation skills provided by caregivers.

When assessing the role of parenting in children's brain development, appropriate caregiving has been postulated to underlie efficient organization of the frontal lobes (Glaser, 2000). This notion is supported by work in animal models, as well as cases of severe environmental perturbations such as abuse or neglect, demonstrating impaired higher-order cognitive function in cases of poorer early caregiving environments (for reviews, see Hostinar, Stellern, Shaefer, Carlson, & Gunnar, 2012; Pechtel & Pizzagalli, 2011). Within the frontal lobes, the neural region tied most directly to a wide range of EF skills is the PFC. This region has a protracted developmental course that spans childhood into adulthood. Additionally, the PFC has enhanced production of synapses that begins at age 2 years (Nelson, Thomas, & de Haan, 2006) and pruning in early childhood beginning around 7 years of age (Huttenlocher, 2002). Taken together, these patterns of neural sculpting underlie the protracted structural formation of the PFC, thus providing an extensive a window of opportunity for environmental experiences to significantly influence PFC development and the emergence of EF skills in childhood (Bernier, Carlson, & Whipple, 2010; Nelson & Bloom, 1997; Shore, 2001).

The second route, in which parents take an active role as teachers of self-regulation, is theorized to influence child EF via the explicit instruction of skills that support children's ability to control their behavior (Kopp, 1982). Research in this area has conceptualized parenting as either a unitary construct, or dimensionally, with distinct modes of interaction through which a caregiver can externally help children to regulate (e.g., Harrist & Waugh, 2002; Meins et al., 2002; Moran, Forbes, Evans, Tarabulsy, & Madigan, 2008). Two dimensions of parenting that are especially relevant for the development of EF are sensitivity and scaffolding. Each dimension can have differential effects on children's function as they gradually transition toward self-regulation across infancy into early childhood. The construct of *sensitivity* reflects consistent and appropriate responding by the caregiver to the signals of a child and is most frequently assessed as maternal sensitivity. *Scaffolding* consists of verbal and/or physical prompts from a caregiver offering a child age-appropriate problem-solving options to complete a challenging task. A broader conceptualization of scaffolding has also incorporated parental support of child autonomy, as well as encouragement of child opinions and support of child choices (Matte-Gange & Bernier, 2011).

A growing body of research exploring each of these parenting dimensions, as well as others, provides evidence of both direct and indirect connections between parenting and the development of child EF. For instance, greater maternal sensitivity has been linked to higher child planning skills (Hackman, Gallop, Evans, & Farah, 2015) and lower parental report of EF problems on measures of inhibitory control, attention shifting, working memory, emotional control, and planning at age 4 years (Kok et al., 2014). Earlier assessment of maternal sensitivity, at 12 months, has been linked to higher global EF at age 2, assessed as a composite of inhibitory control, set shifting, and working memory skills (Bernier et al., 2010). Interestingly, this pattern of maternal sensitivity in infancy predicting greater global EF at age 2 has been noted to be especially pronounced among children who get a longer duration of sleep at night (Bernier, Belanger, Tarabulsy, Simard, & Carrier, 2014). This pattern suggests that the benefits of maternal sensitivity in cognitive development may be enhanced by better sleep hygiene.

Similar to maternal sensitivity, the social context in which scaffolding occurs also provides emotional and cognitive support that is conducive to bolstering emerging child EF skills. Scaffolding has broadly been tied to increases in incremental learning and, ultimately, to children's ability to independently engage in problem solving (Bibok, Carpendale, & Müller, 2009). More recently, maternal verbal scaffolding have been directly associated with child inhibitory control (Kahle, Grady, Miller, Lopez, & Hastings, 2017), and indirectly linked to child planning skills. These indirect connections are postulated to occur via maternal scaffolding that boosts children's own verbal skills and their self-directed speech. Specifically, children who receive high maternal verbal scaffolding are more efficient at guiding their own behaviors on tasks that assess planning and inhibitory control components of EF (Fernyhough & Fradley, 2005; Hammond, Muller, Carpendale, Bibok, & Liebermann-Finestone, 2012), as well as goal-directed play behaviors that require planning and complex sequencing skills (Landry, Miller-Loncar, Smith, & Swank, 2002).

Connections between maternal scaffolding and inhibitory control have also emerged in work assessing children of different temperamental styles. Both temperamentally inhibited and temperamentally exuberant children who experienced higher maternal scaffolding of attentional control at age 2 had higher levels of conflict EF at age 4 (Conway & Stifter, 2012). Additional work examining temporal aspects of scaffolding suggests that timing of this form of support matters for the early development of EF skills. Specifically, Bibok and colleagues (2009) found that among 2-year-olds, maternal elaborations that were contingent on the child's activity during a problem-solving task predicted more efficient use of children's attention-shifting skills.

Researchers who have aggregated the components of sensitivity and scaffolding within a parental responsiveness score found positive associations between early maternal responsiveness and later gains in child inhibitory control on both delay of gratification and conflict-based inhibitory control tasks (Merz, Harle, Noble, & McCall, 2016). The combination of these dimensions may provide a more expansive view of parenting influence, as sensitivity and scaffolding are usually elicited in distinct situations that a child may encounter (Bernier et al., 2010); that is, caregiving sensitivity is often elicited in situations of child distress and therefore helps prepare a child to engage more effectively with his or her social environment. In contrast, scaffolding is usually activated in situations of child exploration and supports reasoning and problem-based learning. Thus, assessment of both of these dimensions provides a wider view of the social context through which children can use explicit parental support to build foundational attentional abilities to shape later emerging EF skills. Inclusion of additional parenting dimensions may further expand our understanding in this area.

Although less studied than other parenting dimensions, recent work by Bernier and colleagues (2010) has explored a parenting dimension called *mind-mindedness,* which characterizes parental use of mental terms while talking to a child and indicates that specific verbal tools can aid a child in his or her efforts to self-regulate. In contrast to the sensitivity and scaffolding dimensions, which both represent what a caregiver does for a child, the use of mind-mindedness reflects what a caregiver says to a child in regard to the child's thoughts, desires, mental processes, and emotional engagement during a play sequence (Bernier et al., 2010). In the limited work that has examined mind-mindedness and EF, Bernier and colleagues have found that the associations between maternal mind-mindedness and child EF change across toddlerhood into the early preschool years. Specifically, higher use of maternal mind-mindedness at 12 months was associated with enhanced child working memory at 18 months. Interestingly, mind-mindedness did not directly predict later child EF skills, but it did predict change (increase) in an EF composite from 18 months to 2 years of age.

Remarkably, attachment is another aspect of parenting that has received relatively little research attention with regard to assessing connections between normative variations in attachment quality and EF development. Attachment is the preeminent measure of affective quality between a caregiver and a child, and a substantial body of longitudinal work demonstrates significant influence of attachment on child development over time (e.g., Sroufe, 2005). In particular, the reliability and safety experienced by a child within a secure attachment relationship is postulated to provide an optimal framework to develop foundational components of EF by allowing the child to internalize and integrate adaptive regulatory skills modeled by caregivers (Calkins, 2004; Lewis & Carpendale, 2009).

Empirical evidence demonstrating direct links between measures of attachment and EF skills is scarce; however, a handful of studies have indicated a positive connection between secure attachment ratings and child performance on tasks assessing inhibitory control, working memory, planning, and cognitive flexibility. For instance, secure attachment at 1 year of age has been linked to enhanced performance on a composite of EF skills at age 6 (Von der Lippe, Eilertsen, Hartmann, & Killen, 2010). Similarly, secure attachment assessed twice in toddlerhood (at 15 and 24 months) predicted better performance on an EF composite emphasizing inhibitory control and delay of gratification when children were 36 months of age (Bernier, Carlson, Deschenes, & Matte-Gagne, 2012). Importantly, this finding held when researchers controlled for other relevant factors, including child verbal ability, SES, and parenting behaviors, thus suggesting a unique role for attachment in promoting EF development in young children. Moreover, a follow-up study of these children confirmed the continuity of these associations; that is, early secure attachment was related to enhanced child performance in kindergarten for EF skills spanning inhibitory control, planning, and cognitive flexibility, as well as lower teacher ratings of global EF problems (Bernier, Beauchamp, Carlson, & Lalonde, 2015). Combined, these findings underscore a pivotal role for early secure attachment in supporting efficient EF development.

There are likely multiple mechanisms shaping the association between attachment and EF. One intriguing possibility is that the findings summarized earlier might be influenced by both attachment security and maternal EF skills, such that mothers with higher EF skills may be more efficient at providing a calm, reliable environment that is conducive to developing a secure mother–child attachment (Bernier et al., 2012). No work to date has been able to examine maternal EF as an antecedent of mother–child attachment; however, the strong correspondence found between maternal EF and child EF assessed in toddlerhood hints at a role for shared genetic characteristics (Cuevas et al., 2014). However, another possibility might be that mothers with high EF are more effective at transmitting EF skills to their children. It is also plausible that sensitivity, which plays an important role in promoting secure attachment, contributes to the facilitation of EF skills transfer between parent and child. Additional work is needed to assess potential relations among these processes concurrently and within a longitudinal perspective.

Although positive associations between secure attachment and emergence of EF in children contribute to a promising view of how optimal caregiving practices can adaptively shape children's cognitive skills, the converse pattern is also likely, such that poor attachment quality may negatively impact EF skills. Indeed, emerging evidence in typically developing children classified as insecurely attached suggests such a pattern, with lower-quality attachment style in early childhood (i.e., disorganized attachment) linked to poorer inhibitory control skills and increased risk of externalizing problems in middle childhood (Bohlin, Eninger, Brocki, & Thorell, 2012; Thorell, Rydell, & Bohlin, 2012). Along these lines, another body of research has examined attachment in relation to EF in the context of extreme early life adversity and presents both biological and behavioral evidence for poor EF outcomes in the face of extreme negative caregiving. This literature is discussed below.

Early Adversity, Caregiving, and EF

Along with the emphasis of parent–child interaction skills predicting EF, researchers have also focused on the role of the broader social environment in shaping individual differences in the emergence of EF skills in young children. Collectively, the previously covered relational elements of parenting are considered proximal levels of social influence on EF development in children; however, there are also distal levels of social influence to consider (Swanson et al., 2003). For instance, SES is a distal level of social influence that has a substantial impact on child brain development (e.g., McEwen & Gianaros, 2010; Noble, Norman, & Farah, 2005), with lower levels of SES linked to poorer performance on EF tasks (e.g., Mezzacappa, 2004; Raver, Blair, & Willoughby, 2013). Also well documented is that the PFC is a brain region substantially impacted by stress hormones (e.g., Arnsten, 2000), which makes performance on EF tasks an important index of the impact of stress on cognitive development in young children (Blair et al., 2011; Cerqueira, Mailliet, Almeida, Jay, & Sousa, 2007).

One way that chronic early adversity in the social environment impacts brain function underlying EF skills is via altered stress responding. Although flexible modulation of the cortisol response is beneficial for maintaining self-regulation, children who experience chronic stress frequently develop hyper- or hyporesponsiveness that interferes with the development of EF skills and increases risk of negative outcomes (see Gunnar & Quevedo, 2007, for a review).

Nevertheless, even among children exposed to chronic stress, individual differences in the ability to adaptively engage the cortisol response can be conducive to developing EF skills and potentially contribute to resilience in the face of adverse early-life circumstances. Indeed, a study of 5-year-olds from low incomes families who attended Head Start provides preliminary support for this notion. This study found that effective modulation of the stress response (characterized by an initial increase and subsequent down-regulation of cortisol) was shown to be positively associated with children's EF performance on inhibitory control and cognitive flexibility tasks, as well as teacher report of self-regulation in the classroom (Blair, Granger, & Razza, 2005).

Data from the large, longitudinal Family Life Project (FLP) indicate that among low-income families, elevated levels of cortisol across infancy are associated with lower EF performance at age 3 years. Interestingly, the influence of parenting on this association was a positive one: Children who exhibited more adaptive stress reactivity (the ability to effectively modulate cortisol) in infancy, and who experienced positive parenting, demonstrated higher EF (Blair et al., 2011). It is important to note that the assessment of positive parenting tapped into elements of high sensitivity and scaffolding, and the EF tasks spanned multiple components, including working memory, attention shifting, and inhibitory control. As such, these findings suggest that both emotional and cognitive support from parents may buffer children from the detrimental influence of poverty on the stress response and brain development. Since parental buffering can foster growth of EF skills, it is a highly relevant area for potential intervention, as stronger development of self-regulation has been implicated as a crucial factor in children's ability to cope with the multiple demands of chronic poverty in childhood (Evans & Kim, 2013).

Extreme early adversity, as in the case of child maltreatment, is similarly associated with reduced EF competence in childhood. Some of these difficulties can be pervasive, with certain EF skills enduring at lower levels among maltreated children compared to their typically developing peers, even after placement in an enriched caregiving environment. To date, work on maltreatment and EF in preschool-age children has primarily assessed individuals who experienced profound neglect during infancy in the form of institutionalized care. Among these children, the magnitude of EF impairment has been linked to the duration of neglect experienced (e.g., Colvert et al., 2008; Hostinar et al., 2012), with inhibitory control and working memory skills appearing especially vulnerable (Pollak et al., 2010). Furthermore, among children who experienced early institutional deprivation, the development of working memory skills has been shown to moderate risk for attention-deficit/hyperactivity disorder (ADHD) in later childhood (Tibu et al., 2016). These patterns of EF impairments align with neural work that demonstrates a lasting negative impact of early neglect on control regions of the brain as assessed by multiple imaging techniques, including event-related potentials (ERPs) (e.g., Loman et al., 2013), structural magnetic resonance imaging (Sheridan, Fox, Zeanah, McLaughlin, & Nelson, 2012), positron emission tomography (PET) (e.g., Chugani et al., 2001) and diffusion tensor imaging (DTI) (e.g., Eluvathingal et al., 2006). Jointly, these behavioral and neural findings underscore how vulnerable EF skills are to perturbations in the early caregiving environment (Garon et al., 2008; Merz et al., 2016).

Likewise, when children are removed from adverse caregiving experiences in the first few years of life, as in case of placing children who experienced institutionalized care in infancy into high-quality foster care, moderately better performance has been noted on certain EF tasks in middle childhood (Bos, Fox, Zeanah, & Nelson, 2009; McDermott, Westerlund, Zeanah, Nelson, & Fox, 2012). Similarly, patterns of improved neural functioning in children placed into high-quality foster care in early childhood indicates the potential to diminish differences in brain structure and function that may relate to the efficient emergence of EF skills (Sheridan et al., 2012; Vanderwert, Marshall, Nelson, Zeanah, & Fox, 2010; Vanderwert, Zeanah, Fox, & Nelson, 2016). As a whole, the work on extreme cases of early neglect highlights what a monumentally salient, experience-expectant process caregiving represents when considering development of EF skills and subsequent self-regulation (see Merz et al., 2016). This work also accentuates a potentially powerful, sensitive period in which interventions applied before age 2 may enhance chances of adaptive EF outcomes in children experiencing neglect in infancy.

Future Directions

Future investigation of antecedents of EF development may be particularly relevant to informing intervention work. One burgeoning area of exploration involves elucidating the role of fathers in the growth of EF in young children. Initial research indicates that the father's support of child autonomy via positive encouragement of active participation during problem-solving tasks is an important contributor to EF in young children because it provides opportunities for children to practice reflection and decision making. Meuwissen and Carlson (2015) found that fathers' autonomy support was related to a composite of EF when children were 3 years old. Importantly, this study assessed parenting during a play session between fathers and their preschool-age children, a context that may be particularly well suited to inducing cognitive stimulation in children through high-arousal play and evoking fathers' key parenting contributions to children's cognitive growth.

Similar positive patterns have emerged in father–child mutually responsive play/sensitivity during the toddler years and later emergence of inhibitory control (Bernier et al., 2012) and child EF assessed as a unitary construct in a low-income sample (Towe-Goodman et al., 2014). These studies embrace the perspective of fathers as coparents rather than helpers; therefore, they underscore more opportunities for caregiving influence on child EF growth than previously measured in EF work focusing solely on the role of maternal parenting practices. Recent longitudinal work also indicates that support of a father figure among young children in at-risk families has an enduring impact on child EF across the preschool to elementary school years (Meuwissen & Englund, 2016). Future studies that employ a range of EF measurements in both typical and at-risk families may shed light on ways that a whole-family intervention approach can better strengthen child self-regulation.

Another area of influence on EF development that is relevant for intervention work is early child care experiences outside of the home. Current findings, including work that indirectly assess EF function via measures of self-regulation or academic achievement, are mixed in respect to whether child care factors, such as quality or quantity of caregiving in these contexts, enhances or hinders development of EF. As such, recent work has attempted to elucidate the role of individual differences in child response to caregiving, with a particular emphasis on the child's stress system (Phillips, Fox, & Gunnar, 2011). The ultimate goal is to determine when and why children at risk can receive a boost in EF growth and self-regulation skills from out-of-home caregiving contexts. Indeed, work by Berry, Willoughby, Blair, Ursache, and Granger (2014) indicates that children with low levels of basal cortisol in toddlerhood, who spend a greater number of hours per week in child care, actually exhibit more efficient EF skills at age 4. This pattern suggests that the receptiveness of a child to benefit from child care may depend in part on a child's initial arousal levels. Among children who are low in basal levels of cortisol, the experience of a child care setting may raise these children to more optimal levels of arousal that support cognitive growth and EF development. These findings align with parenting studies exploring interactions between the responsiveness of a child's stress system and parental care under conditions of enhanced cumulative risk. Within this area of study, it remains to be determined whether fluctuating changes in poverty conditions across the first few years of life differentially impacts stress responsiveness and alter later emerging EF skills (e.g., Raver et al., 2013). However, additional research is needed to illuminate the unique roles of individual differences and distinct forms of stressors such as poverty, neglect, or parental mental health on the growth of attentional abilities and later EF skills, in order to determine when and how to intervene effectively.

Continued research to inform intervention programs may also be enriched by combining emerging knowledge of foundational attentional measures with the current understanding of how positive parenting practices may enhance EF. Since neural and behavioral plasticity is postulated to be stronger in younger children, and early intervention efforts have been noted to have a significant and lasting impact on brain development (Dawson, Ashman, & Carver, 2000; Wass, 2015), longitudinal work assessing cumulative effects of early intervention is needed to determine whether early support of foundational attentional abilities can prepare a child to use specified EF support at later time points more effectively.

Overall, tracking multiple measures of attention, EF skills and caregiving dimensions across time will be vastly important to hone in on which combinations most powerfully enhance EF among children in the highest risk contexts. Moreover, given increased vulnerability among boys to impoverished caregiving experiences and risk for disorders characterized by impaired EF (e.g., ADHD), it will also be crucial to track potential gender differences in responsivity to interventions supporting EF growth. Thus, an additional consequence of exploring early EF interventions may be the opportunity to note diagnostic risk markers (Hendry et al., 2016) that can help identify infants and toddlers most vulnerable to later problems with EF. Finally, it will be important to explore whether there are windows of opportunity in which certain factors are most effective for supporting different EF skills. With such a knowledge base, new approaches to EF intervention programs could dynamically adjust, from infancy through the preschool years, to provide long-term support to promote EF growth and sustain gains in self-regulation across early childhood.

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