

## From External Regulation to Self-Regulation: Early Parenting Precursors of Young Children's Executive Functioning

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In keeping with proposals emphasizing the role of early experience in infant brain development, this study investigated the prospective links between quality of parent–infant interactions and subsequent child executive functioning (EF), including working memory, impulse control, and set shifting. Maternal sensitivity, mind-mindedness and autonomy support were assessed when children were 12 to 15 months old ( $N = 80$ ). Child EF was assessed at 18 and 26 months. All three parenting dimensions were found to relate to child EF. Autonomy support was the strongest predictor of EF at each age, independent of general cognitive ability and maternal education. These findings add to previous results on child stress-response systems in suggesting that parent–child relationships may play an important role in children's developing self-regulatory capacities.

Growing interest has emerged for the hypothesis that early relational experiences are closely related to child neurocognitive development (e.g., Nelson & Bloom, 1997). In fact, the compelling link between quality of parent–child relationships and child cognitive development is often presumed to be due to the interplay between genetic factors and the social environment in shaping early brain development (De Bellis, 2001; Schore, 1996). One aspect of cognitive development that depends heavily on brain maturation is executive functioning (EF). This term refers to the set of higher order cognitive processes that underlie flexible goal-directed behaviors, such as inhibitory control, working memory, planning, and set shifting (Garon, Bryson, & Smith, 2008; Hughes, 2002; Miyake, Friedman,

Emerson, Witzki, & Howerter, 2000; Zelazo, Carter, Reznick, & Frye, 1997). While there is convincing evidence that variation within the normal range of EF has important implications for child social and cognitive functioning, research on the antecedents of individual differences in EF lags far behind. Based on the demonstrated experience-dependent maturation of the brain in infancy and on the close connections between EF and brain development (Zelazo, Carlson, & Kesek, 2008), this report examines the role of early parent–child relationships in the development of child EF.

### *EF in Children*

Owing to the close connections between EF and the slow-developing prefrontal cortex (Stuss & Benson, 1986), it was long believed that EF developed in adolescence only (e.g., Golden, 1981). It has since been demonstrated that EF develops much earlier and can be assessed at preschool age (e.g., Carlson, Mandell, & Williams, 2004; Diamond, Barnett, Thomas, & Munro, 2007; Hughes, Dunn, & White, 1998; Zelazo, Müller, Frye, & Marcovitch, 2003) or even toddlerhood (Carlson, 2005; Hughes & Ensor, 2005). In fact, some aspects of EF probably emerge

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as early as the end of the 1st year of life (Diamond & Goldman-Rakic, 1989), and individual differences assessed in toddlerhood are moderately stable into the preschool years (Carlson et al., 2004; Hughes & Ensor, 2007).

The feasibility of studying EF in children has led to the crucial finding that this set of self-regulatory processes shows meaningful variation within normally developing children of varying ages. One of the most robust findings is that EF is linked to children's theory of mind understanding concurrently, longitudinally, and cross-culturally (e.g., Carlson & Moses, 2001; Carlson et al., 2004; Chasiotis, Kiesling, Hofer, & Campos, 2006; Hughes & Ensor, 2005, 2007; Müller, Zelazo, & Imrisek, 2005; Perner, Lang, & Kloo, 2002; Sabbagh, Xu, Carlson, Moses, & Lee, 2006; Tardif, Wing-Chee So, & Kaciroti, 2007). Another set of findings indicates that EF is related to children's proficiency in mathematics and arithmetic (Blair & Razza, 2007; Bull & Scerif, 2001; Espy et al., 2004; van der Sluis, de Jong, & van der Leij, 2007). In addition, EF has been found to relate to reading ability (Clark, Prior, & Kinsella, 2002; van der Sluis et al., 2007), verbal and nonverbal reasoning (Carlson, Moses, & Breton, 2002; van der Sluis et al., 2007), academic achievement (Biederman et al., 2004; Kinsella et al., 1997), communication, and social skills (Clark et al., 2002), as well as social and moral competence (Kochanska, Murray, & Harlan, 2000; Kochanska, Murray, Jacques, Koenig, & Vandegest, 1996) and emotion regulation (Carlson & Wang, 2007; Simonds, Kieras, Rueda, & Rothbart, 2007).

Research has thus provided compelling support for the idea that individual differences in EF are meaningful for child cognitive and socioemotional functioning. This stands in sharp contrast to how little we know about the mechanisms that underlie the development of such individual differences. In light of the close connections between EF and frontal brain development (for a review, see Zelazo et al., 2008), and given the increasingly documented impact of environmental input on children's brain development (Chugani et al., 2001; Marshall & Fox, 2004), we propose that the study of early parent-child relationships is likely to be useful in understanding individual differences in children's EF.

#### *Parenting and Child EF*

It is increasingly believed that early environmental experiences have a direct impact on brain development (De Bellis, 2001; Gunnar, Fisher, & the

Early Experience, Stress and Prevention Network, 2006; Nelson, 2000). The first 2 years of life, especially, witness a spurt in brain growth characterized by overproduction of synapses (Nelson, Thomas, & de Haan, 2006). During this phase, experience is presumed to determine to a large degree which synaptic connections persist and which are selectively eliminated due to lack of use (Greenough & Black, 1992; Nelson & Bloom, 1997; Singer, 1995). General support for such an experience-dependent nature of brain development is provided by animal models (e.g., Gunnar et al., 2006; McEwen, 1999) as well as by the study of grossly inadequate environments, characterized by neglect or abuse (Chugani et al., 2001; Curtis & Cicchetti, 2007; De Bellis, 2001, 2005; Marshall & Fox, 2004; Rutter, O'Connor, & the English and Romanian Adoptee Study Team, 2004; Rutter and the ERA Research Team, 1998). These studies suggest that unfavorable environmental experiences are related to problematic brain development, on both structural (e.g., De Bellis, 2001) and functional levels (e.g., Rutter et al., 2004).

Conversely, it is proposed that favorable environmental experiences, especially those embedded within early caregiving relationships, may have a positive impact on brain development (Glaser, 2000; Nelson & Bloom, 1997; Schore, 1996, 2001). Reviewing studies on maternal care and neural development in animal populations, Francis and Meaney (1999) concluded that, "variations in maternal care that fall within the normal range . . . can still have a profound influence on development. One does not need to appeal to the more extreme conditions of abuse and neglect to see evidence for the importance of parental care" (pp. 132-133). Examining similar questions with human populations, Hane and Fox (2006) found that normative variation in quality of parenting among mother-infant dyads was related to different patterns of frontal electroencephalographic asymmetry in infancy. Hence, given its close connections to brain structures, early development of EF is one aspect of child cognitive development that appears likely to be susceptible to strong caregiving influences. According to Glaser (2000), the orderly development of the frontal lobes, strongly implicated in EF, is dependent on "appropriate input and sensitive interaction with the primary caregivers" (p. 101). Given that prefrontal cortex is a slow-developing area, with neural density of the frontal lobes beginning to decline at only about 7 years of age (Huttenlocher, 2002), there is indeed a large window of plasticity during which

caregiving can have a significant impact on the developing structures.

Similar claims are made at the functional level. For instance, Kopp (1982) suggested that early caregiving is a central mechanism in children's developing capacities for self-regulation, the hallmark of EF. In line with this, attachment researchers have often proposed that caregivers initially act as external regulators of the infant's rhythms and affect, gradually facilitating the child's increasing capacity to self-regulate (e.g., Grossmann & Grossmann, 1991; Hofer, 1995; Spangler, Schieche, Ilg, Maier, & Ackermann, 1994). This view is supported by several studies that found links between quality of care and child psychophysiological regulation (see Gunnar & Donzella, 2002, for a review). Parenting may thus be a crucial factor in the development of child EF. However, it may not be optimal to consider parenting as a unitary construct, as empirical research with both animal and human populations increasingly suggests that different dimensions of caregiving can have distinct contributions to child functioning (e.g., Hofer, 1996; Meins, Fernyhough, Fradley, & Tuckey, 2001; Moran, Forbes, Evans, Tarabulsky, & Madigan, 2008).

Carlson (2003) proposes three dimensions of parenting likely to favor the development of child EF: maternal sensitivity, scaffolding, and mind-mindedness. Sensitivity, which consists of appropriate and consistent responses to infants' signals, would provide them with successful experiences of impacting the social environment. Scaffolding, that is, offering children age-appropriate problem-solving strategies, is likely to yield successful experiences of problem-based learning. Finally, mind-mindedness, or the parent's tendency to use mental terms while talking to the child, is thought to offer children verbal tools with which to progress from being externally regulated to self-regulated. Hence, these three parental behaviors represent ways in which caregivers act as external regulators, which according to Harrist and Waugh (2002), serves to help children become gradually more self-regulating away from caregivers. However, each behavior also has distinctive features, and hence possibly distinct contributions to child EF. Sensitivity and scaffolding refer to what the mother does, while mind-mindedness refers to what she says to the child about inner states, and sensitivity and scaffolding are likely to be activated in distinct situations, that is, contexts of personal distress versus exploration, respectively.

### *The Present Study*

Although animal studies have documented the impact of parental care on the development of prefrontal systems (Gunnar et al., 2006), human research is limited, pertaining mostly to highly inadequate caregiving. Accordingly, the main purpose of this report was to examine the prospective links between quality of early mother-infant interactions and child subsequent EF in a normative population. The measurement of mother-infant interactions proceeded along the three dimensions proposed by Carlson (2003): We assessed maternal sensitivity and mind-mindedness at 12 months and maternal autonomy-support, including scaffolding, at 15 months. Child EF was assessed at 18 and 26 months. It was expected that more favorable parenting, indicated by higher sensitivity, more mind-minded comments, and greater autonomy support during mother-infant interactions, would be associated with better child performance on EF tasks at both 18 and 26 months of age, above and beyond parental education and child cognitive functioning. A secondary aim was to continue the recent line of work that has allowed for reliable measurement of EF at increasingly younger ages (Carlson, 2005; Hughes & Ensor, 2005). Hence, while the timing of the second assessment was based on the fact that validated measures of EF start at 2 years of age, the first assessment was planned 6 months before this age to examine the feasibility of assessing earlier manifestations of EF. We thus developed EF tasks for 18-month-olds and examined their capacity to detect individual differences, as well as continuity between child performance at 18 and 26 months of age.

## **Method**

### *Participants*

Eighty middle-class mother-infant dyads (44 girls and 36 boys) living in a large Canadian metropolitan area participated in this study. Families were recruited from birth lists provided by the Ministry of Health and Social Services. Criteria for participation were full-term pregnancy and the absence of any known physical or mental disability or severe developmental delay in the infant. Family income varied from less than \$20,000 CDN to over \$100,000 CDN, with an average of \$70,000 CDN. Mothers were between 19 and 44 years old ( $M = 29.4$ ). Most (78.8%) had a college degree and 81.3% were Caucasian. All but seven were married

or living with the child's father throughout data collection.

### Procedure

The dyads took part in four visits, when the child was 12–13 (T1;  $M = 12.9$ ), 15 (T2;  $M = 15.5$ ), 18 (T3;  $M = 18.3$ ), and 26 (T4;  $M = 26.3$ ) months of age. Home visits were conducted at T1, T2, and T4, while T3 consisted of a laboratory visit. All visits lasted between 70 and 90 min. The first home visit was modeled after the work of Pederson and Moran (1995), and aimed at challenging the mother's capacity to divide her attention between several competing demands, thus reproducing the natural conditions of daily life when caring for an infant. Research tasks included a developmental assessment (the Bayley scales), a brief interview with the mother, a 10-min videotaped mother–infant free play, and questionnaires that mothers had to complete while the infant was *not* looked after or kept busy by the research assistants. Maternal sensitivity was assessed with the Maternal Behavior Q-Sort (MBQS; see below) based on observations made throughout this visit, and mind-mindedness was later coded from the videotaped play interaction. The second home visit was similar in length and structure to the first one. Mothers were asked to help their children complete two puzzles that were designed to be slightly too difficult for the infants, such that they would require some adult assistance to complete them. This interaction was videotaped and later coded for maternal autonomy-supportive behaviors. Other activities included an interview with the mother, free play, and questionnaires. The third visit took place in the laboratory. The EF tasks described below were administered, along with other child and dyadic activities not used in the present study. Finally, the fourth visit took place in the families' homes. Most of the visit consisted of the administration of the EF tasks described below, along with other child and dyadic activities not included in this report.

### Measures

#### Parenting

*Maternal sensitivity.* Maternal sensitivity was assessed using the MBQS (Pederson & Moran, 1995), a 90-item measure designed to assess the quality of maternal behaviors during in-home mother–infant interactions. The observer noted

maternal behaviors throughout the visit and rated the MBQS immediately afterward based on the entire observation period. Items describing potential maternal behaviors are sorted into nine clusters, ranging from very similar to very unlike the observed mother's behaviors. The observer's sort is then correlated with a criterion sort representing the prototypically sensitive mother, which is provided by the developers of the instrument. Sensitivity scores thus vary from  $-1$  (*least sensitive*) to  $1$  (*prototypically sensitive*).

The development of the MBQS is anchored in attachment theory and specifically in the descriptions of sensitive responsiveness provided by Ainsworth, Bell, and Stayton (1974). Pederson and colleagues (Pederson, Gleason, Moran, & Bento, 1998; Pederson & Moran, 1995; Pederson et al., 1990) have presented detailed descriptions regarding the development of the MBQS, as well as its validity and reliability. These authors' longitudinal studies show that the MBQS is useful in predicting multiple aspects of infant development. Moreover, the MBQS is significantly correlated with other assessments of maternal behavior, such as the Home Observation for Measurement of the Environment Inventory and the Ainsworth scales (see Pederson & Moran, 1995).

Previously trained home visitors performed their first few home visits with a more experienced colleague, and these visits were followed by a debriefing session aimed at reviewing the salient elements of the visit before scoring the MBQS. Following this training period, 25 home visits (31%) were conducted by two research assistants, who completed the MBQS independently. Agreement between the two raters' sorts was high, intraclass correlation (ICC) = .89.

*Maternal mind-mindedness* was assessed through a 10-min free-play sequence between mother and infant, in which the mother was instructed to play as she normally would, but with toys that were brought by the research team. Videotaped interactions were later coded by a trained assistant using Meins et al.'s (2001) coding system. Five categories of comments were assessed: (a) on the infant's mental state, such as thoughts, desires, knowledge (e.g., "You want this book"); (b) on mental processes (e.g., "You find this game difficult"); (c) on the infant's emotional engagement (e.g., "You had enough"); (d) on the infant's attempts to manipulate other people's thoughts (e.g., "You're making fun of me"); and (e) comments that involved the mother speaking for the infant (e.g., "See mom, it's

easier this way"). Each comment was then coded as appropriate or inappropriate according to Meins et al.'s guidelines. The number of appropriate comments in each category were summed into a total score, which is used in all subsequent analyses.

A randomly selected 42.5% ( $n = 34$ ) of videotapes were independently coded by a second trained rater. Interrater reliability was satisfactory,  $ICC = .89$ . Mind-mindedness has good convergent and predictive validity with measures of maternal sensitivity, mother-child attachment security, and child theory of mind understanding (Meins et al., 2001; Meins et al., 2002).

*Maternal autonomy support.* The notion of autonomy-support stems from Self-Determination Theory and refers to parental behaviors aimed at supporting children's goals, choices, and sense of volition (Grolnick & Ryan, 1989). Mother-infant dyads were asked to complete a challenging problem-solving task (two puzzles) together during a second home visit when the child was 15 months of age. Following the Grolnick, Frodi, and Bridges (1984) rating system, maternal behaviors were coded along two scales: verbal and nonverbal behaviors. In the current study, we further divided these scales into four categories reflecting the specific behaviors that constitute autonomy-support (Grolnick, Gurland, DeCoursey, & Jacob, 2002). The four Likert scales assess the extent (1–5) to which the mother (a) intervenes according to the infant's needs and adapts the task to create an optimal challenge (equivalent to scaffolding); (b) encourages her child in the pursuit of the task, gives useful hints and suggestions, and uses a tone of voice that communicates to the child that she is there to help; (c) takes her child's perspective and demonstrates flexibility in her attempts to keep the child on task; and (d) follows her child's pace, provides the child with the opportunity to make choices, and ensures that the child plays an active role in the completion of the task. Given the intercorrelations among the four scales (ranging from .51 to .82), they were averaged into a total autonomy support score ( $\alpha = .89$ ). All videotapes were coded by the third author of this report, and 38 of the 80 (47.5%) interactions were independently coded by a second observer. ICC between coders for the total autonomy-support score showed excellent interrater agreement,  $ICC = .86$ .

#### *Child EF: 18-Month Assessment*

The earliest measurement guidelines currently available to assess EF start at 24 months (Carlson,

2005). However, neuropsychological testing suggests that certain aspects of executive functions begin to develop earlier, notably rule use and working memory. We thus developed two downward adaptations of EF tasks originally designed for 2-year-old children.

*Hide the Pots* (adapted from Hughes & Ensor, 2005 [*Spin the Pots*]; see also Uzgiris & Hunt, 1975 [*Scale I, Search for Hidden Objects*]). An attractive sticker was hidden in full sight of the child under one of three opaque pots of different colors. In the warm-up phase, no further action took place, and the child was immediately asked to retrieve the sticker where it was hidden. Three practice trials were conducted (one with each pot). This phase was intended to introduce children to what was expected. In the second phase, the experimenter also hid the sticker once under each pot, but the pots were covered with a blanket before the child was invited to find the sticker on each trial. The child thus had to hold the location of the sticker in memory, remove the blanket, and reach for the pot where the sticker was hidden. Scores consisted of the number of trials (0–3) where the child found the sticker on his or her first attempt.

*Categorization* (adapted from Carlson et al., 2004). We used only the first phase of the original reverse categorization task, because the reverse phase was found to be difficult even for older toddlers (Carlson, 2005). Children were taught a categorization rule whereby baby animals were sorted together in the "baby box," whereas adult animals were placed into the "mommy box." The experimenter used the first six animals (three adults and three babies) to show the child how to sort the toys, and then asked the child to sort the six remaining ones. As many children placed all six animals together in one box (and thus got three "correct" answers by accident), the score was computed as the number of dyads (e.g., mother and baby zebra) that were correctly sorted separately by the child (0–3).

#### *Child EF: 26-Month Assessment*

The tasks conducted at 26 months were chosen based on Carlson's (2005) measurement guidelines with the aim of maximizing detection of individual differences in three dimensions of EF: working memory, inhibitory control, and set shifting.

*Spin the Pots* (Hughes & Ensor, 2005). Children were asked to search for stickers that were hidden in opaque pots, subsequently covered and rotated. Six stickers and eight pots of very different visual

appearances were used. Each time a sticker was found, the pots were covered and rotated again. The score was calculated as 16 minus the number of errors made (i.e., looking under a pot in which no sticker had been hidden or perseverative looking).

*Delay of Gratification* (Kochanska et al., 2000). The experimenter placed a present under a transparent cup and asked children to wait until she rang a bell before retrieving it. Four trials were conducted, where the child had to wait 5, 10, 15, and then 20 s. Scores were the number of seconds waited on each trial.

*Shape Stroop* (Kochanska et al., 2000). Children were first shown six cards depicting three small and three large fruits, and were asked to point to each in turn to ensure they knew the names and sizes of the fruits (e.g., "Show me the big apple"). They were then shown three cards each depicting one of the small fruits embedded in one of the larger ones, and asked to point to each of the small fruits in turn (e.g., "Show me the *small* banana"). The score consisted of the number (0–3) of small fruits correctly pointed to.

*Baby Stroop* (adapted from Hughes & Ensor, 2005). Children learned a rule for feeding two dolls, feeding the "mommy" doll with a larger spoon and the baby doll with a smaller spoon. As soon as the child clearly understood the rule, it was reversed such that the larger doll had to be fed with the smaller spoon, and vice versa. Scores thus ranged from 0 to 2.

At both T3 and T4, administration of the EF tasks was videotaped for later coding. Because we were interested in individual differences rather than group patterns, EF tasks were administered in fixed order.

### Child Cognitive Ability

In order to tap into what is unique to EF beyond general cognitive functioning, we used the Mental Development Index of the Bayley Scales of Infant Development (MDI; Bayley, 1993) at 12 months. The MDI is a well-standardized test of cognitive development for children aged 1–42 months, which shows predictive validity with respect to later verbal and cognitive performance (e.g., Lemelin, Tarabulsky, & Provost, 2006). A total of 23 protocols (29%) were double-coded by independent raters (using the video recording of the administration). ICC between raters' MDI scores suggested good reliability, ICC = .85.

## Results

### Preliminary Analyses

Table 1 presents descriptive statistics for all parenting and EF variables. The three parenting variables showed excellent variability (note that sample size varies slightly due to technical difficulties with certain videotapes). EF tasks also showed adequate

Table 1  
Mean, Standard Deviation, and Range for All Parenting and Executive Functioning (EF) Measures

Variable	N	Mean	Standard deviation	Observed range	Theoretical range
Parenting					
Maternal sensitivity	80	0.59	0.33	-0.60 to +0.86	-1.0 to +1.0
Maternal mind-mindedness	74	14.58	8.71	0–39	0–N/A
Maternal autonomy support	77	3.28	1.13	1–5	1–5
Child EF 18 months					
Hide the Pots	80	1.22	0.91	0–3	0–3
Categorization	80	0.61	1.17	0–2	0–3
Child EF 26 months					
5-s delay	80	4.67	0.95	0–5	0–5
10-s delay	80	8.99	2.36	0–10	0–10
15-s delay	80	11.64	5.17	1–15	0–15
20-s delay	80	14.08	7.78	1–20	0–20
Spin the Pots	80	10.45	3.41	4–16	4–16
Shape Stroop	80	1.50	1.19	0–3	0–3
Baby Stroop	80	0.37	0.66	0–2	0–2

variability, although Categorization at 18 months and Baby Stroop at 26 months were negatively skewed, whereas the 5- and 10-s Delay of Gratification trials were positively skewed.

The two EF tasks at 18 months of age were unrelated to one another,  $r = .11$ , *ns*. These tasks were thus considered separately in all subsequent analyses. Table 2 shows the intercorrelations between EF scores at 26 months. In line with previous studies of EF in toddlers (e.g., Carlson et al., 2004; Hughes & Ensor, 2005), scores were mildly to moderately correlated. They were submitted to a principal component analysis, which yielded a two-factor solution (Eigen values > 1.0) representing 64.7% of the total variance. These two factors were submitted to a principal axis rotation (oblimin). Factor loadings for 10-s delay (.85), 5-s delay (.83), 15-s delay (.79), and 20-s delay (.71) suggest that the first factor taps impulse control, whereas the second factor appears to represent working memory, set shifting, and inhibitory control (Conflict EF): Spin the Pots (.82), Baby Stroop (.67), and Shape Stroop (.59). No cross-loadings (above .25) were observed, and the correlation between the two factors was .32. Given that the factor structure was very clear empirically and reproduced the two dimensions of Impulse Control and Conflict previously identified with young children (Carlson & Moses, 2001; Carlson et al., 2004), two averaged standardized scores were computed and used in further analyses. Impulse Control and Conflict were moderately correlated,  $r = .28$ ,  $p < .05$ .

We next examined whether sociodemographic variables (child gender, number of siblings, maternal and paternal age and education, and family income) or child cognitive ability were related to EF performance at 18 and 26 months of age. Two

relations reached significance at 18 months: Children of more educated mothers ( $r = .22$ ,  $p < .05$ ) and children who had higher mental development scores on the Bayley ( $r = .24$ ,  $p < .05$ ) performed better on Hide the Pots. Maternal education and child overall cognitive functioning (Bayley scores;  $r = .17$ ,  $p < .10$ ) were thus used as covariates in all further analyses pertaining to EF at 18 months. The analyses revealed no significant associations between the two EF dimensions at 26 months and sociodemographics (all  $r$ s < .18,  $p$ s > .10). However, child cognitive functioning was positively related to both EF dimensions: Impulse Control ( $r = .28$ ,  $p < .05$ ) and Conflict EF ( $r = .25$ ,  $p < .05$ ). We thus covaried cognitive functioning in all subsequent analyses involving EF at 26 months. Age was unrelated to EF performance, which was expected given the restricted age range at each time point. Child age was therefore not retained as a covariate in the main analyses.

In line with their definitions as distinct aspects of one global construct, the three parenting dimensions were mildly intercorrelated: sensitivity and mind-mindedness ( $r = .36$ ,  $p < .01$ ), sensitivity and autonomy support ( $r = .26$ ,  $p < .05$ ), and mind-mindedness and autonomy support ( $r = .38$ ,  $p < .01$ ). These three dimensions were thus retained as separate scores.

### Main Analyses

We first examined whether our adaptations of tasks for 18-month-olds tapped into early manifestations of EF by examining longitudinal stability at 18 and 26 months of age. The results showed that Hide the Pots at 18 months was related to both EF dimensions at 26 months (Impulse Control:  $r = .28$ ,  $p < .05$ ; Conflict:  $r = .25$ ,  $p < .05$ ), while Categorization was associated with later performance on Conflict only,  $r = .24$ ,  $p < .05$ .

Table 3 presents the bivariate correlations between the three parenting dimensions and child performance on the two EF tasks at 18 months, as well as the partial correlations when accounting for maternal education and child cognitive functioning. Results indicated that child performance on Hide the Pots was related to all three parenting dimensions, but marginally so in the case of maternal sensitivity. Categorization was related to autonomy support. As expected, relations were positive in all cases.

We next examined relations between the parenting dimensions and child performance on the two EF dimensions at 26 months. Table 4 presents

Table 2  
Intercorrelations Among Executive Functioning Scores at 26 Months

	10 s	15 s	20 s	Spin the Pots	Shape Stroop	Baby Stroop
5 s	.59***	.51***	.28*	.06	.22 <sup>†</sup>	.10
10 s	1.00	.60***	.50***	.03	.19	.09
15 s		1.00	.63***	.11	.21 <sup>†</sup>	.10
20 s			1.00	.24*	.28*	.12
Spin the Pots				1.00	.33**	.22 <sup>†</sup>
Shape Stroop					1.00	.19
Baby Stroop						1.00

Note. 5 s = 5-s delay; 10 s = 10-s delay; 15 s = 15-s delay; 20 s = 20-s delay.

<sup>†</sup> $p < .10$ . \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Table 3  
Bivariate (and Partial) Correlations Between the Three Parenting Dimensions and Child Performance on the Two EF Tasks at 18 months

EF task	Maternal sensitivity	Maternal mind-mindedness	Maternal autonomy support
Hide the Pots	.20 <sup>†</sup> (.18)	.35** (.33**)	.38** (.39**)
Categorization	.08 (.15)	.04 (.04)	.25* (.30*)

Note. Numbers vary between 74 (mind-mindedness) and 80 (sensitivity). Partial correlations while controlling for maternal education and child cognitive functioning are shown in parentheses. EF = executive functioning.

<sup>†</sup> $p < .10$ . \* $p < .05$ . \*\* $p < .01$ .

Table 4  
Bivariate (and Partial) Correlations Between the Three Parenting Dimensions and Child Performance on the Two EF Dimensions at 26 Months

EF dimension	Maternal sensitivity	Maternal mind-mindedness	Maternal autonomy support
Impulse Control	.07 (.03)	.22 <sup>†</sup> (.19)	.13 (.10)
Conflict	.25* (.26*)	.23 <sup>†</sup> (.18)	.31* (.32*)

Note. Numbers vary between 74 (mind-mindedness) and 80 (sensitivity). Partial correlations while controlling for child cognitive functioning are shown in parentheses. EF = executive functioning.

<sup>†</sup> $p < .10$ . \* $p < .05$ .

the bivariate correlations as well as the partial correlations when holding child cognitive functioning constant. All three parenting dimensions predicted later Conflict EF (although the relation with mind-mindedness was marginally significant only). Impulse Control was marginally related to maternal mind-mindedness, but this relation became nonsignificant when accounting for child cognitive functioning.

In summary, autonomy support was found to relate to three of four EF measures, that is, both 18-month tasks and Conflict at 26 months. In all cases, these relations held when controlling for potential confounds that were measured. Maternal sensitivity was associated with Conflict at 26 months and tended to relate to Hide the Pots at 18 months, although this latter relation became nonsignificant when controlling for potential confounds. Finally, mind-mindedness was significantly related to Hide the Pots at 18 months and marginally associated with both EF dimensions at 26 months, but these two latter associations did not hold over and above shared variance due to child cognitive functioning.

Table 5  
Summary of Regression Analyses Predicting Child Performance on Hide the Pots at 18 Months

Block	R <sup>2</sup>	ΔR <sup>2</sup>	F change	β
1. Maternal education				.16
Child cognitive functioning	6.4%	6.4%	1.78*	.18
2. Maternal education				.04
Child cognitive functioning				.10
Autonomy support				.35*
Mind-mindedness	23.9%	17.5%	5.77**	.15

Note. N = 74.

\* $p < .05$ . \*\* $p < .01$ .

Note that in all cases where either maternal sensitivity or mind-mindedness related significantly to child EF, autonomy support related to the same EF index. We thus ran regression analyses to decipher the common and unique contributions of each parenting dimension to the variance in indices of EF that related to more than one parenting dimension (i.e., Hide the Pots at 18 months and Conflict EF at 26 months). Only those control and parenting variables that were significantly related to the EF index of interest were entered in each regression equation. Table 5 presents the results of the first hierarchical regression analysis predicting child performance on Hide the Pots. Maternal education and child cognitive functioning were entered in a first block, followed by mind-mindedness and autonomy support in a second block. Table 5 shows that the model predicted 23.9% of the variance in Hide the Pots,  $F(4, 74) = 3.65$ ,  $p < .01$ , with parenting contributing a unique 17.5% ( $p < .01$ ) over and above what is explained by maternal education and child cognitive functioning. The regression coefficients indicate that while autonomy support was uniquely related to child performance on Hide the Pots when mind-mindedness was accounted for ( $\beta = .35$ ,  $p < .05$ ), mind-mindedness did not relate to Hide the Pots when autonomy support was accounted for ( $\beta = .15$ , *ns*). Note that this pattern of results is consistent with statistical mediation; we return to this in the Discussion.

Table 6 presents the results of the second hierarchical regression analysis with Conflict EF at 26 months as the dependent variable. Child cognitive functioning was entered in a first block, followed by maternal sensitivity and autonomy support in a second block. The overall model was significant,  $F(3, 77) = 2.89$ ,  $p < .05$ , explaining 16.4% of the variance of child performance on Conflict. A unique 10.1% ( $p < .05$ ) was explained by parenting above and beyond child cognitive functioning.

Table 6  
 Summary of Regression Analyses Predicting Child Performance on Conflict EF at 26 Months

Block	R <sup>2</sup>	ΔR <sup>2</sup>	F change	β
1. Child cognitive functioning	6.3%	6.3%	3.11*	.25*
2. Child cognitive functioning Autonomy support				.19 .25*
Sensitivity	16.4%	10.1%	3.59*	.14

Note. *N* = 77. EF = executive functioning.

\**p* < .05.

Quite similar to what was found with Hide the Pots, only autonomy support remained uniquely related to Conflict in the final model ( $\beta = .25$ ,  $p < .05$ ).

In a last step of this analysis, we examined whether parenting predicted EF at 26 months over and above stability in EF between 18 and 26 months. Given its clearer connections to EF at 26 months, we used Hide the Pots as the baseline 18-month EF index. Two regression analyses were conducted, one on Conflict as the dependent variable and one on Impulse Control. Each equation consisted of 18-month Hide the Pots and child cognitive functioning in a first block, followed by all three parenting dimensions in a second block. Analyses revealed that parenting did not contribute to changes in Impulse Control (4.3%, *ns*) but marginally predicted Conflict after accounting for longitudinal stability between 18 and 26 months and child cognitive functioning, 12.4% ( $p < .10$ ). Contrary to expectations, however, this trend was not attributable to autonomy support ( $\beta = .16$ , *ns*) or sensitivity ( $\beta = .10$ , *ns*), but rather to mind-mindedness ( $\beta = .32$ ,  $p < .05$ ). Hence, while autonomy support was related to EF at both 18 and 26 months, mind-mindedness better explained increases in child performance between these two ages.

### Discussion

The main purpose of this study was to investigate the prospective links between quality of parent–infant interactions and subsequent child EF. It was expected that higher quality parenting would predict better child EF performance at both short-term (3–6 months) and long-term (14 months) follow-ups. The results lend general support to this hypothesis. We found that mothers who were more sensitive with their 12-month-old child had children performing better on Conflict EF at 26 months. Their children also tended to perform better on

working memory at 18 months, but this trend did not hold above the controls. Children whose mothers were more mind-minded when they were 12 months old performed better on working memory at 18 months, and tended to perform better on both Conflict and Impulse Control at 26 months, although these two latter trends did not hold when controlling for child cognitive functioning. However, mind-mindedness was related to changes in child performance between 18 and 26 months. Finally, mothers who were more autonomy supportive when their child was 15 months of age had children performing better on working memory and categorization at 18 months as well as on Conflict EF at 26 months. These latter findings held up over the controls.

These results provide support for the assumption that caregiving is involved in children's developing self-regulatory abilities (Hofer, 1995; Kopp, 1982) and suggest that the influence of parenting on the development of children's self-regulation can be observed not only on psychophysiological dimensions (Gunnar & Donzella, 2002) but also in the behavioral and cognitive domains. It remains to be seen whether the results found here suggest that early caregiving impacts brain structures involved in EF or indicate that parenting provides the child with the social context in which to practice emerging regulatory skills. These two possibilities, however, are not mutually exclusive and in fact, it is likely that a transactional process involving both is at play. It has been argued (e.g., Kraemer, 1992) that the effects of early caregiving on brain development, observed in animal studies and samples of maltreated children, may be observable also with normally developing infants. Such an influence could be attributable to the impact of parenting on child stress-response systems (Gunnar et al., 2006). The ensuing orderly development of frontal brain areas would favor the emergence of executive functions, allowing the child to regulate behavior more effectively at an early age. This emerging self-regulation may contribute to the maintenance of harmonious parent–infant interactions, in turn providing the child with a context favorable to increased self-regulation and possibly contributing further to brain development. Hence, early parenting may impact the process both by affecting the child's developing neurobiological structures and through the social environment provided to the child, and bidirectional effects between parenting and child EF are likely.

This is among the first studies to document links between early parent–child relationships and later

child EF. In fact, extremely little is known about any antecedents of child EF, besides intrinsic factors such as child cognitive functioning (e.g., Carlson et al., 2004; Hughes & Ensor, 2005) and more distal factors such as socioeconomic status (SES; e.g., Mezzacappa, 2004). Hughes and Ensor (2005) examined relational factors and found that although quality of parenting was positively related to child EF in 2-year-olds, this relation did not hold after accounting for child age and verbal ability. The difference in results between their study and ours is particularly intriguing given that in both studies, great care went into the assessment of parenting, using both live observation and videotaped interactions in a variety of contexts, and multi faceted coding systems. In addition, our prospective design constituted a stringent test, making shared method variance especially unlikely to inflate the results. One explanation for the discrepant findings may relate to the nature of the samples: While our sample was predominantly middle-class, most families in Hughes and Ensor's sample were from lower SES backgrounds. Growing evidence suggests that the impact of caregiving on child outcomes may vary according to the social conditions of the dyad (see, e.g., Bernier and Meins's, 2008, analysis of parenting and attachment in low- vs. high-risk samples). One may speculate that in certain low-SES families, factors such as family chaos or parenting stress may limit the opportunities for joint cognitive activity, while the presumably lower stress experienced by middle-class families may leave more room for competent caregiving to foster development of the child's neural structures and self-regulatory capacities.

The clearest finding from this study is that autonomy support is the aspect of parenting that was most robustly related to age-specific indices of child EF. Autonomy support consists mainly of scaffolding, respecting the child's rhythm, and ensuring that he or she plays an active role in successful completion of the task. One can easily see how this set of behaviors is likely to provide the child with a sense of accomplishment and self-efficacy (cf. Bandura, 1997). That autonomy support would favor the emergence of child EF thus appears sensible, and we would argue that this is likely to be a robust finding. As well, it is possible that the autonomy support measure, which involved externally guided problem solving, provided a more direct contribution than other parenting qualities to self-guided problem solving that was required on the EF tasks administered later. In fact, our results complement the large literature on

scaffolding, a key aspect of autonomy support, which has often been found to impact other aspects of child cognitive development such as language and problem-solving competence (e.g., Landry, Garner, Swank, & Baldwin, 1996; Landry, Smith, Swank, & Miller-Loncar, 2000).

In terms of the respective contributions of the different indices of parenting, however, one needs to take into account the methodological parameters of this study before drawing firm conclusions. Our results would appear to suggest that autonomy support not only relates more consistently to child EF than maternal sensitivity and mind-mindedness but also that it is responsible for most links found between child EF and either sensitivity or mind-mindedness. Recall that the regression analyses revealed that when two parenting dimensions were entered concurrently to predict an age-specific aspect of child EF, we did not find additive contributions, but rather that autonomy support remained the only significant predictor when either sensitivity or mind-mindedness was accounted for. A possible explanation is that this pattern of results, consistent with a statistical mediation, does indeed reflect true mediation. It stands to reason that a mother who is skilled at interpreting her child's signals correctly and responding appropriately (sensitivity), or is well aware of her child's mental processes while interacting with him or her (mind-mindedness), is well equipped to provide the child with an autonomy-supportive environment characterized by appropriate scaffolding, perspective taking, and respect for the child's rhythm in problem solving. However, the design of the current study does not permit us to rule out an alternative, methodological explanation. Autonomy support was assessed closer in time to EF than sensitivity and mind-mindedness (at 15 months vs. 12 months). Thus, the fact that autonomy support appeared to mediate the relations between sensitivity or mind-mindedness and child EF might also be attributable to different degrees of temporal proximity.

When predicting increments in EF performance, we found a slightly different picture: Mind-mindedness remained the only significant predictor of 26-month Conflict EF after accounting for child cognitive functioning, 18-month EF, and the other parenting indices. Combined with the finding that autonomy-support is related to both 18- and 26-month EF performance, this suggests that while autonomy support accounts for stability in EF performance, mind-mindedness rather accounts for changes between these two age periods. However, given that regression coefficients can be quite

sensitive to the inclusion of correlated predictors in the equation, one should probably interpret the findings cautiously. While these analyses reaffirm the role of parenting in the *development* of EF through an especially stringent test, they also highlight the need for replication in larger samples before drawing firm conclusions on the role of specific aspects of parenting in changes and stability in EF. Similarly, given that part of what is observed with the Bayley scales may be presumed to be executive in nature, one may speculate that the analyses controlling for the MDI may actually be underestimating the predictions from parenting variables.

Nonetheless, the findings with mind-mindedness appear to suggest that parent attunement and talk about the child's mental states can build on basic levels of EF that were created, in part, by autonomy-supportive parental behavior, and give the child verbal tools to expand further on emerging regulatory abilities. This is speculative however, and teasing apart the true contributions of distinct aspects of caregiving to the development of child EF will necessitate assessment of different parenting indicators under methodologically equivalent conditions (including delay with subsequent assessment of EF). As well, research with higher risk samples may yield more variation in the lower spectrum of all three caregiving indicators, thus providing more power to detect links to child EF.

An important connection to previous research concerns the concept of effortful control (Blair & Razza, 2007; Kochanska et al., 1996; Kochanska et al., 2000; Rueda, Posner, & Rothbart, 2005). Whereas EF has its origins in neuropsychological research, effortful control refers to temperamentally based differences in the control of attention (Rothbart, 1989). Based on previous work suggesting that Kochanska's tasks provided excellent measurement of individual differences in EF (Carlson, 2005), we used some of those procedures at 26 months. Using a battery of effortful control tasks at 22 and 33 months, Kochanska et al. (2000) found that maternal responsiveness at 22 months, but not at 9 nor 14 months, was related to child effortful control at both 22 and 33 months. Our research shares comparable findings, suggesting that parenting assessed between 9 and 15 months does not relate to impulse control (this study) or effortful control (Kochanska et al., 2000). However, Kochanska et al.'s positive findings with responsiveness assessed at 22 months suggest that this may change as the child gets older or, again, that more proximal measurement points are more strongly related. More longitudinal studies of parenting are needed

to shed light on concurrent and prospective links between parenting and child EF at different ages. Furthermore, and in line with recent research, one might speculate that caregiving and child temperament interact in influencing the development of certain aspects of EF (see Crockenberg & Leerkes, 2006; Kochanska, Aksan, & Joy, 2007, for recent examples of such moderating influences on other child outcomes).

A secondary aim of this study was to develop EF measures for younger age groups. We simplified tasks originally designed for 24-month-olds and examined their capacity to detect variation as well as their relations to validated measures at 26 months and to parenting. Despite their low intercorrelation, both 18-month tasks (Hide the Pots and Categorization) were found to be positively related to Conflict at 26 months, and Hide the Pots was associated with later Impulse Control as well. The magnitude of these longitudinal links was similar to that reported by Hughes and Ensor (2007) between 2 and 3 years of age. This tentatively suggests that both tasks may be valid assessments of early manifestations of EF. However, one may also argue that Hide the Pots is more valid than the sorting task, given that it showed more variability, clearer connections to 26-month tasks, and more compelling links with parenting. Overall, the current adaptation of Spin the Pots can reasonably be considered as a useful first step in developing EF measures for 18-month-olds, but more research is needed before one can confidently conclude that either of our 18-month tasks can be used by itself as an indicator of early EF.

This study provides among the first longitudinal evidence that early parent-child relationships may be useful in understanding the origins and growth of individual differences in child EF. Given that the associations found were derived from observations of different individuals (parent behavior vs. child performance), assessed in different contexts and at different times (with delays of up to 14 months), one can reasonably assume that the links are conceptually robust. Given that parenting contributed substantial additional variance in child EF above its well-documented precursors (child cognitive functioning and maternal education), we argue that further exploration of parenting is likely to be a fruitful path for research on childhood EF. However, intriguing questions remain, for instance, with respect to which aspects of parenting contribute to which components of EF, at which ages, and via which neural and social mechanisms. Given the impressive range of child cognitive and

socioemotional outcomes related to EF, the search for the social contexts most likely to favor its development is an important task for future research.

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