Rochette, É., & Bernier, A. (2016). Parenting and preschoolers' executive functioning: A case of differential susceptibility? *International Journal of Behavioral Development*, *40*,151–161.

Abstract

A growing body of theoretical and empirical work has been attempting to answer the questions of how and how much of the effects of children's early experience may depend on their inner characteristics. Theory and evidence suggest that some children, notably those with difficult temperaments, are more susceptible to both negative and positive aspects of parenting. The purpose of the current study was to investigate whether child temperament moderated the links between the quality of mother-infant interactions, observed when children were 1 year of age, and two components of child executive functioning (EF) at 3 years, namely impulse control and conflict EF, among 74 mother-child dyads. The results were consistent with the notion that children with more difficult temperaments may be more susceptible to maternal behaviors than children with less difficult temperaments, but only regarding the development of impulse control abilities. There was no clear evidence of such moderation for conflict EF. These results support the idea that distinct mechanisms may underlie the development of different dimensions of child EF.

Keywords: parenting, temperament, differential susceptibility, executive functions, preschoolers.

Parenting and preschoolers' executive functioning: A case of differential susceptibility?

Over the course of everyday interactions parents create, or not, a coherent, warm, and predictable environment that facilitates children's adaptation to challenges and novelty (Bowlby, 1988). A long tradition of research has suggested convincingly that high-quality parenting plays a key role in numerous spheres of child development. Research in the field has often, however, focused on main effects, supposing that children are equally affected by parenting. As meaningful as those results are, main effect studies often do not consider interaction effects that could be important in explaining how and how much of the effects of parenting may depend on child inner characteristics (Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2007). Those inner characteristics, or susceptibility factors, often refer to difficult temperament, which mainly entails negative emotionality (Belsky, 2005; Belsky & Pluess, 2009). Difficult temperament is recognized as the most valid behavioral manifestation of susceptibility that could be associated with physiological particularities or to the presence of vulnerable genes or risk alleles (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2011). Hence, it is proposed that certain biological characteristics of children, often manifested in their observable temperament, could moderate the association between environmental influences and various facets of child development. In line with this position, Belsky (1997; 2005) proposed Differential Susceptibility Theory (DST). A central aspect of DST is that more temperamentally difficult children are proposed *both* to be more affected by negative or harsh parenting (dark side of DST) *and* to benefit more than their peers from warm and responsive parenting (bright side of DST). These children are believed to show heightened sensitivity to environmental influences, making them more susceptible to rearing influences, "for better and for worse" (Belsky et al., 2007).

Research has often focused on interactions that occur in the range of poor or difficult environments and their negative influences on child development (Belsky & Pluess, 2009). Studies inspired by the diathesis-stress model (Monroe & Simons, 1991) and by gene-environment interaction research (Burmeister, McInnis, & Zollner, 2008) have provided clear support for the dark side of DST. Hence, numerous studies support the hypothesis that susceptible children are at greater risk of developing cognitive, social, emotional, or physical health problems when faced with environmental challenges, including harsh parenting (e.g., Boyce, 2007; Boyce et al., 1995; Caspi et al., 2002; Eisenberg et al., 2012; McLoyd, 1998). However, DST also highlights the importance of considering interactions that occur in rich and beneficial environments and assessing positive outcomes, proposing that susceptible children are more receptive to positive influences as well (Bakermans-Kranenburg & Van IJzendoorn, 2007; Belsky, 2005; Van IJzendoorn, Belsky, & Bakermans-Kranenburg, 2013). This hypothesis has received support with respect to numerous outcomes, including externalizing and internalizing behavior problems (Drury et al., 2012; Sturge-Apple et al., 2012; for a meta-analysis see Bakermans-Kranenburg & Van IJzendoorn, 2011), compliance and moral internalization (Feldman, Grennbaum, & Yirmiya, 1999; Kochanska, Kim, Barry, & Philibert, 2011), social competence (Kochanska et al., 2011), and attachment security (Klein Velderman, Bakermans-Kranenburg, Juffer, & Van IJzendoorn, 2006).

Hence, there is compelling empirical evidence that more biologically susceptible children, often operationalized in terms of difficult temperament, can benefit to a greater degree from positive environments, and experience more adverse consequences when exposed to detrimental conditions. Remarkably however, this question has received very little attention with

respect to one of the pillars of child development: cognitive functioning. This report focuses on one aspect of child cognition, namely executive functioning.

Parenting and executive functioning: A case of differential susceptibility?

In the last decade, research has paid much attention to executive functioning (EF), which is a set of higher-order cognitive skills, such as working memory, set-shifting, inhibitory control, and planning, that play a central role in the deliberate control of thought and action (Garon, Bryson, & Smith, 2008). The quality of parental behavior during parent-child interactions is increasingly recognized as one of the most promising predictors of individual differences in young children's EF. For instance, studies have found that better parental scaffolding, which refers to offering children strategies to solve problems that they cannot master on their own, is related to better child performance on EF tasks (Bernier, Carlson, & Whipple, 2010; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012; Hughes & Ensor, 2009).

An important consideration, however, is that the links to parenting appear to vary according to which aspect of child EF is under study. Theoretical and empirical research strongly suggests that motivationally significant situations appeal to different executive functions than neutral or non-emotional contexts. Hence, several studies have demonstrated that child performance on EF tasks clusters in factors (e.g., Garon et al., 2008), with a two-factor structure often reported among toddlers and preschoolers (see Beck, Schaefer, Pang, & Carlson, 2011): "impulse control" (akin to "hot EF"), that is, the ability to delay or suppress an impulsive response, and "conflict EF" (akin to "cool EF"), the ability to respond appropriately in the face of a salient conflicting response option. Impulse control refers to functions called upon in affectively challenging ("hot") contexts, while conflict EF generally implies a non-affective ("cool") context, for instance in tasks that only or mostly require working memory and/or set-

shifting. Zelazo and Cunningham (2007) propose a model in which these two dimensions lie at opposite ends of a continuum of executive functions. This model is supported by behavioral and neural evidence. For instance, performance on these two types of EF tasks is affected differently by brain lesions, such that impairment can be observed in one sphere but not in the other. In addition, tasks calling upon conflict-EF mostly activate the lateral prefrontal cortex, whereas impulse control is mainly subsumed by the orbitofrontal cortex and other medial regions of the brain (see Zelazo & Carlson, 2012). Performance on impulse control and conflict EF also shows different relations to child factors such as intelligence, age, and temperament (Hongwanishkul, Happaney, Lee, & Zelazo, 2005), bilingualism (Bialystok & Martin, 2004; Carlson & Meltzoff, 2008), or theory of mind (Carlson & Moses, 2001; Jahromi & Stifter, 2008). Finally, this two-factor structure has been identified with exploratory factor analyses in several independent samples of young children by at least three different teams (Bernier et al., 2010; Carlson, Mandell, & Williams, 2004; Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Conway & Stifter, 2012), and recently by Carlson, White, and Davis-Unger (2014) using a confirmatory factor analytic approach.

With respect to parenting, several studies have found links between positive and negative aspects of mother-child interactions and child conflict EF (Bernier et al., 2010; Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Blair et al., 2011; Hammond et al., 2012; Hughes & Ensor, 2009; Kraybill & Bell, 2013), while attempts at finding similar relations with impulse control have been sometimes successful (e.g., Kochanska, Murray, & Harlan, 2000; Taylor, Eisenberg, Spinrad, & Widaman, 2013), sometimes not (e.g., Bernier et al., 2010; 2012). Inconsistent relations between a predictor and an outcome are often due to the presence of a moderating effect, that is, the expected association is present but only for a specific non-random portion of

the population, and thus can go undetected with a main effects analysis. Therefore, previous inconclusive findings pertaining to child impulse control might be due to a phenomenon of differential susceptibility, such that relations to parenting do exist, but only or mainly among temperamentally difficult children. In fact, this is suggested by studies that have found stronger links to parenting among genetically or temperamentally vulnerable children for constructs with close connections to impulse control, such as self-control (Feldman, Greenbaum, & Yirmiya, 1999), effortful control (Cipriano & Stifter 2010), or self-regulation (Kochanska, Philibert, & Barry, 2009).

Conway and Stifter (2012) were the first to investigate interactions between child temperament and maternal behaviors in the prediction of child EF. Three types of temperament, namely inhibited, exuberant, and low reactive, and two types of maternal behaviors during problem-solving, namely attention maintaining and attention redirection, were assessed at 2 years of age in the laboratory. Both EF dimensions (impulse control and conflict EF) were assessed as well, two and a half years later. Maternal attention maintaining referred to verbal and non-verbal behaviors that support child attention to keep the focus on the task, whereas maternal attention-redirecting behaviors referred to behaviors that redirect child attention away from the task. Results suggested that maternal attention-maintaining behaviors predicted higher levels of conflict EF, but only for inhibited and exuberant children. Maternal attention redirection predicted poorer impulse control and conflict EF, but only for inhibited children. To our knowledge, these were the first results to suggest that the links between parenting and child EF may vary according to children's temperamental traits.

It may also be important to note that Conway and Stifter (2012) measured maternal behaviors that precisely support (or hinder) attention regulation, and found more compelling

results with conflict EF than impulse control. This is noteworthy because conflict EF tasks, including those used by these authors, require children's attentional and working memory resources, for instance to remember the rules and remain focused on the appropriate response despite being distracted by the pre-potent impulsive response. In contrast, many impulse control tasks are less taxing on attentional resources, merely necessitating that children refrain from enacting an impulsive response. This raises the possibility that the functional link between the aspect of parenting considered and the specific executive processes predicted may play a role in interactions with temperament. Given that links to parenting have proven more challenging to demonstrate in the case of impulse control than conflict EF, whether considering main (Bernier et al., 2010; 2012) or interactive effects (Conway & Stifter, 2012), one aim of the current report was to examine interactions between child temperament and maternal behaviors which prior research suggests may be especially relevant to children's impulse control capacities.

As mentioned above, scaffolding has often been found to predict child EF. Notwithstanding the robustness of this finding, it is likely that other aspects of parenting may prove useful as well, in light of decades of research showing that the quality of parent-child interactions is multidimensional, with different dimensions making unique contributions to child functioning (see Grusec & Davidov, 2010, for a review). In fact, there is evidence of this in the EF literature: aspects of mother-child interactions which are less task-oriented than scaffolding, but rather describe the overall affective quality of the relationship (positive, non-intrusive parenting; mutually responsive interactions; maternal warmth; positive emotional verbal tone; attachment security), have been found to relate to child EF overall (Blair et al., 2011; Kraybill & Bell, 2013), as well as to impulse control or similar constructs specifically (Bernier et al., 2012; Cipriano & Stifter 2010; Kochanska et al., 2000; Taylor et al., 2013). Thus, while there is no

doubt that specific task-oriented aspects of maternal behavior are relevant to children's EF, it appears that broader affective features of parent-child relationships are important too, notably for impulse control. To our knowledge, however, the potential moderating role of child temperament in the links between child EF and such dimensions of parent-child relationships has yet to be examined. This was the core aim of this study.

An especially well-suited measure to do so is the Maternal Behavior Q-Sort (MBQS; Pederson & Moran, 1995). The MBQS is heavily influenced by attachment research, and thus mostly focuses on assessing the affective quality of mother-infant interactions. An additional asset of the MBQS is its multidimensional nature: although it has traditionally been used to derive one global score of maternal sensitivity, its authors argue that the sole use of this global score may result in significant loss of information (Morley et al., 2010). They have therefore developed seven domains of maternal behavior that can be extracted from the MBQS: response to positive signals, response to distress, positive affect sharing, hostility/rejection, physical proximity, sensitivity, and teaching orientation. The first six of these domains describe mostly the emotional quality of mother-child interactions, while the last is more cognitively oriented, and thus more proximal to the type of maternal behaviors assessed by Conway and Stifter (2012). The use of the MBQS will thus allow for the unpacking of maternal behavior, advocated by Grusec and Davidov (2010), and for the examination of several aspects of maternal behavior that may be especially relevant to the development of child impulse control. The availability of several scores indexing one global construct (the quality of maternal behavior) will also be useful psychometrically, to estimate the robustness of results and avoid the interpretation of chance findings. Roisman et al. (2012) noted that Type I error rate may be especially high in tests of

differential susceptibility, and recommended that researchers test the robustness of results across different indicators of constructs so as to avoid capitalizing on chance.

Therefore, the present study uses these domains to assess the quality of maternal behavior, with the aim of investigating whether dimensions of parenting that pertain to the emotional quality of the mother-child relationship relate to individual differences in child EF (perhaps impulse control in particular) among children with difficult temperaments. The use of the seventh dimension of the MBQS (Teaching orientation) was more exploratory, given that this scale was found to be considerably less reliable ($\alpha = .55$) than the others (all α's $> .80$) when it was developed (Morley et al., 2010).

Goals and hypotheses of the present study

The main purpose of this report was to investigate whether child temperament moderated the links between the quality of mother-infant interactions and two components of subsequent child EF, namely conflict EF and impulse control, using a longitudinal multi-method design. Given that difficult temperament, or a child's tendency toward fussiness, negative emotionality, and difficulties being soothed (Bates, 1980), is considered to be the most reliable behavioral expression of the susceptibility factor (Belsky, 2005), it is used here to index child temperament. Based on previous results with other developmental outcomes (see Bakermans-Kranenburg & Van IJzendoorn, 2011) and the recent results of Conway and Stifter (2012), we hypothesized that links would be more pronounced among children with more difficult temperaments, perhaps especially in the sphere of impulse control. Although this study cannot demonstrate causality, we expected a pattern of results consistent with the notion that compared to their less difficult counterparts, the EF performance of more difficult children would be more vulnerable to higher

negative and lower positive maternal behaviors, *and* would benefit more from lower negative and higher positive maternal behaviors.

Method

Participants

Seventy-four mother-child dyads (33 boys and 41 girls) 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. Mothers were between 20 and 45 years old (M = 31.50; SD = 4.27). They had approximately 15 years of education on average (M = 15.61; SD = 2.16) and the majority (90.5%) was White Caucasian. Other family ethnicities included Middle-Eastern, Caribbean, and Hispanic. Family income varied from less than $20,000 to more than $100,000 CDN, with an average of $70,000 CDN. Most mothers (90.5%) were married or living with the child's father, while 8.1% were in a blended family and one was a single mother.

These 74 families with complete data until age 3 were part of an original sample of 87 families who had MBQS data at 1 year. Thus, the retention rate was 85% across the 2-year interval. Attrition analyses revealed that families who left the study were not different from others on demographic or maternal behavior variables. The only difference that approached significance was that mothers who dropped out had marginally fewer years of education (M = 15.0) than mothers who stayed in the study (M = 15.6), $t(85) = 1.95$, $p = .08$.

Procedure

The mother-child dyads took part in three home visits, when children were 12 months (T1; M = 12.50 months; SD = 1.12), 15 months (T2; M = 15.40 months; SD = .79) and 3 years of

age (T3; *M* = 36.82 months; *SD* = .86). All visits lasted 70 to 90 minutes and were organized in a similar way: the research assistant first administrated research tasks, and mothers and children were then asked to participate in different dyadic activities that are not used in this report, except for the context that they provided for the observation of maternal behavior at T1, later used to rate the MBQS (see below). Child temperament was assessed by maternal report when children were 15 months (T2). The questionnaire was completed by mothers after the home visit and returned by mail. Most research tasks at T3 were EF tasks, described below. The parents of all participating children signed a consent form at the outset of the study that informed them on the nature and risks of participating, and they received a toy for the child as compensation.

The first home visit also included a period where mothers were asked to complete questionnaires while infants were not engaged with the mother or kept busy by the research assistant. The procedure for this visit was modeled after the work of Pederson and Moran (1995), and aimed at challenging mothers' capacity to divide their attention between several competing demands, thus reproducing the natural conditions of daily life when caring for an infant. The home-visit protocol was thus purposely designed to create a situation where maternal attention was being solicited by both the research tasks and the infant's demands, which placed the dyad in a challenging situation, likely to activate both the infant's attachment system and the mother's caregiving system in response. This provided an optimal context for the observation of mother-child interactions (Pederson & Moran, 1995).

Given its central role in the current study, great care went into the assessment of maternal behavior. In order to maximize the reliability of observations, we followed Pederson and Moran's (1995) recommendations for training our home visitors. Research assistants attended a two-day training workshop pertaining to early mother-infant interactions, behavioral observation,

and techniques of home visiting. They reviewed several videotapes of mother-infant interactions in order to practice using the MBQS. After the workshop, the assistants performed their first few home visits with a more experienced colleague, and they completed the MBQS together. When the junior home visitors were ready to rate maternal behavior without the assistance of a colleague, the next two or three visits were followed by a debriefing session either with the P.I. or with an experienced graduate student, in order to review the salient elements of the visit before scoring the MBQS. The assistants then went on to rating the MBQS independently.

Measures

Maternal behaviors. The 90-item Maternal Behavior Q-Sort (MBQS; Pederson & Moran, 1995) was used at T1 (1 year of age). This measure is designed to assess the quality of maternal behavior during mother-child interactions in the home. Each item describes a potential maternal behavior. Based on observations performed throughout the visit, the 90 items were sorted by the observer into nine piles of 10 items each, according to their degree of resemblance with the mother's observed behavior. Each item is thus assigned a score between 1 and 9, indicating the extent to which it resembles the mother's behavior as observed during the visit.

Recently, Pederson, Moran and their colleagues (e.g., Morley et al., 2010) subdivided the MBQS items into seven domains of maternal behavior: 1) Response to positive signals (12 items; $\alpha = .75$; e.g., *Notices when B smiles and vocalizes*); 2) Response to distress (7 items; $\alpha = .83$; e.g., *Responds immediately to cries or whimpers*); 3) Positive affect sharing (6 items; $\alpha = .76$; e.g., *Praises child*); 4) Hostility/Rejection (8 items; $\alpha = .59$; e.g., *Is punitive or retaliatory*); 5) Sensitivity (27 items; $\alpha = .71$; e.g., *Interprets cues correctly, as evidenced by child's response*); 6) Physical proximity (7 items; $\alpha = .72$; e.g., *Molds child to self when holding*); and 7) Teaching orientation (9 items; $\alpha = .39$; e.g., *Is instructive during interactions with child*). This

multidimensional approach is used here to operationalize the quality of maternal behavior. Of course, ensuing results will be not be independent, but will rather be useful in estimating the extent to which results can be considered robust and not due to chance. Given, however, the low reliability for the Teaching orientation domain in the current sample (presented above), which is consistent with the findings of the original validation study (Morley et al., 2010), it is not considered further.

The development of the MBQS is anchored in the descriptions of sensitive responsiveness provided by Ainsworth, Bell, and Stayton (1974). Pederson and colleagues (e.g., Pederson et al., 1990; 1998; Pederson & Moran, 1995) have provided detailed descriptions of the development of the MBQS as well as its validity and reliability. These authors' longitudinal studies, and those of other labs (e.g., Bordeleau, Bernier, & Carrier, 2012; Lemelin, Tarabulsy, & Provost, 2006) show that the MBQS is useful in predicting multiple aspects of infant development. The predictive validity of the MBQS is demonstrated by meta-analytic data, which reveal that it is currently the sensitivity measure that is most predictive of infant attachment security (Van IJzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004). In this study, a second research assistant was present for 18 home visits (24.3%) and completed the MBQS independently. Agreement between the two raters' sorts was high, ICC = .87.

Temperament. When children were 15 months (T2), their mothers completed the *Infant Characteristics Questionnaire,* 13-24-month version (ICQ; Bates, Freeland, & Lounsbury, 1979). This instrument assesses mothers' perceptions of their child's characteristics with 32 items rated on a 7-point Likert scale, tapping into four temperamental dimensions: unadaptability, persistence, difficultness, and social fear. The ICQ has good psychometric

properties, including satisfactory internal consistency, temporal stability, and cross-reporter correspondence (see Bates et al., 1979; Guerin & Gottfried, 1994; Merbert, 1989).

As mentioned earlier, this study focuses on difficult temperament as an indicator of the susceptibility factor (Belsky, 2005); the 16-item difficultness subscale is therefore used here. Examples of difficultness items include "*How easily does your infant get upset?*"; "*How difficult is it for you to calm or soothe your baby when he/she is upset?*"; or "*How much does your baby smile and make happy sounds?*" (reversed). Internal consistency for the difficultness subscale in this sample was $\alpha = .85$.

Executive functioning was assessed at T3, when children were 3 years old. The tasks were chosen based on Carlson's (2005) empirically-derived measurement guidelines with the aim of maximizing reliable detection of individual differences in three dimensions of EF: working memory, inhibitory control, and set-shifting.

Bear/Dragon (Reed, Pien, & Rothbart, 1984). This task mostly calls upon working memory and inhibition. Experimenters introduced children to two puppets: a « nice bear » and a « naughty dragon ». Children were asked to perform the actions requested by the bear only. For example when the bear asked "Touch your head" children had to touch their head, but they had to stand still if the dragon made the same request. There were two series of six requests each, alternating in a pseudo-random order requests by the bear and the dragon, all pertaining to touching a body part. Scores corresponded to the total number of correct responses, and could thus vary from 0 to 12.

Day/Night (Gerstad, Hong, & Diamond, 1994). Experimenters first showed two separate pictures to children: a black card displaying stars and a moon, and a white card displaying a yellow sun. Children were asked to say "day" when they were shown the stars and moon, and

"night" when shown the sun. The task, focusing on set-shifting and inhibition, consisted of 16 trials, alternating in a random but previously defined order the sun and the moon, and children's scores were computed as the percentage of correct answers.

Dimensional Change Card Sort (DCCS; Zelazo, 2006). Experimenters showed children a red card depicting a truck, and a blue card depicting a star, and explained that they would play a sorting game. In the first round, children were instructed to classify the cards given to them, one by one, by shape. In the second round, they were instructed to sort the cards by color. Between the two rounds, the experimenter explained the new rule. There were six trials in each round. This task mostly taps into set-shifting and working memory. Scores represented the number of correct answers on the post-switch trials (0–6).

Delay of Gratification (Kochanska et al., 2000). The experimenter explained children that they could take a treat, placed under a transparent cup in front of them, only when she rang the bell. Four trials of increasingly longer duration were used (5, 15, 30 and 45 seconds), tapping into inhibition. Scores were the number of seconds waited on each trial.

Child verbal ability. Given the well-documented links between child EF and verbal ability (e.g., Carlson et al., 2004), the Peabody Picture Vocabulary Test 3 (PPVT-3; Dunn & Dunn, 1997) was used to index verbal ability at 3 years. The PPVT-3 is a widely used norm-referenced test of receptive vocabulary for ages 2.5 and above.

Results

Preliminary analyses

Table 1 presents the descriptive statistics for maternal behavior, child temperament, and child scores on EF tasks. All variables showed good variability, although children's average performance on the delay of gratification trials and the DCCS was very good. EF scores were

standardized and then submitted to a principal component analysis in order to reduce the number of data points and compute reliable aggregate estimates. This analysis yielded a two-factor solution (*Eigen* values > 1.0), representing 61.1% of the total variance. These two factors were submitted to a principal axis rotation (oblimin). Factor loadings for the 5-second Delay (.85), 15-second Delay (.95), 30-second Delay (.91), and 45-second Delay (.42) trials suggest that the first factor taps impulse control, whereas the second factor appears to represent working memory and set-shifting (conflict EF): Bear/Dragon (.73), Day/Night (.76), and DCCS (.59). No cross loadings were observed and the correlation between the two factors was $r = .23$, $p < .05$. Studies of EF in young children have found similar factor structures (e.g., Carlson et al., 2004; Carlson & Moses, 2001; Conway & Stifter, 2012). Given that the current factor structure was very clear empirically and reproduced these two documented dimensions, two averaged standardized scores were computed and used in further analyses.

Children's sex and exact age, as well as maternal age, were unrelated to Impulse Control or Conflict EF, and therefore not retained for further analysis. However, family SES (a standardized averaged score of maternal education and family income, $r = .62$, $p < .001$) was significantly related to Conflict EF, $r = .25$, $p < .05$, although not to Impulse Control, $r = .13$, *ns*. For uniformity purposes, family SES will be considered in the prediction of both EF dimensions. Finally, concurrent language skills were significantly related to Conflict EF, $r = .26$, $p < .05$, and marginally to Impulse Control, $r = .22$, $p < .10$. Given that child language is sometimes used as a covariate when predicting EF (e.g., Carlson et al., 2004) and at other times considered as a mediator explaining part of the links between parenting and child EF (Matte-Gagné & Bernier, 2011), analyses will be reported with and without controlling for child language.

In line with their theoretical definitions as distinct aspects of one global construct, the six domains of maternal behaviors were found to be moderately to highly inter-correlated (see Table 2), with correlations ranging from r = .30 (Response to positive signals – Hostility/Rejection) to r = .70 (Response to distress – Sensitivity) (mean r = .49). Given our study aims, the six domains will be considered separately in the analyses. However, given the non-independence of these scores, any ensuing results should be interpreted as providing confirmatory rather than incremental evidence for the underlying relations. As shown in Table 2, no relations were found between the moderator (child difficultness) and the outcomes (subsequent performance on either Impulse Control or Conflict EF), which constitutes a condition to test for differential susceptibility (Belsky et al., 2007). Three domains of maternal behaviors were found to relate to Impulse Control (Positive affect sharing, r = .33, p < .01; Hostility/Rejection, r = -.26, p < .05; Physical proximity, r = .27, p < .05).

Main analyses

We next examined whether the links between maternal behavior and subsequent child EF were greater among more difficult children. We thus conducted moderation analyses to examine whether maternal behavior interacted with difficult temperament in predicting child subsequent EF. Impulse Control and Conflict EF were submitted to distinct sets of regression equations. In each equation, SES was entered in a first block, followed by difficult temperament and one of the domains of maternal behavior (both centered) in a second block, and finally by the interactive product of these centered scores in a third block.

As displayed in Table 3, child difficultness interacted with all six domains of maternal behavior considered in the prediction of child Impulse Control (all p's < .01). These interactions were broken down according to guidelines provided by Aiken and West (1991) and Cohen and

Cohen (1983), plotting fitted regression lines at pre-determined levels of the moderator, in our case at one standard deviation above and below the mean for difficult temperament. In all cases, the links between the quality of maternal behavior and child subsequent Impulse Control were positive (negative in the case of Hostility/Rejection) and significant for more difficult children: the β coefficients were .48 for Response to positive signals, .44 for Response to distress, .42 for Positive affect sharing, -.48 for Hostility/Rejection, .52 for Sensitivity, and .41 for Physical proximity (all *p*'s < .01). In contrast, the β coefficients were low and consistently non-significant for children considered to be less difficult: -. 05 for Response to positive signals, -.02 for Response to distress, -.06 for Positive affect sharing, .19 for Hostility/Rejection, -.14 for Sensitivity, and .02 for Physical proximity. Given that graphed results looked strikingly similar across dimensions, only two interactions are displayed graphically for illustration purposes (see Figure 1): one with a positive dimension of maternal behavior (Positive affect sharing), and one with the negative dimension of Hostility/Rejection.

In contrast, Table 4 shows that only one interaction with child difficultness was significant when predicting Conflict EF: that involving maternal sensitivity. While the direction of this interaction was the same as those for Impulse Control reported above, post-hoc tests revealed that the link between maternal sensitivity and child Conflict EF was non-significant, both for more difficult (β = .25, *ns*) and for less difficult (β = -.23, *ns*) children.

Supplemental analyses

Given the limited variability in Impulse Control scores and the modest sample size, data were screened for outliers. None were found that were likely to drive the results. Next, we re-ran all regression analyses while entering child language in the first block, along with SES. The results remained almost the same, for both Conflict EF (no significant interaction) and Impulse

Control (five significant interactions and one marginally significant interaction, that involving Positive affect sharing). Finally, one concern with all the above analyses is that multiple tests were run on closely related constructs (the six domains of maternal behavior). To offer some control over Type-I error, we applied a statistical correction known as FDR (false-discovery rate). FDR presents the advantage of being more powerful than classic methods like the Bonferroni correction, which are very strict and present high rates of false negatives (Benjamini & Hochberg, 1995, 2000; Keselman, Cribbie, & Holland, 1999). Briefly, the procedure is different from classic methods in that it does not provide one *p* value (say, .05/6 = .008) that becomes the uniform level of significance for all performed tests. The procedure rather penalizes incrementally for each additional test performed, such that in our case (running six non independent tests), the smallest obtained *p* value is not corrected, the second smallest *p* value is multiplied by 6/5, the third smallest by 6/4, and so on (see Benjamini & Hochberg, 1995, 2000 for details and underlying rationale). The result of this multiplication becomes the corrected *p* value, which can be interpreted as usual. After applying this procedure to the results of the equations pertaining to Impulse Control, we found that the five of the six interactions between child temperament and maternal behavior remained significant (Hostility/Rejection, Response to distress, Physical proximity, Response to positive signals, and Positive affect sharing; corrected *p*'s varying between .001 and .018), whereas the interaction involving the Sensitivity domain became marginal (corrected $p = .054$). Thus, the findings were not inflated by multiple testing.

Discussion

The aim of this report was to investigate whether child temperament moderated the links between the quality of early mother-infant interactions and two components of child subsequent EF, namely impulse control and conflict EF. It was expected that children with a relatively more

difficult temperament would appear to be more susceptible to higher negative and lower positive maternal behaviors, and to benefit more from higher positive and lower negative behaviors, compared to children with a relatively less difficult temperament. Due to the emotionally significant nature of the maternal behaviors assessed, which have often been found to relate to children's capacity to control their impulses (e.g., Kochanska et al., 2000; Taylor et al., 2013), these moderating effects were expected mainly in the sphere of impulse control. Overall, results were consistent with these hypotheses.

To infer a differential susceptibility effect, several criteria must be met (Belsky et al., 2007). As described above, all slopes pertaining to more difficult children were significantly different from zero, and significantly steeper than the slopes for less difficult children. The fact that the low difficultness slopes are all non-significant, along with the absence of relation between temperament and impulse control, are further evidence of differential susceptibility. Furthermore, no relations were found between temperament and any domain of maternal behavior (see Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001). Finally, the multidimensional approach to maternal behavior allowed us to consider the degree of different positive and negative maternal behaviors, not just the absence versus presence of one or the other. The results show that children with more difficult temperament who are exposed to hostile and negative maternal behaviors, and/or to low levels of positive behaviors at one year, performed the worst two years later on impulse control, but these children actually performed the best when experiencing positive, warm, and responsive maternal behaviors and/or low levels of negative behaviors. Note that although only two interactions are depicted here, all other interactions were graphed and suggested the same pattern. Overall, the results with impulse control are consistent with a differential susceptibility phenomenon. This suggests that previously established relations

between maternal behaviors and children's impulse control or inhibitory control capacities (e.g., Cipriano & Stifter 2010; Kochanska et al., 2000; Taylor et al., 2013) may be moderated by children's temperament, such that relations are more pronounced among children perceived as more difficult by their mothers.

However, our attempt to approach maternal behavior from a multidimensional perspective was somewhat unsuccessful, given the moderate to high inter-correlations found between the MBQS dimensions. Hence, it is best to view the findings obtained here with different aspects of maternal behavior as providing partially overlapping evidence for one global phenomenon, rather than independent results. A true multidimensional approach will require the assessment of maternal behavior at different times, with different instruments, and in different contexts, to decrease shared method variance, as well as the consideration of aspects of maternal behavior qualitatively different from maternal sensitivity, for instance those pertaining to child attention regulation (Conway & Stifter, 2012). In addition, the use of such an approach with large samples would allow for the simultaneous examination of several dimensions of parenting and their interactions with temperament, instead of the separate analyses that we had to conduct here to preserve statistical power. Entering all main and interactive effects in one equation would help determine whether certain dimensions of parenting are more relevant than others, or alternatively, if it is the common variance describing the overall quality of parenting that is meaningful – both would represent equally stimulating findings. All in all, though, the consistency of results across the six domains of maternal behaviors, despite sometimes moderate inter-relations, does suggest the reliability of the results with impulse control. In contrast, there was hardly any evidence of differential susceptibility when predicting conflict EF.

The specificity of the results to impulse control may relate to the reward sensitivity involved in impulse control, and generally, in hot EF tasks. Numerous differential susceptibility studies considered, as susceptibility factors, physiological or genetic characteristics that are related to the dopaminergic system, which is involved in motivational and reward mechanisms (Ellis et al., 2011; Tripp & Wickens, 2008) called upon in impulse control tasks. From another angle, Belsky (1997) speculated that difficultness in children is the behavioral manifestation of a highly sensitive nervous system, and this sensitivity to environmental input may also be associated with the dopamine system (Aron & Aron, 1997; Posner & Rothbart, 2007). Considering this, along with the pattern of results found here, it appears to be a sound possibility that the development of impulse control in the preschool period, perhaps due to its motivational components, be a case of differential susceptibility modulated by child temperamental difficultness and underlying physiological factors.

Recall also that Conway and Stifter (2012) investigated similar questions and rather found more convincing interactions with conflict EF, however by examining maternal behaviors which support children's attention systems. We were unable to investigate the same question, given that only one dimension of the MBQS taps into such behaviors (teaching orientation), and this dimension could not be assessed reliably with this sample. Nor, actually, in the original study by Morley et al. (2010), perhaps suggesting that the type of semi-structured home visit conducted here, inspired by the Pederson and Moran tradition, is ill-suited to assess this aspect of maternal behavior. Nonetheless, the current study and that by Conway and Stifter (2012) appear to converge toward two broad conclusions. First, the links between parenting and EF development in the preschool period may represent a case of differential susceptibility. Second, it is conceivable that the exact nature of the interactions at play between maternal behaviors and

child temperament could vary according to which executive processes are considered. Future studies using a theoretically driven multidimensional approach to the assessment of parenting are needed to investigate the possibility that child temperament interacts specifically with parental behaviors with clear functional connections to the particular dimensions of child EF that are being predicted. It is plausible, although hypothetical, that interactions with task-focused parental behaviors aimed at supporting children's attention systems could be more relevant to explaining conflict EF (as suggested by the results of Conway & Stifter, 2012), while interactions between temperament and parental behaviors pertaining to the general emotional quality of the relationship may explain more variability in impulse control (as suggested by the current results and those of Kim & Kochanska, 2012, with parental-child affective mutuality and child effortful control).

It is also the case, however, that the specificity of our findings to impulse control might be due to the exact aspect of temperament that we have considered (difficultness), which is different from the aspects of inhibited and exuberant temperaments studied by Conway and Stifter (2012). One might speculate, for instance, that difficultness may be a susceptibility factor for parenting effects on impulse control, whereas inhibited, exuberant or other aspects of temperament act as susceptibility factors for parenting effects on conflict EF. Alternatively, the findings could be attributable to developmental considerations: as reported by Carlson (2005), conflict EF is generally more difficult for young children than impulse control, and indeed, the children in this sample performed very well on average on impulse control. All in all, while the links between early mother-infant interactions and children's subsequent EF are emerging as an area where differential susceptibility may be at play, research in this domain is in its infancy, and much further work is needed to disentangle the different factors (domains of maternal behavior,

EF dimension, aspects of child temperament, age, etc.) that are currently confounded in the interpretation of different studies' findings.

This study presents a number of limitations, first the modest sample size which may have limited our ability to detect some interactive effects by reducing statistical power. Second, the use of only one task to assess impulse control may have limited variation, in addition to reducing what was assessed to children's delay ability, specifically. A more optimal approach would entail the use of several tasks with different behavioral demands so as to obtain a richer and more thorough assessment of children's impulse control abilities (e.g., Kochanska et al., 2009). Likewise, variation on the DCCS was low, which certainly limited our ability to find direct or moderated links between conflict EF and parenting. Furthermore, we assessed child temperament via maternal report. This presents the advantage of tapping into a broad range of child behavioral and emotional characteristics, potentially more representative of children's everyday functioning than lab-based observational measures (Rothbart & Hwang, 2002). However, the addition of an observational assessment would surely produce more objective estimates, and assessing temperament before or concurrently to the assessment of maternal behavior would be ideal. In fact, given that both maternal behavior and child temperament were assessed only once, we cannot rule out the possibility that part of the results be due to stability in these concepts, such that concurrent parenting and temperament at age 3 would be responsible for some of the links uncovered with age-3 child EF. Of course, given the above-mentioned methodological and empirical proximity amongst the dimensions of maternal behavior assessed, one should not view the different interactions found as independent from each other, but rather as providing confirmatory evidence for one phenomenon tackled from slightly different angles. Finally, the

low-risk nature of this community sample limits the generalizability of the findings, which may be quite different in samples characterized by greater economic, psychosocial, or biological risk.

Considering the current results with those of the only other study (to our knowledge) that specifically investigated interactions between child temperament and parenting in predicting child EF (Conway & Stifter, 2012), we would argue that much more research is needed to clarify which types of maternal behavior interact with which aspects of child temperament in the prediction of different child executive processes. Answers to these questions may vary with child age as well. Becoming more specific in the identification of the antecedents of child EF and their interactions with inner child characteristics will be relevant to the development of intervention programs targeting specific cognitive processes to reduce impulsivity and support self-regulatory capacities. The "bright side" of DST, which the current findings reiterate, may be especially appealing to parents who perceive their child to be difficult. Although there is no doubt that temperamentally difficult children can be challenging for parents, it may be particularly motivating for these children's parents to see them as "little sponges" who, while seemingly fussy and reactive, are rather very sensitive to environmental influence, and thus markedly prone to absorb the benefits of warm, nurturing, responsive parenting. Meta-analytic data show that brief behavioral intervention is effective in promoting such warm, responsive parenting (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003). The next step appears to be to identify the children for whom this may be especially beneficial, and whether this differs according to the particular developmental outcomes that one aims to improve.

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Table 1

Descriptive statistics for the key study variables

Measure	Range	Mean	Standard deviation
Maternal behavior :			
- Response to positive signals	4.09 - 8.45	7.32	.90
- Response to distress	2.86 - 8.57	7.24	1.18
- Positive affect sharing	1.43 - 8.71	7.46	1.00
- Hostility/Rejection	1.38 - 6.50	2.69	.81
- Sensitivity	4.33 - 7.48	6.50	.86
- Physical proximity	2.29 - 8.14	6.77	1.04
Temperament : Difficultness	1.81 - 4.56	3.00	.72
Bear/Dragon	3 – 10	6.59	2.01
Day/Night (%)	0 – 100	58.17	35.20
DCCS	0 – 6	5.37	1.64
Delay of Gratification			
- 5 seconds	0 – 5	4.74	.94
- 15 seconds	1 – 15	13.54	3.86
- 30 seconds	1 – 30	27.37	7.29
- 45 seconds	0 – 45	40.11	13.15

Table 2

Intercorrelations among child sex, age, temperament, maternal behaviors, and child EF

	2	3	4	5	6	7	8	9	10	11
1. Sex	.07	-.05	.16	.13	-.02	.13	.23*	.01	.05	.16
2. Age	-	-.07	.20†	.00	.05	-.07	.09	.28**	.22†	.09
3. Temperament		-	.07	.10	-.02	.08	.14	.10	-.05	-.13
4. Response to positive signals			-	.63***	.49***	-.30**	.54***	.58***	.17	.01
5. Response to distress				-	.41***	-.31**	.70***	.60***	.16	-.04
6. Positive affect sharing					-	-.56***	.31**	.55***	.33**	.08
7. Hostility/Rejection						-	-.38**	-.49***	-.26*	.10
8. Sensitivity							-	.51***	.13	-.05
9. Physical proximity								-	.27*	.02
10. Impulse Control									-	.23*
11. Conflict EF										-

† $p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Table 3

Summary of regression analyses predicting child impulse control from maternal behavior and child difficult temperament

	B	SE *B*	β	R^2 interaction term (%)	R^2 total model (%)
SES	.09	.05	.17		
Difficult temperament	-.04	.12	-.04		
Response to positive signals	.24	.10	.27*		
Interaction	.38	.13	.33**	8.8%	12.9%
SES	.09	.05	.18		
Difficult temperament	-.01	.12	-.01		
Response to distress	.18	.08	.28*		
Interaction	.34	.11	.38**	11.9 %	12.6 %
SES	.10	.05	.21*		
Difficult temperament	-.01	.12	-.01		
Positive affect sharing	.19	.09	.24*		
Interaction	.36	.13	.33**	8.3 %	18.8 %
SES	.09	.05	.19†		
Difficult temperament	.00	.12	.00		
Hostility/Rejection	-.16	.11	-.16		
Interaction	-.49	.14	-.39***	12.7 %	17.8 %
SES	.00	.00	-.04		
Difficult temperament	-.02	.13	-.02		
Sensitivity	.19	.11	.20†		
Interaction	.44	.16	.32**	9.3%	11.5%
SES	.07	.05	.15		
Difficult temperament	-.01	.12	-.01		
Physical proximity	.19	.08	.25*		
Interaction	.29	.09	.35**	12.2%	21.9%

† $p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Table 4

Summary of regression analyses predicting child Conflict EF from maternal behavior and child difficult temperament

	B	SE *B*	β	R^2 interaction term (%)	R^2 total model (%)
SES	.00	.01	.01		
Difficult temperament	-.12	.12	-.12		
Response to positive signals	.04	.10	.05		
Interaction	.14	.13	.13	1.7 %	3.2 %
SES	.00	.01	.00		
Difficult temperament	-.10	.12	-.10		
Response to distress	.02	.08	.02		
Interaction	.17	.11	.20	3.5 %	5.2 %
SES	.00	.01	.02		
Difficult temperament	-.10	.12	-.10		
Positive affect sharing	.00	.09	.00		
Interaction	.22	.13	.21†	4.2 %	6.4 %
SES	.00	.01	.02		
Difficult temperament	-.13	.12	-.13		
Hostility/Rejection	.14	.11	.15		
Interaction	-.16	.15	-.13	2.4 %	4.5 %
SES	.00	.01	-.02		
Difficult temperament	-.08	.12	-.07		
Sensitivity	.01	.10	.01		
Interaction	.32	.16	.24*	5.6%	7.3%
SES	.00	.01	.01		
Difficult temperament	-.12	.13	-.11		
Physical proximity	.02	.09	.02		
Interaction	.07	.10	.09	0.8%	2.5 %

† $p < .10$; *$p < .05$

Figure 1

Child impulse control performance according to two specific domains of maternal behavior and level of child difficultness