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Understanding the terrible twos: A longitudinal investigation of the impact of early executive function and parent–child interactions

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Abstract

Impairments in both executive function and parent–child interactions are associated with child externalizing behavior, but few studies have tested the uniqueness of these associations in the first years of life. Addressing these gaps, the current study involved an international sample ($N = 438$; 218 boys) who, at 14 and 24 months, completed an innovative battery of executive function tasks and were filmed at home in dyadic interaction with their mothers, enabling detailed observational ratings of maternal support. In addition, parents rated infant temperament at 4 months and externalizing behavior at 14 and 24 months. Cross-lagged longitudinal analysis showed a unidirectional developmental association between executive function at 14 months and externalizing behavior at 24 months. In addition, infant negative affect moderated the inverse association between maternal support at 14 months and externalizing behavior at 24 months. The benefits of maternal support were only evident for children with low levels of negative affect in infancy. We discuss this finding in relation to theoretical models that highlight child effects (e.g. models of vantage sensitivity).

KEYWORDS

executive function, externalizing behavior, infant, longitudinal, parenting, toddler

1 | INTRODUCTION

As implied by the phrase ‘terrible twos’, externalizing behaviors (e.g. temper tantrums, physical aggression, and frequent noncompliance) are common in toddlerhood but become less common in the preschool years (Alink et al., 2006). Alongside developmental declines in the mean level of externalizing behavior in early childhood, the first years of life are also characterized by the emergence of stable individual differences in externalizing. For example,

longitudinal studies show that individual differences in externalizing behavior exhibit moderate-to-strong rank-order stability across early childhood (e.g., Campbell, Spieker, Burchinal, Poe, & NICHD ECCRN, 2006; Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006; Rose, Rose, & Feldman, 1989; Smith, Calkins, Keane, Anastopoulos, & Shelton, 2004). With few exceptions, existing efforts to explain the origins of individual differences in early externalizing behavior have focused on either (a) executive function (EF) (i.e. the higher-order processes associated with the functions of the prefrontal cortex

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that underpin the control of thought and action) (e.g., Hughes, Dunn, & White, 1998) or (b) adverse early parent-child interactions (e.g., Pinquart, 2017). Despite progress within each of these strands of research, the first two years of life remain relatively unexplored. To address this developmental gap and provide a bridge between research on neurocognitive and family factors, we examine the unique roles of children's EF and the quality of early parent-child interactions in predicting individual differences in externalizing behavior in 2-year-old children.

1.1 | Executive function and externalizing behavior

More than two decades ago, Moffitt (1993) proposed that executive dysfunction might explain the characteristic difficulties of inhibiting emotions and controlling behavior associated with externalizing problems. Hughes et al. (1998) extended this 'executive account' of externalizing behavior to a community sample of 'hard-to-manage' preschoolers, who were shown to perform poorly on measures of planning, inhibition, and flexibility, when compared with typically-developing peers. Subsequently, a meta-analysis of 22 studies of 3- to 6-year-old children reported a moderate but significant association between EF and externalizing behaviors, $r = .22$ (Schoemaker, Mulder, Dekovic, & Matthys, 2013). While the association between EF and externalizing was stronger among clinical/referred samples, $r = .29$, it was also significant among community-dwelling preschool children, $r = .18$. Executive dysfunction may therefore underpin even normative individual differences in early childhood externalizing behaviors. Although associations between externalizing behaviors and EF have been reported in children as young as 2 ½ years old (e.g., Hughes & Ensor, 2005), little is known about younger infants. That said, studies of infant effortful control indirectly support the executive account. Specifically, Kochanska, Murray, and Harlan (2000) found that 22-month-old toddlers who resisted taking a desired snack showed lower levels of anger than peers who did not exert effortful control. Furthermore, effortful control at 22 months was negatively correlated with externalizing behaviors at age 6 (Kochanska & Knaack, 2003). More recently, Adrichem, Huijbregts, Van der Heijden, van Goozen, and Swaab (2019) reported negative associations between infant effortful control at 12 months (observed during a parent-child dyadic interaction) and physical aggression at 20 months. Likewise, Frick, Forslund, and Brocki (2019) reported negative associations between observed sustained attention at 10 months and parent-rated ADHD symptoms at 36 months. We build on these studies and on recent breakthroughs in measuring EF in infancy (e.g., Devine, Ribner, & Hughes, 2019; Miller & Marcovitch, 2015) to investigate the relations between individual differences in EF and externalizing behaviors in the first 2 years of life.

Although EF and externalizing behaviors (e.g. tantrums, physical aggression, defiant noncompliance and persistent rule-breaking) are correlated in early childhood, the heavy reliance on cross-sectional designs (Schoemaker et al., 2013) means that this correlation is open

Research Highlights

- This study examines the unique influences of executive function and parent-child interactions on externalizing behavior at a very young age (24 months).
- The study involves a large longitudinal sample and combines age-appropriate executive function tasks, observational ratings of parent-child interactions, and ratings of temperament and externalizing behaviors.
- Cross-lagged analysis show that poor executive function at 14 months predicts externalizing behaviors at 24 months (but not vice versa).
- High quality parent-child interactions at 14 months predict reduced externalizing behaviors at 24 months, but only among children with low levels of negative affect.

to at least two interpretations. According to Moffitt's (1993) account, executive dysfunction underpins the emergence of externalizing behaviors. If this executive account holds then longitudinal data will reveal a unidirectional link between early EF and later externalizing behaviors. Alternatively, by hindering children's involvement in social activities that foster internalization of strategies to enhance inhibition, flexibility, or forethought, early externalizing behaviors might constrain the emergence of EF (e.g., Hughes & Ensor, 2008). If externalizing behaviors set the stage for poor EF, then longitudinal data will reveal a unidirectional link between early externalizing behaviors and later EF. Only a small number of longitudinal studies involving children aged over 2½ years (Hughes & Ensor, 2008; Kahle, Utendale, Widaman, & Hastings, 2018; Sulik, Blair, Mills-Koonce, Berry, & Greenberg, 2015) have tested these competing accounts. The findings to date favor the view that poor EF is a precursor of externalizing behaviors and not *vice versa*. Using a longitudinal cross-lagged model, our first aim was to extend the developmental scope of this work by testing, for the first time, the strength and direction of association between EF and externalizing behaviors in children under the age of 2 years.

1.2 | Parent-child interactions and externalizing behaviors

In a recent meta-analysis, Pinquart (2017) examined the relations between parent-child interactions and children's externalizing behaviors. High levels of parental support characterized by warmth and responsiveness were weakly (but significantly) associated with low levels of externalizing behaviors. Longitudinal studies indicated that while some dimensions of parenting (e.g. harsh control) exhibited bidirectional associations with children's externalizing behaviors (i.e. child and parent effects), other aspects, such as parental behaviors that support children's choices, exhibited unidirectional longitudinal associations with children's

externalizing behaviors. That is, increases in parental support were linked with lower levels of externalizing behaviors in children (Pinquart, 2017). Complementing these meta-analytic results, Frick et al. (2019) reported that observed maternal sensitivity at 10 months was associated with reduced child ADHD symptoms at 36 months. These results are consistent with self-determination theory, which proposes that autonomy supportive parenting, aimed at bolstering children's goals, sense of competence, and need for warmth, is crucial for healthy child adjustment (Ryan, Deci, & Vansteenkiste, 2015). Autonomy supportive parenting has been studied from infancy (e.g., Grolnick, Frodi, & Bridges, 1984) through to adolescence using a range of age-appropriate observational measures (Ryan et al., 2015).

Recent meta-analytic data also indicate that a range of parenting measures are associated with variation in children's EF performance (Valcan, Davis, & Pino-Pasternak, 2018). Of note, autonomy supportive parenting (measured using parent-child observations) at 15 months predicted children's performance on tests of EF at 18, 26, and 36 months (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Bernier, Carlson, & Whipple, 2010). Moreover, responsive parent-child interactions at 15 months were associated with children's performance on measures of effortful control (e.g. waiting for a desirable snack) at 25 months (Kim & Kochanska, 2012). Interestingly, a more global measure of parental sensitivity at 10 months did not uniquely predict inhibition task performance at 18 months (Frick et al., 2018). In line with self-determination theory, these findings suggest that links between EF and externalizing behaviors may reflect common associations with variation in parenting quality, and more specifically, the degree to which parents support their child's emerging autonomy. Thus, our second aim was to examine the strength, uniqueness and direction of association between observed maternal autonomy support, EF and child externalizing behavior in the first two years of life.

The recognition that adverse or positive family environments can have contrasting effects upon different children has considerably advanced our understanding of how family environments influence child adjustment (Belsky, Bakermans-Kranenburg, & Van IJzendoorn, M.H., 2007). According to the classic 'diathesis-stress' (i.e. vulnerability) accounts (e.g., Monroe & Simons, 1991), some children are more vulnerable to adverse environments than others. Conversely, theorists have called for researchers to investigate variation in the extent to which children benefit from positive environments. This 'vantage sensitivity' is distinct from both classic vulnerability and 'for-better-or-worse' effects of differential susceptibility (Pluess & Belsky, 2013). Infant temperament is a useful marker of children's responsiveness to environments. Infant negative affect, a dimension of temperament, can be measured early in development, exhibits relative stability over time, and reflects variation in infants' responsiveness to environments (Putnam, Rothbar, & Garstein, 2008; Slagt, Dubas, Dekovic, & van Aken, 2016). Moreover, meta-analysis indicates that, compared with other dimensions of temperament including surgency and effortful control, negative affect or 'difficult' temperament is a particularly consistent moderator of parental

influences on child outcomes (Slagt et al., 2016). Moderating effects of negative affect on the relations between parenting and child outcomes may explain the relatively weak nature of direct associations between parenting and externalizing reported in Pinquart's (2017) meta-analysis. Several studies have examined this moderating role of infant negative affect on the relation between parenting and externalizing behavior at age 3 years or under. For example, Kochanska and Kim (2013) found that it was only in the context of 'difficult' child temperament that high maternal responsiveness at 30 months predicted low levels of externalizing at 40 months. Likewise, Rochette and Bernier (2016) found that it was only in the context of difficult temperament at 15 months that parent-child positive affect (measured at 12 months) predicted children's EF at 36 months. The third aim of our cross-lagged longitudinal study was to extend existing work by examining the moderating influence of infant negative affect on the link between parental support and child externalizing behavior in the second year of life.

1.3 | Summary of aims

Individual differences in externalizing behaviors emerge early, show stability, and predict later dysfunction. In an effort to understand individual differences in early externalizing behaviors, our longitudinal study of 438 children and their parents had three aims. Extending the developmental scope of existing research on the relations between EF and externalizing behaviors, we first examined the strength and direction of longitudinal associations between EF and externalizing behaviors across the second year of life. Second, we examined whether individual differences in EF and early parent-child interactions make unique contributions to the emergence of externalizing behaviors in the second year of life. Third, we tested the moderating effect of infant temperament on the association between maternal support and externalizing behaviors.

2 | METHOD

2.1 | Participants

We recruited 484 expectant couples from antenatal clinics, ultrasound scans, and parenting fairs in the East of England, New York State, and the Netherlands. To be included in the study, participants had to: (a) be first-time parents, (b) be expecting delivery of a healthy singleton baby, (c) be planning to speak English (or Dutch) as a primary language with their child, and (d) have no history of severe mental illness (e.g. psychosis) or substance misuse. In addition, families were only included if their baby had a healthy full-term delivery. Ten families were ineligible for follow-up when the infants were 4 months old due to birth complications or having left the country. Of the 474 families, 23 families withdrew and 445 (93.8%) agreed to a home visit when their infants (224 boys, 221 girls) were 4 months old, $M_{\text{Age}} = 4.26$ months, $SD = 0.46$ months, range: 2.97–6.23 months.

At the next time point, 13 of the 451 remaining families became ineligible for follow-up due to having left the country. Six families withdrew from the study and six families who missed appointments at 4-months took part. Thus, 422 of 438 eligible families (96.3%) took part when their infants (214 boys, 208 girls) were 14 months old, $M_{\text{Age}} = 14.42$ months, $SD = 0.57$ months, range: 9.47–18.40 months. At the final time point, 12 of the 438 families became ineligible for follow-up due to having left the country. Sixteen families declined to take part and 10 families returned to the study having missed their previous appointment. Thus, 404 of 426 eligible families (94.8%) took part when their children (209 boys, 195 girls) were 24 months old, $M_{\text{Age}} = 24.47$ months, $SD = 0.78$ months, range: 19.43–26.97 months. At the birth of their child mothers were, on average 32.24 years old, $SD = 3.92$, range: 21.16–43.76 years. Both mothers had high levels of educational attainment: 84.3% had an undergraduate degree or higher.

2.2 | Procedure

The National Health Service (NHS UK) Research Ethics Committee and New York University and Leiden University Institute Review Boards approved the study protocol. All parents provided written informed consent at each wave of data collection. Expectant parents completed an online questionnaire and in-person interview during the final month of their pregnancy (estimated as 1-month before the due date). Families participated in a 4-month, 14-month, and 24-month visit. Mothers and fathers completed the Infant Behavior Questionnaire at 4 months and the Brief Infant-Toddler Social and Emotional Assessment at 14 months. Mothers in all three sites completed the Strengths and Difficulties Questionnaire at 24 months. At 14 and 24 months each family completed one home visit lasting approximately 1 hr. These visits consisted of short parent–child observations, parental interviews, and a cognitive testing session (lasting approximately 10 min) with each child. EF tasks were administered in a fixed order at 14 (i.e. Prohibition Task, Multi-location Search, Ball Run task) and 24 months (i.e. Multilocation Search, Ball Run Task, Baby Stroop Task).

2.3 | Measures

2.3.1 | Executive function

Children completed a short battery of three tasks (for details see: Devine et al., 2019) at 14 and 24 months. Children sat on their parent's lap across a table from the examiner. Parents remained silent during each task. Children received praise at the end of each task regardless of performance to maintain their interest in participating.

Children completed the *Prohibition Task* (Friedman, Miyake, Robinson, & Hewitt, 2011) during the 14-month visit. Children were required to resist touching an attractive toy for up to 30 s following the examiner's command ('Don't touch!'). Scores were coded

into two categories (i.e. 0 = touches before 30s; 1 = does not touch before 30 s). Children completed the *Baby Stroop Task* (Hughes & Ensor, 2005) during the 24-month visit. Children participated in a 'silly game' in which they pointed to a large spoon when the examiner said 'Baby' and a small spoon when the examiner said 'Mummy'. Children completed six trials (with feedback) and passed if they performed correctly on 4 or more trials.

Children completed a *Multilocation Search Task* (Miller & Marcovitch, 2015) during both home visits. Children searched for a number of toy cars (i.e. three at 14 months and five at 24 months) hidden in distinct toy garages after a delay of 5 s between each search. The task continued until the child retrieved all cars or made three consecutive errors. Children passed if they retrieved all of the hidden cars.

Children completed the *Ball Run Task* (Devine et al., 2019) at both visits. In the learning phase, the examiner demonstrated how to activate a musical switch by placing a colored ball (e.g. red) into one of two colored holes (e.g. red hole). The other hole (e.g. green) was sealed from beneath and could not be used to activate the switch. Children completed six learning trials with feedback. In the reversal phase, the examiner demonstrated how to activate the toy by placing a different colored ball (e.g. green) into the previously unused hole (e.g. green). The original hole was sealed from beneath and could no longer be used to activate the switch. Children completed six reversal trials with feedback. Children passed a phase if they performed correctly on four or more trials.

We created an EF score for each time point by summing together the number of tasks each child passed. Table S1 shows the numbers of children passing each EF task and Table S2 shows the tetrachoric correlation matrix for the EF tasks. The reliability coefficient (i.e. ordinal alpha based on tetrachoric correlations) was modest at 14 months ($\alpha = 0.37$) and 24 months ($\alpha = 0.58$). These results were consistent with the modest EF task correlations in this age range reported elsewhere (Johansson, Marciszko, Brocki, & Bohlin, 2016; Kochanska & Knaack, 2003; Miller & Marcovitch, 2015). In addition to reducing the number of variables in our models, we opted for a single aggregate score for EF because these scores exhibit greater stability over time than individual task scores in the second year of life (Miller & Marcovitch, 2015).

2.3.2 | Maternal support

We observed mother–child dyads in a 4-min play session involving an inset jigsaw puzzle at 14 months and a building block puzzle at 24 months. We measured maternal support by coding the observations using the Autonomy Support Coding manual (Whipple, Bernier, & Mageau, 2011). This coding scheme provides a global rating of the extent to which parents support their children's interests, choices, and goals during play. Autonomy support ratings show stability over time and are correlated with measures of parental sensitivity and parents' proclivity to view children as mental agents (Bernier et al., 2010; Matte-Gagné, Bernier, & Lalonde, 2015). Parents

received a rating on a 1–5 scale (from not autonomy supportive to very autonomy supportive) on 4 items indicating the degree to which mothers: (a) provided appropriately tailored help; (b) used hints, instructions, and encouragement; (c) kept their child on-task, and (d) involved the child as an active participant. Following training and feedback, graduate raters' scores were compared against a reliability set of 30 cases from 14 months and 30 cases from 24 months rated by the lead authors. We calculated a mean autonomy support rating at 14 ($\alpha = 0.87$) and 24 months ($\alpha = 0.83$). Inter-rater reliability coefficients for the mean autonomy support rating at 14 (ICC = 0.73) and 24 months (ICC = 0.74) were acceptable.

2.3.3 | Child externalizing behavior and temperament

Mothers and fathers completed the Brief Infant Behavior Questionnaire (Putnam, Helbig, Garstein, Rothbart, & Leerkes, 2014) prior to the 4-month visit to measure infant negative affect. We averaged items from the Distress to Limitations scale across mothers and fathers and then summed the items to create a single score with higher scores indicating greater levels of negative affect ($\alpha = 0.83$). Mothers and fathers completed the *Brief Infant-Toddler Social and Emotional Assessment* (BITSEA) (Briggs-Gowan, Carter, Irwin, Wachtel, & Cicchetti, 2004) as part of the 14-month questionnaire. The BITSEA consisted of 30 items measuring a range of externalizing behaviors including emotional problems, externalizing behaviors, and dysregulation and is suitable for use with children aged between 12 and 24 months. Items were averaged across parents and summed together to create a total problems score ($\alpha = 0.75$). Mothers in all three sites completed the *Strengths and Difficulties Questionnaire* (2- to 4-year-old version) (SDQ) (Goodman, 2001) as part of the 24-month questionnaire. The 10 items measuring externalizing behaviors (i.e. conduct problems, hyperactivity) were summed together to create an externalizing score (Goodman, Lamping, & Ploubidis, 2010) ($\alpha = 0.68$).

2.3.4 | Control variables

Mothers completed the *Ladder of Subjective Social Status* (Singh-Manoux, Adler, & Marmot, 2003) at each study time point indicating

their placement on a 10-rung ladder where the top represented those with the best education, income, and employment and the bottom those with worst. Ratings were averaged across the three post-natal visits to create an index of social status ($\alpha = 0.85$). In the English-speaking subsamples (i.e. UK and USA) we administered the receptive vocabulary test of the Wechsler Preschool and Primary Scale (WPPSI) (Rust, 2003). Children pointed to a picture matching a word read aloud by the researcher. We used the total score to provide an index of verbal ability at 24 months.

3 | RESULTS

3.1 | Analytic strategy

We used structural equation modeling in *Mplus* (Version 8) (Muthén & Muthén, 2017) to analyse the data. We applied a maximum likelihood estimator with robust standard errors (MLR) in each of our models to account for the non-normal distribution of our indicators. We evaluated model fit using three primary criteria: Comparative Fit Index (CFI) > 0.90, Tucker Lewis Index (TLI) > 0.90, Root Mean Square Error of Approximation (RMSEA) < 0.08 (Brown, 2015). Table 1 shows the descriptive statistics for each key study measures and the extent of missing data. We used a full information approach (where model parameters and standard errors were estimated using all available data) under the assumption that data were missing at random so that all eligible families who participated in the prenatal and at least one follow-up phase ($N = 438$; 218 boys) were included (see Online Appendix for information on Missing Data). Table 2 shows the correlations between each variable in the dataset.

3.2 | Model results

We tested two cross-lagged autoregressive models to examine the relations between children's EF, maternal support, and child externalizing behavior between the ages of 14 and 24 months. In Model 1, we examined the longitudinal association between each independent variable at 14 months (i.e. 14 month EF, maternal autonomy support, and externalizing behavior) and each dependent variable at 24 months (i.e. 24-month EF, autonomy support, and externalizing

TABLE 1 Descriptive statistics

	14 month visit			24 month visit		
	M (SD)	Range	N	M (SD)	Range	N
Executive function total	0.91 (0.85)	0–3	421	2.11 (1.08)	0–4	398
Maternal support	3.20 (0.80)	1–5	419	3.26 (0.85)	1–5	390
Externalizing behaviors: BITSEA	10.52 (4.55)	0–25	399			
Externalizing behaviors: SDQ				5.84 (2.98)	0–14	351

TABLE 2 Robust maximum likelihood estimates for correlations between tasks

	1	2	3	4	5	6	7	8	9	10	11
1 14M EF	—										
2 24M EF	0.126*	—									
3 14M Aut Sup	0.083	0.044	—								
4 24M Aut Sup	0.088	0.106*	0.370**	—							
5 14M Ext Beh	0.003	-0.017	-0.218**	-0.201**	—						
6 24M Ext Beh	-0.139**	-0.049	-0.128*	-0.056	0.366**	—					
7 4M Neg Aff	0.001	-0.077	-0.165**	-0.105*	0.433**	0.200**	—				
8 Age	0.091	0.082	-0.056	-0.029	0.134**	-0.059	0.032	—			
9 Gender	-0.067	0.085	0.038	0.099	-0.168**	-0.121*	-0.038	-0.061	—		
10 Ladder	-0.003	0.080	0.060	0.007	-0.108*	-0.098	-0.125**	0.006	0.125**	—	
11 Education	0.030	0.060	-0.063	0.049	0.020	-0.056	0.127**	0.068	0.064	0.376**	—
12 Employment	-0.043	0.064	0.158**	0.146**	-0.161**	-0.010	-0.085	-0.032	0.075	-0.090	-0.093

Note: Correlations with age show concurrent correlations.

Abbreviations: Aut Sup, Maternal Support; EF, Executive Function; Ext Beh, Externalizing behavior; Neg Aff, Negative Affect.

* $p < .05$.

** $p < .01$.

behaviors), while accounting for stability in each of the dependent variables (Newsom, 2015). We controlled for individual differences in potential confounding variables by regressing the 24-month dependent variables onto: child age, gender (i.e., male = 1, female = 2), maternal socioeconomic status (i.e. subjective social status, employment, and education), two dummy variables representing country of origin (i.e. UK vs. Netherlands; UK vs. USA), and child negative affect at 4 months. Independent variables were permitted to correlate in the model.

The model provided an acceptable fit to the data, $\chi^2(30) = 41.409$, $p = .0803$, RMSEA = 0.029, 90%CI [0.00, 0.05], CFI = 0.984, TLI = 0.958, and explained 20.6% of the variance in 24-month externalizing behaviors, 19.0% of the variance in 24-month maternal autonomy support, and 6.4% of the variance in 24-month child EF. Figure 1 shows a simplified path diagram excluding the covariates. Table 3 shows the key model results. Table S3 displays the complete model output. The autoregressive paths indicated modest but significant rank-order stability in EF, externalizing behaviors, and maternal autonomy support from 14 to 24 months. Cross-lagged paths indicated a small unique longitudinal association between 14-month EF and children's externalizing behaviors at 24 months, $R^2 = 0.015$. There was no significant association between 14-month maternal autonomy support and children's externalizing behavior at 24 months. We compared the strength of the path between 14-month externalizing behavior and 24-month EF with the path between 14-month EF and 24-month externalizing behavior by constraining these paths to equality. The Wald test revealed a difference in the strength of these two paths, $\chi^2(1) = 7.288$, $p = .007$, indicating a unidirectional developmental association between early EF and later externalizing behavior. There was no significant difference between the path linking 14-month maternal autonomy support and later externalizing behavior and the path linking 14-month externalizing behavior and later maternal autonomy support, $\chi^2(1) = 1.272$, $p = .2594$.

We conducted follow-up analyses using multiple-groups structural equation modeling (MG-SEM) to examine whether the cross-lagged regression paths were similar in boys and in girls. To this end we first estimated the model simultaneously in boys and girls. This unconstrained baseline model provided an acceptable fit to the data, $\chi^2(56) = 78.324$, $p = .026$, RMSEA = 0.043, 90%CI [0.015, 0.064], CFI = 0.969, TLI = 0.921. We then estimated a series of nested models in which corresponding cross-lagged paths (e.g., path between 14-month externalizing behavior and 24-month EF) were constrained to equality in boys and girls (see Table S4). Paths were considered to differ in strength if the constraint produced a decrease in model fit as indicated by a significant increase in the Satorra-Bentler χ^2 difference test and decrease in CFI of > 0.002 (Brown, 2015; Meade, Johnson & Braddy, 2008). The regression path linking negative affect at 4 months and autonomy support at 24 months differed in strength between boys and girls but neither path was statistically significant (see Table S4). Model comparisons revealed that there were no other differences between boys and girls in the strength of regression paths. Patterns of association between variables were therefore similar in boys and girls.

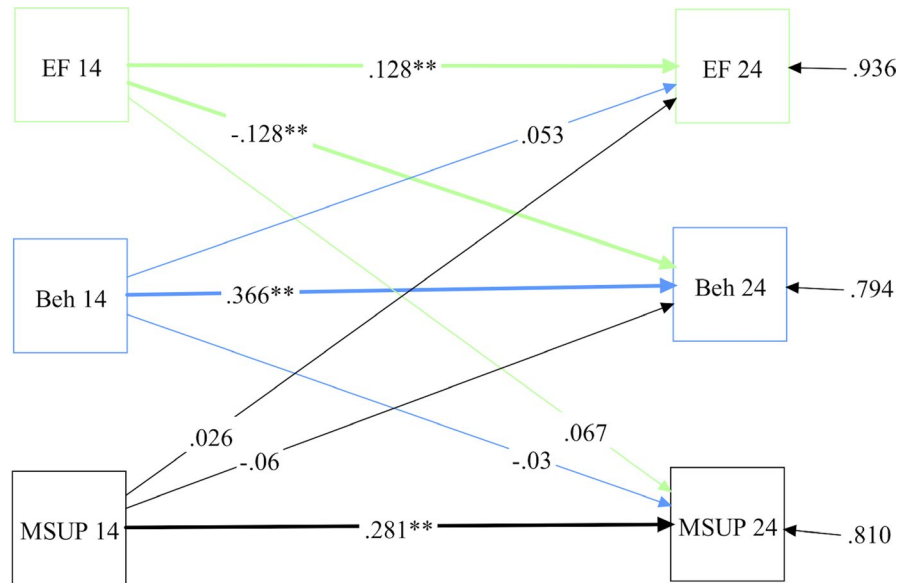


FIGURE 1 Simplified path diagram showing standardized robust maximum likelihood estimates for the key results from the cross-lagged model. EF, Executive function; Beh, Externalizing Behavior; MSUP, Maternal Support

TABLE 3 Robust maximum likelihood estimates for longitudinal structural equation model

	24M executive function			24M externalizing behavior			24M maternal support		
	Est.	SE	Std. Est.	Est.	SE	Std. Est.	Est.	SE	Std. Est.
Age	0.175	0.067	0.128**	0.031	0.166	0.008	0.017	0.057	0.016
Gender	0.209	0.109	0.096	-0.277	0.301	-0.046	0.112	0.079	0.066
Country (UK v NL)	-0.072	0.169	-0.030	0.943	0.446	0.142*	0.390	0.116	0.207**
Country (UK v USA)	-0.241	0.165	-0.099	-0.374	0.462	-0.056	-0.009	0.134	-0.005
Ladder of Social Status	0.059	0.052	0.063	-0.046	0.136	-0.018	-0.035	0.042	-0.047
Education	0.050	0.049	0.056	-0.043	0.142	-0.017	0.094	0.033	0.132**
Employment	0.096	0.059	0.081	0.029	0.181	0.009	0.038	0.041	0.041
Negative Affect 4M	-0.104	0.073	-0.090	0.330	0.199	0.102	0.023	0.051	0.025
Executive Function 14M	0.162	0.060	0.128**	-0.449	0.171	-0.128**	0.066	0.047	0.067
Externalizing Behaviors 14M	0.013	0.016	0.053	0.241	0.040	0.366**	-0.006	0.012	-0.030
Maternal Support 14M	0.036	0.076	0.026	-0.225	0.189	-0.060	0.298	0.053	0.281**
Negative x Maternal	-0.035	0.075	-0.024	0.459	0.205	0.111*	—	—	—

Abbreviations: 4M, 4-Month Visit; 14M, 14-month Visit; 24M, 24-month visit; Est, Unstandardized Estimate; Std Est, Standardized Estimate.

* $p < .05$.

** $p < .01$.

Verbal ability measures at 24 months were available for the UK and USA subsamples ($N = 314$). To examine the specificity of the association between EF and externalizing behavior, we re-ran Model 1 in this subsample and regressed each of the dependent variables on verbal ability. Even when verbal ability was held constant, 14-month EF exerted a unique effect on 24-month externalizing behavior, $Est. = -0.529, SE = 0.203, \beta = -0.15, Z = -2.642, p = .008$, but not *vice versa*, $Est. = 0.011, SE = 0.020, \beta = 0.04, Z = 0.531, p = .595$.

These paths differed significantly, $\chi^2(1) = 7.019, p = .0081$, supporting a unidirectional link between early EF and later externalizing behavior.

To assess the moderating effect of child temperament on the relation between maternal autonomy support and child externalizing behavior, we regressed 24-month child externalizing behavior onto the grand-mean centered interaction term for negative affect and 14-month maternal autonomy support using the whole

sample (Hayes, 2018). All other features of Model 2 were the same as Model 1. Model 2 provided an acceptable fit to the data, $\chi^2(40) = 63.87$, $p = .009$, RMSEA = 0.037, 90%CI [0.018, 0.053], CFI = 0.967, TLI = 0.925. There was a small but significant effect of the multiplicative interaction term on 24-month externalizing behavior. Figure 2 shows the predicted values for externalizing behavior based on the conditional effect of maternal autonomy support for children at the 16th, 50th, and 84th percentile for negative affect. We probed the interaction using a regression centering approach in which we centered the moderator variable around the 16th, 50th, and 84th percentiles (Hayes, 2018). There was a significant negative association between maternal autonomy support and externalizing behavior among children in the 16th percentile for negative affect, *Std. Est.* = -0.179, *SE* = 0.068, 95%CI [-0.313, -0.045], $Z = -2.612$, $p = .009$. There was no association between maternal support and externalizing behavior among children in the 50th percentile, *Std. Est.* = -0.066, *SE* = 0.050, 95%CI [-0.165, 0.033], $Z = -1.313$, $p = .189$, or 84th percentile, *Std. Est.* = 0.065, *SE* = 0.076, 95%CI [-0.084, 0.213], $Z = 0.853$, $p = .393$.

4 | DISCUSSION

Our study yielded three main findings about individual differences in externalizing behavior in the second year of life. First, there was a modest but significant unidirectional negative association between EF at 14 months and externalizing behavior at 24 months. Second, this unique predictive association held up even when potential effects of verbal ability or maternal support were considered. Third, only infants with low levels of negative affect benefitted from maternal autonomy support, such that only this group showed an inverse association between 14-month maternal autonomy support and externalizing behavior at 24 months.

4.1 | EF predicts externalizing behavior in the second year of life

Although externalizing behaviors are more common among 2 year olds than among 4 year olds, there are striking individual differences in the extent to which children engage in externalizing behaviors even in the second year of life (Alink et al., 2006). Understanding individual differences in externalizing in toddlerhood matters because longitudinal studies show that externalizing behaviors are moderately stable across childhood (Campbell et al., 2006; Cote et al., 2006; Rose et al., 1989; Smith et al., 2004). Converging support for Moffitt's (1993) proposal that EF sets the stage for early externalizing behavior comes from three previous longitudinal studies that have adopted cross-lagged designs in preschool and school-aged children (Hughes & Ensor, 2008; Sulik et al., 2015; Kahle et al., 2018). While prior studies point to a link between related constructs like effortful control and externalizing behavior in the second year of life (e.g., Adrichem et al., 2019; et al., 2000), to date cross-lagged analyses in this age range have not been undertaken. The current study extends the developmental scope of research on the executive account of externalizing behavior by examining the nature and direction of this association in children under the age of two. Our findings indicate that individual differences in toddlers' externalizing behavior and EF performance each show modest temporal stability. Cross-lagged models permitted comparison of the strength of developmental associations between these two constructs. EF at 14 months predicted externalizing behavior at 24 months, even when 14-month externalizing behavior was considered. In contrast, there was no reciprocal association between toddler externalizing behavior at 14 months and EF at 24 months. These findings support the executive account, expand the developmental scope of previous work (Schoemaker et al., 2013), and strengthen the view that EF provides a useful focus for interventions aimed at mitigating externalizing

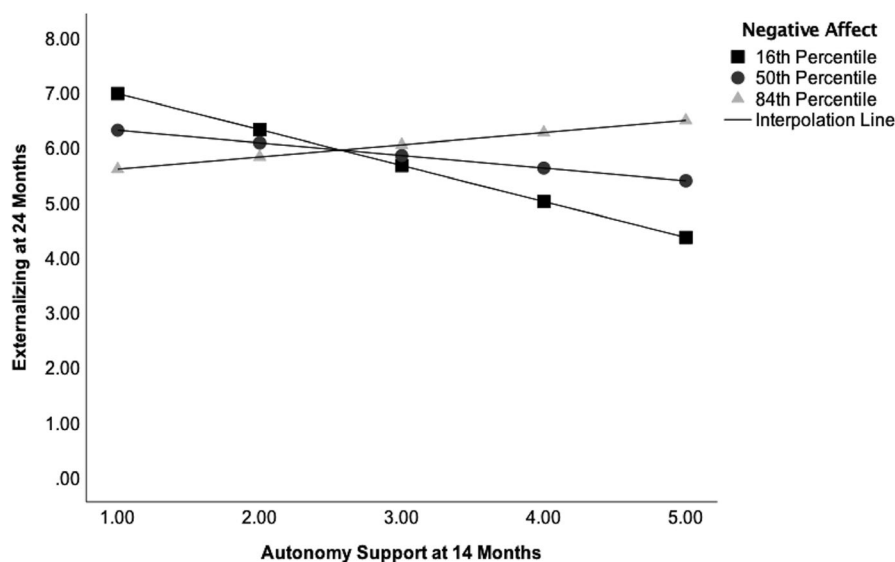


FIGURE 2 Child negative affect moderates the association between maternal support and child externalizing behavior

behavior. Our results also suggest that the correlation between EF and externalizing in the first two years of life is similar in magnitude to that reported for community-based preschool children (Schoemaker et al., 2013). While beneficial for understanding predictors of between-person individual differences, autoregressive cross-lagged panel models do not provide insight into how within-person changes in EF lead to within-person changes in externalizing behavior (or *vice versa*) (Berry & Willoughby, 2017). Future studies, incorporating three or more time points will permit researchers to examine the links between within-person change in each domain using autoregressive latent trajectory models (Berry & Willoughby, 2017).

Note that our protocol included three EF tasks. This relatively small EF task battery was useful in minimizing demands upon 14-month-old infants and 24-month-old toddlers, but constrained analyses regarding which EF components best predict variation in later externalizing behavior. Individual aspects of EF may well act in concert to promote children's adjustment. For example, complying with a parental request to tidy up toys requires children to (a) inhibit their current (enjoyable) activity, (b) shift attention to the new goal of tidying up, and (c) hold this plan in working memory. Future work is needed to examine the contribution that distinct aspects of EF play in early externalizing behavior.

4.2 | Comparing effects of EF and maternal support on externalizing behavior in the second year of life

With notable exceptions focused on outcomes later in childhood (e.g., Frick et al., 2019), the links between externalizing behavior, EF and parental support have typically been examined in isolation, such that little is known about their relative overlap and uniqueness in the first 2 years of life. A second aim of our study was to address this gap in understanding by including both experimental measures of EF and direct observational ratings of maternal support at each time-point. Consistent with a previous longitudinal study of parent-child dyads from 15 to 36 months (Matte-Gagné et al., 2015), ratings of maternal autonomy support showed modest stability between 14 and 24 months. The association between EF at 14 months and externalizing behavior at 24 months remained significant even when variation in maternal autonomy support was considered. Self-determination theory predicts that parents who support their infant's emerging volition, competence, and need for relationships, will exhibit fewer externalizing behavior and better EF than their peers (Ryan et al., 2015). Our results present a challenge to this account. While there were significant correlations between autonomy support and EF at 24 months and between autonomy support and externalizing behavior at 14 and 24 months, observed maternal autonomy support at 14 months did not uniquely predict either EF or externalizing behavior at 24 months. These results contrast with evidence indicating direct associations between parental behavior and EF in preschool children (e.g., Hughes & Devine, 2017) but echo recent work showing no unique association between parental

sensitivity at 10 months and EF at 18 months (Frick et al., 2018). One possibility worthy of future study is that emerging EF may become more susceptible to parental influence with the growth of language in the second year of life.

Investigations of early family relationships have overlooked child-driven effects (Davidov, Knafo-Noam, Serbin, & Moss, 2015). In this regard, it is worth noting that Pinquart's (2017) meta-analytic findings from studies of in school-aged children and adolescents indicate contrasting results for different aspects of parenting in relation to externalizing behavior. Specifically, while harsh parental control showed a bidirectional link with child externalizing behavior, maternal support showed a weak unidirectional effect upon child externalizing behavior. Note that the association between maternal support and child externalizing behavior in the current study was similar in magnitude to that reported by Pinquart (2017) (i.e., $r = -0.06$, as compared with -0.05), but was not statistically significant, indicating the potential interplay with child characteristics.

4.3 | Maternal support predicts reduced externalizing behavior for infants with low levels of negative affect

Our model showed no direct effect of maternal support upon children's externalizing behavior. This is consistent with a study reporting no direct association between autonomy supportive parenting at 15 months and child aggression at age 6 (Sirois & Bernier, 2018). While these findings may challenge self-determination theory (Ryan et al., 2015), the results are consistent with predictions from vantage sensitivity (e.g., Pluess & Belsky, 2013). Infants with low levels of negative affect at 4 months benefitted more from high levels of maternal support at 14 months than those with average or high levels of negative affect, such that for this group alone there was a significant inverse association between early maternal support and later externalizing behavior. Interestingly, prior work on related domains (e.g., maternal responsiveness and externalizing) has shown that children with 'difficult temperaments' were *more* susceptible to responsive parenting such that there was an inverse association between parental responsiveness at 30 months and child externalizing at 40 months (Kochanska & Kim, 2013). One possibility, suggested by the between-study contrast in child age periods is that the moderating effects of child temperament are developmentally specific. That is, in late infancy, children with easy temperaments may gain most from high quality maternal support whereas by the preschool years, maternal support may have most impact on children with difficult temperaments.

It is also worth noting that infant negative affect at 4 months showed an inverse association with maternal support at both 14 and 24 months. Mothers of infants prone to distress may have attempted to minimize frustration by providing greater assistance during goal-directed tasks and thereby inadvertently limiting their child's autonomy. This correlation could indicate child-driven effects (Belsky et al., 2007), rather than an example of vantage sensitivity. Further work is needed

to investigate this interaction effect. Vantage sensitivity for infants with low negative affect may indicate limits on the extent to which maternal support can influence children's externalizing behavior, with weaker benefits for infants prone to distress.

5 | CAVEATS AND CONCLUSIONS

It is worth acknowledging that the low-risk nature of the sample potentially limited the generalizability of study findings and the sensitivity of some of our analyses. Effects of environmental adversity on child externalizing behavior may display a threshold effect, such that the limited demographic diversity in our sample may explain the lack of association between family affluence and child outcomes. That said, maternal education was positively related to maternal support in our model, indicating that there was variation in family background. Note also that the large sample size precluded the collection of observational data on child externalizing behavior and temperament. It is reassuring that our results are consistent with previous studies involving smaller samples that have included multi-informant ratings of externalizing behavior (e.g., Hughes & Ensor, 2008). The two-wave cross-lagged design allowed us to examine the direction of developmental associations in our data but did not allow tests of mediation hypotheses linking parent-child interaction, EF and externalizing behavior (e.g., Roman, Ensor, & Hughes, 2016). Future studies involving at least three time-points are required to investigate whether EF might mediate the relations between parent-child interaction and later externalizing behaviors (Cole & Maxwell, 2003).

To our knowledge, this is the first study to adopt a cross-lagged design to investigate the nature and direction of associations between EF and externalizing behavior in children under the age of 2 years. Our results show that early difficulties with EF contribute to the individual differences in externalizing behavior, even before children's second birthdays. These findings support the executive dysfunction account of child externalizing behavior. Our results underscore the need to examine how the effects of maternal support on early externalizing behavior are moderated by temperamental factors such as negative affect. By including both experimental measures of child EF and direct observations of parental support our study extends existing work on toddlers and preschoolers by bridging two disparate approaches in investigating the origins of externalizing behavior in the first two years of life and provides a comprehensive model to be tested in future studies involving diverse samples.

CONFLICTS OF INTEREST STATEMENT

There are no conflicts of interest.

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DATA AVAILABILITY STATEMENT

Data are available from the UK Data Service: Hughes, C., Devine, R.T., Mesman, J., & Blair, C. (2018). *The New Fathers and Mothers Study*. [Data Collection]. Colchester, Essex: UK Data Service. 10.5255/UKDA-SN-853278.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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