Mothers' and fathers' executive function both predict emergent executive function in toddlerhood

NewFAMS Investigators

DOI:
10.1111/desc.13263

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Accepted for Publication in *Developmental Science* on 23rd March 2022

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ACKNOWLEDGEMENTS
This work was funded by the Economic and Social Research Council, UK (Grant Number: ES/LO16648/1), Netherlands Organisation for Scientific Research (NWO) (464-13-141) and National Science Foundation, USA (NSF) (1429152). Additional support was provided by NIH NICHD F32 HD102106-01 to AR. The NewFAMS Team (in alphabetical order): Lenneke Alink, Marjolein Branger, Wendy Browne, Rosanneke Emmen, Sarah Foley, Lara Kyriakou, Anja Lindberg, Gabrielle McHarg, Andrew Ribner, Mi-Lan Woudstra.

CONFLICTS OF INTEREST STATEMENT
There are no conflicts of interest.

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. 1.5255/UKDA-SN-853278.

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Research Highlights

- Both mothers' and fathers' executive function uniquely predict toddlers' executive function over and above stability from 14 to 24 months.
- Characteristics of caregiving behaviors—namely autonomy support and sensitivity—are associated with better child executive function.
- Some, but not all, of the intergenerational associations between parents' and children's executive function operates through parenting practices.

Abstract

There are multivariate influences on the development of children's executive function throughout the lifespan and substantial individual differences can be seen as early as when children are one and two years of age. These individual differences are moderately stable throughout early childhood, but more research is needed to better understand their origins. To some degree, individual differences in executive function are correlated between mother and child, but no research to date has examined these associations prior to when children are preschool age, nor have any studies considered the role of fathers' and mothers' executive function in tandem. Here, we use a sample of 484 families (Mothers 89.2% white; Fathers 92.5% white) in three countries (UK, USA, Netherlands) to investigate the role of each parents' executive function on the development of children's (49.7% female) executive function from 14 (M=14.42, SD=.57) to 24 (M=24.47, SD=.78) months, as well as parenting practices that underlie these associations. Results of structural equation models suggest stability in some—but not all—components of executive function and growing unity between components as children age. We replicate extant findings such that mothers' executive function predicts children's executive function over and above stability and extend these findings to include associations between father and child skills. We find an additive role of fathers' EF, similar in magnitude to the role of mothers' EF. Finally, for both mothers and fathers we find that sensitivity and autonomy supportive practices mediate the relations between parents' and children's executive function.

Keywords: Executive Function, Autonomy Support, Sensitivity, Toddlerhood, Fathers

Introduction

While the development of "mature" executive function (EF) is a protracted process that extends from birth through early adulthood (Hughes, 2011; Huizinga et al., 2006), individual differences in EF already have important implications in early childhood. Early EF is associated with children's academic performance (Blair & Razza, 2007; Schmitt et al., 2017) and social skills (Caporaso et al., 2019; Devine & Hughes, 2014; Rinsky & Hinshaw, 2011), and with children's ability to learn from classroom instruction (Ribner, 2020) as they enter formal schooling. EF also predicts important long-term outcomes including educational attainment (McClelland et al., 2013) and adult earnings (Deer et al., 2020). EF falls under the broad umbrella of self-regulation and refers to a multidimensional construct made up of higher-order skills that support humans' ability to regulate their behaviors, emotions, and actions in the effortful pursuit of goals (Diamond, 2013). Despite flourishing recent research describing the importance of early EF and its antecedents and consequences, much of the extant literature has focused on the development of EF during preschool and early elementary years. Substantial individual differences in EF are evident in the first years of life and show modest stability from infancy and toddlerhood to later years (Devine et al., 2019; Hughes et al., 2020; Hughes & Ensor, 2007); however, existing research has typically relied on cross-sectional designs and adopted a narrow focus on maternal influences. The present investigation fills these gaps by extending inquiry to include fathers—an understudied, yet unique and important presence in children's early developmental—and by examining the development of EF across toddlerhood.

Many leading models of EF suggest the construct is comprised of the three overlapping abilities: Working memory, inhibition, and shifting (including attention shifting; e.g., Diamond, 2013). Working memory refers to the ability to hold multiple pieces of information in mind at a given time and to update and manipulate that information considering novel or changing information. For example, an infant or toddler might be asked to find three hidden objects in different locations without replacement, requiring them to recall where they have previously located objects so as to not search the same location multiple times (Miller & Marcovitch, 2015). Inhibition refers to the ability to ignore or override the urge to perform an inappropriate or pre-potent behavior in favor of a more appropriate or correct response. In infancy or toddlerhood, this may be observed in children being asked to not do something that would be natural for a child to do (e.g., grab an attractive object; Friedman et al., 2011) or to ignore a well-established association (e.g., refer to an adult-sized object as "for baby" and a toddler-sized object as "for mommy;" (Hughes & Ensor, 2005). Finally, shifting refers to the ability to (re)focus attention to relevant stimuli and attend to new rule sets. For example, an infant or toddler might be asked to form one association (e.g., which arbitrary images of trucks will result in them getting a treat) and then reform a different association (e.g., the trucks that previously did not give treats now gave treats, and vice versa; Hughes & Ensor, 2005).

Although single-task studies have been used to investigate the emergence of EF in infants and toddlers since the 1980s (e.g., Diamond, 1985), recent years have seen a growth of interest in understanding the functional organization of EF in the first two years of life using multi-task batteries (e.g., Devine et al., 2019; Johansson et al., 2016; Miller & Marcovitch, 2015). This approach draws on the widespread adoption of multi-task batteries to investigate the structure of EF in adults, adolescents and children (for meta-analysis see: Karr et al., 2018). Using data from multi-task batteries, researchers have proposed that EF first emerges as a unitary ability in childhood and, although there are specialized EF abilities in adulthood, a common EF factor underpins performance across all EF components (Friedman & Miyake, 2017; Friedman &

Robbins, 2022). However, emerging studies now indicate that, unlike in older children and adults, in the first two years of life, EF skills are largely separable (as indicated by limited overlap between tasks) (Devine et al., 2019; Johansson et al., 2016; Miller & Marcovitch, 2015; Wiebe et al., 2010). This supports the view that basic EF skills may emerge separately, gradually becoming more coordinated with development (e.g., Garon et al., 2008). On this basis, performance on EF tasks in the first two years of life should show little overlap and longitudinal data should reveal increasing associations between EF tasks in infancy and toddlerhood.

Parent EF is Associated with Child EF

Individual differences in EF are—at least to some degree—correlated in parents and their biological offspring. That is, throughout childhood and adolescence, children of parents with good EF are more likely than their peers to have good EF themselves (Brieant et al., 2017; Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Distefano et al., 2018; Jester et al., 2009; Kim et al., 2017; Korucu et al., 2020). Several hypotheses have been proposed to explain these intergenerational trends. While there is evidence for physiological processes involved in these correlations—such as genetic predispositions (Friedman et al., 2008; Jester et al., 2009; Leve et al., 2013) and hormone exposure *in utero* (Braren et al., 2021; Buss et al., 2011; Camerota & Willoughby, 2020)—there is also a large role for social and environmental influences.

According to the transactional model of self-regulatory skill development (Sameroff, 2010), children's skills develop in a careful balance between their own self-regulation and "other"-regulation (resulting in a dynamic process of "co-regulation"; e.g., Armstrong-Carter et al., 2021). Early in life, infants rely on other-regulation for nearly everything: Caregivers do what is necessary to keep the child safe, warm, and fed, as children are unable to do it themselves. As children age and their capacities mature such that they are better able to regulate their own behaviors, actions, and emotions, the need for other-regulation diminishes. This interplay between self- and other-regulation sets the stage for children's self-regulatory skill development: Children learn successful regulatory strategies from the provision of other-regulation, and a paucity of other-regulation may not afford necessary scaffolding for children to learn how to self-regulate. On the other hand, children who are over-regulated by caregivers are given less opportunity to practice and hone their own self-regulatory capacities.

Several facets of parenting practices and parent–child relationships are implicated in the development of children's early EF (Fay-Stammbach et al., 2014; Hendry et al., 2016). In particular, parental autonomy support and sensitive caregiving practices have been suggested as mechanisms by which EF is transmitted from parent to child. Autonomy support—a construct closely related to and in part overlapping with "scaffolding"—refers to parents supporting children's pursuit and achievement of goals and choices. In practice, autonomy support can be seen in parents offering age- and skill level-appropriate strategies and hints for problem solving and task completion, as well as encouraging the child to lead in interactions and following their lead (Carlson, 2003; Matte-Gagné & Bernier, 2011). Several studies have suggested parental autonomy support is related to children's EF (Distefano et al., 2018; Matte-Gagné et al., 2015; Matte-Gagné & Bernier, 2011) and emergent evidence suggests a causal link (Meuwissen & Carlson, 2019). Similarly, several studies have suggested parental sensitivity—broadly defined as having interactions that demonstrate positive affect, warmth, and an absence of hostility—is related to children's EF (Blair et al., 2011, 2014; Hughes & Devine, 2019).

As a parent, completing tasks aimed at toddlers (e.g., assembling a six-piece puzzle), or allowing toddlers free rein of an activity are both easy. It is much harder to recognize moment-to-moment nuances in child skill and attention and provide appropriate adaptation that creates a challenging, yet attainable context for the child to complete a task. This dynamic process of ramping up and rolling back support as children show reduced or improved task mastery is likely to necessitate parents' own self-regulatory skills and so offers a potential explanation for the correlation between parent and child EF. Indeed, parents with higher levels of EF tend to display both higher autonomy support and sensitivity in their interactions with their children (Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Distefano et al., 2018; Hughes & Devine, 2019; Korucu et al., 2019), and recent studies have reported indirect effects of parent EF on child EF through autonomy support and sensitivity. One recent study of 85 preschool-aged parent–child dyads from socioeconomically diverse backgrounds found that parental autonomy support fully mediated the relation between parent and child EF (Distefano et al., 2020). Another study with 62 mother–child dyads found that a composite of parenting practices which are broadly associated with sensitivity—comprised of facilitating attention, physical stimulation, negative affect, and intrusiveness averaged across three time points ranging from when children were 10 months to when they were 36 months of age—mediated associations between mother and child EF (Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014). These studies, while promising, are both underpowered to detect all but the largest effects (Fritz & MacKinnon, 2007) and are focused on preschool-aged children and only one caregiver (primarily mothers). The current study includes a large sample of 2-year-old children from three countries (USA, UK, Netherlands) and tests whether both mothers' and fathers' parenting practices account for the association between parent and child EF.

Current Study

In this study, we explore the association between both mothers' and fathers' EF and their biological child's EF when children are 24 months of age over and above stability in EF from when children are 14 months. Data were collected as a part of the New Fathers and Mothers Study, a longitudinal study which recruited nearly 500 families across the United Kingdom, the United States, and the Netherlands. Each parent completed assessments of EF when children were 14 months of age; children completed a battery of EF tasks when they were 14 and 24 months of age. In addition, each parent was observed interacting with their child in separate semi-structured tasks from which ratings of autonomy support and sensitivity were obtained.

We investigate the following questions: (1) is there an association between both mothers' and fathers' EF and the development of their child's EF? In keeping with prior literature (Brieant et al., 2017; Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Distefano et al., 2018; Jester et al., 2009; Kim et al., 2017; Korucu et al., 2019), we expect maternal EF will be related to child EF. Despite a paucity of research, we anticipate positive associations between paternal EF and children's EF as well (see Jester et al., 2009 for evidence of a father–child link in adolescence). We also ask (2) whether parenting practices (i.e., autonomy support and sensitivity) serve as mediating mechanisms underlying the association between parent and child EF. Prior studies have suggested either autonomy support or sensitivity might be responsible for the association between mother and child EF, but no studies have tested both autonomy support and sensitivity while also taking into account the other, nor have any studies examined the role of fathers' EF and caregiving practices. We hypothesize a role for both autonomy support and sensitivity in the transmission of EF from parent to child and explore whether these mediating mechanisms differ for mothers and fathers. Finally, it should be noted that we take an exploratory approach to the relations between maternal and paternal EF (each measured using a single task) and components of children's EF (measured using three separate tasks, one each ostensibly measuring inhibition, working memory, and shifting), as we do not have a clear theoretical rationale as to whether parents' EF relates to only one component of emergent EF versus another.

Methods

Participants

Participants were recruited as a part of a larger longitudinal study of parents and their first-born children in the United Kingdom (UK), the United States (US), and the Netherlands (NL). To be eligible for the current study, potential participants had to: (1) be first-time parents, (2) be expecting to deliver a healthy singleton baby, (3) be planning to speak the native language of the recruiting country (i.e., English or Dutch) as the child's primary language, and (4) have no history of severe mental illness (e.g., psychosis) or substance misuse. We recruited 484 expectant couples attending prenatal classes and appointments at local hospitals in the East of England (n = 221) and in New York City (n = 131), and at maternity events in the Netherlands (n = 132). Ten families were ineligible for follow-up when 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_{Age} = 4.26 months, SD = .46 months, range: 2.97–6.23 months. When children were approximately 14 months of age, 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_{Age} = 14.42 months, SD = .57 months, range: 9.47– 18.40 months. Finally, when children were 24 months of age, 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_{Age} = 24.47 months, SD = .78 months, range: 19.43–26.97 months.

Both mothers and fathers overwhelmingly identified as white (89.2%, 92.5%, respectively); the remainder of parents identified as Asian (Mothers: 6.5%, Fathers: 4.6%), Black (Mothers: 1.7%, Fathers: 0.7%), or Other (Mothers: 2.6%, Fathers: 2.2%); 5.0% of mothers and 5.9% of fathers chose not to report their race. At the time of child birth mothers were, on average 32.24 years old, SD = 3.92, range: 21.16–43.76 years; fathers were, on average 33.80 years old, SD = 4.58, range: 23.00-51.87. Both mothers and fathers had high levels of educational attainment: 84.3% had an undergraduate degree or higher.

All procedures performed were in accordance with the ethical standards of the institutional and/or national research committees involved and were acceptable according to the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The National Health Service (NHS UK) Research Ethics Committee (London Bloomsbury), the Leiden University Institute Review Board, and the University Committee on Activities Involving Human Subjects at New York University approved the study protocol (REF: 14/LO/1113).

Procedure

Researchers visited participating families' homes when mothers were approximately 36 weeks pregnant and when participating children were approximately 4, 14, and 24 months of age; however, for the purposes of the present investigation, only data from 14- and 24-month visits are used. Both mothers and fathers were present for home visits which were completed by two trained data collectors and lasted approximately 2 hours. Visits were completed with tasks in a fixed order and consisted of videorecorded parent–child interactions, parent interviews, and direct assessment of child and parent executive function skills (each of which lasted approximately 10 minutes). At the 14-month visit, mothers completed a set of semi-structured interactions with the child while fathers completed EF tasks, after which the child completed direct EF assessments with both parents present (Prohibition, Multi-Location Search, Ball Run); fathers then completed a set of semi-structured interactions with the child while mothers completed EF tasks. At the 24-month visit, again mothers completed a set of semi-structured tasks, followed by child EF assessment (Baby Stroop, Multi-Location Search, Ball Run), then fathers completed a set of semi-structured tasks.

Measures

Parent EF

During the 14-month visit, parents completed the Hearts and Flowers task (Davidson et al., 2006), which had three blocks. In each block, participants saw a fixation cross in the center of the screen before the start of each trial, after which a red stimulus appeared on either the left or right side of the screen. The first block (congruent block) comprised 8 practice items followed by 12 test trials: Participants were instructed to press a button as fast as they can on the same side as the heart appeared. The second block (incongruent block) comprised 8 practice items followed by 12 test trials: Participants were instructed to press a button on the opposite side from which a flower appears. The third block (mixed block) comprised 40 test trials: Participants saw hearts and flowers intermixed and were instructed to use the same rules as before (i.e., if the stimulus is a heart, press the button on the same side; if a flower, press the button on the opposite side). In every block, the stimulus image presented for 750 ms and participants were allowed 1250 ms to register a response; a fixation cross was presented for 500 ms between trials. Response time (RT) for each correct response was recorded; responses under 200 ms were discarded as anticipatory, as it was faster than the amount of time a participant would need to register and respond to the presentation of the stimulus image. An inverse efficiency score was computed for each participant by dividing the average RT for every correct response on the mixed block by percent correct on the mixed block in order to provide an index of processing efficiency while taking into account possible speed-accuracy trade-offs (Townsend & Ashby, 1978; Yang et al., 2011). Scores were then multiplied by (-1) for the purposes of interpretability such that higher scores indicated more efficient performance (i.e., better EF).

Autonomy Support

At the 24-month visit, each parent was video recorded with the child in separate 4-minute dyadic sessions involving one of two sets of Duplo blocks, one containing pieces for and visual depictions of a dog and a rabbit, the other of a giraffe and a caterpillar. Parents were instructed to work with their toddler to complete the task and to keep them on task for the duration of the time; the researcher then left the room or turned away so as to not distract the child.

Videos were coded offline using the Autonomy Support Coding manual (Whipple et al., 2011). Each interaction was coded on a scale from 1 (*not very autonomy supportive*) to 5 (*very autonomy supportive*) on four domains: Concern for competence (providing appropriately tailored help to the child's needs), verbalizations (giving appropriate hints, instructions, and encouragement), flexibility and perspective taking (keeping child on-task if they lose focus on the task) and following the child's pace and providing opportunities for choice (involving the child as an active participant). Research assistants received training and feedback, after which they completed a reliability set of 30 cases. Inter-rater reliability with the lead coder was acceptable (ICC = .74).

Sensitivity

Parental sensitivity was coded from video recordings of separate five-minute free play sessions with each mother and father at the 24-month visit. Parents were given a set of toys that included two soft stuffed toys (i.e., a rabbit and elephant or a polar bear and giraffe), a toy picnic basket with play food, a wheeled vehicle, a non-permanent drawing implement, and a plastic play object with multiple components (i.e., colored eggs in a plastic carton or a shape sorter blender with plastic food) and told to play with their child as they normally would. Videos were coded offline by trained research assistants; inter-rater reliability for mothers' and fathers' videos were computed separately and were acceptable, ICC > .7.

Child EF

During each of the 14- and 24-month data collection visits, children completed a battery of three EF tasks described in greater detail by Devine, Ribner & Hughes (2019) and by Hughes, Devine, Mesman, & Blair (2020).

Inhibition. At 14 months, children completed the Prohibition Task (Friedman et al., 2011). Toddlers were shown a glittery wand by the experimenter whilst the examiner verbally engaged the infant. Next, the examiner instructed the child not to touch and placed the wand within reaching distance of the toddler, then turned around for 30s. The latency to the first time the toddler touched the wand was recorded (possible range: 0-30s); however, because resulting data were bimodally distributed (28.8% of valid cases waited ≤ 3.0 seconds; 32.2% waited the full 30 seconds), an indicator variable representing whether the child touched the wand within the 30 seconds was computed. At 24 months, children completed the Baby Stroop Task (Hughes & Ensor, 2005). After two practice trials, children were told they were playing a in a 'silly game' in which they were asked to point to a large spoon when the examiner said 'Baby' and a small spoon when the examiner said ‘Mummy’. Children received a score of “0” for each incorrect trial and “1” for each correct trial. Possible scores ranged from 0 to 6. The Baby Stroop Task demonstrated adequate reliability for the present sample, ω = .836.

Working Memory. At both visits, children completed a Multi-Location Search Task (Miller & Marcovitch, 2015). At 14 months, toddlers were asked to find three different colored plastic cars hidden in matched-color garages. Children were given the chance to find cars in a series of searches; after each success, the child was allowed to play with the car briefly before it was very obviously placed behind the examiner. The door to the garage was then closed conspicuously. Between searches, there was a short delay in which the view of the garages was obstructed, and the experimenter counted to 5. Since all garages contained a car, the toddler was always successful on the first trial. If toddlers pointed to an empty garage the examiner opened the garage, looked inside and said “Oh, it’s not there. Let’s have another go” and closed the door before starting the next trial. This continued until all cars were found or until the child made three consecutive errors. At 24 months, toddlers completed the same task but with five different colored cars. Possible scores for cars found ranged from 1 to 3 at 14 months and 1 to 5 at 24 months.

At both time points, the task continued until the child retrieved all cars or made three consecutive errors. Coding took place offline; scoring was adapted from Garon, Smith, and Bryson (2014) in a similar task and created scores to reflect the total number of searches to find each car following the first (i.e., 0 = did not find; 1 = 3 searches; 2 = 2 searches; 3 = 1 search). A strategy score was derived to indicate the approach used to search for the hidden cars with higher scores indicating a more efficient search strategy (i.e., 0 = starts in the middle, 1 = starts at either edge, 2 = starts at either edge and then selects middle but then repeats a search, 3 = starts at edge, then middle, then other edge). The Multi-Location Search Task demonstrated adequate reliability at both 14 months (ω = .736) and 24 months (ω = .771).

Cognitive Flexibility. Finally, at both visits, children completed The Ball Run task based on the Trucks Task developed by Hughes and Ensor (2005). A toy that had three circular holes on the top running from left to right (i.e., green, yellow, red) and a metal chute that allowed a ball to roll down through the toy was introduced to the infant. The middle hole (yellow) was sealed for the whole task, and the two holes on either end could be sealed or opened. The bottom of the toy was fitted with a speaker which played 5 seconds of a nursery song ("The Wheels on the Bus") when pressed by the ball. There were two phases; in the rule learning phase, the examiner illustrated how to play, either by green ball in the green hole or the red ball in the red hole (counter-balanced across children). The examiner then handed the ball to the toddler directly over the middle of the toy and looking at the infant and said, "Now you try!". Toddlers were praised for each correct placement and reinforced through activation of the musical switch; incorrect tries were met with "Oh, it didn't work!" and were followed by the next of six trials. For those children who placed the ball correctly four or more times, a rule-reversal phase was carried out. To begin, the researcher conspicuously put away the ball that had been used (e.g., the green ball). Next, the examiner got the other ball (e.g., the red ball) and swapped the brackets to open the corresponding hole and close the hole for the ball that was put away. One example was shown to the child, and the examiner then repeated the experiment in the same way with the new ball. Children received 1 point for each correct placement. Toddlers who did not place 4 or more balls correctly in the learning phase received a score of 0 on each trial of the reversal phase. Possible scores at both 14 and 24 months ranged from 0 to 12. The Ball Run Task demonstrated adequate reliability at both 14 months (ω = .962) and 24 months (ω = .915).

Covariates

A series of covariates was included in inferential analyses. As there was some variability around when children were assessed at 24 months, we included a covariate for child age. In addition, we included an indicator variable for parent education representing whether each parent had earned a bachelor's degree or higher, as well as a covariate for parent-reported subjective social status. This consisted of a single item in which each parent was asked, "this ladder represents where people stand in society. Where would you be on this ladder?" On a range from "1" = "The worst off people are at the bottom of the ladder—these people have the least education and money and the worst jobs" to "10" = "The best off people are at the top of the ladder—these people have the most education and money and the best jobs," (Singh-Manoux et al., 2003). A single variable was generated averaging both parents' responses to represent an average of the household's perceived social status; $r = .51$, $p < .001$. The composite was highly correlated with both mothers' and fathers' responses (rs > .87, ps < .001). We chose to include a measure of subjective social status rather than a more objective metric of socioeconomic status (i.e., income) in part due to limitations around comparing income in geographic areas with different costs of living and availability of government services (e.g., New York City versus the broader New York City area versus East- and South-East of England versus the Netherlands).

Analysis Plan

To address our first research question as to whether parent EF predicts development of child EF, we estimated a series of structural equation models. We first estimated a measurement model for child EF at each 14 and 24 months. For EF at 14 months, we fit a measurement model consistent with the model established in Devine et al. (2019). For EF at 24 months, we began by estimating an exploratory factor analysis to allow for a data-driven approach to factor enumeration. After the model was established at 24 months, we then fit a structural model wherein EF at 24 months was regressed on the latent factor representing the same component skill 14 months (e.g., working memory at 24 months was regressed on working memory at 14 months) to estimate stability in components of EF across toddlerhood. We then added parent EF as a predictor of 24-month EF in order to estimate the contribution of parent EF to child EF over and above stability.

We next estimated a measurement model for parental autonomy support with two latent factors—one each for mother and father—in preparation to address our second research question as to whether parenting practices (autonomy support and sensitivity) serve as mediating mechanisms underlying the intergenerational correlation of EF. We then estimated a structural model identical to the one above with parameters added such that each latent factor representing 24-month EF was regressed on both parents' autonomy support and sensitivity, and each parent's autonomy support and sensitivity were regressed on their parent EF. Indirect effects were assessed using bootstrapped confidence intervals with 1000 bootstraps.

Analyses were carried out using MPlus 8 (Muthén & Muthén, Bengt O, 2017). In order to account for systematic differences as a result of country, standard errors were clustered within country. All models were evaluated for fit using baseline cutoff criteria presented by Brown (2015): Root Mean Square Error of Approximation (RMSEA) < .08, Comparative Fit Index (CFI) > .90, Tucker Lewis Index (TLI) > .9. Dichotomous and categorical variables (i.e., indicators for items in each child EF task) were identified as categorical; other variables were assumed continuous. Full Information Maximum Likelihood estimation was used to account for missing data in the case of models with all continuous variables. This approach considers the covariance matrix for all available data on the independent variables to estimate parameters and standard errors for all cases and provides more accurate estimates than do listwise deletion or mean replacement (Cummings, 2013; Enders, 2001). Models which involved one or more categorical variable(s) used Weighted Least Squares estimation (Asparouhov & Muthén, 2010).

Results

Descriptive Statistics

Descriptive statistics and bivariate correlations among study variables are displayed in Table 1.

Does Parent EF Relate to Development of EF in Toddlerhood?

Measurement Model

Separate factor models were estimated at 14 and 24 months. For 14-month data, each of the task indicators loaded onto separate latent factors representing working memory and cognitive flexibility. As the inhibition task was comprised of a single indicator, we did not estimate a latent factor. The factors for each working memory and cognitive flexibility, as well as the indicator for inhibition were allowed to correlate. This model provided a good fit to the data, χ^2 (102) = 213.623, $p < .0001$, RMSEA = .051, 90%CI [.041, .061], CFI = .973, TLI = .968. Detailed information about item-level task performance and latent variable estimation and reliability are reported elsewhere (Devine et al., 2019). The estimated model is depicted visually in Figure 1, Panel A. Consistent with prior reports using the UK data (Devine et al., 2019), the components were separable as indicated by weak and non-significant correlations (rs < .12, ps > .14).

At 24-months, we first estimated an exploratory factor analysis with all indicators to allow for a data-driven approach to the structure of EF at age 2. A CF-EQUAMAX rotation was used, as prior analysis has suggested its utility with dichotomous data (Finch, 2011). Model comparison results indicate a two-factor model fit better than did a one-factor model, χ^2 (22) = 343.080, $p < .0001$, and that a three-factor model fit better than did a two-factor model, χ^2 (21) = 185.422, $p < .0001$. A three-factor model also resulted in the first non-significant chi-square test of model fit, χ^2 (187) = 215.461, $p = .0753$, indicating a well-fitting model. A visual inspection of the item loadings demonstrated indicators from each task loaded onto a latent variable representing that task (i.e., one each representing the Baby Stroop Task, Multi-Location Search Task, and the Ball Run Task; Table 2). Following the exploratory results, we estimated a confirmatory factor analysis with no cross-loadings wherein each of the task indicators loaded onto separate latent factors representing inhibition, working memory, and cognitive flexibility. The three latent factors were allowed to correlate. This model provided a good fit to the data, χ^2 (227) = 265.220, $p = .0416$, RMSEA = .021, 90%CI [.004, .030], CFI = .984, TLI = .982. The estimated model is depicted visually in Figure 1, Panel B. Working memory was correlated with both inhibition and shifting (rs = .21, ps < .007); inhibition and shifting were uncorrelated (r = .12, p = .098).

We then estimated a measurement model with all components at both 14 and 24 months. The resulting model fit the data well, χ^2 (691) = 776.388, $p = .0130$, RMSEA = .017, 90%CI [.008, .023], CFI = .984, TLI = .982. Factors representing shifting abilities were correlated across time (r = .14, p = .041); in contrast, the inhibition factor at 24 months was negatively correlated with the indicator of inhibition at 14 months (albeit only marginally so, r = -.17, p = .061). Factors representing working memory were uncorrelated (r = .03, p = .686), and there were no cross-component correlations (ps > .24). The estimated model is depicted visually in Figure 1, Panel C.

Structural Model

To address our first research question as to whether parent EF relates to the development of child EF in toddlerhood, we added variables representing both parents' EF (plus covariates) and directional associations on the basis of temporal precedence to the measurement model described above. Given a lack of cross-domain associations between components of EF at 14 months and EF at 24 months, we estimated only within-component stability (e.g., working memory at 24 months was regressed on working memory at 14 months, but not on inhibition or shifting); however, given correlations at 24 months, outcome variables (EF at 24 months) were allowed to correlate to account for shared variance that begins to emerge as children develop into toddlerhood. The estimated model fit the data well, χ^2 (892) = 992.264, p = .0104, RMSEA = .016, 90%CI [.008, .021], CFI = .982, TLI = .980. Results are shown in Table 3 and are depicted visually in Figure 2.

Parent EF related to the development of children's working memory and shifting from 14 to 24 months. Both mothers' and fathers' EF as indexed by the efficiency score on the Hearts and Flowers task was related to children's working memory (β = .07, $p < .001$; β = .05, $p < .001$, respectively), and mothers' but not fathers' EF was related to children's shifting (β =.09, $p <$ .001, β = -.03, p = .115). Neither parents' EF was related to children's inhibition.

Do Parenting Practices Account for Associations between Parent and Child EF?

We then sought to address whether characteristics of parent–child interaction mediate relations between parent and child EF. We first estimated a measurement model of parental autonomy support in which the four contexts of providing autonomy support loaded onto a factor for each mother and father; within-couple autonomy support was allowed to correlate. The measurement model fit the data well, χ^2 (19) = 46.273, p = .0005, RMSEA = .060, 90%CI [.038, .082], CFI = .980, TLI = .971 and is displayed in Figure 3. Parents' autonomy support was correlated ($r = .40$, $p < .001$) such that mothers who were more autonomy supportive tended to be partnered with fathers who were also more autonomy supportive (and vice versa).

We then estimated a structural model wherein each component of 24-month EF was regressed on earlier EF, parent EF, latent variables representing each parents' autonomy support, and each parent's sensitivity; autonomy support and sensitivity were also regressed on that parent's EF. The structural model fit the data well, $\chi^2(1362) = 1526.219$, $p = .0012$, RMSEA = .017, 90%CI [.011, .021], CFI = .966, TLI = .963 and is displayed in Figure 4. Children of parents who provided a more autonomy supportive environment had better inhibition (Mother: $\beta = .09$, $p = .001$; Father: $\beta = .15$, $p < .001$). Mothers' autonomy support was positively related to children's shifting, whereas fathers' was not (Mother: $\beta = .05$, $p = .001$; Father: $\beta = .01$, $p = .673$). In contrast, fathers' autonomy support was positively related to children's working memory whereas mothers' was not (Mother: $\beta = .08$, $p = .193$; Father: $\beta = .11$, $p = .001$). The same general trend was true of the relation between parental sensitivity and child EF: Both mothers' and fathers' sensitivity were positively related to all components of children's EF, (Inhibition: $\beta_M = .16$, $p < .001$, $\beta_F = .13$, $p < .001$; Shifting: $\beta_M = .05$, $p = .019$, $\beta_F = .05$, $p < .001$; Working memory: $\beta_M = .20$, $p < .001$, $\beta_F = .22$, $p < .001$).

Parents with higher EF also demonstrated higher levels of autonomy support and sensitivity. A standard deviation increase in fathers' EF was associated with approximately a third of a standard deviation increase in both autonomy support ($\beta = .33$, $p < .001$) and sensitivity ($\beta =.31$, $p < .001$). Similarly, a standard deviation increase in mothers' EF was associated with approximately a fifth of a standard deviation increase in both autonomy support ($\beta = .21$, $p < .001$) and sensitivity ($\beta = .23$, $p < .001$). Results are shown in Table 4.

Finally, we examined indirect associations between parents' and children's EF through parenting practices. For fathers, there was evidence that—at least in part—the association between both biological parents' EF and their child's EF operated through parenting practices. Analyses revealed an indirect effect of fathers' EF on children's EF inhibition and working memory through autonomy support (β = .05, 95%CI [.04,.06]; β = .01, 95%CI [.01,.02], respectively), but not on shifting (β = .003, 95%CI [-.01,.02]). There was also an indirect effect through sensitivity on all components of children's EF (Inhibition: β = .01, 95%CI [.01,.02]; Shifting: β = .01, 95%CI [.004,.01]; Working memory: β = .03, 95%CI [.02,.04]). In other words, fathers who had more efficient EF had had higher autonomy support and sensitivity, which in turn resulted in better child EF; however, indirect associations were relatively weak. Mothers' EF was also weakly indirectly related via autonomy support to children's inhibition (β = .01, 95%CI [.00,.01]) and shifting (β = .01, 95%CI [.00,.01]), but not working memory, β = .01, 95%CI [-.004,.01]). Similarly, mothers' EF was related to all components of children's EF via sensitivity, albeit very weakly (Inhibition: β = .01, 95%CI [.004,.02]; Shifting: β = .01, 95%CI [.002,.01]; Working Memory: β = .02, 95%CI [.00,.03])

Discussion

This study is one of the first to examine intergenerational associations between EF in both biological parents and their children's EF in toddlerhood, as well as mechanisms of parenting practice that might underlie transmission. Drawing on the transactional model of self-regulation development (Sameroff, 2010), we hypothesized that parents' EF would affect children's EF in part due to both the ways in which parents model successful regulatory strategies for their children and the provision of an appropriate amount of regulation to facilitate and hone children's abilities to self-regulate in the absence of other-regulation. Our hypotheses were partially supported.

Using data from a large, multi-national cohort of first-time parents and their young children, we add to the growing literature that suggests mothers' EF predicts the development of children's EF (e.g., Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Distefano et al., 2018; Korucu et al., 2019); we complement these findings by adding to the literature regarding the contribution fathers' EF makes to the development of children's EF. We find that fathers' EF is predictive of the development of children's EF to a similar degree as mothers', and that both parents' EF additively predict development of children's EF when considered together. Furthermore, while we find neither parental autonomy support nor sensitivity fully accounts for the intergenerational transmission of EF, we find evidence that multiple aspects of parenting practices uniquely account for associations between parents' and children's EF.

Emergent EF and Intergenerational Transmission

Emergent EF remains understudied (at least in comparison to studies of the development of EF in the preschool years and beyond). To date, relatively few studies have examined the organization, stability, and change in EF across the first years of life; those that have point to there being some amount of stability over time, though there is some inconsistency in findings (e.g., Bernier et al., 2010; Devine et al., 2019; Hughes et al., 2020; Johansson et al., 2016). We replicate the factor structure of EF presented by Devine and colleagues (2019) at 14 months, and find evidence for a similar tri-partite model when children are 24 months; however, we begin to see additional coherence among the three factors at 24 months than at 14 months. This is not inconsistent with research that has suggested EF is best represented as a unitary construct in preschool through early elementary years: It might be that precursors to EF in infancy (e.g., attention, processing speed, maintaining and updating) coalesce into the three components of EF described here, which in turn become more unified to be representative of the structure of EF in preschool-age children (Hendry et al., 2016; e.g., Brydges et al., 2014; McKenna et al., 2017; Wiebe et al., 2008, 2011; Willoughby et al., 2010, 2012).

We see some evidence of stability in early EF, though we found differences by component where shifting at 14 months was correlated with shifting at 24 months, but we found no such correlation for working memory and we in fact find a negative association between inhibition at 14 months and inhibition at 24 months. Others have reported this seeming absence of rank-order stability in very early EF (Miller & Marcovitch, 2015). It is possible the lack of longitudinal stability reflects the difficulty in reliably measuring EF in very early childhood, or an indication that the dramatic improvements in EF that characterize the infant and toddler years attenuate the stability of EF across this period. While prior work has found the assessments used here to be reliable and valid (e.g., Devine et al., 2019), robust rank-order stability in EF over the second year of life has typically only described using courser indices of EF performance (i.e., aggregate pass/fail scores on several tasks; Hughes et al., 2020; Miller & Marcovitch, 2015). It is possible that the noise inherent to using fine-grained, item-level data from infants and toddlers obscures a broader pattern of findings that—while reducing variance—might better represent EF. Further research is needed to test optimal ways of modeling EF in early childhood replicate and to better understand this puzzling pattern of associations.

Beyond the structure and maturation of EF, we found that both parents' EF related to the development of children's EF as hypothesized. That is, over and above the within-couple covariance in parents' EF, both mothers' and fathers' EF contributed unique variance to the development of children's EF from 14 to 24 months. Thus our findings indicate that the association between mothers' EF and their biological child's EF reported in previous studies (e.g., Cuevas, Deater-Deckard, Kim-Spoon, Wang, et al., 2014; Cuevas, Deater-Deckard, Kim-Spoon, Watson, et al., 2014; Distefano et al., 2018; Korucu et al., 2019) are matched by a parallel association between fathers' and children's EF. To our knowledge, the only other study to examine the relative contribution of both parents' skills (Jester et al., 2009) focused on families with adolescents and computed separate models for mother–child associations and father–child associations. By contrast, in this study we focused on families with toddlers and estimated intergenerational associations net of shared variance in parent EF, treating EF as a unitary construct. As such, there is little basis for comparison. Jester and colleagues (2009) found that both mothers' and fathers' EF was correlated with their adolescent children's EF and that the magnitude of association was stronger for mothers than for fathers. However, the magnitude of the association between father and child EF in that study was similar to the one reported here. Additional studies are needed to elucidate whether the current findings are specific to infancy and toddlerhood or can be replicated in samples of different age groups.

Mechanisms Underlying Transmission of EF

Generally, children of parents who provided more autonomy supportive and sensitive caregiving environments had better EF. This is consistent with findings from prior studies (e.g., Blair et al., 2011, 2014; Distefano et al., 2018; Hughes & Devine, 2019; Matte-Gagné et al., 2015; Matte-Gagné & Bernier, 2011; Meuwissen & Carlson, 2019; NICHD, 2005; Rhodes et al., 2011). In line with results reported by Distefano and colleagues (2018), we found indirect effects of parent EF on the development of child EF via autonomy support. In contrast with those results, however, we found evidence that parental autonomy support only partially mediated the association between parent and child EF. There may be several reasons for this. First, this might indicate a role for developmental time at which data are collected. Children in the Distefano et al. study were preschool aged, meaning they will have had more opportunity to develop their own regulatory skills than the toddlers in the present study. Second, it is possible that the inclusion of data from a second parent and the substantial within-couple covariance in autonomy support affected the variance contributed to children's skills. Finally, there was greater alignment in the EF tasks completed by parents and children in the Distefano et al. study (both completed a version of the Minnesota Executive Function Scale) than in the present study, allowing for what might be cleaner test of intergenerational associations of a very specific type of EF skills.

Limitations and Next Steps

Although there were several strengths to this study, including the longitudinal design, multiple measurements of child EF, and data collection including both parents, a number of limitations merit discussion. First, it is important to note that, despite the ability to establish temporal precedence in some measures by including children's prior EF scores in our model, we are unable to infer causality from these results. Further research is needed to better understand the nature of and mechanisms underlying the intergenerational transmission of EF. In particular, intervention research is needed to better understand whether improving parents' EF yield improvements in child EF, or whether there is an as-yet-undiscovered role of timing for parent EF to affect child EF. Indeed, prior studies have demonstrated a potential role for the prenatal environment in shaping the EF of the developing child (Braren et al., 2021; Buss et al., 2011; Camerota & Willoughby, 2020). However, despite evidence for within-couple physiological synchrony affecting the prenatal environment (e.g., Braren et al., 2020, 2021), this does not fully explain the role of fathers in the development of children's early EF.

Second, we acknowledge that data from the present study may not be widely generalizable. Despite having been recruited across three countries—all of which are Western, industrialized, rich, and highly educated—participating parents were a largely homogeneous group: Over 80% of all parents in the study had a bachelor's degree or higher (though we still see a meaningful difference in caregiving practices on the basis of paternal educational attainment), over 90% of parents identified as white, and all parents voluntarily enrolled in a study that involved visits to and videorecording of their homes, inevitably leading to further selection bias. In addition, at ages 32 and 34 for mothers and fathers, respectively, participating parents were substantially above the average age at which parents in each country tend to give birth to their first child (Organisation for Economic Co-operation and Development, 2019). While there is a possibility that some of the described associations exist across socio-demographic spectra and around the world, it would be overstating to suggest this pattern of findings represents a universal truth. Some studies have suggested different patterns of associations groups experiencing adversity (Brieant et al., 2017; Kim et al., 2017; Peviani et al., 2019) and in non-Western countries (e.g., Ellefson et al., 2017)). Further research is needed with a more diverse set of participants to better understand whether and how EF is transmitted intergenerationally.

Finally, it is possible that variables not measured in the present investigation may be systematically associated with parents' EF, children's EF, and/or parenting practices and might affect relations among constructs. For example, as our results suggest that EF is transmitted—at least in part—via parenting practices, it is likely the influence of both parents' EF on the development of children's EF may be affected by the amount of time parents spend interacting with their child. Similarly, children who spend time in non-parental care may see effects of teachers, peers, and settings in the development of EF skills. In addition, there are likely other characteristics of parenting, the caregiving environment, and the people around the developing toddler—including, but not limited to, control and disciplinary practices (e.g. Bindman et al., 2013; Roskam et al., 2013), early electronic media use (e.g., McHarg et al., 2020a, 2020b), household adversity and/or chaos (e.g., Andrews et al., 2021). Other studies still have demonstrated a role of genetics in the development of child EF (e.g., Friedman et al., 2008; Jester et al., 2009). Additional studies are needed to better understand the multi-dimensional influences on the development of children's EF.

Conclusions

Parents' EF matters for the development of children's EF. Perhaps most critically given its lack of attention in the extant literature, *fathers'* EF matters for the development of their children's EF. Nearly all research to date has focused on the intergenerational transmission of EF from mothers to children, whereas our findings suggest an important additive role of fathers in early EF development. That is not to say a continued focus on mothers' influences is not also necessary. We find that each parents' EF and parenting practices including both autonomy support and sensitivity contribute unique variance to the development of children's EF in toddlerhood, providing more evidence for the well-established belief that influences on the development of EF are multidimensional and varied. Further research is needed with more robust measurement of both parents' EF, as well as children's EF at several time points throughout children's early development to test time-specific associations between parents' EF and the development of children's EF and to explore differential mechanisms of intergenerational transmission over time. Nevertheless, this study highlights the importance of continuing to examine influences from both parents on the development of very early EF.

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Table 1. Descriptive Statistics and Correlations Among all Study Variables

		1	2	3	4	5	6	7	8	9	12	13	14	15	16	17	18
1	24mo Child Age	—															
2	24mo WM	.18***	—														
3	24mo Shifting	.11**	.20***	—													
4	24mo Inhibition	.03	.26***	.16***	—												
5	14mo WM	.19	.02	.06***	.02	—											
6	14mo Shifting	.08***	.09**	.13***	.00	.18***	—										
7	14mo Inhibition	.10	.05	.09***	-.12***	.07	.09	—									
8	Mother HF Efficiency	-.11	.04	.20***	-.03**	-.28***	.29***	-.18***	—								
9	Father HF Efficiency	-.09	.15***	.04	-.06***	.22*	.06	-.03	.83***	—							
12	Subj. Social Status	-.03	.02	.03***	.10***	.05	.07***	.02	-.14**	-.29*	—						
13	Mother Bachelor +	.05	.10***	-.01	.00	-.12**	-.03	-.02	-.04	-.09**	.29***	—					
14	Father Bachelor +	.03	.13**	.08**	.02	.04***	-.01	-.08***	-.30***	-.68***	.46**	.82***	—				
15	Mother Sensitivity	.01	.27***	.06**	.24***	.03***	-.03***	.02***	.11***	.09***	-.01***	.00	-.03***	—			
16	Father Sensitivity	-.03	.19***	-.02	.16***	.11***	.02	-.03*	-.43***	-.47***	.08*	.03*	.31***	-.05***	—		
17	Mother A-S	-.03	.20***	.07*	.31***	-.09***	.11***	-.07	-.35	-.35	.05	.01	.10	-.04	.18	—	
18	Father A-S	-.01	.12***	-.02**	.16***	.10**	.00	-.05**	-.40***	-.39***	.06	.01	.26***	-.04***	.19***	.45***	—
	Mean	24.47	-0.02	-0.03	0.00	0.03	0.01	0.33	6.49	6.33	7.38	0.82	0.74	6.53	6.27	-1.07	-1.56
	SD	0.79	0.44	0.41	0.39	0.93	0.75	0.47	1.34	1.13	1.03	0.38	0.44	1.44	1.39	0.85	0.77
	Min	19.43	-0.92	-0.98	-0.46	-0.76	-0.85	0	-13.16	-14.03	3.09	0	0	1	2	-2.17	-1.93
	Max	26.97	0.58	0.54	0.61	1.48	1.59	1	-3.93	-4.25	10	1	1	9	9	1.69	1.78

NOTE: *** $p < .001$, ** $p < .01$, * $p < .05$; HF Efficiency—Hearts and Flowers Efficiency Score (-1*[RT / % Correct] on mixed trials); A-S—Autonomy Support; Bachelor + indicates having attained a bachelor's degree or above.

Table 2. Results of exploratory factor analysis of 24-month child executive function indicators

	Factor 1	Factor 2	Factor 3
MLS Searches to Find Car 2	0.435*	-0.072	0.077
MLS Searches to Find Car 3	0.737*	-0.032	0.001
MLS Searches to Find Car 4	0.812*	-0.054	-0.013
MLS Searches to Find Car 5	0.751*	-0.054	0.011
MLS Search Strategy	0.297*	-0.187*	0.060
BR Pre-Switch Trial 1	0.109	0.380*	-0.016
BR Pre-Switch Trial 2	0.078	0.404*	0.008
BR Pre-Switch Trial 3	-0.054	0.678*	0.080
BR Pre-Switch Trial 4	-0.020	0.452*	-0.180
BR Pre-Switch Trial 5	0.062	0.646*	0.021
BR Pre-Switch Trial 6	0.088	0.712*	-0.007
BR Post-Switch Trial 1	0.134*	0.693*	0.037
BR Post-Switch Trial 2	0.229*	0.600*	0.078
BR Post-Switch Trial 3	0.049	0.809*	0.022
BR Post-Switch Trial 4	0.024	0.752*	0.028
BR Post-Switch Trial 5	0.052	0.757*	0.067
BR Post-Switch Trial 6	0.123*	0.837*	0.018
BS Trial 1	0.026	-0.197*	0.430*
BS Trial 2	0.145*	-0.009	0.653*
BS Trial 3	-0.028	-0.038	0.813*
BS Trial 4	0.078	0.114*	0.714*
BS Trial 5	-0.067	0.003	0.577*
BS Trial 6	-0.017	-0.004	0.761*

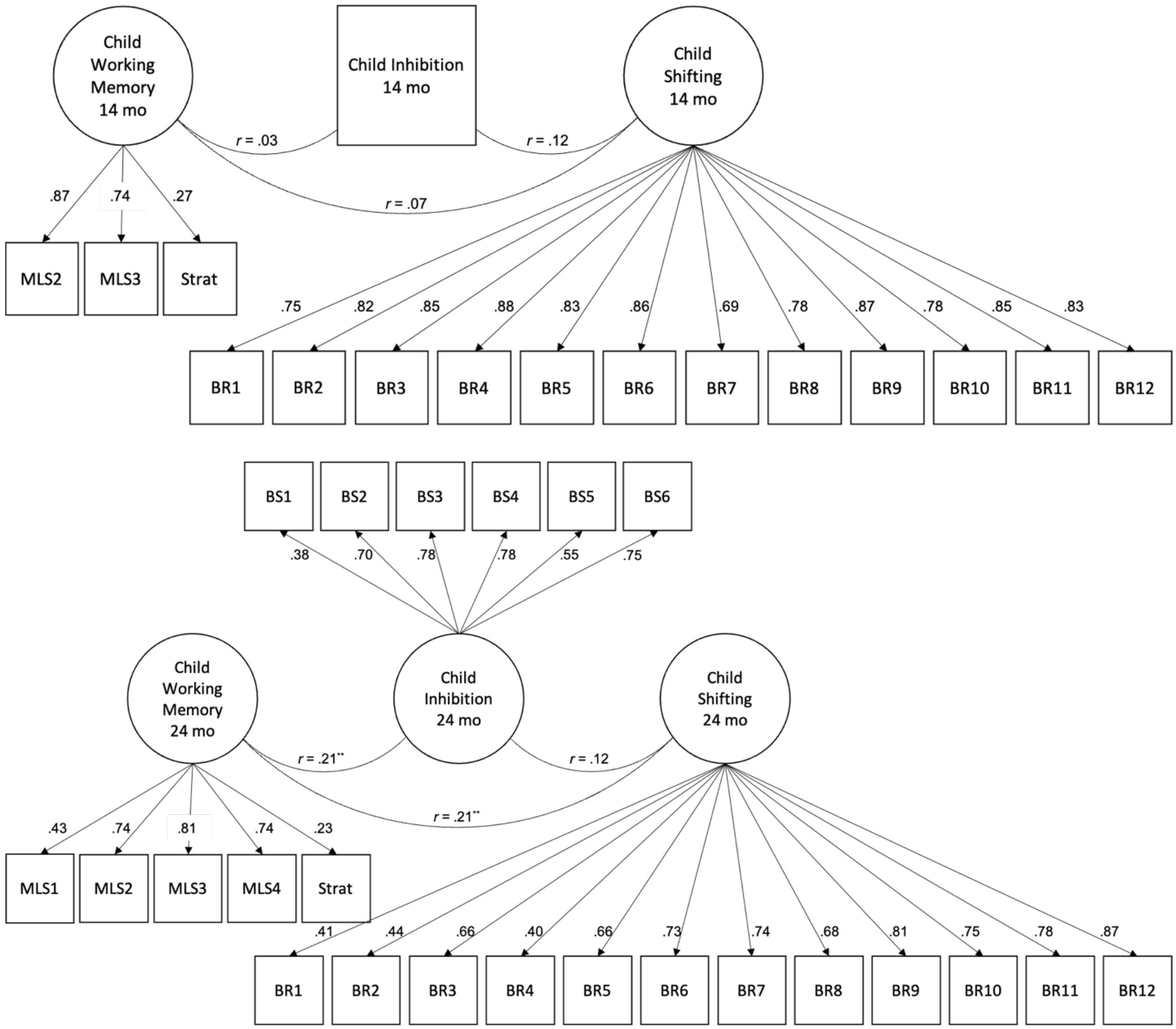
NOTE: * Loading significant $p < .05$; Values indicate lambda values with CF-EQUAMAX rotation; MLS—Multi-Location Search; BR—Ball Run; BS—Baby Stroop

Table 3. Results of Structural Equation Model Predicting Child EF

	Working Memory						Shifting						Inhibition					
	Beta	*SE*	*p-value*	*Beta*	*SE*	*p-value*	*Beta*	*SE*	*p-value*	*Beta*	*SE*	*p-value*	*Beta*	*SE*	*p-value*	*Beta*	*SE*	*p-value*
14 Month EF Component	0.03	0.05	.551	0.06	0.04	.117	0.11	0.02	<.001	0.11	0.04	.004	-0.16	0.01	<.001	-0.13	0.04	.002
Mother HF Efficiency	0.07	0.02	<.001	-0.02	0.03	.574	0.09	0.02	<.001	0.06	0.03	.109	-0.02	0.03	.546	-0.10	0.01	<.001
Father HF Efficiency	0.05	0.01	<.001	-0.13	0.05	.005	-0.03	0.02	.115	-0.04	0.02	.005	-0.05	0.04	.206	-0.11	0.02	<.001
Child Age 24mo	0.21	0.05	<.001	0.14	0.03	<.001	0.14	0.03	<.001	0.14	0.02	<.001	0.09	0.13	.479	0.03	0.05	.534
Subjective Social Status	-0.01	0.03	.820	0.01	0.02	.621	0.03	0.02	.075	0.03	0.01	<.001	0.13	0.02	<.001	0.08	0.03	.001
Mother Bachelor's Degree +	0.08	0.03	.003	0.06	0.01	<.001	-0.06	0.01	<.001	-0.02	0.02	.426	-0.05	0.06	.383	-0.03	0.02	.214
Father Bachelor's Degree +	0.03	0.01	<.001	0.05	0.02	.036	0.07	0.02	.003	0.05	0.02	.051	0.00	0.05	.991	0.04	0.04	.360
Father Autonomy-Support				0.11	0.03	.001				0.01	0.02	.673				0.15	0.02	<.001
Mother Autonomy-Support				0.08	0.06	.193				0.05	0.02	.001				0.09	0.03	.001
Father Sensitivity				0.22	0.04	<.001				0.05	0.01	<.001				0.13	0.03	<.001
Mother Sensitivity				0.20	0.03	<.001				0.05	0.02	.019				0.16	0.01	<.001

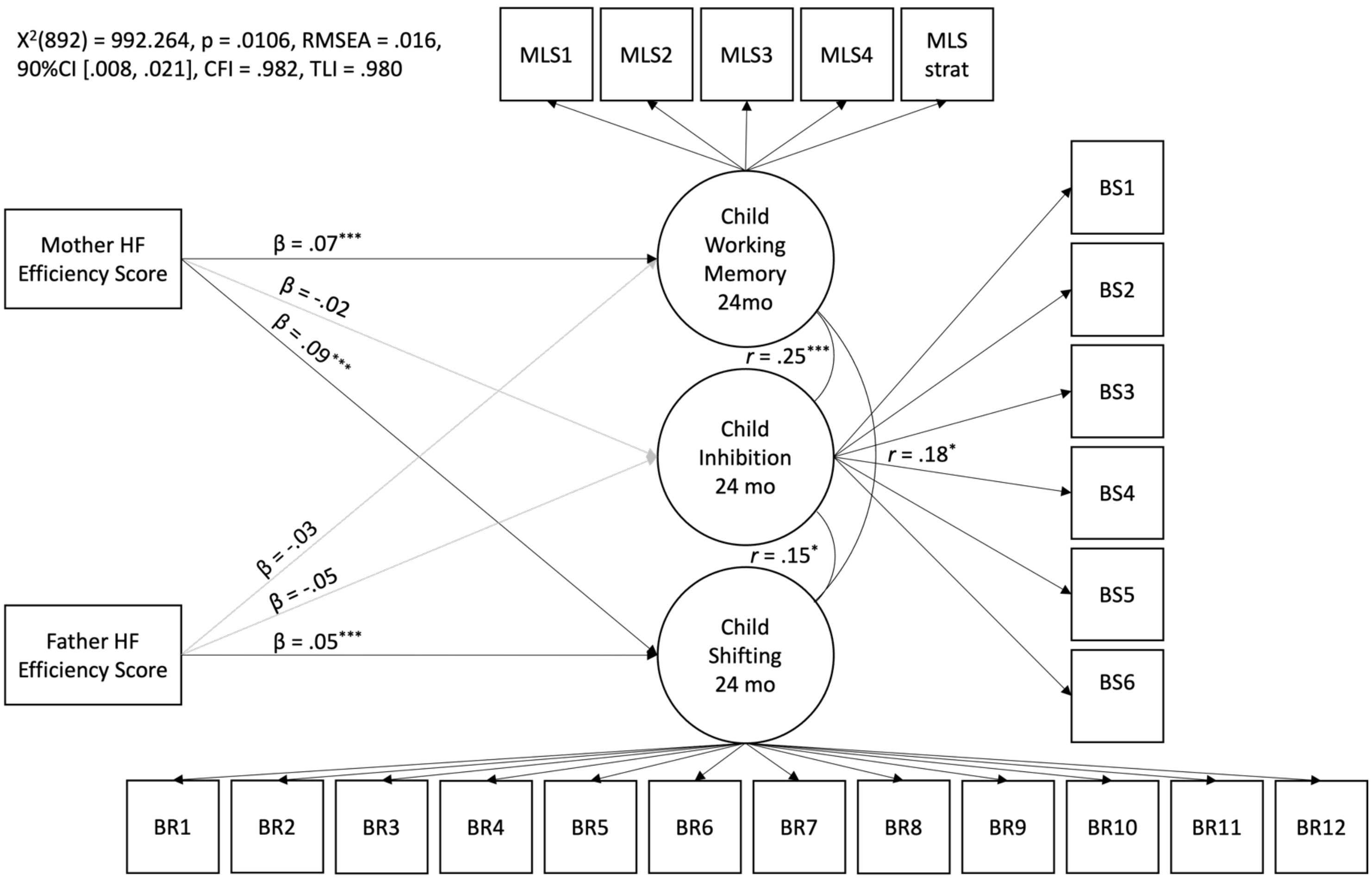
NOTE: EF—Executive Function; HF Efficiency—Hearts and Flowers Inverse Efficiency Score (-1*[RT / % Correct] on mixed trials)

Figure 1. Measurement Models for Executive Function at 14 and 24 Months



NOTE: $^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$; MLS—Multi-Location Search; BR—Ball Run; BS—Baby Stroop

Figure 2. Structural Model Predicting Child EF from Parent EF at 24 Months



NOTE: $^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$; Hearts and Flowers Efficiency Score (-1*[RT / % Correct] on mixed trials). Model includes covariates for child age at 24 months and for each component of executive function at 14 months. Grey lines signify estimated but non-significant paths.

Figure 3. Measurement Models for Parental Autonomy Support

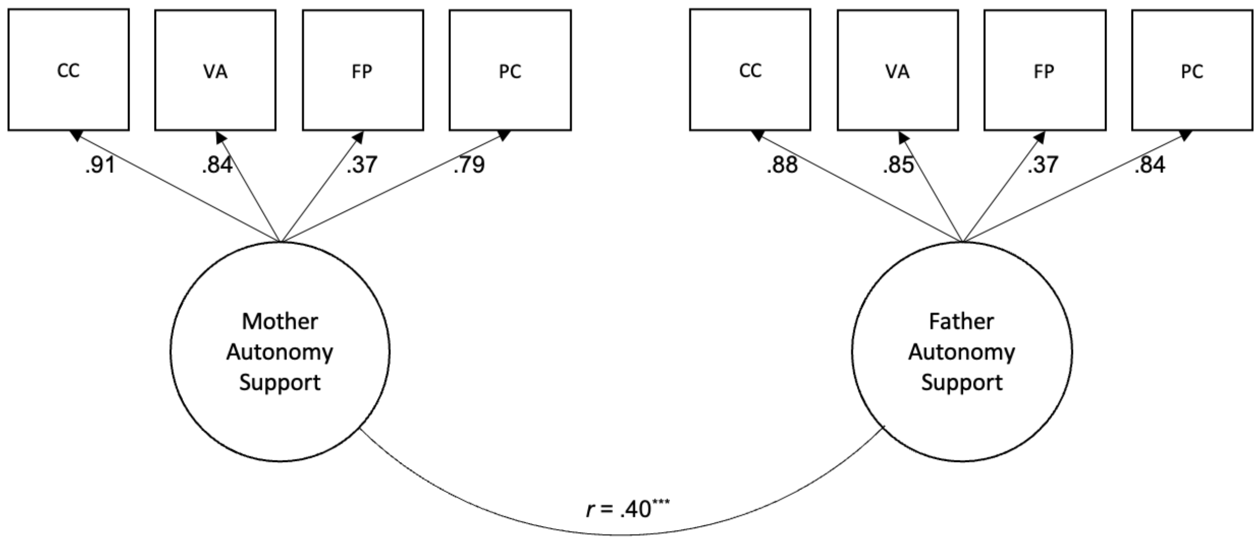
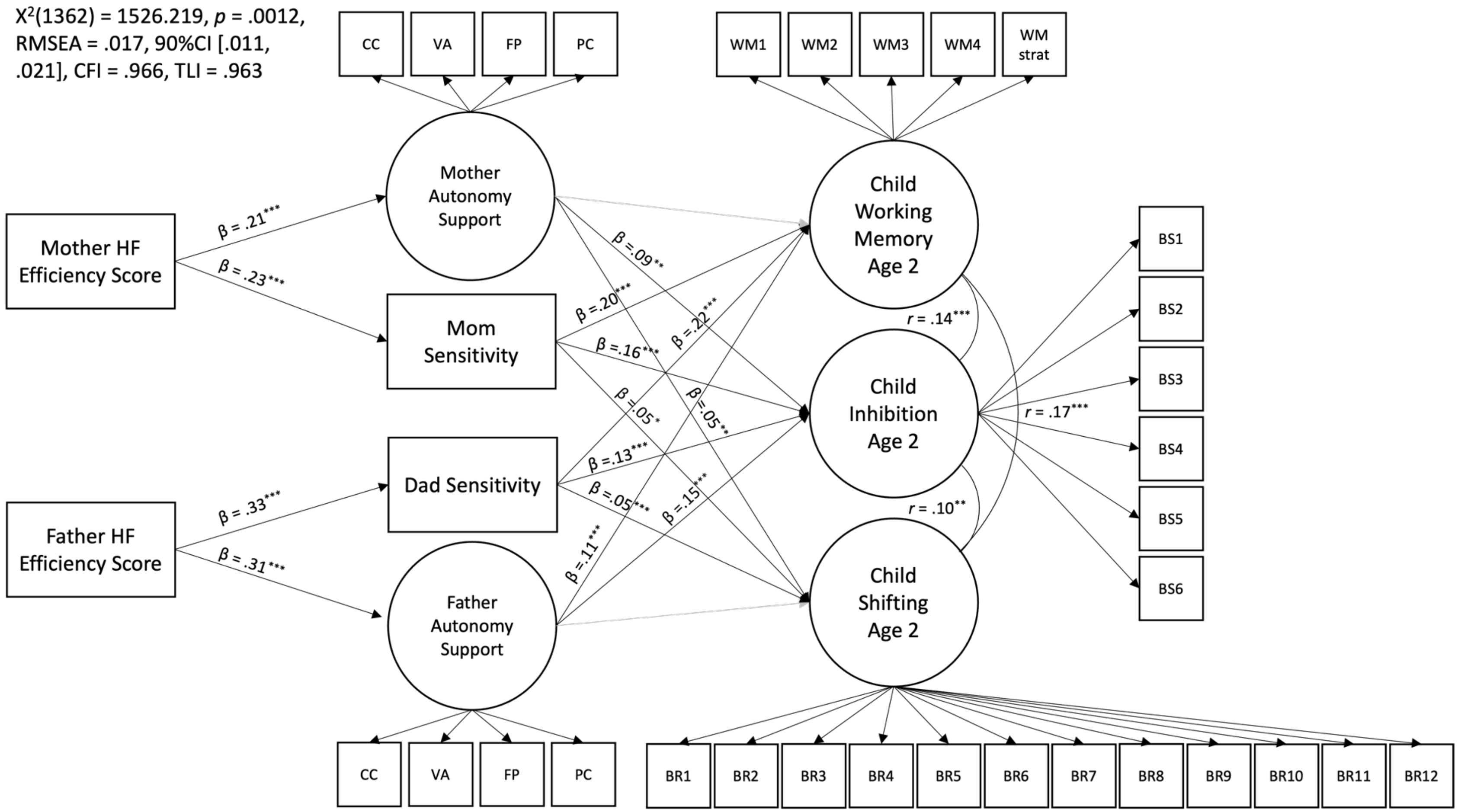


Figure 4. Structural Model Predicting Child EF from Parent EF and Parenting Practices at 24 Months



NOTE: *** $p < .001$, ** $p < .01$, * $p < .05$; Hearts and Flowers Efficiency Score (-1*[RT / % Correct] on mixed trials). Model includes covariates for child age at 24 months and for each component of executive function at 14 months. Grey lines signify estimated but non-significant paths.