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RESEARCH ARTICLE

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The role of parent–child attachment in toddlers' executive functions: a longitudinal two-parent study

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ABSTRACT

This longitudinal study examined the respective contributions of father–child and mother–child attachment to children's later executive functions (EF) during toddlerhood. The sample included 88 Canadian toddlers (51% boys) and their parents (89% White) visited in their homes at about 13 (T1) and 19 (T2) months of age. At T1, father–child and mother–child interactions were evaluated using the Attachment Q-Set. At T2, toddlers' hot and cool components of EF were assessed using behavioral tasks. Findings from two sets of analyses converged to suggest that developing secure attachment relationships with both parents may be optimal for the development of cool EF during toddlerhood.

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KEYWORDS
Father–child attachment; mother–child attachment; two-parent families; child executive functions; toddlerhood

Executive functions (EF) encompass higher-order cognitive skills that are crucial for children's social, behavioral, and academic adjustment, such as working memory, cognitive flexibility, and inhibitory control (Diamond, 2013). A broad conception of EF is that they serve to control thoughts, actions, and emotions in a conscious, goal-directed manner (Zelazo & Carlson, 2012). EF emerge during infancy and toddlerhood (Cuevas et al., 2017) (Thériault-Couture et al., 2025); and are associated with a broad range of positive outcomes throughout the lifespan (for a meta-analysis, see Stucke & Doebel, 2024). EF have both hot, affectively salient and cool, decontextualized dimensions. Hot components are involved in situations where strong feelings or the potential for reward significantly influence decisions and behaviors and are typically measured with tasks that require delaying or inhibiting the impulse to achieve rewards (Zelazo & Carlson, 2012). Cool components of EF enable children to process abstract information and are generally assessed using affectively neutral tasks involving rule switching or working memory (Zelazo & Carlson, 2012). There is evidence that hot and cool components of EF differ in their developmental course, underlying neural processes, predictors, and associations with child outcomes (Hongwanishkul et al., 2016; Kim et al., 2013; Moriguchi, 2022; Zelazo, 2015). In light of their importance for optimal functioning, it appears vital to identify factors involved in the development of both hot and cool dimensions of EF.

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A well-documented predictor of children's EF is the quality of parent–child relationships (Valcan et al., 2018). Current theory postulates that, as a result of experiencing external regulation by the soothing and calming efforts of their caregivers, children develop EF through internalization of self-regulatory skills (Carlson, 2009). Moreover, the prolonged postnatal development of the frontal brain regions strongly implicated in EF suggests an extended period of susceptibility to social influences (Hackman & Farah, 2009). Importantly, the quality of parental care has been linked to the functional development of these frontal brain regions during infancy (Bernier et al., 2016). Hence, the early development of EF is highly likely to be influenced by the quality of caregiving relationships. Although parent–child interactions are likely to affect child EF at different ages (Carlson, 2009), toddlerhood may provide an important window for parental influence (Garon et al., 2008) given the remarkable development of EF during this period (Cuevas et al., 2017; Thériault-Couture et al., 2025).

A widely recognized indicator of the quality of parent–child relationships in toddlerhood is attachment. Yet, few studies have investigated the associations between attachment and child EF, and even fewer have included fathers (Bendel-Stenzel et al., 2022). This is a significant gap, considering that fathers are increasingly involved in the lives of their children (Bakermans-Kranenburg et al., 2019). In fact, recent meta-analyses reveal that father–child attachment is reliably associated with child socioemotional and language outcomes (Dagan et al., 2022, 2024; Deneault et al., 2021). For child socioemotional outcomes, effect sizes for father–child attachment were comparable to those observed for mother–child attachment (Deneault et al., 2021). However, whether that may also be the case with child EF is not known, as research on EF is just beginning to include father figures (Meuwissen, 2020). Some studies have found that self-reported and observed paternal behaviors are related to early childhood EF (e.g. Khalil Toor & Hanif, 2023; Meuwissen & Carlson, 2018; Regueiro et al., 2020), even when the quality of maternal parenting is considered (e.g. Lucassen et al., 2015; Ribner et al., 2022). However, few studies consider maternal and paternal influences simultaneously (Meuwissen, 2020), even though studying either parent in isolation may lead to an overestimation of this parent's influence (Schoppe-Sullivan & Fagan, 2020). To address these empirical gaps, the current longitudinal study examines the predictive role of both mother–child and father–child attachment security in child EF in toddlerhood.

Parent–child attachment

Attachment security refers to the quality of the enduring emotional bond between children and their primary caregivers formed during the first year of life (Cassidy & Shaver, 2008). Secure parent–child relationships are thought to foster successful dyadic regulation between children and caregivers, particularly when children face emotional or cognitive difficulties (Calkins, 2011). Over time, it is believed that repeated experiences of effective joint regulation with caregivers facilitate the internalization of regulatory strategies by children, enabling them to independently apply these strategies in different tasks or contexts (Calkins, 2011). Therefore, secure attachment relationships may enhance children's ability to independently regulate their own thoughts and behaviors by creating an emotionally supportive learning environment where they can develop top-down self-regulation skills. Securely attached children are also thought to dedicate less cognitive

resources to monitoring the caregiver's availability while exploring their environment (Grossmann et al., 2002). The resulting surplus of cognitive resources, referred to as "security of exploration," can be redirected towards competent exploration, allowing for the development of self-regulated actions that are central to EF (Grossmann et al., 2002). Consistent with this, some studies have found that more secure mother–child attachment during toddlerhood was associated with superior performance on several tasks targeting cool EF during the preschool and school periods (Bernier et al., 2012; Matte-Gagné et al., 2018; Regueiro et al., 2020). The current study expands on these previous findings by also considering father–child attachment.

Father–child attachment

In their pioneering research, Schaffer and Emerson (1964) observed that most infants developed attachments to their fathers by their second year of life. Despite notable progress in the past decades toward including fathers in socialization research, current understanding of the role of fathers in child development still significantly lags behind that of mothers (Ahnert & Schoppe-Sullivan, 2019; Cabrera et al., 2018; Schoppe-Sullivan & Fagan, 2020). Grossmann et al. (2002) proposed that father–child interactions play a crucial role in the development of skills necessary for regulating emotions, attention, and behaviors. These authors emphasize that the heightened levels of stimulation and challenge often observed in father–toddler play provide valuable opportunities for children to practice self-regulation. Although heightened levels of stimulation and challenge might provide opportunities to practice the regulatory skills that form the core of EF, such opportunities can only be successful if they occur in a safe, emotionally supportive relational atmosphere. Thus, there is reason to believe that the quality of father – child attachment may contribute to individual differences in child EF, independently of maternal influences. However, only a handful of studies have explored the role of attachment security to father in child EF.

One study found that adolescent girls with insecure attachment representations of their fathers displayed more EF difficulties (as reported by parents) in comparison to girls with secure attachment representations (Gambin et al., 2020). Similarly, Kamza and Putko (2021) found that perceived attachment to father, but not to mother, had a unique direct positive effect on cool EF, but not hot EF, among children aged 8 to 12 years. In contrast, another study found no significant association between preschoolers' attachment representations of their fathers and their performance on hot or cool EF tasks (Mukti & Hendrawan, 2018). These studies relied on representational measures of attachment, based on self-reports or narratives, which may be influenced by factors like verbal skills or the ability to reflect on experience. In contrast, observational measures of attachment involve direct behavioral observation of parent–child interactions. Yet, to our knowledge, only one study has used an observational measure of child attachment to father to address its relations to child EF. Bendel-Stenzel et al. (2022) found that the security of both mother–child and father–child attachment, assessed at 15 months via independent observations with the Attachment Behavior Q-Set, was positively associated with child performance on cool EF tasks at 5 years of age (associations were similar in magnitude for father–child and mother–child attachment). These findings suggest that father–child attachment should be considered alongside mother–child attachment to understand

parental influences on child EF. However, hot EF tasks were not administered in that study, and separate sets of analyses were used for mother– and father–child dyads; therefore, whether father–child and mother–child attachment each uniquely contributes to child cool and hot EF remains unexamined.

Studies have shown similarities between attachment to fathers and mothers during infancy and toddlerhood (Pinquart, 2022); hence, the observed association between child EF and attachment security with one parent could be partly explained by the unconsidered attachment relationship with the other parent (Schoppe-Sullivan & Fagan, 2020). To our knowledge, no study has examined the predictive role of observed parent – child attachment security in child EF while considering both parents simultaneously. Therefore, it remains unclear whether mother–and father–child attachment security each independently predict unique portions of child hot and cool EF competence.

The simultaneous consideration of both parents also allows researchers to examine whether attachment relationships may jointly, rather than independently, impact child EF. The integrative hypothesis (van IJzendoorn et al., 1992) suggests that the network of attachment relationships between an infant and his or her mother and father may more powerfully predict developmental outcomes than either of these relationships alone. Expanding on this integrative model, Dagan and Sagi-Schwartz (2018) proposed a framework to advance the investigation of the influence of attachment networks on children's outcomes. These authors argue that assessing children's attachment network (i.e. the interrelated attachment relationships formed by children with their mothers and fathers), may provide superior predictive power of developmental outcomes compared to a single-parent focus. Studies using this research framework are still rare but partially support the "additive hypothesis" (Dagan et al., 2022, 2024). According to this hypothesis, secure attachment to both parents (S-S) leads to the most optimal outcomes, followed by a secure attachment to either parent (S-I), and finally by insecure attachment to both parents (I-I), which leads to the poorest outcomes. In other words, there is a dose-response association, such that children with more secure relationships have more adaptive outcomes than those with fewer (S-S > S-I > I-I).

In an individual participant data (IPD) meta-analysis pertaining to child language outcomes, Dagan et al. (2024) found support for the additive hypothesis: children who had two secure attachment relationships showed superior language competence than those with only one, who themselves exhibited higher language competence than those with no secure relationship. In another IPD meta-analysis, Dagan et al. (2022) found partial support for the additive hypothesis: children with only one secure attachment relationship displayed more internalizing behavior problems than those with two. However, children who had no secure relationship showed internalizing problem scores comparable to those who had one (I-I = S-I).

Overall, these results suggest that considering the configuration of mother–child and father–child attachment relationships may prove useful in deciphering how these two relationships jointly influence child development in biparental families. However, to our knowledge, no study has used an integrative attachment network framework to examine the associations between attachment relationships and child EF. Therefore, it remains unknown whether having secure attachment relationships to both parents leads to better EF outcomes than having only one secure relationship, which itself would convey an advantage relative to having none.

The present study

The present longitudinal study aimed to more fully understand the associations between attachment relationships and toddlers' cool and hot EF. In line with previous studies that considered attachment to both parents simultaneously, albeit with non-executive outcomes (Boldt et al., 2014; Deneault et al., 2022), we expected child attachment to father and mother to uniquely predict child EF above and beyond each other. To submit these associations to a more stringent test, we controlled for other well-documented predictors of child EF: child vocabulary and parental education. Toddlers more securely attached to their parents were expected to show superior EF performance, above child vocabulary and parental education. Moreover, in line with previous studies using an attachment networks framework (Dagan et al., 2022, 2024; Paquette et al., 2024), we hypothesized that children who had secure attachments to both their parents would show better performance on EF tasks compared to those with secure attachment to only one parent or none (S-S > S-I and I-I). We also expected that children with only one secure attachment would show superior EF performance compared to those without any secure attachment (S-I > I-I), considering that this portion of the additive hypothesis has been supported with child language (Dagan et al., 2024), a cognitive outcome that shows much greater overlap with EF than internalizing behavior problems, for which it has not been supported (Dagan et al., 2022).

Method

Participants

The current study is part of a larger ongoing longitudinal project, following a birth cohort of typically developing children and their two parents. To overcome the well-known challenge of recruiting fathers, we solicited fathers directly (rather than their spouses) that were registered with the Québec Parental Insurance Plan (QPIP). At least 70% of fathers in Québec are registered to the QPIP (Conseil de gestion de l'assurance parentale, 2022).Conseil de gestion de l'assurance parentale The QPIP is a social insurance program providing benefits for new parents taking parental leave after the birth of a child. Lists of fathers living in Québec City (Canada) were randomly generated and provided to the research team by the Ministry administering the QPIP. Fathers were contacted by phone five months after the birth of their infant. Criteria for participation were to live in Québec City at the time of recruitment, full-term pregnancy, and the absence of any known physical or mental disability or severe developmental delay in the infant. Written informed consent was obtained from both parents at the beginning of the study. The project was approved by the Université Laval's research ethics committee (Approval No. 2015–174).

In this study, we focused on two assessments conducted when children (51% boys) were aged between 11.80 and 16.11 months (T1; $M = 13.28$, $SD = 0.96$) and between 17.65 and 21.15 months (T2; $M = 19.15$, $SD = 1.02$). Families with assessments of both father–child and mother–child attachment at T1 and with available data on child cool ($N = 80$) and hot ($N = 75$) EF at T2 were included in the analyses. Among the 88 families who participated in the T1 assessment, four dropped out of the study before completing the T2 assessment due to relocation or lack of time, and some had missing data on child cool

($n = 4$) and hot ($n = 9$) EF because of a lack of child cooperation during EF task administration. All data included in the present report were collected before the pandemic. Families with missing data at T2 did not differ (all $ps > .05$) from those with complete data on sociodemographic characteristics, child vocabulary or attachment scores.

At the time of the recruitment, the participating fathers were on average 33 years old ($SD = 4.39$, varying from 25 to 49 years) and mothers 31 years old ($SD = 4.20$, varying from 22 to 40 years). Most fathers (82.4%) and mothers (83.7%) were born in Canada. Most parents were of European descent (> 89%). Fathers had between 9 and 27 years of education ($M = 16.87$, $SD = 3.28$) and mothers had between 11 and 22 years of education ($M = 17.13$, $SD = 2.55$). Half of fathers and 58% of mothers had a university degree. The average annual gross income was $59,961 CAD ($SD = $25,685, ranging from $13,000 to $200,000) for the fathers and $46,761 CAD ($SD = $21,440, ranging from $0 to $125,000) for the mothers. The average gross family income was $105,272 CAD ($SD = $33,551, ranging from $43,000 to $246,000). In the Canadian context, this is a moderate to high SES sample.

Procedure

Families were met in their homes by two research assistants at T1 and T2. At T1, in a randomized counterbalanced order, parents took turns participating in 45-min filmed semi-structured activities with their toddlers. The first home visit (T1) was designed based on the work of Pederson and Moran (1995), to create a situation in which parental attention was solicited by both the research tasks and the toddler's demands simultaneously. This was intended to reproduce the need for multitasking that occurs while caring for a toddler on a daily basis. Parents were asked to fill out questionnaires including the child vocabulary measure (see below) and answer interview questions while the toddler was playing nearby and not looked after by the experimenter, to help their toddler solve difficult problems (e.g. puzzles), and to play freely with their toddler with a standardized set of toys. Mothers were in a different room when fathers were with their children, and vice-versa.

Child attachment to mother and father was rated using the Attachment Behavior Q-Set (AQS; Waters, 1995) by independent coders based on observations made throughout the 45-min sequence with each dyad (one coder per parent). To maximize the reliability of the observations performed during home visits, research assistants first attended a two-day training workshop offered by AQS experts. The training consisted of seminars related to early parent–infant interactions, behavioral observation, and techniques of home visiting. Furthermore, during the workshop, the research assistants reviewed several videotapes of parent–infant interactions to practice coding child attachment. At T2, toddlers' EF were measured using the three tasks described below: one task involving hot EF and two targeting cool EF. Toddlers were seated across a table from the examiner on a parent's lap during task administration.

Measures

Child attachment to mother and father

Child attachment was assessed around 13 months (T1) using the AQS (Waters, 1995), which was completed by the experimenters immediately after the home visits. The AQS is

comprised of 90 items describing potential child behaviors. Items are sorted by the observer into nine piles, reflecting the degree to which the items describe the behavior of the child under observation. The observer's sort is then correlated with a criterion sort provided by the author of the instrument, representing the prototypically securely attached child. This correlation constitutes the child's attachment security score, which can thus vary from −1 = *most insecure* to 1 = *prototypically secure*. Prototypical security is characterized by a dynamic balance between exploring the environment and seeking appropriate support from the caregiver when necessary. 25% of the dyads were double-coded using the filmed parent–child interactions (which were video-recorded throughout the visit). Interrater agreements were excellent for both mother–child and father–child dyads (ICCs > .80).

To test the additive hypothesis (S-S > S-I > I-I) of the integrative model of attachment networks, AQS scores were also recoded into binary secure/insecure variables such that scores above .40 were considered secure (based on previous studies: Dagan et al., 2022; Verhage et al., 2018). Children were then grouped into three categories: secure-secure (S-S; $n = 33$), secure-insecure (S-I; $n = 26$), and insecure-insecure (I-I; $n = 21$).

Meta-analytic data (Cadman et al., 2018; van IJzendoorn et al., 2004) suggest that the AQS shows moderate temporal stability and excellent construct validity, with scores converging with maternal sensitivity and child attachment assessed with the Strange Situation. Considering its excellent validity, the AQS is considered one of the gold-standard measures of attachment security (van IJzendoorn et al., 2004).

Child EF

Around 19 months (T2), toddlers' EF were measured with a battery of three tasks that are often used to assess the early building blocks of EF (for a scoping review on the assessment of EF before 36 months, see Escobar-Ruiz et al., 2023). In previous studies using the current sample (Thériault-Couture et al., 2024, 2025), inter-rater reliability for these tasks was found to be acceptable to excellent (*ICCs* ranging from .72 to 1) and significant growth in performance on these three tasks throughout toddlerhood (1–3 years) was found, supporting their validity.

Prohibition (Friedman et al., 2011). The experimenter placed an attractive toy (a colorful car) on the table and said, "No, [child's name], don't touch" (while shaking his or her head in a "no" gesture). The experimenter then looked away for 30 seconds. Time latency before touching the toy was recorded, with a possible range of 0 to 30 seconds. Child performance on this task is relatively stable between 1 and 3 years ($r = .30$, $p < .001$) and predicts subsequent performance on EF tasks up to 14 years later (Friedman et al., 2011). Toddlers' performance on this task has also been found to be associated with performance on other EF tasks administered concurrently or subsequently during the preschool period (Devine et al., 2019; Hughes et al., 2020; Johansson et al., 2016) and to predict language skills and socioemotional problems (Thériault-Couture et al., 2024, 2025). Therefore, this task provides a reliable and valid assessment of hot EF during toddlerhood.

Reverse Categorization (Johansson et al., 2016). The child was presented with two buckets, one red and one yellow, and a set of four yellow blocks. In the first round, children were instructed to put the blocks, handed to them, one by one, into the yellow

bucket (preliminary trials establishing the dominant response). In the second round, they were instructed to put the same blocks into the red bucket and were not corrected if blocks were put in the wrong bucket (experimental trials). The final score consisted of the number of blocks correctly sorted on the first attempt during the experimental trials, with a maximum score of four. The validity of this task is supported by studies that demonstrated relations between performance on this task and other EF tasks during the preschool period (Johansson et al., 2016) and longitudinal and concurrent associations with language skills during toddlerhood (Thériault-Couture et al., 2025).

Hide-and-Seek (Johansson et al., 2016). Children were instructed to participate in a game of searching for a hidden toy placed underneath opaque plastic glasses. For the first three trials, three glasses of different colors were placed upside down in a row on a tray, just out of the child's reach. In each of the three trials, the toy was hidden underneath a different glass. To divert the child's attention, the experimenter clapped their hands and prompted the child to look away from the glasses. Subsequently, the tray was moved closer to the child, who was encouraged to search for the toy. The child could lift one glass at a time until the toy was found. If the toy was not discovered, the lifted glass was placed back on the tray. Finding the toy immediately upon lifting a glass earned three points, while the number of points decreased as more glasses had to be lifted before finding the toy (lifting more than three glasses resulted in a score of zero). After these three trials, two more glasses of different colors were added to increase the level of difficulty of the task. Hence, two additional trials were administered with five glasses (scores ranging from 0 to 5). The scores from the five trials were summed, resulting in a range of 0 to 19. Performance on Hide-and-Seek tasks during infancy or toddlerhood is associated with performance on other tasks measuring working memory (Fernandez-Baizan et al., 2021), supporting the validity of this type of task for measuring EF during the early years.

The Prohibition task involves hot EF, while the Hide-and-Seek and Reverse Categorization tasks both target cool EF (scores were standardized and averaged to create a composite score of cool EF). Scores on the Hide-and-Seek and Reverse Categorization tasks were inter-correlated ($r = .23$, $p = .04$), whereas performance on the Prohibition task was not correlated with performance on the other tasks ($r < .12$, $p > .26$), supporting the hot versus cool distinction.

Child vocabulary (covariate)

Child vocabulary was measured at T1 using the French-Canadian adaptation (Trudeau et al., 1999) of the MacArthur Communicative Development Inventory (MCDI) Short-Form (Fenson et al., 2000) completed by mothers. Mothers were presumed to be more accurate reporters of their child's vocabulary because they were on maternal leave at home, whereas fathers were mostly working full-time. Mothers were thus likely to be more exposed to children's verbal expression compared to fathers and therefore, to be the parent most knowledgeable of the child's vocabulary skills at 12 months. The MCDI is a widely used parent-report vocabulary checklist containing 89 words that is used to gauge infants' and toddlers' receptive (understanding of a word) and productive (production of a word) vocabulary. Mothers had to indicate from a list the words that their child "understands" (receptive vocabulary) or "understands and says" (expressive vocabulary).

Total receptive and expressive vocabulary scores were extracted. The excellent psychometric properties of this measure are well documented both in the original version and in several linguistic adaptations worldwide (Fenson et al., 2000). Excellent test-retest reliability and good convergent and predictive validity have been demonstrated for the French-Canadian adaptation of the MCDI (Boudreault et al., 2007).

Results

Preliminary analyses

Descriptive statistics and correlations among the main variables are presented in Table 1. Variability on all main variables was good and examination of skewness and kurtosis values (≤1.25) showed that all variables were normally distributed (cutoff used: ±2, Hair et al., 2009). As expected, hot and cool components of EF were not correlated. Father–child ($r = .40$, $p < .001$) and mother–child ($r = .39$, $p < .001$) attachment security were both significantly and positively associated with cool EF, but not with hot EF. Father–child attachment security was found to be significantly associated with mother–child attachment security ($r = .42$, $p < .001$), which supports the importance of considering both simultaneously when looking at their predictive effects on child EF. Mean levels of father–child and mother–child attachment security were not significantly different ($t(79) = 1.16$, $p = .25$). Furthermore, the association between the categorial variables representing father–child and mother–child attachment security was significant ($X^2(1, N = 80) = 9.17$, $p = .002$, $V = .34$).

Associations between the main variables and parental education (paternal and maternal years of schooling averaged), family income, as well as child vocabulary at T1 and age at T2 were also examined. Child age and family income were not associated with child hot or cool EF. Parental education was associated with cool EF ($r = .23$, $p = .04$), but not with hot EF ($r = .05$, $p = .66$), while child vocabulary was associated with hot EF ($r = .23$, $p = .03$), but not with cool EF ($r = .03$, $p = .81$). Thus, both parental education and child vocabulary were covaried in regression analyses performed to test the unique contribution hypothesis.

Concerning categorical attachment scores, differences between attachment network groups were found in child vocabulary and parental education ($F(2,85) = 5.87$, $p = 0.004$ and $F(2,83) = 4.89$, $p = 0.01$, respectively). When the groups differ on the covariate in an analysis of variance, removing the variance shared by the covariate and the dependent variable will also remove some of the variance shared by the grouping variable and the

Table 1. Descriptive statistics and correlations among main variables.

	M	*SD*	Observed range	Correlations 2.	3.	4.
1. Cool EF at T2	0.06	0.71	−1.76–0.94	.03	.40***	.39***
Reverse Categorization	2.64	1.35	0–4	–	–	–
Hide-and-Seek	17.19	2.21	10–19	–	–	–
2. Hot EF at T2	9.21	12.18	0–30	–	.10	−.05
3. Father – child attachment at T1	0.43	0.21	−0.18–0.76	–	–	.42***
4. Mother – child attachment at T1	0.39	0.25	−0.42–0.75	–	–	–

T1 = mean age of 13 months; T2 = mean age of 19 months.
***$p < .001$.

dependent variable, thus obscuring their relationship (Miller & Chapman, 2001). Therefore, it is recommended not to enter covariates that relate to the groups in an ANCOVA, as this will bias the results (Miller & Chapman, 2001). Thus, parental education and child vocabulary were not covaried in the mean comparisons analyses and ANOVAs (rather than ANCOVAs) were used to test the additive hypothesis.

Main analyses

Unique contributions

Regression analyses were performed to examine the unique contributions of father–child and mother–child attachment in the prediction of child EF. Parental education and child vocabulary were entered in the first block, followed by mother–child and father–child attachment in the second block. As can be seen in Table 2, the analyses revealed unique predictive effects on cool EF: father–child ($\beta = .31$, $p = .01$) and mother–child ($\beta = .22$, $p = .05$) attachment security both contributed uniquely to the prediction of toddlers' cool EF above and beyond each other and parental education and child vocabulary. On an exploratory basis, we examined the interaction between father–child and mother–child attachment. The interaction term was not significant ($p = .99$). Interactions between father–child and mother–child attachment and child sex were also examined and found to be non-significant ($p > .16$). None of the predictors were found to be significantly associated with child hot EF ($\beta < .09$ for mother–child and father–child attachment and all $ps > .14$) and the variance explained by the blocks was very small and not significant ($R^2 < .04$; $p > .37$). Thus, results pertaining to hot EF are not displayed.

Additive hypothesis

To test the additive hypothesis (S-S > S-I > I-I), ANOVAs with two planned contrasts were performed: one contrast compared the EF performance of children with secure relationships with both parents (S-S) to that of children having only one (S-I) or no secure relationship (I-I), and the other compared children with only one secure relationship (S-I) to those with no secure relationship (I-I).

The results are presented in Table 3. For cool EF, we obtained partial support for the additive hypothesis: children securely attached to both parents (S-S) performed better than children with either one (S-I) or no (I-I) secure attachment relationship ($t(77) = 2.34$, $p = .02$; $d = .53$, 95% $CI = .08, .99$). However, contrary to the additive hypothesis, children

Table 2. Regression analyses predicting toddlers' cool EF at 19 months.

Predicted variable	Block	Predictors	*B*	*SE*	R^2	ΔR^2
Cool EF at T2	1	Child vocabulary at T1	.24*	.00	.11	
		Parental education	.24*	.03		
	2	Child vocabulary at T1	.09	.00	.29*	.18
		Parental education	.25*	.03		
		Father – child attachment security at T1	.32**	.39		
		Mother – child attachment security at T1	.22*	.31		

T1 = mean age of 13 months; T2 = mean age of 19 months. Parental education = paternal and maternal years of schooling averaged.
*$p < .05$; **$p < .01$; ***$p < .001$.

Table 3. Planned comparisons for testing the additive effects of attachment relationships on child hot and cool EF.

Outcomes	Attachment patterns									ANOVAs	Planned contrasts	
	Secure-secure (S-S)			Insecure-secure (S-I)			Insecure-insecure (I-I)				S-S > S-I/I-I S-I > I-I	
	n	*M*	*ET*	*n*	*M*	*ET*	*n*	*M*	*ET*		*d*	*d*
Cool EF	33	0.29	0.56	26	0.03	0.58	21	−0.17	0.89	$F(2,77) = 3.13$*	.53*	.30
Hot EF	33	10.33	12.36	26	10.96	13.10	16	5.31	9.76	$F(2,72) = 1.22$	.18	.47

*$p < .05$.

with no secure attachment exhibited similar cool EF performance as those with one secure attachment ($t(77) = 1.03$, $p = .31$; $d = .30$, 95% $CI = -.28, .88$). For hot EF, no differences ($d < .47$, $p > .15$) were found between children securely attached to both parents and the two other groups or between children securely attached to one parent and those insecurely attached to both parents.

Discussion

While the role of mother–child relationships in the development of child EF is now well established, this body of research is just beginning to include father figures. Therefore, little is known of the role of father–child attachment, whether in itself or as combined with mother–child attachment. This study is the first to simultaneously examine the contributions of observed mother–child and father–child attachment to child EF. Overall, the findings replicate the growingly documented association between mother–child attachment and child cool EF. Especially noteworthy is the finding that early attachment security to each parent has a unique contribution, with the quality of each relationship predicting unique portions of individual differences in cool EF (but not hot EF), even after accounting for other well-documented precursors of child EF like child vocabulary and parental education. The current study also used an innovative attachment networks framework to test the joint effects of attachment relationships on child EF. Children with two secure relationships were found to show higher levels of cool EF skills than those with one or no secure relationship.

The results concerning cool EF are consistent with the assumption that cognitive regulatory mechanisms that emerge during early childhood are shaped within the context of attachment relationships (Calkins, 2011; Sroufe, 1996). Attachment security is thought to enable children's engagement in exploration of the physical and social environment without being worried about attachment concerns, providing them with increased learning opportunities (Grossmann et al., 2002). These early experiences are expected to promote the development of self-regulatory skills (Pallini et al., 2018). It is also likely that secure attachment relationships foster child cool EF development by supporting the growth of the neural systems that are responsible for EF (Bernier et al., 2014). There is evidence to suggest that secure attachment and higher-quality parenting are linked to more optimal neural functioning and larger gray matter volume in frontal and frontotemporal brain regions in young children (Bernier et al., 2016; Leblanc et al., 2017). Thus, secure attachment may foster child cool EF by promoting the orderly development

of its neural substrates. Why these processes, however, would relate specifically to cool EF, and not to hot EF, remains intriguing.

We had hypothesized that attachment security would be associated with children's EF but made no specific predictions about differential effects on cool and hot EF. Studies on attachment relationships and EF are scarce and they rarely consider or distinguish hot and cool EF. Bernier et al. (2012) found that children more securely attached to their mother at 15 and 24 months of age showed higher performance on cool (called conflict EF), but not hot (delay of gratification), EF tasks at 3 years of age. Another study found that perceived attachment security with father was associated with cool though not hot EF in middle childhood (Kamza & Putko, 2021). Other studies on different aspects of the parent–child relationship also found significant associations with cool, but not hot, EF (Bernier et al., 2010; Distefano et al., 2024; Kamza et al., 2016). We therefore argue that the links between parent–child attachment and cool EF are beginning to show some robustness, whereas the parental and relational antecedents of hot EF appear more elusive.

Whereas we did not observe an association between attachment relationships and hot EF in the current sample, we did find a positive association between hot EF and child vocabulary. Thus, hot EF might be more strongly influenced by children's capacity to use language as a tool to control impulsive behaviors (such as touching an attractive prohibited toy) than by familial factors. Theoretical and empirical links between children's language skills and EF are well established (Bruce & Bell, 2022; Thériault-Couture et al., 2025). A previous study found that children's expressive vocabulary acted as a mediator between maternal autonomy support during infancy and hot EF at the age of 3 (Matte-Gagné & Bernier, 2011). On the other hand, in that previous study, maternal autonomy support showed a direct, non-mediated association with cool EF. These findings, combined with those of the present study, suggest that individual differences in hot and cool EF may be influenced by distinct mechanisms. In fact, hot and cool EF are subsumed by neural networks involving different parts of the prefrontal cortex (ventral and medial vs. lateral; Moriguchi, 2022; Zelazo, 2015), and the outcomes of hot and cool components of EF are also known to be different (Zelazo, 2015). Thus, these two aspects of EF need to be distinguished in research, including attachment research.

The present findings pertaining to cool EF are also in line with the family systems perspective (Cox & Paley, 1997) and support the assumption that father–child interactions play a crucial role in the development of skills necessary for regulating emotions, attention, and behaviors (Grossmann et al., 2002). The predictive contributions of father–child and mother–child attachment to child cool EF were found to be comparable in magnitude, both significant when considered simultaneously, and did not interact with each other in the prediction of cool EF. Thus, attachment to each parent has an equivalent and unique contribution in predicting these crucial cognitive skills. According to some authors (Grossmann et al., 2002), fathers primarily contribute to their children's sense of security by offering sensitive support during exploratory and mildly challenging play, while mothers primarily contribute by providing comfort and support when the child is experiencing distress. According to this view, mothers mostly act as a "safe haven" for children during times of emotional vulnerability or need, whereas fathers mostly serve as a secure base, providing support during child exploration. Having both a secure base from which to explore and a safe haven to return to when difficulties arise might be important for developing cool EF. Such resources may provide children with both quantity and quality

of exploration. The secure base triggers frequent opportunities to go out and explore, while the safe haven helps children engage in those exploratory endeavors without anxious arousal, knowing that they can retreat to protection should a threat arise. This anxiety-free state should allow them to reap optimal benefits from their numerous opportunities for exploration.

The present findings concerning cool EF are also consistent with the integrative attachment networks framework and partially support the additive hypothesis (Dagan & Sagi-Schwartz, 2018). The most favorable outcomes were found for children who had secure attachment relationships with both parents. These children had significantly higher cool EF performance scores compared to children with either one or two insecure attachment relationships. However, the cool EF skills of children with one secure relationship were found to be comparable (not statistically different) to those who had none. These findings suggest that two – and not merely one – secure attachments to primary caregivers may optimize cool EF development. However, the current study was underpowered to detect small differences between groups. The small number of children in each attachment group might have hindered our capacity to detect small mean-level differences. Although not significantly different at a p-value < .05, the average performance on cool EF tasks for children who had one secure attachment (M = .03) was higher than the average performance of children with none (M = -.17). Likewise, limited statistical power may explain why the S-I > I-I contrast did not emerge as significant with hot EF, despite seemingly non-negligible mean differences (Table 3). Overall, this study needs to be replicated with larger samples to draw more robust conclusions about the additive hypothesis as it pertains to child EF.

Limitations

The longitudinal design and the home-based observational measures used in the current study are important strengths. However, this study has some limitations. First, the low-risk nature of the sample and its small size limit the generalizability of the results and preclude generalization to risk populations where children are more vulnerable to cognitive problems (Burchinal et al., 2000). In the current study, we also focused on mostly White and Canadian families. Future studies are encouraged to expand the current findings by evaluating the degree to which executive competence of children from at-risk populations can be predicted by their attachment relationships. Moreover, the current results should be expanded by including families from diverse cultural contexts (van IJzendoorn et al., 2006) and non-traditional families (e.g. same-sex parents; Van Rijn van Gelderen et al., 2025). We also focused on attachment to mothers and fathers. An attachment network can also include non-parental (e.g. professional) caregivers, which may affect children's developmental outcomes significantly (Bakermans-Kranenburg, 2021). We encourage researchers to include non-parental attachment figures when assessing attachment networks. Moreover, the portion of variance in EF explained by attachment to parents was modest in magnitude. Many other biological and environmental factors not assessed here, including parental EF (Ribner et al., 2022) and child stress physiology (Wagner et al., 2016), are likely to play a significant role in the early development of EF. It should also be acknowledged that this study did not

examine whether, and to what extent, types of insecure attachment (i.e. insecure-avoidant and insecure-resistant) may have influenced the associations observed between attachment networks and children's EF. Although attachment theory and research have long highlighted qualitative distinctions among insecure subtypes (Dagan et al., 2024), progress in exploring their potential effects on cognitive development remains limited despite earlier calls for such investigations (e.g. de Ruiter & van IJzendoorn, 1993). This study also had insufficient power to determine whether the gender of the parent with whom the child had a secure attachment relationship mattered for EF competence. As explained by Dagan et al. (2022), a large number of mother–child and father–child attachment assessments are needed to permit comparisons between the four different attachment network configurations: insecure with both parents (I-I), secure with mother, insecure with father (SM-IF), insecure with mother, secure with father (IM-SF), secure with both parents (S-S). The current study was underpowered to compare the four configurations.

Furthermore, the current design was longitudinal but correlational. Therefore, the associations observed may not be indicative of causal relations between attachment and EF. To examine the causal nature of the observed longitudinal associations, future studies should employ experimental designs. Lind et al. (2017) found that an attachment-based intervention implemented in foster care was effective in enhancing toddlers' EF, suggestive of a causal role of attachment in EF development. However, research on attachment-based interventions is mostly focused on female caregivers; hence, the potential benefits of the promotion of father–child attachment for child EF are unknown. We also assessed father–child and mother–child attachment based on 45 minutes of observation each, whereas studies using home-based assessments of attachment often use at least 60 minutes. This slightly reduced length of observation was, however, required for assessing both relationships while maintaining a reasonable burden on families, and the results suggest that attachment scores are reliable. Also, assessing both relationships on the same day likely increased the magnitude of the observed association between attachment security to mother and father, as the child was essentially in the same state (mood, previous night's sleep, etc.). Thus, analyzing father–child attachment and mother–child attachment simultaneously in the same model was important to account for any method-induced common variance. We also counterbalanced the order of assessments to avoid systematic order effects (e.g. ensure that children were not systematically more fatigued with their mother than father or vice-versa). Finally, hot EF was assessed with only one task and not found to be related to father–child nor mother–child attachment, making it challenging to interpret whether there really is no association with attachment or whether the measurement approach failed to adequately capture this dimension. The Prohibition task used to capture this dimension of EF is well validated, but future research should include several hot-EF tasks to increase the robustness of assessment.

Conclusion

Child development is intricately intertwined within a network of family relationships, wherein both mothers and fathers exert separate and interconnected influences (Cox &

Paley, 1997). Attachment experts increasingly advocate for the inclusion of both parents in research, highlighting potential differences and similarities in child outcomes associated with father–child and mother–child attachment security (Boldt et al., 2014; Dagan et al., 2024; Deneault et al., 2022). By including fathers alongside mothers, this study led to a more comprehensive understanding of attachment dynamics that might foster the early development of child EF. Findings from two sets of analyses converged to suggest that developing a secure attachment relationship with both parents may be optimal for the development of cool EF during toddlerhood. This finding is in line with empirical research suggesting that the contributions of mothers and fathers in child development are similar in magnitude (e.g. Deneault et al., 2021, 2023) and that having secure attachments with both parents is associated with the most favorable outcomes (Dagan et al., 2024). The current study also suggests differential associations between attachment relationships and hot and cool aspects of EF. Why attachment relationships were found to be predictive of cool, but not hot, EF remains unclear. These results highlight the need for more studies distinguishing hot and cool aspects of EF. Finally, while causality has yet to be investigated, the current findings add to a recent yet rapidly growing literature suggesting that studying mothers alone is insufficient to provide a comprehensive understanding of attachment influences on child EF, and that paternal influences need to be considered as well.

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