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Early predictors of infant executive functioning: Contributions of maternal sensitivity and mind-mindedness across distress and non-distress contexts

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ABSTRACT

Executive functioning (EF) in early childhood plays a critical role in shaping later cognitive, socioemotional, and academic outcomes. Although the influence of caregiving on EF is well documented in preschool and older children, relatively little is known about how early relational factors contribute to the emergence of rudimentary EF abilities during the first year of life. The present study examined the contributions of maternal sensitivity and mind-mindedness to the emergence of EF in infancy. Fifty-one typically developing infants aged 9–13 months were invited to participate. Infants completed the A-not-B task to assess their EF abilities. Maternal sensitivity and appropriate mind-minded comments were assessed during a structured interaction task, which included both non-distress (free-play) and distress-eliciting episodes. Results showed that both maternal sensitivity and appropriate mind-minded comments were related to infant EF, yet only mind-mindedness in non-distress contexts emerged as a significant predictor of early EF abilities. These findings emphasize the importance of caregivers' attunement to their infants' mental states in fostering the emergence of EF.

Executive functioning (EF) refers to a set of higher-order cognitive processes that enable individuals to regulate their thoughts and behaviours in pursuit of goal-directed actions (Diamond, 2013). A widely used model of EF's internal structure, by Miyake and colleagues (2000) has proposed that EF is comprised of three separable, but also partially interrelated components: working memory (WM), inhibitory control (IC), and cognitive flexibility (CF). Studies of EF's putative components, that use batteries of EF tasks and factor analysis, also revealed that EF is less differentiated in children (Karr et al., 2018). In particular, findings from Lee et al. (2013) and Miller et al. (2012) indicated that a two-factor model (inhibitory control and working memory) better explained preschoolers' EF abilities, suggesting that these abilities may be operating distinctively from preschool years onward.

Together, these core components support the emergence of increasingly complex forms of self-regulation during early development (Buss & Spencer, 2014; Diamond, 2013; Hendry et al., 2016; Miyake et al., 2000). In fact, Blair and Ursache's (2011) bidirectional model of EF and self-regulation hypothesizes that EF and self-regulation share a feedback-based relationship, in which EF seems to be bottom-up influenced by emotional systems and simultaneously shapes top-down emotional regulation.

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Early EF skills have wide-ranging implications for later developmental outcomes: they shape children's socioemotional functioning (Caporaso et al., 2019; Kochanska et al., 2000; Riggs et al., 2004; Sulik et al., 2015), language development (Kuhn et al., 2014), and key domains of cognition, such as theory of mind (Benson et al., 2013). Early EF is also a predictor of academic achievements (Bull & Lee, 2014; Schmitt et al., 2017; Zelazo & Carlson, 2020), school readiness (Blair & Raver, 2015), children's competencies to learn from classroom instructions (Ribner, 2020), and reading abilities (Arrington et al., 2014). Moreover, difficulties in EF have been consistently linked to symptoms of neurodevelopmental conditions, including ADHD and ASD (Gewirtz et al., 2009; Hill, 2004; Kofler et al., 2011; Raiker et al., 2012), underscoring the importance of assessing these abilities in early childhood.

While substantial advances in EF occur during the first years of life, with particularly rapid growth observed across the preschool period (Best & Miller, 2010; Garon et al., 2008), our understanding of EF development during infancy remains comparatively underexplored. This is in part because EF processes are still rudimentary, but also because methodological constraints limit assessment in preverbal infants. Yet, accumulating evidence indicates that early precursors of EF can be detected within the first year of life, including emerging forms of executive control, observable from approximately six months of age (Cuevas et al., 2017; Holmboe et al., 2018). These rudimentary EF abilities in the first year of life take the form of inhibitory control – where infants can already inhibit looking toward distractors (Holmboe et al., 2018) – and working memory capacities – reflected in their emerging ability to detect changes in a single location when marked by salient landmarks (Oakes et al., 2011). These early EF indicators parallel rapid structural and functional developmental of the prefrontal cortex, a pattern demonstrated in classic studies showing that improvements in the A-not-B task performance correlate with dorsolateral prefrontal cortex development (Bell & Fox, 1992, 1997). Given the long-term predictive value of EF (Benson et al., 2013; Caporaso et al., 2019; Kuhn et al., 2014; Zelazo & Carlson, 2020) and increasing stability from infancy onward (Devine et al., 2019; Hughes et al., 2020), expanding research on EF during the first year of life is essential.

The few studies conducted on EF in the first year of life have largely focused on identifying individual predictors of EF development (e.g., Bell, 2012; Blankenship et al., 2019). This research has consistently shown, for instance, that early attentional abilities are associated with EF, with infant attention at five months predicting EF outcomes at 10 months – with infants demonstrating higher accuracy on the A-not-B looking task, as reflected by a greater proportion of correct responses (Blankenship et al., 2019) –, as well as at 24, 36, and 48 months (Cuevas & Bell, 2014). However, environmental factors—especially those rooted in early caregiver–infant interactions—have been strikingly understudied during this sensitive developmental window, despite the high plasticity of the infant brain and its heightened sensitivity to environmental input (Hodel, 2018). Caregiver–infant interactions have been proposed as a critical factor in shaping individual differences in EF (Ramos et al., 2023). Although most evidence comes from preschoolers (e.g., Baptista et al., 2017), theoretical perspectives grounded in attachment theory emphasise that infants depend heavily on caregivers for the regulation of their emotional and behavioural states, suggesting that interactive quality may already influence rudimentary EF processes during infancy (Eisenberg et al., 1998; Sroufe, 1997).

Among the caregiving behaviours found to contribute to early child development, maternal sensitivity—defined as the caregiver's ability to accurately perceive, interpret, and respond promptly and appropriately to an infant's cues (Ainsworth et al., 1978)—has received particular attention. Research with preschool-aged children shows that sensitivity supports EF development (e.g., Bernier et al., 2010; Kraybill & Bell, 2012), although findings are not entirely consistent; one study conducted with preschool-aged children reported that sensitivity was associated with higher levels of inhibitory control, but not with its growth (Geeraerts et al., 2021). Moilanen et al. (2010) found a different result, revealing that positive parenting behaviors were associated with faster growth in inhibitory control abilities, from 2 to 4 years of age. These mixed results suggest that sensitivity may not be the only parenting dimension influencing EF, particularly as children grow older. Nevertheless, infancy is characterized by heightened dependency on caregivers, implying that sensitivity may play an especially foundational role in supporting early processes related to EF during this formative period. This is supported by evidence showing that maternal sensitivity in early infancy supports development in attention and in brain structure (Bornstein & Tamis-LeMonda, 1997; Samdan et al., 2020; Sethna et al., 2017; Yu & Smith, 2016). Given that both attention and early neurodevelopment are critical contributors to the emergence of EF, maternal sensitivity may play a key role in fostering the development of early EF processes. Surprisingly, however, the role of maternal sensitivity in predicting EF during infancy remains largely unexplored.

While maternal sensitivity is believed to play a critical role in supporting early EF, it may not account for all variation in these emerging abilities, highlighting the potential contribution of other parenting dimensions. Meins and colleagues (2012) proposed that maternal mind-mindedness—a caregiver's tendency to treat the infant as an intentional agent with mental states (Meins et al., 2001)—may exert distinct and potentially stronger effects on EF than sensitivity alone. Indeed, parental appropriate mind-related comments appear particularly influential during infancy, shaping infants' emerging emotion regulation capacities, which in turn may scaffold early EF, by providing a predictable, socially contingent context in which infants learn to monitor, interpret, and modulate their own internal states (Zeegers et al., 2018). Supporting this view, evidence shows that maternal mind-mindedness at 9 months predicts later inhibitory control at ages 2 and 3, whereas sensitivity does not (Cheng et al., 2018). More recently, Dong et al. (2023) also found that maternal mind-mindedness during the second year of life was associated with children's inhibitory control. Although conducted with preschool-aged children, other studies have shown that maternal use of mental-state comments during picture-storybook sharing tasks significantly predicts children's EF performance, even after accounting for sociodemographic factors such as age, sex, and parental education (Baptista et al., 2017; Toor & Hanif, 2022). Taken together, this body of evidence suggests that mind-mindedness may function as a key relational mechanism supporting the emergence of EF, complementing the potential foundational role of maternal sensitivity.

An additional gap in the literature concerns whether the caregiving context—distress vs. non-distress—matters for EF development during infancy. We recently proposed that sensitivity expressed in distress-eliciting situations may support different developmental pathways than sensitivity expressed during positive or neutral interactions (Ramos et al., 2023). Supporting this claim, research found

that sensitivity to infant distress cues has been linked to attachment security (Del Carmen et al., 1993; Leerkes, 2011), whereas sensitivity to infant non-distress cues has been associated with attentional processes (Bornstein & Tamis-LeMonda, 1997). Sensitivity to distress and non-distress contexts seems to serve different socialization goals, with sensitivity to distress being closely related to providing comfort and protection, while sensitivity to non-distress is linked to reciprocity and learning (Grusec & Davidov, 2010). Importantly, evidence indicates that these forms of sensitivity have more unshared than shared variance, and that caregiving responses to distress versus non-distress cues differentially activate neural and physiological processes (Groh & Roisman, 2009; Leerkes et al., 2009). Interestingly, appropriate mind-related comments (mother's speech that reveals mind-mindedness towards the infant and is also appropriate to the context), typically assessed in free play, have likewise been shown to vary across caregiving contexts—e.g., bath, mealtime, and play (Farkas et al., 2018; Flynn & Masur, 2007). Longobardi and colleagues (2022), for instance, found that mothers produced more appropriate mind-related comments during free-play with their 16-month-old children, than during other everyday routines such as mealtime. This raises the possibility that both sensitivity and mind-mindedness may function differently depending on the interactional context, with potential implications for how these behaviours support EF during the first year of life.

1. The present study

Despite substantial evidence highlighting the influence of maternal sensitivity and mind-mindedness on multiple domains of child development (e.g., Bornstein & Tamis-LeMonda, 1997; Cheng et al., 2018; Samdan et al., 2020), their specific contribution to infants' emerging EF abilities has yet to be directly examined. The present study addresses this gap by investigating the associations between three measures: (1) maternal sensitivity, (2) mind-mindedness—assessed in response to infants' cues during both non-distress and distress-eliciting interaction contexts—and (3) infants' EF skills within the first year of life. We measured the infant's EF using the A-not-B task, a task already used in studies of EF development in early infancy (Blankenship et al., 2019; Holmboe et al., 2008; Holmboe et al., 2018).

Drawing on previous findings linking these parenting dimensions to EF development in older children (Baptista et al., 2017; Bernier et al., 2010), we expect that both higher levels of maternal sensitivity and higher levels of appropriate mind-related comments will be associated with more advanced infant EF performance. Based on theoretical accounts that have emphasized the role of parents' mental-state awareness in scaffolding self-regulatory development (Baptista et al., 2017; Meins et al., 2001), we further anticipate that maternal mind-mindedness will show a stronger relation to infants' EF skills than sensitivity alone. In addition, we hypothesize that maternal behaviours during non-distress contexts will more strongly predict EF development. This expectation is informed by studies suggesting that during non-distress contexts, caregivers typically provide cognitive inputs to stimulate their children's learning and scaffold their exploration (i.e., following the child's lead when exploring the environment, scaffolding the child's efforts during challenging tasks) (King et al., 2019) and that maternal engagement during free-play interactions supports early cognitive processes (e.g., Yu & Smith, 2016), including attentional control, a foundational precursor to later EF (Blankenship et al., 2019; Cuevas & Bell, 2014).

2. Method

2.1. Participants

Participants were drawn from a larger project examining individual and relational predictors of rudimentary EF during the first year of life. A total of 66 infants and their mothers were initially recruited, corresponding to the full cohort of infants in this age range included in the broader sample; however, 15 infants were excluded from the present analyses because they did not complete the

Table 1
Sociodemographic Characteristics of Participants.

	n	*M (SD)*	%	range
Infants' age (in months)	51	10.78 (1.63)		9–13
Mothers' age (in years)	51	33.63 (5.19)		20–43
Infants' sex				
Male	27		52.9	
Female	24		47.1	
Infants' age group				
9–10 months	28		54.9	
12–13 months	23		45.1	
Maternal education				
9 years of education	1		2.0	
12 years of education	7		13.7	
Bachelor degree	27		52.9	
Master's or PhD	16		31.4	
Marital status				
Single	2		3.9	
Married	47		92.2	
Divorced	2		3.9	

minimum number of valid trials on the A-not-B task used to assess EF (see procedure below). No significant differences emerged between included and excluded infants in age ($t(64) = 1.960$, $p = .059$), sex ($\chi^2(1) = .183$, $p = .669$), or maternal education ($\chi^2(1) = 2.282$, $p = .131$). The final sample, therefore, comprised of 51 mother-infant dyads (sample description is in Table 1). Infants ranged in age from 9 to 13 months ($M = 10.78$, $SD = 1.63$), and just over half were male ($n = 27$; 52.9%). Mothers were between 20 and 43 years old ($M = 33.63$, $SD = 5.19$), and the majority were married or cohabiting ($n = 47$; 92.2%), and held a bachelor's degree or higher ($n = 43$; 84.3%).

2.2. Procedure

Families were recruited from Portuguese daycare centres. Eligible infants were required to be between 9 and 13 months of age, born full-term, free of significant medical conditions or birth complications, and within the typical developmental range. Developmental functioning was screened using the short form of the Caregiver-Reported Early Development Instruments (CREDI), a 20-item measure of early development for children under 36 months (McCoy et al., 2018). Caregivers completed the age-appropriate form (6–11 or 12–17 months) using a yes/no format, and all infants scored within the expected developmental range. This study was approved by the Institutional Ethics Committee of [University name removed for blind review] (Ref 128/2022). Written informed consent was obtained from all participating mothers.

Assessments were conducted at the daycare centres or in families' homes, depending on caregiver availability. Mothers first completed a set of questionnaires, including demographic information. Infants' EF was then assessed using the A-not-B task, administered while infants were seated on their mothers' laps. Subsequently, each dyad participated in a 12-minute structured interaction task, following the procedure described by Baptista et al. (2018), designed to assess parental quality of relational care. The task comprised four consecutive three-minute episodes, presented as a continuous interaction. The first was a non-distress free-play episode during which mothers and infants interacted with developmentally appropriate toys. This was followed by three episodes intended to elicit progressively greater levels of challenge for the dyad – that will refer to as distress episodes. In the first of these, mothers and infants interacted without toys; in the second, they engaged with a toy selected to be above the infant's developmental level; and in the final episode, the mother briefly left the room for three minutes while a trained researcher interacted with the infant using the same age-developmentally challenging toy introduced in the previous interaction episode, after which the mother and infant were reunited. All interactions were video-recorded for subsequent coding of maternal sensitivity and maternal mind-mindedness. Families received a small token of appreciation for their participation.

2.3. Measures

2.3.1. Infant executive functioning

The A-not-B task (Piaget, 1954) was used to assess early EF. The apparatus, based on the design described by Smith et al. (1999), consisted of a rectangular box measuring 30x23x5.5 cm. It featured two circular wells, each with a radius of 4.5 cm and a depth of 4.5 cm; the center of the wells was 12.5 cm apart. The lids had a radius ranging from 4.7 cm to 5 cm and were equipped with handles. Infants sat on their mothers' laps and faced the experimenter, who also provided instructions to the mother. The instructions included saying that the infant was not allowed to touch the box before the signal from the experimenter and that the mother could not indicate where the toy was hidden.

The procedure used is a version of the A-not-B task that uses multiple reversals and varying delays over time. In the first trial, the experimenter hides the toy in location A and covers the locations with the lids simultaneously. An initial delay of 2 s was imposed for 9–10-month-old and of 5 s for 12–13-month-old infants (Diamond, 1990). The delay imposed varied according to the infant's performance: if the child reached correctly two times in a row, the location of the hidden toy would switch, and the delay would increase by 1 s; if the child answered incorrectly in two consecutive trials, the delay would decrease by 2 s. If the child touched the two lids, the trial was repeated. Testing would end after 25 trials or if the child refused to continue. A different hiding toy would be introduced when the child demonstrated no longer being interested in the task to maintain the child's engagement in the task. A cumulative measure of the A-not-B task was obtained by calculating the sum of delays tolerated in the correct trials and dividing by the total number of trials completed, with higher scores indicating better EF performance (Holmboe et al., 2018). Infants were included in the analysis if they completed a minimum of eight trials (blind for review). To assess reliability, 25% of the sessions were independently coded by two trained raters, yielding excellent interrater reliability (ICC =.95).

2.3.2. Maternal Sensitivity

Maternal sensitivity refers to the mother's ability to perceive and accurately interpret her infant's signals and respond promptly and appropriately to those cues. Maternal sensitivity was assessed using the Ainsworth et al. (1978) Sensitivity/Insensitivity scale. This instrument was applied to the 12-minute videotaped interaction task, in which trained coders rated how appropriately mothers responded to their infants' cues, in both non-distress and distress-eliciting contexts. Scores range from 1 (highly insensitive) to 9 (highly sensitive). Each episode of the interaction task was coded independently. The three episodes that were more distress-eliciting (no toys, difficult toy, and reunion) were also significantly intercorrelated (all $p < .001$). Based on this finding, we averaged them and created a composite distress sensitivity score. Interrater reliability was assessed for 18% of the sample, coded independently by two trained raters, and demonstrated excellent agreement (ICC ranging between.78 and.97).

2.3.3. Maternal appropriate mind-minded comments

Maternal mind-mindedness was coded from verbatim transcripts of the videotaped mother–infant interaction task, following the coding system developed by Meins and Fernyhough (2015). Verbal references to the infant's internal states—such as thoughts, emotions, or desires—were classified as mind-related comments. These comments were subsequently coded as appropriate when they accurately described or inferred the infant's internal state, or as non-attuned when they misinterpreted or imposed an incorrect mental state. To control maternal verbosity, a proportion of appropriate mind-related comments was calculated relative to the mother's total number of utterances; this was done for the non-distress and distress episodes, and this proportion served as the mind-mindedness variable used in all analyses. As with maternal sensitivity, the three distress-eliciting episodes were averaged, creating a mean score that captures mind-mindedness in distress-eliciting contexts and that we also label as distress appropriate. Interrater reliability was assessed for 22% of the sample and was excellent (ICC ranged between.86 and.99).

2.3.4. Sociodemographic questionnaire

Mothers completed a sociodemographic questionnaire providing information on their educational attainment, marital status, and their child's age and sex.

2.4. Data analysis

All analyses were conducted using IBM SPSS Statistics (version 29.0.2). We began by computing descriptive statistics for all study variables. Paired-sample comparisons were then performed to examine differences in maternal sensitivity and mind-mindedness between the non-distress episode (free-play) and the distress-eliciting episodes (no toys, difficult toy, and reunion). Next, we examined bivariate associations between infants' performance on the A-not-B task and each parenting measure—maternal sensitivity and appropriate mind-mindedness—using Pearson correlations. Additional correlations were conducted to explore associations between EF and parenting variables and sociodemographic characteristics. Finally, to assess the unique contribution of maternal relational care to infants' emerging EF abilities, hierarchical regression analyses were conducted. Sociodemographic variables that showed significant associations with A-not-B performance in preliminary analyses were entered as covariates in the first step, followed by maternal care (maternal sensitivity and mind-mindedness were entered simultaneously in the second step).

3. Results

Table 1 presents the descriptive statistics for all study variables, and Table 2 shows the bivariate correlations. With regard to the A-not-B task, infants completed an average of 11.43 trials (SD = 3.32). Performance showed substantial variability, with cumulative scores ranging from 0.00 to 4.89 (M =.92, SD =.91).

Mothers displayed significantly higher sensitivity in the non-distress episode (M = 6.8, SD = 1.3) than in the distress-eliciting episodes (M = 6.07, SD = 1.3), $t(50) = -4.387$, $p < .001$. Maternal sensitivity in the non-distress and distress contexts was strongly correlated ($r = .571$, $p < .001$), indicating that mothers who were more sensitive during free play tended to maintain higher sensitivity when interactions became more challenging. For mind-mindedness, no significant differences were observed in the proportion of appropriate mind-related comments across contexts (i.e. proportion of mothers' comments that were about the infant's internal mental state and were also adequate for the situation), although mothers tended to produce slightly more appropriate comments in the non-distress episode (M =.014, SD =.02) than in the distress-eliciting episodes (M =.011, SD =.01), $t(50) = 1.499$, $p = .140$. Appropriate mind-minded comments in the non-distress episode were positively correlated with maternal sensitivity in the same context ($r = .409$, $p = .003$). In contrast, appropriate mind-mindedness in the distress-eliciting episodes showed only a marginally significant association with appropriate mind-mindedness in the non-distress episode ($r = .272$, $p = .058$). No significant correlations were found between mind-mindedness and maternal sensitivity in the distress-eliciting episodes ($p > .05$).

Table 2
Descriptive Statistics and Correlations for Study Variables.

	n	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Infants' sex[a]	51			-								
2. Infants' age	51	10.78	1.63	.199	-							
3. Mothers' age	51	33.63	5.19	.076	.137	-						
4. Maternal education[a] [b]	51			.407**	.009	.336*	-					
5. Non-distress: Maternal appropriate mind-minded comments	51	.014	.016	.088	.145	-.151	.115	-				
6. Distress-eliciting: Maternal appropriate mind-minded comments	51	.011	.01	.006	.036	-.042	.028	.272 +	-			
7. Non-distress: Maternal sensitivity	51	6.82	1.29	.192	.181	.148	.236^{+}	.409**	.132	-		
8. Distress-eliciting: Maternal sensitivity	51	6.07	1.35	.136	.439**	.283*	.225	.204	.050	.571***	-	
9. AB: Cumulative measure	51	.92	.91	-.159	.544***	-.003	-.162	.349*	.051	.126	.289*	-

Note. [a] Point-biserial correlations are reported for associations involving dichotomous variables; all other values represent Pearson correlations. [b] Maternal education was dichotomized as up to 12 years of education vs. higher education; AB = A-not-B task; $^{+}$ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

3.1. Associations Between Early EF and Quality of Relational Care

As shown in Table 2, both the proportion of appropriate mind-minded comments in the non-distress episode ($r = .349$, $p = .012$) and maternal sensitivity in the distress-eliciting episodes ($r = .289$, $p = .039$) were positively associated with infants' performance on the A-not-B task. Regarding sociodemographic factors, infants' age was positively associated with A-not-B performance ($r = .544$, $p < .001$), indicating that older infants displayed better EF performance. The infant's age was also positively related to maternal sensitivity in the distress context ($r = .439$, $p = .001$), but not in the non-distress episode ($p > .05$). Maternal age was similarly associated with sensitivity in the distress context ($r = .283$, $p = .044$), suggesting that older mothers tended to display higher sensitivity when interactions became more challenging. Neither infant sex nor maternal education was significantly associated with EF performance, sensitivity, or the proportion of appropriate mind-minded comments ($p > .05$).

3.2. Predicting Early EF from Maternal Relational Care

Table 3 summarizes the regression models that we estimated. A linear regression analysis was conducted to evaluate whether maternal sensitivity and mind-mindedness predicted infants' A-not-B performance, while controlling for infant age—the only sociodemographic factor significantly associated with EF. In line with our analytic strategy, only variables that showed significant correlations with the A-not-B performance in preliminary analyses were entered into the regression model – i.e. appropriate mind-minded comments in the non-distress context, and maternal sensitivity in the distress eliciting context. The overall model was statistically significant, explaining 33% of the variance in the A-not-B performance, $F(3, 47) = 9.233$, $p < .001$. The infant's age emerged as a significant predictor ($\beta = .498$, $t(47) = 3.858$, $p < .001$). In addition, the proportion of appropriate mind-minded comments in the non-distress episode predicted higher A-not-B scores ($\beta = .274$, $t(47) = 2.314$, $p = .025$). In contrast, maternal sensitivity in the distress-eliciting contexts did not significantly contribute to the prediction of EF performance ($p = .908$).

4. Discussion

Only a small number of studies have investigated the predictors of EF during infancy (Bell, 2012; Blankenship et al., 2019), despite growing evidence that foundational EF abilities start to emerge within the first year of life (Cuevas et al., 2017; Holmboe et al., 2018) and predict a wide range of developmental outcomes (e.g., Benson et al., 2013; Caporaso et al., 2019; Zelazo & Carlson, 2020). Attention and early brain development play a central role in supporting rudimentary forms of EF skills (Blankenship et al., 2019; Cuevas & Bell, 2014; Holmboe et al., 2018; MacNeill et al., 2018), yet research has offered comparatively limited insight into how environmental inputs—particularly parenting behaviours—shape these early developmental pathways.

Prior research with preschool-age samples (e.g., Bernier et al., 2010; Kraybill & Bell, 2012) suggests that maternal sensitivity may already be contributing to early EF. The temporal stability of sensitivity further reinforces this inference (Bigelow et al., 2010; Kim & Kochanska, 2025). Notwithstanding, Meins and colleagues (2012) suggested that mind-mindedness—with known links to EF in preschool years (Baptista et al., 2017)—may also be contributing to rudimentary EF processes during the first year of life, even playing a more significant role than sensitivity. Accordingly, this study examined how maternal sensitivity and mind-mindedness, assessed in both non-distress and distress-eliciting interaction contexts, relate to infants' EF skills during the first year of life.

4.1. Maternal Sensitivity and Mind-Mindedness Across Contexts

Consistent with previous research, mothers in this study exhibited significantly higher sensitivity in non-distress contexts than in contexts that are more likely to elicit distress signals from the infant. Non-distress contexts are emotionally less demanding and occur in low-arousal settings (Leerkes et al., 2009), whereas distress-eliciting contexts require rapid regulation of caregivers' own emotions, making sensitive responses more challenging (Leerkes, 2010). Experimental and observational research has documented the negative impact of stress on maternal sensitive behaviours (Booth et al., 2018; Finegood et al., 2016; Qian et al., 2024), potentially mediated by cascading effects of parental psychological distress on emotion regulation and responsiveness (Carreras et al., 2019). Mind-minded comments were also more frequent in the non-distress episode than in distress-eliciting contexts, although this difference did not reach statistical significance. This pattern may reflect the less disruptive nature of infants' social cues during free play, which do not

Table 3
Prediction of infants' EF.

	B	*SE*	*β*	*t*	*p*
Block 1					
(Constant)	−2.356	.730	-	−3.227	.002
Infants' age	.304	.067	.544	4.538	< .001
Block 2					
(Constant)	−2.364	.730	-	−3.238	.002
Infants' age	.278	.072	.498	3.858	< .001
Non-distress: Maternal appropriate mind-minded comments	15.628	6.754	.274	2.314	.025
Distress-eliciting: Maternal sensitivity	.010	.088	.015	.116	.908

Note. Adjusted $R^2 = .33$, $F(3, 47) = 9.233$, $p < .001$.

require intense regulation of affect, whereas in distressing situations, caregivers are primarily focused on soothing and managing the child's emotional state (Leerkes et al., 2012), leaving fewer opportunities to produce mind-related comments.

Interestingly, appropriate mind-minded comments in the non-distress episode were positively correlated with sensitivity in the same context, consistent with previous research (Meins et al., 2012). Mind-mindedness is conceptualised as a specific aspect of sensitivity directed toward infants' internal states, which may explain the association between these dimensions (Zeegers et al., 2017). Furthermore, maternal sensitivity across non-distress and distress contexts was also intercorrelated, supporting the conceptual link between these two dimensions (Leerkes et al., 2009). However, mind-mindedness did not show stability across contexts, in line with studies suggesting that maternal mind-mindedness may be context-dependent and relational rather than a fixed trait (Giovanelli et al., 2019; Helmerhorst et al., 2019; Longobardi et al., 2022). The fact that mothers were assessed solely in play contexts—albeit under varying levels of induced stress—may have limited opportunities for mind-mindedness to manifest consistently across episodes, helping explain the lack of contextual stability observed.

4.2. Associations Between Caregiving and Early EF

Regarding links between parenting behaviours and EF, only maternal sensitivity in distress-eliciting contexts was positively associated with infants' A-not-B performance. This is contrary to our initial expectation that sensitivity in the non-distress episode would be more strongly predictive. Attachment theory provides a plausible explanation for finding: the activation of the attachment system in response to child distress elicits sensitive caregiving, promoting a sense of security and allowing infants to regulate their emotions within a safe environment (Ainsworth et al., 1978; Bowlby, 1969, 1979; Sroufe, 2000). Failure to respond to distress cues may impair regulation of the hypothalamic-pituitary-adrenal (HPA) axis (Atkinson et al., 2013; Lupien et al., 2009), which can in turn constrain cognitive processing (Lupien et al., 2005). Once regulatory needs are met, infants can safely engage their exploratory system, highlighting the co-regulatory role of caregivers in supporting emerging EF (Feldman et al., 1999). Similarly, the proportion of appropriate mind-minded comments in the non-distress episode was positively associated with EF. These maternal comments focused on infants' current activities, potentially supporting infants' cognitive engagement by providing contingent, meaningful framing of their ongoing experiences. This aligns with previous research showing that exposure to a higher quality of maternal mental-state talk in preschool predicts overall EF (Baptista et al., 2017). In preschool-age children, exposure to mental-state talk facilitates EF partly by enriching the vocabulary and representational tools used to reflect on thoughts and emotions (Vallotton & Ayoub, 2011). Infants, however, benefit in more foundational—prelinguistic—ways: appropriate mind-related comments may act as regulatory cues that help infants organise attention, detect regularities between their internal states and caregivers' responses, and experience affective states as predictable and co-regulated. These early relational processes may constitute the developmental groundwork upon which later representational abilities relevant to EF are built. On the other hand, the proportion of appropriate mind-minded comments in the distress context was not related to infants' EF. Although the difference between contexts did not reach statistical significance, the lower mean proportion observed in the distress context suggests that maintaining appropriate mind-mindedness is more challenging under conditions of infant distress. Additionally, in these distress-eliciting contexts, and given the infants' young age, mothers may have relied more on nonverbal regulatory strategies, such as touch, rather than on verbal comments to support their children's regulation. This is consistent with the proposal by King et al. (2019), who argued that emotional inputs may be predominantly provided in distress-like contexts, rather than cognitive inputs. Our linear regression analyses further indicated that, after controlling for the infant's age, appropriate mind-minded comments in the non-distress episode significantly predicted EF, whereas sensitivity in distress-eliciting contexts did not. These findings support Meins et al. (2001)'s proposition that mind-mindedness may exert a stronger influence on early EF than sensitivity. Conceptually, sensitivity primarily facilitates emotional regulation, helping children manage affective arousal (Zelazo & Müller, 2002) and buffering stress-related HPA activation (Gunnar & Donzella, 2002). Mind-mindedness, in contrast, reflects a reflective, cognitive orientation toward the child as an intentional agent with distinct desires, emotions, and cognitions, thereby supporting behaviours linked to these mental states. Taken together, these findings suggest that sensitivity and mind-mindedness may play complementary roles: sensitivity provides emotional scaffolding, whereas mind-mindedness contributes to early cognitive scaffolding (Meins, 1997; Meins et al., 2001).

High variability in A-not-B performance is consistent with the developmental emergence of EF during the first year (Cuevas et al., 2017; Holmboe et al., 2018) and reflects the interplay between maturational and environmental factors (Bernier et al., 2016). The infant's age was a significant predictor of EF, with older infants performing better. This is expectable, given the considerable amount of evidence on the A-not-B task and the period of 8–10–12 months of age. It is also consistent with prior findings that EF improves with age (Best & Miller, 2010). The infant's age was also associated with higher maternal sensitivity in distress-eliciting contexts but not in non-distress episodes. This pattern suggests that as children grow, mothers may become more effective in regulating infants' emotional arousal during distress, whereas sensitivity in non-distress settings – contexts that are more neutral and less likely to elicit distress signals – may be less contingent on developmental level, given that they also are less demanding in terms of emotional regulation.

4.3. Limitations and Directions for Future Research

Despite the contributions to research on EF in infancy, this study does not exist without its limitations. First, the small sample size limits the generalizability of the findings. Reduced statistical power may have obscured associations of small to moderate magnitude, and therefore some effects should be interpreted with caution. Second, maternal psychopathology was not assessed, representing a significant limitation given its documented impact on maternal sensitivity (Ku & Feng, 2023), on mind-mindedness (Baron-Cohen et al., 2025), and on infants' EF development (e.g., Gueron-Sela et al., 2018; Hughes et al., 2013). Furthermore, individual

differences in attentional processes—central predictors of early EF (Blankenship et al., 2019)—were not included. Attentional control may moderate the influence of proximal caregiving behaviours on EF, and studies integrating both biological and environmental factors are needed to clarify such interactional mechanisms. Additionally, the study relied solely on observational play-based episodes, which, although ecologically valid, may not fully capture the breadth of sensitivity and mind-mindedness expressions across daily routines. Future research should consider multi-method, multi-context approaches, including naturalistic home observations, physiological measures of stress regulation, and longitudinal designs to map developmental change. Finally, future studies should examine these associations in at-risk or clinically vulnerable populations, such as premature infants. Preterm children display heightened difficulties in early cognitive tasks and stress regulation during the first year of life (Feher et al., 2025), and caregiving processes may operate differently—or exert stronger effects—in these populations. Understanding how sensitivity and mind-mindedness function as protective factors may guide the development of targeted early interventions.

5. Conclusions

Despite these limitations, very few studies have examined environmental predictors of EF during the first year of life, particularly distinguishing the contributions of sensitivity and mind-mindedness across distress and non-distress contexts. The present findings advance the literature by showing that both maternal sensitivity and mind-mindedness are linked to infants' emerging EF, and by illustrating how these distinct caregiving dimensions—emotional attunement and mental-state attunement—may differentially support early EF processes. Importantly, the results indicate that sensitivity and mind-mindedness are already developmentally meaningful for EF within the first year, suggesting that the relational foundations of EF begin to take shape earlier than typically assumed. These insights have implications for early intervention: programmes designed to foster EF development may benefit from strategies that strengthen sensitive caregiving in emotionally demanding moments and promote caregivers' awareness and interpretation of infants' mental states. Together, these relational capacities may provide a dual scaffolding—emotional and cognitive—supporting the earliest building blocks of EF.

Ethics Statement

This study was approved by the Ethics Committee of Iscte-IUL (Ref 128/2022). Informed consents were obtained from all individual participants included in the study.

CRediT authorship contribution statement

Joana Baptista: Writing – review & editing, Project administration, Conceptualization. **Cláudia Ramos:** Writing – original draft, Conceptualization. **Alfredo F. Pereira:** Writing – review & editing, Project administration, Conceptualization. **Vera Mateus:** Writing – review & editing.

Declaration of Competing Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data availability

Data will be made available on request.

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