Social Development

WILEY

ORIGINAL ARTICLE OPEN ACCESS

No Consistent Evidence for Family Concordance in Eye-Tracking-Based Assessment of Face Engagement – A Finnbrain Birth Cohort Study

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Received: 7 May 2025 | **Revised:** 7 July 2026 | **Accepted:** 10 July 2026

ABSTRACT

Most infants look longer at pictures of faces compared to non-faces. This visual behavior, referred to as face engagement, may play an important role in early social-emotional development. Previous research suggests that genetic and environmental factors influence attention to social stimuli, but whether face engagement is shared within families remains unclear. This cross-sectional study examined the concordance in face engagement between both parents and their 5-year-old children using an eye-tracking paradigm, while exploring the quality of mother-child interaction as a potential mediating factor for concordance. Eye tracking was used to measure attention to various faces and non-social patterns in both adults and children in the Finnbrain birth cohort ($N = 612$), and mother-child interaction was assessed using the Emotional Availability Scales during a free-play session. Using a structural equation modeling approach, we found a common face engagement factor in mothers, fathers, and children, suggesting a similar tendency to engage with faces regardless of facial expression across groups. However, there was no evidence of consistent within-family concordance in face engagement, nor a mediating effect of mother-child interaction in the relationship between mothers' and children's face engagement. These findings indicate that, while face engagement appeared comparable across development, family-level shared variability in this tendency may be limited or difficult to detect under the present methodological conditions.

1 | Introduction

From infancy, humans exhibit a distinct visual preference for pictures of faces over pictures of other objects (Johnson et al., 2015), possibly reflecting early social engagement. Eye-tracking studies suggest that infants' visual engagement with pictures of faces and facial expressions of emotions is associated with important developmental outcomes, such as prosocial behaviors in early childhood (Donohue et al., 2024; Eskola et al., 2023; Grossmann et al., 2018; Peltola et al., 2018). Conversely, reduced face engagement during infancy is associated with callous-unemotional traits (Bedford et al., 2015; Peltola et al., 2018) and autism spectrum disorders (Jones & Klin, 2013). Given their potentially significant impact on early social development, individual differences in face engagement and contributing factors have become a growing focus of research.

Individual differences in attention to faces versus non-face objects (Portugal et al., 2024) and eye versus mouth regions factors (Constantino et al., 2017), are significantly influenced by genetic factors. However, early environment—particularly caregiver interactions—may also shape these attentional patterns. Differences in children's attention to faces have been linked with parental mood, infant attachment, and parent-child interaction quality (Aktar et al., 2018; Eskola et al., 2024; Forslund et al., 2019; Kammermeier et al., 2020; Kammermeier & Paulus, 2020; Kataja et al., 2019; Luotola et al., 2024; Peltola et al., 2015, 2020; Taylor-Colls & Pasco Fearon, 2015; Vallorani et al., 2023). In line with the idea of intergenerational transmission of information processing biases (Aktar, 2022; Aktar et al., 2022), social learning processes within families may serve as one mechanism contributing to attentional patterns, as family members influence each other's behaviors during daily interactions. Yet, few studies have examined whether the level of face engagement is shared within families. This study aims to address this gap by investigating the concordance in face engagement between both parents and their children, proposing that such concordance may originate from shared genetic and environmental factors.

Strength of the current study is the inclusion of eye-tracking data from both mothers and fathers alongside their children, allowing examination of face engagement patterns across the family triad. Previous studies investigating the link between parent and child social-emotional attention have primarily focused on emotion-specific biases (i.e., the tendency to look longer at certain emotional expressions compared to others). A recent study by Aktar et al. (2022) reported a positive association between infant and parent attentional biases to threat-related versus happy facial expressions. However, parents of infants who showed greater attention to threat-relevant and happy faces also tended to show greater attention to both types of faces, indicating that the association was not specific to threat-relevant expressions. Similar to the present study, their sample included both mothers and fathers, but no significant gender differences were observed.

Furthermore, studies investigating pupil responses have reported similarity in infants and their parents' pupil mimicry while viewing dynamic videos of eye regions (Aktar et al., 2020), as well as a positive association in mean pupil responses to negative and neutral faces (Aktar et al., 2021). Additionally, a recent longitudinal study found bidirectional associations between mothers' and infant's responses to emotional facial expressions (Dela Cruz et al., 2023), although mothers' responses were measured with an emotion recognition task instead of using eye tracking methodology.

While prior studies focused on specific emotional attention biases, our study investigates a broader tendency to attend to faces in children and their parents. Screen-based eye-tracking research consistently shows that infants look longer at faces than other objects, regardless of emotional expression, and that this general bias towards faces may vary between individuals. Although fearful faces have been shown to elicit longer looking times than happy or neutral faces (Peltola et al., 2008), Pyykkö et al. (2019) found that attention dwell times are highly correlated across faces displaying different emotions and less so between faces and non-face patterns. Together, these findings support a view that, in addition to possible emotion specific biases, there is a common "face factor" that appears to explain a large proportion of variability in infant attention dwell times in screen-based studies. This idea is also supported by a previous study (Luotola et al., 2024), where a similar conceptualization was applied to describe individual differences in children's attention to faces. Therefore, our focus here is on a general bias to preferentially attend to faces (regardless of facial expression). As a comparison condition, we included a non-face pattern.

Previous findings further suggest that a decline in attention to faces relative to non-social stimuli is a typical developmental change after infancy (Kataja et al., 2022; Peltola et al., 2018), with evidence for a partial return of face bias around age five (Kataja et al., 2022). These shifts indicate a non-linear developmental trajectory, potentially reflecting adaptive processes and influences of environmental factors such as caregiving behaviors (Luotola et al., 2024) and maternal mental health (Kataja et al., 2019; Vallorani et al., 2023). While previous research has focused on infants and their parents, this study examines face engagement in 5-year-old children and their parents to assess whether parent–child similarities in attention to faces persist beyond early childhood. Investigating concordance at this age may offer new insights into familial aspects of social attention as children engage in increasingly complex social environments.

Previous studies have not examined whether parental attention to faces may be associated with their interaction behaviors. This is relevant because the quality of parent-child interaction may help explain alignment in face engagement patterns between parents and children. In this study, we explored emotional availability in mother-child interaction in relation to face engagement. Emotional availability, a widely used framework for assessing parent-child interactions, refers to the quality of emotional connection between a parent and a child (Biringen, 2008). It includes a parent's ability to interpret their child's social and emotional cues, such as facial expressions, as well as respond to them in a timely and appropriate manner, often through their own facial expressions. These dyadic processes could shape how children attend to faces across early to mid-childhood, as suggested by previous findings using similar methodologies (Luotola et al., 2024). Furthermore, emotional availability in early mother-child interaction has been linked to other child social-emotional outcomes (Lahtela et al., 2026; Saunders et al., 2015) and parental factors, like pre- and postnatal mental health (Hakanen et al., 2019) and executive functioning (Harris et al., 2021; Nordenswan et al., 2021).

While prior research has identified developmental patterns of face engagement, fewer studies have examined whether these tendencies are shared within families. It is important to distinguish between population-level similarity in attentional patterns and within-family concordance, referring to the extent to which face engagement is shared between parents and children, potentially due to genetic or environmental factors. This study assessed both the presence of a common face engagement factor across adults and children and the extent of within-family associations. We used cross-sectional data from the Finnbrain birth cohort study (Karlsson et al., 2018); applying a similar eye-tracking paradigm to assess dwell times for faces and patterns under distraction (Peltola et al., 2008) in 5-year-old children and their parents. Similar to a previous study (Luotola et al., 2024), we formed a face engagement factor based on observed dwell times for different face conditions for the child and both parents. Parent-child interaction quality for the mothers, but not fathers, was assessed using Emotional Availability (EA) Scales, and data were combined into one emotional availability factor. The preregistered (https://osf.io/94hjc/) study questions were:

1. Is there evidence for a common face engagement factor in adults similar to the factor previously reported among children by Luotola et al. (2024)?
2. Is parents' engagement with faces positively correlated with child's engagement with faces at 5 years of the child's age?
3. Is there within-family similarity in engagement with faces (i.e., family-level variance in the face engagement factor) at 5 years of the child's age?
4. Does mother-child interaction quality mediate the expected association between mother and child's engagement with faces at 5 years of the child's age?

In line with the existence of a common face engagement factor in children (Luotola et al., 2024), we expected to find a comparable factor structure in adults, reflecting similar underlying patterns of face engagement across adults and children. Based on previous findings of positive associations between parent and child attention to emotional facial expressions (Aktar et al., 2022) and evidence for familial concordance in face engagement based on genetic and shared environmental factors (Constantino et al., 2017; Portugal et al., 2024), we expected positive associations between parent and child face engagement and concordance within family units. Although the mediating effect of mother-child interaction quality has not been previously studied in the context of social-emotional attention, studies using other type of methodologies and examining other aspects of child development and parental functioning suggest a mediating role for parent-child interaction quality (Larrucea-Iruretagoyena & Orue, 2023; Reiss et al., 2022; Russotti et al., 2023; Rutter, 2005). In line with these findings, we hypothesized that higher emotional availability in mother-child interaction would partly mediate the expected relationship between mothers' and children's engagement with faces.

2 | Methods

2.1 | Participants

Participants of this study were a sub-sample of families in the Finnbrain birth cohort (Karlsson et al., 2018). This longitudinal study, comprising 3808 families followed from early pregnancy onward, was originally established to study how pre- and postnatal stress are associated with child development. All families included in the cohort were recruited between 15/12/2011 and 14/06/2015 through maternity clinics at gestational week 12 during ultrasound visits in South-Western Hospital District and Åland Islands. The cohort is representative of the northern European source population. A sub-sample of the cohort families, called the "Focus Cohort" ($N = 1227$), are followed more intensely, and invited to laboratory visits of different sub-studies. The Focus Cohort was initially established to investigate the development of children exposed to elevated versus low levels of prenatal maternal distress (Karlsson et al., 2018). Prenatal distress was assessed with the Edinburgh Postnatal Depression Scale (Cox et al., 1987), Symptom Checklist-90 Anxiety scale (Holi et al., 1998), and Pregnancy Related Anxieties Questionnaire-Revised (Huizink et al., 2016) at gestational week 14, 24, and 34. The Focus Cohort criteria are specified in the report by Karlsson et al. (2018).

Participants were families from the Focus Cohort and additional families from the general Finnbrain cohort population invited to laboratory visits. Children have been followed longitudinally with repeated assessments across development, whereas parents participated in a single assessment when the child was 5 years old. At this timepoint, eye-tracking assessments (conducted in separate visits for children and parents) and mother–child interaction assessments were carried out at the Child Development and Parental Functioning Lab. Parental participation in the eye-tracking assessment was based on separate recruitment and was therefore not obtained from all parents of participating children, reflecting differences in recruitment procedures and resource allocation across visits. Mother–child interaction data were collected during the same visit as the child eye-tracking assessment. Overall, fathers were less frequently available to participate.

A total of 437 children, 216 mothers, and 147 fathers participated in the eye-tracking assessments, representing 558 families. For the mother-child interaction assessment, 467 dyads participated. Using a structural equation modeling approach, all available data meeting the inclusion criteria (described below) from one or more assessments were utilized, resulting in a final sample of $N = 612$ children, mothers, and fathers. In five families, data were available from twin children, resulting in multiple observations per family. The majority of children (94%) were born full-term. Demographic details and prenatal maternal distress levels are outlined in Table 1.

Before the laboratory sessions, parents provided written informed consent for both their participation and their children's involvement. The participants were briefed on the specifics of the study and were informed of their right to withdraw at any point without needing to give a reason. The study protocol was approved by the Ethics Committee of the Hospital District of Southwest Finland. All procedures complied with the principles outlined in the Helsinki Declaration.

2.2 | Data Availability and Missing Data

Due to the multimethod design, not all participants contributed data to all measures. This pattern of missing data primarily reflects the study design and recruitment procedures (i.e., separate laboratory visits and partly separate participant pools), rather than systematic dropout. Figure 2 illustrates the sample size for each participant group (children, mothers, and fathers) and the extent of data overlap between children, mothers, and fathers within families. To address potential selection bias, we examined whether parents with available eye-tracking data differed from

TABLE 1 | Demographic characteristics of participants ($N = 612$ observations).

Variable	Statistics
Boys, N (%)	339 (55.4)
Girls, N (%)	273 (44.6)
GA (weeks), M (range)	39.7 (27.7–42.4)
Mother age at birth, M (SD)	31.1 (4.4)
Father age at birth, M (SD)	32.4 (5.2)
Maternal education, *N* (%)	
High school/vocational	146 (23.9)
Polytechnics	179 (29.2)
University	270 (44.1)
Data missing	17 (2.8)
Paternal education, *N* (%)	
High school/vocational	155 (25.3)
Polytechnics	136 (22.2)
University	131 (21.4)
Data missing	190 (31.0)
Maternal prenatal distress, *N* (%)	
Elevated	121 (19.8)
Low	282 (46.1)
Other	209 (33.9)

Note: N refers to the number of observations included in the analyses ($N = 612$), comprising 437 children (including five twin pairs), 216 mothers, and 147 fathers. In families with twins, multiple observations per family were included. Abbreviation: GA = gestational age.

those without data in their demographic characteristics. No statistically significant differences were found. Specifically, mothers with and without available data did not differ in maternal age at childbirth ($p = 0.842$) or education ($p = 0.730$), and maternal prenatal distress group was not associated with data availability ($p = 0.157$). Similarly, fathers with and without available data did not differ in paternal age ($p = 0.121$) or education ($p = 0.210$). Regarding children, recruitment and participation procedures have been described in detail in previous publications based on the same cohort (Kataja et al., 2022; Luotola et al., 2024).

2.3 | Eye-Tracking Procedure

We used eye tracking to assess children's and parents' visual attention to faces when the child was 5 years old. Assessments were conducted in a dimly lit room using EyeLink1000+ eye tracker (SR Research Ltd, Toronto, Ontario, Canada). During the child's assessment, the child sat alone on a chair 50–70 cm from the computer screen and eye tracker, while the parent sat next to the child but was instructed not to comment. During the parent's assessment, the parent sat alone 50–70 cm from the eye tracker and 65–85 cm from the screen. In both assessments, the researcher operated a host computer positioned next to the participant behind a curtain to avoid interference. A five-point calibration procedure, with an audiovisual animation sequentially presented on the screen in five locations, was used before measurement. The maximum error in gaze detection in the validation phase was set to 1.0 degrees. If the tracker failed to detect the eye, the calibration was repeated during measurement. A sampling frequency of 500 Hz was used.

An overlap paradigm (Peltola et al., 2008) was used to examine children's and their parents' dwell times on centrally presented faces or non-faces (i.e., a scrambled face control stimulus) upon presentation of a lateral distractor. This task was selected as part of a broader longitudinal assessment framework, in which methodological continuity across developmental time points has been prioritized. The attentional overlap task has been widely used to assess attention to faces and emotionally salient stimuli across age groups, including both young children and adults. In the present cohort, the task has been administered repeatedly in children at multiple developmental stages, allowing continuity in the assessment of attentional engagement and disengagement across development. Parents were assessed when the child was 5 years old using an age-adapted version of the same overlap paradigm, allowing examination of face engagement across family members.

In the adults' experiment, parents viewed child face stimuli obtained from the Child Affective Facial Expression (CAFE) set (LoBue & Thrasher, 2015). Adults were presented with photographs of children around 5 years of age, two boy and two girls posing neutral, happy, and angry facial expressions. A total of 48 trials were presented: 12 trials per facial expression condition and 12 trials for the non-face control condition. In the child experiment, similar adult face stimuli were used as those in a study by Peltola et al. (Peltola et al., 2008). Children were presented with photographs of one female posing neutral, happy, and fearful facial expressions. A total of 24 trials were presented: 6 trials per facial expression condition and 6 trials for the non-face control condition. The length of the children's assessment was reduced (compared to prior measurement points) as the children were also participating in other eye tracking experiments during the same visit (these will be reported elsewhere). Same non-face control stimulus obtained from the study by Peltola et al. (Peltola et al., 2008) and distractor stimuli, which were vertically arranged black and white rectangles or circles (15.4° x 4.3°) were used in both experiments.

In the children's experiment, a picture of a neutral, happy, or fearful face or a non-face control stimulus was shown at the center of the screen for 1000 ms. Then, a salient lateral distractor appeared 13° to the left or right side of the face or non-face stimulus for 3000 ms, making each trial 4000 ms in total. The central stimuli were semi-randomized so that the same stimulus was not presented more than three times in a row, and the side of the lateral stimulus was randomized. Before each trial, a brief animation captured the child's attention at the center of the screen, and the researcher initiated the trial once the child's gaze was centered. The adult procedure was similar, except the onset asynchrony of the face and lateral stimulus varied (1000 ms, 2000 ms, 3000 ms), and total trial duration ranged from 2500– 4500 ms. The onset asynchrony was varied randomly across trials to reduce predictability of the task and to prevent anticipatory gaze shifts, and also to maintain engagement, as adult participants were explicitly instructed to shift their gaze from the central to the lateral stimulus upon its appearance.

The xy coordinates of the participants' gaze position were stored and analyzed using a custom MATLAB (Leppänen et al., 2015) and R functions (R Core Team, 2023). Attention dwell time on the face stimulus was used to measure engagement with faces, defined as the interval from lateral stimulus onset until gaze shifted from the central face stimulus to the lateral stimulus or until a 1000 ms time-out. Dwell time for non-faces was calculated similarly. Data validity followed criteria from prior studies (Kataja et al., 2022; Luotola et al., 2024). Preprocessing procedures were applied as follows.

For children, who were not explicitly instructed to shift their gaze, all valid trials were included; if gaze did not shift within 1000 ms, dwell time was set to 1000 ms. For parents, who were instructed to shift gaze to the lateral stimulus, only trials with a gaze shift within 1000 ms were included. These preprocessing procedures differed between children and adults due to differences in task instructions. In children attention was guided using salient visual cues, as young children may not reliably follow verbal instructions. In contrast, adult participants were explicitly instructed to shift their gaze to the lateral stimulus upon its appearance.

The majority of adults (>79%) showed near complete compliance with the instruction, resulting in very few missing gaze shifts. However, a subsample of adults (~16%) exhibited an unusually high proportion of missing gaze shifts (>75% of trials). As this group had low number of valid trials and deviated from both the task instructions and the overall response pattern, these participants were excluded from the analyses. Consequently, different procedures were used for handling trials with missing gaze shifts in the child and adult datasets, reflecting differences in task implementation and response distributions across the two age groups. As a sensitivity analysis, the main models were repeated treating 1000 ms child trials as missing observations and excluding children who no longer met the criterion of at least three valid trials per condition. This preprocessing approach did not meaningfully change the pattern of findings or the main conclusions of the study.

Additional analyses were conducted to examine potential effects of stimulus onset asynchrony (SOA) on dwell times in the adult data (see Table S1 and Figure S1). These analyses showed that, although onset asynchrony affected overall dwell times and the magnitude of the face versus non-face difference (i.e., the face effect was largest at the shortest 1000 ms onset asynchrony); the difference between face and non-face stimuli was evident across all onset asynchrony conditions. Because unequal distributions of valid trials across SOA conditions could potentially bias estimation of the face engagement factor, we also examined whether the proportion of valid trials with the shortest onset asynchrony (1000 ms), where the face effect was strongest, was associated with individual face dwell times and found no significant association (see Supplementary Materials). These findings suggest that variation in the distribution of SOA conditions was unlikely to meaningfully bias estimation of the face engagement factor. Finally, after preprocessing, a multilevel modeling approach was applied to the trial-level data to compute face engagement factors for children and parents, as detailed below.

2.4 | Mother-Child Interaction Procedure

The mother–child interaction was evaluated from a video recorded play session in a quiet laboratory setting. The session included a 15-min free-play, a 5-min structured task, and a 5-min snack time. For the free-play, analyzed separately, mother-child dyads were provided with a standard set of age-appropriate toys and instructed to play with or without the toys, as they would play at home.

The Emotional Availability (EA) Scales (Biringen, 2008) was used to code mother-child interaction during free-play. The EA Scales include six dimensions: four assessing parental caregiving behaviors—sensitivity, structuring, non-intrusiveness, and non-hostility—and two assessing child behaviors—responsiveness and involvement. Sensitivity refers to behaviors and emotions that create and maintain a healthy and positive connection with the child. Structuring involves behaviors that age-appropriately support the infant's autonomy and learning. Non-intrusiveness refers to the ability to follow the child's lead without interference. Non-hostility reflects the regulation of negative emotions toward the child. As for the child dimensions, responsiveness refers to the emotional and social responses of the child towards the caregiver, while involvement refers to the child's ability to include the caregiver in the interaction.

Each dimension has 7 subscales with a maximum total score of 29, along with a direct score on a 7-point Likert-type scale describing the evaluator's overall view of the interaction. In the present study, we used the direct scores, with higher scores indicating a healthier emotional connection between mother and child. A detailed description of the scoring is available in the EA manual (Biringen, 2008). Coding was performed by three blinded, certified coders. Reliability, assessed for 10% of the videos using intraclass correlation coefficients, was .91 for sensitivity, .90 for structuring, .81 for non-intrusiveness, .80 for non-hostility, .87 for child responsiveness and .88 for child involvement. Differences were discussed between the coders and consensus ratings were used in subsequent analyses.

In previous literature, EA dimensions are commonly studied either as independent qualities of parent-child interaction or as composite score, describing emotional availability across four parental or all six dimensions (Biringen et al., 2014). In this study, we used confirmatory factor analysis to form a single EA factor, allowing the inclusion of all available mother and child EA data in the same model. The strength of the factor analysis approach is decreasing the number of variables and considering the collinearity between EA dimensions (Aran et al., 2022; Rodrigo et al., 2016; see also Barone et al., 2018; Garvin et al., 2012; Kertes et al., 2009). To highlight our interest in the role of dyadic mother-child interaction in the current study, we formed one EA factor including both the mother's and the child's side of the interaction.

2.5 | Statistical Analyses

A prospective analysis plan for this study was published in the Open Science Framework (https://osf.io/94hjc/). Descriptive statistics for dwell time variables as well as EA variables were

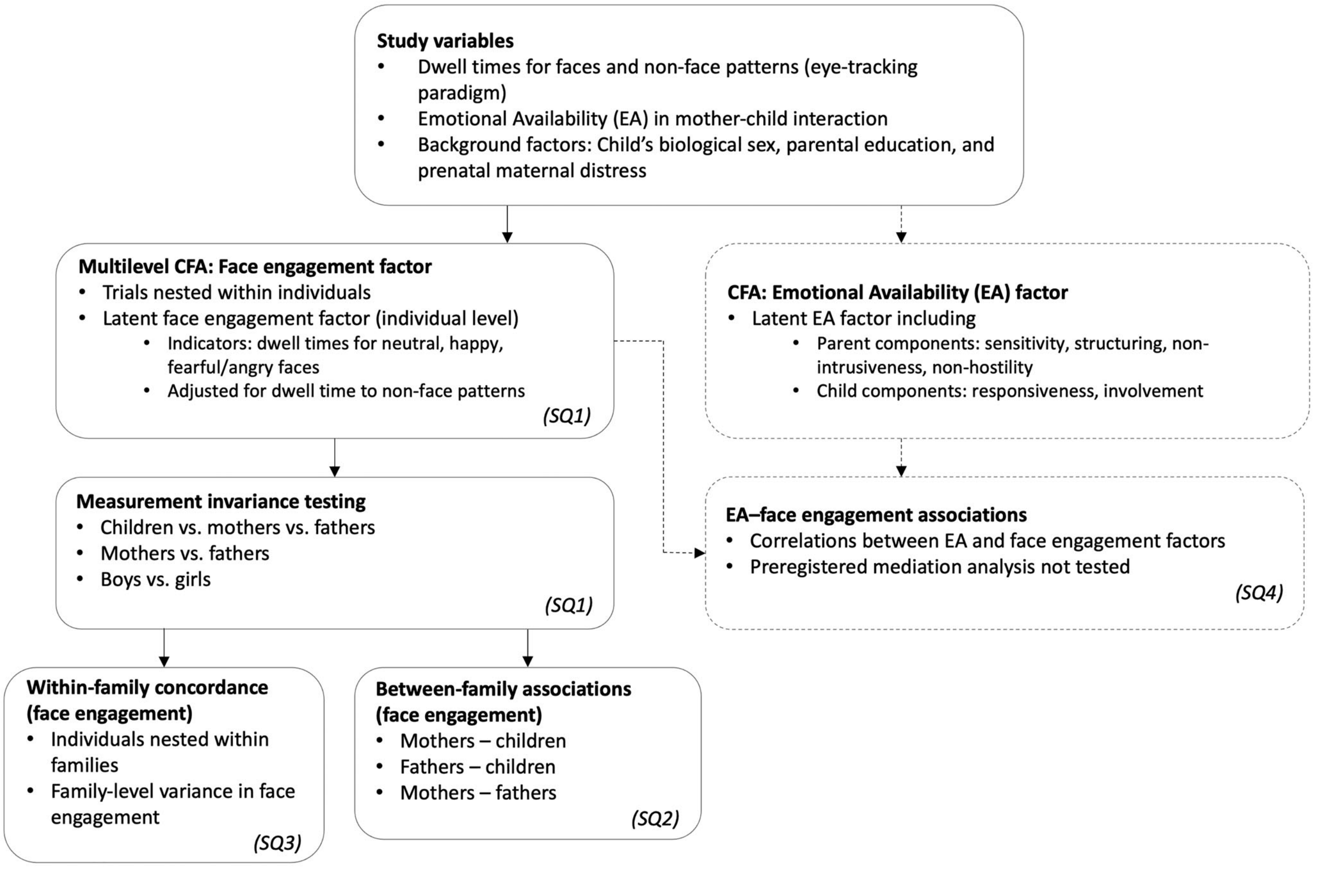

FIGURE 1 | A flowchart illustrating the analytical steps used to address the study questions (SQ1–SQ4).

first examined using IBM SPSS Statistics for Macintosh, version 29.0.2.0. Next, structural equation model analyses were conducted using Mplus version 1.8.10. An overview of the complete analytical strategy is illustrated in Figure 1.

2.5.1 | Multilevel Modeling of Eye-Tracking Data

Confirmatory factor analyses were conducted to establish the expected face factors for children, mothers, and fathers. A comprehensive multilevel model was employed to establish a single factor for each family member (child, mother, and father). A multilevel approach (Eckardt et al., 2021; Hoffman, 2019) accounts for the hierarchical structure of the eye-tracking data, with repeated trials nested within individuals (see also Luotola et al., 2024). An advantage of this approach is that it handles missing intraindividual data by utilizing all available observations and provides less biased estimates under maximum likelihood estimation (Gabrio et al., 2022).

As each face condition (happy, neutral, and fearful/angry) consisted of multiple trials, the eye tracking data were coded in a long format and organized under child identification number. A multilevel model was employed, with level one representing the trial level and level two representing the individual level. Our focus being on the individual-level effects (i.e., level 2), all variances and covariances were estimated at the trial level, creating a saturated model at level 1. This allowed for all trial-level effects to be controlled, making the individual-level effects less likely to be biased. The variation in dwell times for different face conditions between these two levels was used to create a single factor, representing overall engagement with faces at the individual level. Similar multilevel structure was applied for the dwell times for non-face stimuli (i.e., scrambled face), although they were not included in the factor, but used as a covariate in the analyses. This decision was made based on the observation that dwell times for face conditions were highly correlated, while the correlations between face and non-face dwell times were lower. Similar findings have been reported in prior analysis of children's data for this cohort (Luotola et al., 2024) or are evident in reports of other datasets (Peltola et al., 2018; Pyykkö et al., 2019; Vallorani et al., 2023). To further examine the validity of the face factor in adult data, specifically whether face-related dwell times reflect variability beyond general attentional disengagement, additional analyses comparing within- and cross-category correlations were conducted (see Tables S2–S7). These analyses showed that the face–face correlations were generally higher than face–pattern correlations, suggesting that there is face-specific variability beyond general disengagement time in adults. However, analyses conducted separately for mothers and fathers indicated that the evidence was less consistent for fathers than for mothers. After face factors were established, measurement invariances (Putnick & Bornstein, 2016; Steenkamp & Baumgartner, 1998) were examined to confirm that the same construct (face engagement) was measured across children, mothers, and fathers. Additionally, we tested for measurement invariance between mothers and fathers, as well as between boys and girls. Configural, metric, and scalar invariance models were compared using cut-off criteria

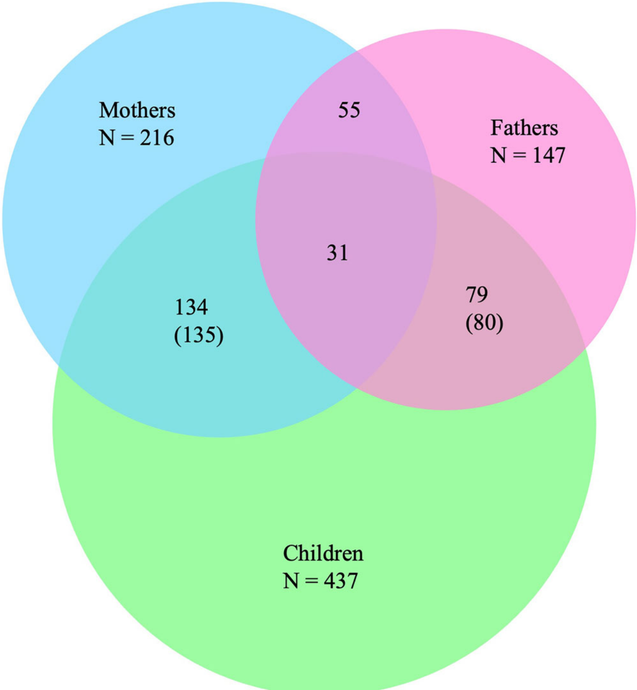

FIGURE 2 | Overlap of available eye-tracking data across children, mothers, and fathers. *Note:* Overlap is presented at the family-level (N = 558), such that each family contributes one observation regardless of whether data were available from one or both twin children. Counts in parentheses refer to the number of observations when twin children are considered separately.

suggested by Chen (Chen, 2007), where difference in CFI below .01 was considered as indicator of invariance.

Finally, the associations between family member's face engagement factors were tested within the multilevel model. As mentioned above, the face factors were adjusted for the individual variation in dwell times for non-faces to ensure observed effects were linked to the stimuli category (face vs. non-face). This approach controls for individual differences in general attention to visual stimuli.

2.5.2 | Testing for within-Family Concordance

To examine within-family concordance in more detail, a three-level multilevel approach was applied to test whether family-related similarity existed in the variances of a common face engagement factor. For this purpose, the data were coded in a long format, and organized under a common family identification number. The three-level model examines similarity among family members in their dwell times for faces while considering family-level (i.e., level three) and individual characteristics (i.e., level two), and accounting for the repeated nature of the trials within individuals (i.e., level one). Intraclass correlations (ICCs) were examined to investigate the degree of within-family similarity in the observed variables (i.e., dwell times per stimulus category). The ICC serves as an estimate of the extent to which within-family homogeneity contributes to the overall variance observed in a variable, delineating the impact of between-family differences.

2.5.3 | Analyses of Mother-Child Interaction Data

In the preliminary analyses on the mediating role of mother-child interaction, a confirmatory factor analysis was initially performed to ensure that the mother-child interaction data conformed to the expected emotional availability (EA) factor. Here, we tested whether the four subscales of maternal EA (sensitivity, structuring, non-intrusiveness, and non-hostility) and the two subscales of child EA (responsiveness and involvement) reflected a common latent factor of mother-child interaction quality. A mediation model, included in the preregistered analysis plan, was not tested because the expected association between mother and child's face engagement was not found in our data as reported below. However, correlations between EA and face factors were examined in a structural equation model where the two-level multilevel structure was restricted to the eye tracking data, and EA data were employed in the between-level analysis only.

2.5.4 | Confounding Factors and Additional Analyses

Child's biological sex, parental education, and prenatal maternal distress (elevated/low/other) were considered as relevant background factors for the analyses. Preliminary analyses indicated there were no significant group differences for EA dimensions or mean dwell times for different face conditions in relation to maternal prenatal distress. Significant group differences were observed for mean dwell time variables based on child's biological sex and for EA variables based on child's sex and both parents' education. Child's biological sex was also associated with both child face and EA factors in further analyses, while only maternal education was associated with the EA factor. Based on these initial findings, along with the previous research suggesting that girls may dwell longer on faces than boys during infancy (Kataja et al., 2019), we conducted non-registered exploratory analyses to examine whether the relationship between face and EA factors differs by biological sex.

2.5.5 | Model Parameters

The Full-Information Maximum Likelihood (FIML) estimation, which accounts for missing data, was used to estimate the model parameters. Model fit was evaluated using the Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Standardized Root Mean Square Residual (SRMR). Good model fit is typically indicated by an RMSEA below 0.06, a CFI above 0.95, and an SRMR below 0.08 (Hu & Bentler, 1999).

3 | Results

3.1 | Face Engagement Factor in Adults and Children

The descriptive statistics for the dwell time variables are outlined in Table 2. A one-factor structure was identified for the child's face engagement, consistent with findings from the same cohort. Similarly, a one-factor structure was identified for both mothers and fathers. Factor loadings ranging from .930–1.000 were consistently strong across all family members, indicating that each face condition contributed substantially to the face engagement factor.

TABLE 2 | Attention dwell times (ms) for faces and nonfaces.

Participant	Face condition	M	SD	Min	Max	n
Child	Nonface	439.148	163.859	166.4	891.2	437
	Neutral	604.526	195.088	195	1000	437
	Happy	524.698	186.154	168.8	1000	437
	Fearful	629.310	182.992	194	1000	437
Mother	Nonface	273.279	54.735	157.333	542.889	216
	Neutral	294.340	73.002	143.167	612.667	216
	Happy	299.234	66.446	193.50	572.00	216
	Angry	292.212	67.722	185.80	632.00	216
Father	Nonface	283.121	67.982	142.25	512.727	147
	Neutral	287.170	68.784	175.556	536.80	147
	Happy	299.735	78.541	170.75	591.167	147
	Angry	287.208	73.628	137.778	534.00	147

Note: This table presents descriptive statistics for attention dwell times to faces and non-faces across different participant groups.

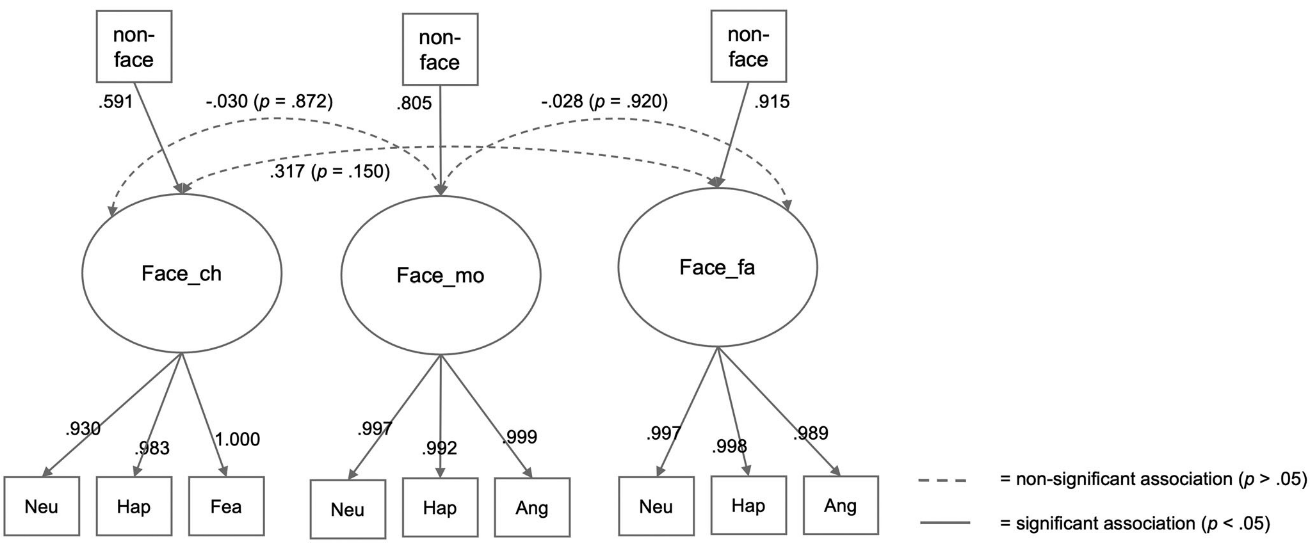

FIGURE 3 | A structural equation model (SEM) analysis assessing the relations between mothers', fathers', and children's face factors. *Note:* Face = face engagement factor; ch = child; mo = mother; fa = father; non-face = dwell time for non-faces; Neu = neutral; Hap = happy; Fea = fearful; Ang = angry.

Face factors are described in Figure 3. Supplementary analyses examining face- and non-face dwell time correlations in the adult data are presented in Tables S2–S7.

Measurement invariance in the face factors was tested across three different sets of groups: 1) mothers versus fathers versus children, 2) mothers versus fathers, and 3) boys versus girls. Configural invariance was supported across all three comparisons, indicating that the underlying structure of the face engagement factor, which includes indicators of neutral, happy, and fearful/angry facial expressions, was consistent across the groups. Metric invariance was generally supported across all comparisons, although for mothers and fathers the change in CFI was only marginally above the recommended cut-off (ΔCFI = 0.011). These findings suggest that the strength of the relationships between facial expressions and the latent construct of face engagement (i.e., factor loadings) were consistent across groups. Scalar invariance was achieved in the comparisons between mothers versus fathers and boys versus girls, as indicated by minimal changes in CFI. This suggests that the factor means (i.e., baseline levels of face engagement) are comparable between mothers and fathers, as well as boys and girls. However, scalar invariance was not supported in the comparison between children and parents, indicating that the baseline levels of face engagement differ between these groups. Together, these results suggest a common face engagement factor in adults and children. Detailed overall and comparative model fits are reported in Tables 3–5.

TABLE 3 | Measurement invariance testing across children, mothers, and fathers.

Model	Test	$\chi 2$	*df*	*p*	CFI	TLI	SRMR	RMSEA	|ΔCFI| (<.01)	Model comparison
1	Configural invariance	3.157	4	0.534	1.000	1.000	0.007	0.000	—	—
2	Metric invariance	15.692	7	0.028	0.994	.983	0.009	0.024	.006	1 & 2
3	Scalar invariance	92.455	11	0.000	0.939	.901	0.045	0.058	.055	2 & 3

Note: This table presents the results of measurement invariance testing for the face factor across children, mothers, and fathers. Model fit indices (χ^2, df, p, CFI, TLI, SRMR, RMSEA) and model comparison criteria (ΔCFI) are provided for each tested model.

TABLE 4 | Measurement invariance testing across mothers and fathers.

Model	Test	$\chi 2$	*df*	*p*	CFI	TLI	SRMR	RMSEA	|ΔCFI| (<.01)	Model comparison
1	Configural invariance	1.758	2	0.415	1.000	1.000	0.002	0.000	—	—
2	Metric invariance	14.352	4	0.006	0.989	.968	0.043	0.036	0.011	1 & 2
3	Scalar invariance	16.909	6	0.001	0.989	.977	0.041	0.028	0.000	2 & 3

Note: This table presents the results of measurement invariance testing for the face factor across mothers and fathers. Model fit indices (χ^2, df, p, CFI, TLI, SRMR, RMSEA) and model comparison criteria (ΔCFI) are provided for each tested model.

TABLE 5 | Measurement invariance testing across boys and girls.

Model	Test	$\chi 2$	*df*	*p*	CFI	TLI	SRMR	RMSEA	|ΔCFI|(<.01)	Model comparison
1	Configural invariance	1.260	2	0.533	1.000	1.000	0.008	0.000	—	—
2	Metric invariance	1.387	4	0.847	1.000	1.000	0.011	0.000	0.000	1 & 2
3	Scalar invariance	4.145	6	0.657	1.000	1.000	0.018	0.000	0.000	2 & 3

Note: This table presents the results of measurement invariance testing for the face factor across boys and girls. Model fit indices (χ^2, df, p, CFI, TLI, SRMR, RMSEA) and model comparison criteria (ΔCFI) are provided for each tested model.

3.2 | Associations between Parents' and Children's Face Engagement

Correlations between both parents' and the child's factors were assessed at the between-individual level in a structural equation model including all available data. In the model, each factor was controlled for non-face dwell times. The model had an acceptable fit $\chi^2(53) = 38.719$, $p = 0.929$, CFI = 1.000, RMSEA < 0.001, SRMR = 0.103. No significant associations were found between the face engagement factors of children and fathers ($r = 0.317$, $p = 0.150$), children and mothers ($r = -0.030$, $p = 0.872$), or mothers and fathers ($r = -0.028$, $p = 0.920$). A description of the factors and their correlations are shown in Figure 3.

3.3 | Within-Family Similarity in Face Engagement

The intraclass correlations (ICCs) for the observed family-level variables (i.e., dwell times per stimulus category) were 0.018 for non-faces, 0.015 for neutral faces, 0.022 for happy faces and 0.017 for negative facial expression (fearful or angry). ICCs close to zero did not support further evaluation of the preregistered three-level multilevel model. These results suggest there is little to no variance in face engagement that is explained by family membership.

3.4 | Mother-Child Interaction Quality and Face Engagement

The descriptive statistics for EA subscales are outlined in Table 6. The one-factor structure was replicated for mother-child EA and all factor loadings were statistically significant. Factors loadings varying from 0.484–0.996 revealed dimensions of both maternal and child emotional availability had moderate or considerable influence on the EA factor. The full model, including the EA and face factors, and their association, had acceptable fit: $\chi^2(130) = 202.667$, $p < 0.001$, CFI = 0.984, RMSEA = 0.011, SRMR = 0.088. We found no significant associations between EA

TABLE 6 | Descriptive statistics for the subscales of mother-child Emotional Availability (EA).

EA subscale	M	SD	Min	Max	n
Sensitivity	5.273	0.971	2.5	7	467
Structuring	4.877	0.959	2	7	467
Non-intrusiveness	5.956	0.787	3	7	467
Non-hostility	6.259	0.768	2.5	7	467
Responsiveness	5.310	0.922	2	7	467
Involvement	5.153	0.911	3	7	467

Note: This table presents descriptive statistics for the subscales of Emotional Availability (EA) assessed during mother-child interaction.

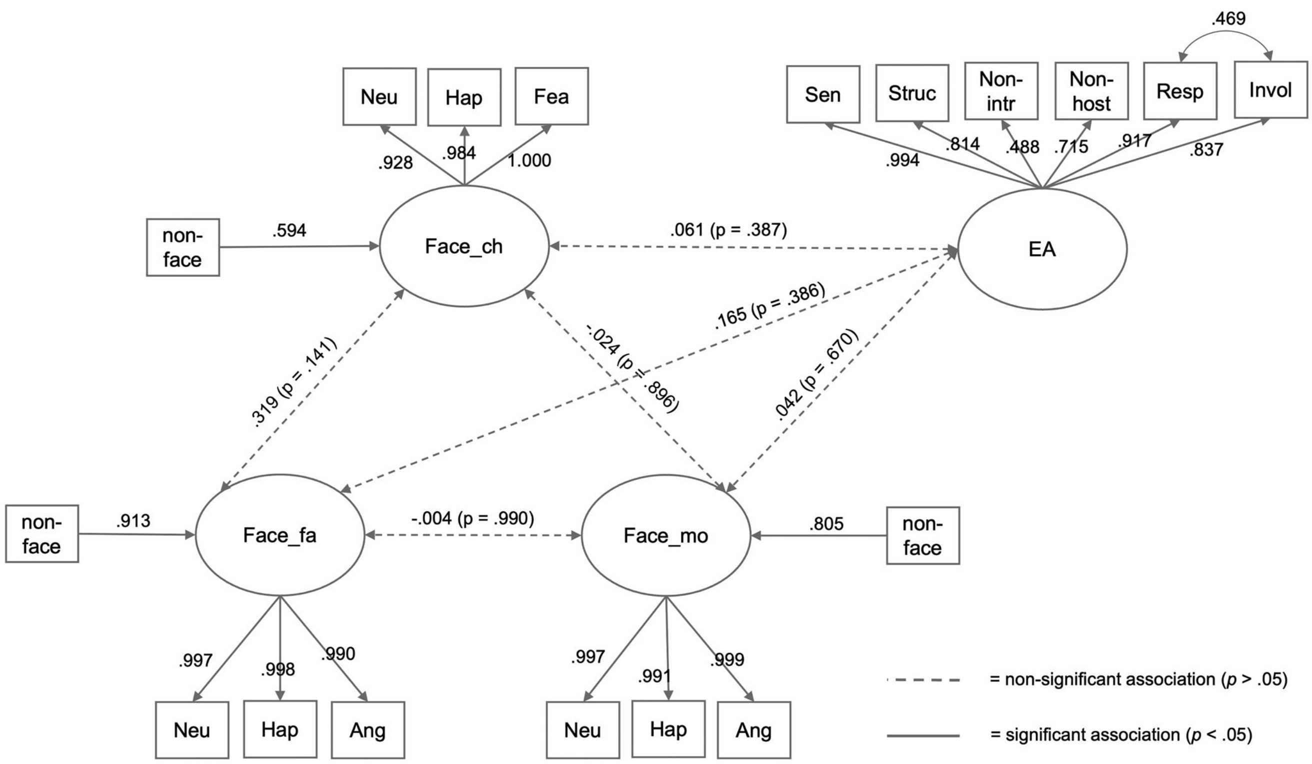

FIGURE 4 | A structural equation model (SEM) analysis assessing relations between emotional availability and face factors. *Note:* Face = face engagement factor; ch = child; mo = mother; fa = father; non-face = dwell time for non-faces; Neu = neutral; Hap = happy; Fea = fearful; Ang = angry; EA = emotional availability factor; Sens = sensitivity; Struc = structuring; Nintr = non-intrusiveness; Nhost = non-hostility; Resp = responsiveness; Invol = involvement.

and face factors ($p \geq 0.386$). The expected association between mother and child's face factors was not found and thus, the preregistered mediation analysis was not conducted. The model is described in Figure 4.

3.5 | Additional Analyses

In exploratory analyses not outlined in the preregistration, we tested associations between face engagement and EA factors separately for boys and girls using a multigroup structural equation model ($\chi^2(284) = 346.597$, $p = 0.007$, CFI = 0.986, RMSEA = 0.009, SRMR = 0.093). We found no significant associations between children's and mothers' face engagement in either group (boys: $r = -0.072$, $p = 0.760$; girls: $r = -0.015$, $p = 0.966$). Similarly, no significant associations between children's and fathers' face engagement were observed in either group (boys: $r = 0.203$, $p = 0.629$; girls: $r = 0.383$, $p = 0.113$). Among girls, EA showed a significant positive association with fathers' face engagement ($r = 0.425$, $p = 0.048$) and a similar positive, but non-significant, association with mothers' face engagement ($r = 0.334$, $p = 0.089$). Similar associations were not observed among boys (mothers: $r = -0.021$, $p = 0.860$; fathers: $r = 0.025$, $p = 0.930$).

4 | Discussion

This preregistered study assessed face engagement in parents and their 5-year-old children using an eye-tracking paradigm measuring visual attention to faces in the presence of a lateral distractor (Peltola et al., 2008). This approach evaluated individuals' tendency to engage with faces in the presence of a competing non-social stimulus, with parents viewing child faces and children viewing adult faces. Mother-child interaction was assessed during free-play at 5 years using the Emotional Availability Scales (Biringen, 2008). These assessments provided a framework to explore concordance in face engagement between parents and children. Specifically, we examined whether adults and children display comparable tendency to engage with faces (i.e., face engagement factors), whether face engagement patterns are related between parents and their children and/or consistent within family units. Mother-child interaction quality was examined as a potential mediator in the relationship between mothers' and children's face engagement.

In line with our hypotheses, results indicated that parents and children share a common face engagement factor, suggesting a comparable tendency to engage with faces regardless of emotional expression. However, contrary to our hypotheses, face engagement levels were not related between parents and children, nor was there evidence of within-family concordance across entire family units. Mother–child interaction quality was not associated with face engagement for any family member, and we found no evidence supporting the preregistered mediation hypothesis.

The finding of a common face engagement factor in adults and children is consistent with previous research that has reported similar patterns in children's attention to different facial expressions (Kataja et al., 2022; Luotola et al., 2024; Peltola et al., 2018; Pyykkö et al., 2019; Vallorani et al., 2023). Furthermore, supplementary analyses among adults provided support for face-specific variability beyond general disengagement tendencies, although the evidence was less consistent for fathers than for mothers when analyzed separately. Importantly, measurement invariance analysis confirmed that the conceptual structure and relationships between observed dwell times for faces and the latent face engagement factor were consistent across groups, while baseline levels of face engagement varied between children and adults, but not between mothers and fathers or between boys and girls. These differences likely reflect typical developmental changes in face processing from childhood to adulthood.

Contrary to our hypotheses and previous studies suggesting that increased parental attention and responsiveness to emotional faces is associated with greater attentiveness to faces in infants (Aktar et al., 2021, 2022), we found no evidence of associations between parents' and children's face engagement. In addition, the lack of family-level variance in face engagement further suggests that such tendencies are not systematically shared within families at this developmental stage. Overall, these findings provide no evidence of relations between parent and child face engagement, either within dyads or across broader family units.

Finally, in the primary analyses, we found no evidence linking emotional availability in mother-child interaction to how parents engage with faces. While a prior study reported stable trait associations and longitudinal relations between changes in maternal interaction behavior and child's face engagement over the first five years (Luotola et al., 2024), it is possible that other factors play a more significant role in contributing to maternal behavior and emotional availability at this developmental stage. Interestingly, exploratory analyses by child sex suggested a positive association between mother–child emotional availability and parental face engagement among girls, whereas no corresponding associations were observed among boys. These findings should be interpreted with caution. If replicated, they may suggest sex-specific associations between parental face engagement and mother–child emotional availability, although these interpretations remain tentative. In this study, data on father–child interaction were not available, limiting our ability to examine whether fathers' face engagement is related to the quality of father–child interaction. This would have been particularly relevant given previous evidence that fathers tend to engage in more stimulating and arousing interactions than mothers (Feldman et al., 2019).

Some other limitations should be considered. First, there is potential selection bias in our sample, particularly among fathers. Fathers who volunteered for the study might be more involved in parenting than the general population, while mothers' participation is more common and may reflect a broader range of parenting involvement. Second, potential methodological issues should be noted. The use of static stimuli in the eye-tracking paradigm may not fully capture relevant differences in face engagement during dynamic, real-life social interactions (Fu et al., 2024). While stationary paradigms have consistently shown a visual preference for faces, recent mobile eye-tracking studies suggest that children may not attend to their parents' faces as frequently as previously assumed (Franchak et al., 2018). Future research could benefit from using mobile or interactive paradigms to better assess family concordance in face engagement in more natural settings.

The lack of concordance in face engagement could also be influenced by differences in the design between the adult and child experiments. These differences included the use of different face stimuli (adult vs. child faces), emotion categories (fearful vs. angry), trial durations and the use of variable onset asynchronies in the adult task, as well as task instructions and the preprocessing procedures applied to trials without a gaze shift. While parents were explicitly instructed to shift their gaze to the distractors, children received no such instruction; instead, their attention was guided using salient visual cues. This approach was adopted for developmental reasons, as verbal task instructions may not be reliably followed by children at age 5. For adults, explicit instructions to disengage gaze were provided to ensure consistent task performance across trials and to minimize variability in viewing behavior. In addition, the use of unfamiliar faces from a different age group may have influenced responses, as children may attend differently to adult faces than to peer faces, and adults may respond differently to child versus adult faces, consistent with evidence on own-age biases in face processing (Kuefner et al., 2008; Rhodes & Anastasi, 2012). Altogether, these methodological choices may have influenced how attention was elicited and guided across age groups. However, measurement invariance analyses indicated that a comparable underlying construct of face engagement was captured across groups, suggesting that these methodological differences did not compromise task comparability across ages or the validity of the family-level concordance analyses.

Finally, the relatively small sample size, particularly in clusters with more than two family members, may have limited the ability to detect any relevant effects. Alternatively, the lack of family unit similarity could reflect variability, where some families show similar face engagement and others may exhibit dissimilar patterns, resulting in minimal overall consistency. It is possible that family members are not necessarily similar in their levels of engagement, but instead display distinct individual patterns that together form a family-level profile. Therefore, future research could benefit from a different analytical approach than the one used in the present study to better detect possible face engagement profiles within families.

This study is among the first to explore the links between parental face engagement, children's face engagement, and mother-child interaction in this context. Our findings suggest the presence of a common face engagement factor across parents and children, indicating a comparable tendency to attend to faces in adults and children. However, there was no evidence of concordance in face engagement between parents and their children or within family units, nor any associations between mother–child emotional availability and face engagement in the primary analyses. Exploratory analyses suggested that the association between mother–child emotional availability and parental face engagement may differ by child sex, but these findings require replication. Overall, the absence of the expected associations between parental and child face engagement, together with the lack of consistent links with mother–child emotional availability, may partly reflect the developmental timing of the assessment, as such associations may be stronger earlier in development, when facial cues play a particularly central role in caregiver–child interaction.

Together these findings contribute to our understanding of family-level dynamics in social-emotional attention and suggest that parents' and children's face engagement is not consistently related by mid-childhood. The study also highlights the potential of eye-tracking as a tool for measuring general attention biases toward social cues, while noting its limitations in capturing attentional patterns in dynamic, real-life social interactions. Given the limitations of the present study, further research is required to validate these findings and the results discussed here should be considered as possible directions for future investigation.

Author Contributions

Aino Luotola: conceptualization, funding acquisition, visualization, writing – original draft, formal analysis, investigation, methodology. **Hetti Lahtela**: investigation, methodology. **Tuomo Häikiö**: software, methodology, writing – review and editing. **Riikka Korja**: funding acquisition, project administration, supervision, writing – review and editing, conceptualization, investigation, methodology. **Elisabeth Nordenswan**: investigation, methodology, writing – review and editing. **Saara Nolvi**: investigation, methodology, writing – review and editing. **Akie Yada**: formal analysis, methodology, writing – review and editing. **Hasse Karlsson**: project administration. **Eeva Eskola**: investigation, methodology, writing – review and editing. **Linnea Karlsson**: project administration. **Eeva-Leena Kataja**: conceptualization, investigation, methodology, writing – review and editing, supervision. **Jukka Leppänen**: data curation, supervision, formal analysis, methodology, investigation, conceptualization, writing – review and editing.

Acknowledgments

We would like to thank the participating families for their valuable contribution and commitment to the FinnBrain project. We also acknowledge the efforts of the students who helped with data collection, as well as the FinnBrain staff and support personnel for their dedicated work.

Open access publishing facilitated by Turun yliopisto, as part of the Wiley - FinELib agreement.

Funding

This study was supported by personal grants to Aino Luotola from the Finnish Cultural Foundation and Olvi Foundation. The study also received funding from the Research Council of Finland (grant numbers 346121, 308176, 308589), Strategic Research Council (SRC) within the Research Council of Finland (352648, 352655), Jane and Aatos Erkko Foundation, Signe and Ane Gyllenberg Foundation and Finnish State Grants for Clinical Research.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data are not publicly available due to restrictions protecting the privacy of research participants. However, requests for collaboration, including access to data supporting the findings of the present study, are reviewed by the Board of the FinnBrain Birth Cohort Study. Both international and domestic collaboration are encouraged and integral to the project.

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Supporting Information

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

Supporting Information: sode70082-supp-0001-SuppMat.docx