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Beyond the familial: The development of emotional communication with mothers, fathers, and strangers

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Abstract

Interaction with unfamiliar partners is a component of social life from infancy onward. Yet little is known about preverbal communication with strangers. This study compared the development of infant communication with strangers to communication with mothers and fathers and examined the contribution of temperament to partner-specific communication patterns. A sample of 58 infants was observed at four and eight months during separate home-based face-to-face interactions with three partners (mother, father, and stranger). Infant visual, facial, and vocal communication behaviors were coded microanalytically. Each parent reported on infant temperament at both ages. Multilevel regression analyses indicated that infants gazed longer at strangers than at fathers, exhibited less smiling to strangers than to mothers, and produced fewer vocalizations with strangers than with either parent. Both age and temperament moderated these differences. Vocal communication with fathers became more frequent at eight months; smiling to mothers was accentuated among infants with higher levels of temperamental surgency. Importantly, levels of communication behaviors with strangers were concurrently and longitudinally associated with those with mothers and fathers. Overall, findings suggest that infant

emotional communication patterns are modulated by individual temperamental differences and are reproduced in and over time, though at different levels, when interacting with novel partners.

1 | INTRODUCTION

Social interactions during infancy are characterized by dynamic and multimodal preverbal emotional communication. Infant participation in these early social interactions represents the earliest expression of social interest and affiliation toward familiar and unfamiliar interaction partners (Colonnesi et al., 2012; Lin & Green, 2009). Hence, it is central to the child's emotional, social, and cognitive development (e.g., Beebe, 2006; Beebe et al., 2010; Feldman, 2007; Messinger & Fogel, 2007). Contextual factors, like the familiarity of the interaction partner, and individual predispositions, such as temperament, all contribute in shaping socio-emotional developmental trajectories (Aktar & Pérez-Edgar, 2020; Fu & Pérez-Edgar, 2015; MacNeill & Pérez-Edgar, 2019; Ollas et al., 2020). While prior research has described infant emotional communication with mothers, and occasionally fathers, less is known about infant communication patterns with unfamiliar partners (Beebe et al., 2009; Lin & Green, 2009). Yet communication with strangers characterizes social interactions from infancy onward. The present study was designed to compare the development of infant emotional communication with strangers to their communication with both mother and father, while examining the role of infant temperament in conditioning these early communication patterns.

1.1 | Preverbal emotional communication

By the fourth month of life, when their interest in dyadic face-to-face interactions reaches its peak (Beebe, 2006; Hsu & Fogel, 2001), infants engage in social interactions by temporally coordinating visual, facial, and vocal communication modalities (Colonnesi et al., 2012; Yale et al., 2003). The visual modality is a measure of the infant's attention and interest and is frequently conceptualized in terms of gaze direction *at* or *away from* the partner (Lavelli & Fogel, 2005; Weinberg & Tronick, 1994). The facial/affective modality is central to communicating emotional states, which are expressed on a continuum ranging from positive to negative facial expressions: Positive affect is indexed with smiles, while negative affect is indexed with frowns, scowls, and cry faces (Messinger, 2002). Vocalizations are produced to gain the partner's attention and communicate affective engagement (Goldstein et al., 2009; Hsu et al., 2001; Jaffe et al., 2001). Like adults, infants dynamically assemble visual, facial, and vocal behaviors in real time so as to reinforce communicative messages, express internal states, and respond to interaction partners (Grossman, 2010; Weinberg & Tronick, 1994; Yale et al., 2003).

Infant emotional communication develops during early dyadic interactions with parents and becomes progressively more complex throughout the first year of life, as infants increasingly contribute to the social interaction (Hsu & Fogel, 2003). Although the majority of studies have been conducted in the context of infant face-to-face interactions with mothers, research in the last decades has provided insights into communication with fathers as well. Infant communication with mothers is characterized by long visual engagement and positive affect as well as recurrent vocalizations, while communication with fathers features high-intensity, but brief, bursts of gaze, positive affect, and vocalizations

(Aktar et al., 2017; Colonnesi et al., 2012; Feldman, 2003; Field et al., 1987; Forbes et al., 2004). Interactions with mothers and fathers uniquely, and often complementary, contribute to aspects of the child's socio-emotional development (e.g., Bögels & Phares, 2008; Paquette, 2004). Considering that four-month-old infants tend to generalize the communication patterns developed during interactions with their mother to interactions with strangers (Beebe et al., 2009), it is plausible that parent-specific communication patterns (those with mother and father) are two potentially differing templates for infant social interactions.

1.2 | Preverbal interaction with strangers

Beyond interacting with their parents, infants often engage in social exchanges with unfamiliar partners. When interacting with a stranger, high levels of novelty and uncertainty are involved, such that novel communicative patterns tend to emerge (Beebe, 2014). Prior research observed that by the second month of life, infants exhibit higher levels of visual engagement with a stranger than with mother (Beebe et al., 2009; Bigelow, 1998; Ioannou et al., 2021; Kurzweil, 1988; Lin & Green, 2009; Sherrod, 1979), presumably an index of alertness to novelty. Differential levels of positive affect and vocalization with strangers are only evident from four months (Bigelow, 1998; Bigelow & Rochat, 2006; Contole & Over, 1981; Lin & Green, 2009), which may reflect the development of expectations relevant to interactions with familiar communication patterns (Bigelow, 1998). It remains unclear, however, whether infants enhance or temper facial and vocal behavioral patterns of emotional communication as a function of the familiarity of the interaction partner.

Findings on infant expressive communication with strangers tend to be scarce and inconclusive. Moreover, prior studies comparing strangers and mothers are based on laboratory observations. Bigelow (1998) observed that four- to five-month-old infants were more affectively and vocally responsive during face-to-face interactions with their mother, unless the stranger's level of contingency was similar to that of the mother, in which case infants did not exhibit differential positive affect and vocalizations. Beebe et al. (2009) reported that four-month-old infants' positive affect tended to be more evident with mothers, while vocal communication was more frequent with the stranger. In contrast, Lin and Green (2009) found that during face-to-face interactions with toys at four, seven, and ten months, infants exhibited longer positive affect expressions with strangers than with mothers. Although no differential vocalization frequency was present at earlier ages, authors observed that ten-month-old infants vocalized more with their mother than with the stranger (Lin & Green, 2009).

1.3 | The contribution of temperament

Temperament is a biologically based factor that predisposes a person's attentional, emotional, and motor responses to the environment, in terms of emotional reactivity and self-regulation (Bowman & Fox, 2018; Rothbart, 2007; Rothbart & Bates, 2006). While the emergence of self-regulation begins late in the first year of life, differences in temperamental reactivity are evident as early as four months of age (Fox et al., 2001; Gartstein et al., 2010; Rothbart, 2007). They are observable in the infant's positive and negative emotionality, commonly referred to as surgency and negative affectivity (Rothbart & Bates, 2006). Surgency describes the infant's levels of sociability, impulsivity, and eagerness to engage with novel situations in a positive mood of excitement, while negative affectivity refers to irritability, negative mood, and likelihood to feel distress from limitations, including sadness, anger, or fear of novelty (Gartstein & Rothbart, 2003; Putnam et al., 2008).

Prior studies commonly employed maternal, and occasionally paternal, reports to measure temperament in the first years of life. Evidence converges in indicating that children with higher levels of temperamental surgency are advantaged in their communicative development, including triadic joint attention skills (Nichols et al., 2005; Vaughan et al., 2003), gesture production (Ollas et al., 2020), and language abilities (Karrass & Braungart-Rieker, 2003; Laake & Bridgett, 2014; Morales et al., 2000; Moreno & Robinson, 2005; Pérez-Pereira et al., 2016). Temperamental negative affectivity, on the other hand, tends to be adversely associated with language development (McNally & Quigley, 2014; Salley & Dixon, 2007; but see also Molfese et al., 2010; Moreno & Robinson, 2005; Pérez-Pereira et al., 2016) and dyadic synchrony with parents (Pratt et al., 2015). Despite its early behavioral manifestations, so far little is known about the role of infant temperament in shaping preverbal communication in the first months of life (Aktar & Pérez-Edgar, 2020). Yet individual differences in infant temperamental reactivity may interact with contextual factors, such as the familiarity of the partner, shaping the experience of the interaction with a stranger into a positive event for some infants and a distressing one for others (Escalona, 1968; Rothbart & Bates, 2006).

1.4 | The present study

The present study employed a longitudinal design to compare infant emotional communication with strangers to infant communication with mothers and fathers, while examining the contribution of temperament to these early communication patterns. We adopted an innovative approach, which characterized differences as well as similarities in infant communication between partners over development. To capture day-to-day interaction patterns as they naturally unfold, infants were observed at the family's home (Cychosz et al., 2020; Tamis-LeMonda et al., 2017). Naturalistic observations of infants at four and eight months were obtained during three separate two-minute face-to-face interactions. A face-to-face interaction without toys was chosen because of the greater communicative demands it places on infants (Tronick et al., 1989). Infant visual engagement, positive and negative affect, and vocalizations were systematically analyzed second by second, while temperament was reported by each parent at both ages. This study is the first to longitudinally examine the associations between emerging trajectories of emotional communication with mothers, fathers, and strangers and both mother- and father-reported temperament in the first half-year of life.

The first goal of the present study was to examine differences in the development of infant visual, facial, and vocal communication patterns between strangers and each parent. We anticipated that infants would display longer visual engagement with strangers than with either parent, particularly fathers (Beebe et al., 2009; Bigelow, 1977, 1998; Colonnesi et al., 2012; Iannou et al., 2021; Lin & Green, 2009). Conversely, we expected that infants would exhibit briefer positive affect and fewer vocalizations when interacting with strangers than when interacting with mothers, and perhaps fathers as well (Beebe et al., 2009; Bigelow, 1998; Colonnesi et al., 2012; Forbes et al., 2004). Furthermore, we predicted that differences between infant communication with strangers and parents would increase from four to eight months of age as infants and parents create shared communication patterns (Kokkinaki & Vasdekis, 2015; Messinger et al., 2010).

The second aim of our research was to determine how individual differences in the development of infant communication with strangers (vs. mothers and fathers) are modulated by infant levels of temperamental reactivity. Infant communication patterns were expected to be generally primed by temperamental surgency and tempered by negative affectivity (e.g., Laake & Bridgett, 2014; Nichols et al., 2005; Pérez-Pereira et al., 2016; Pratt et al., 2015). In addition, we anticipated that infant levels

of temperamental reactivity would modulate differences in communication between interaction partners (Aktar & Pérez-Edgar, 2020; Escalona, 1968; Rothbart & Bates, 2006).

Our third goal was to examine concurrent and longitudinal associations between infant communication with strangers and each parent. We anticipated that infants would adopt communication patterns developed with familiar partners, hence mother and father, as interaction templates for interactions with strangers (Beebe et al., 2009; Bigelow & Rochat, 2006). Specifically, since maternal interactional styles are characterized by nurturing, soothing, and protective behaviors, while paternal interactional styles tend to be more dynamic, playful, and stimulating (e.g., Aktar et al., 2017; Möller et al., 2013), we predicted that infant communication with strangers would be generalized to a greater extent from interactions with fathers.

2 | METHODS

2.1 | Participants

The initial sample consisted of 60 children (27 girls, 33 boys) and their parents, who were part of a cohort of families involved in a longitudinal study on social-communicative development over the first two years of life. Participants were recruited in the city of Amsterdam and surrounding areas via childcare centers, such as kindergartens and schools, therapists, educa-tors, babysitters, pregnancy courses, family friendly locations (e.g., cafés with play areas, maternity shops, etc.), and advertisements in magazines and social media platforms. Eligible for inclusion were families with an infant younger than four months, who had at least one older sibling and at least one biologically related parent. Families were required to have participated in at least one out of the two home visits. Two participants were not present at both four and eight months and were therefore not included in the final sample (i.e., $N = 58$, 25 girls). An overview of families' sociodemographic characteristics is presented in Table 1.

This project was conducted according to the Declaration of Helsinki and approved by the Ethics Review Board of the University of Amsterdam, Faculty of Social and Behavioral Sciences (protocol code 2016-CDE-7403). Preceding the experiment, informed written consent was obtained by both parents, who were also notified about the possibility to withdraw from the study at any time. Families were compensated with a 10€ voucher at each home visit and, at the end of the larger longitudinal study, with a USB flash drive containing all the video recordings of the visits collected over the years.

2.2 | Design

We adopted a longitudinal design, in which each infant was tested at four and eight months of age (within a range of $\pm$ two weeks from the child's target ages). Naturalistic observations were employed to characterize infant emotional communication and parent-reported questionnaires to measure infant temperament. The observational measures were collected during home visits that lasted approximately 45 min. Infant age at the first home visit ranged from 111 to 143 days ($M = 126.42$; SD $= 7.93$) and at the second home visit from 227 to 272 days ($M = 250.58$; SD $= 9.67$). Two weeks prior to each visit, parents received via email the link to the online questionnaire booklet, which was filled in separately by mothers and fathers in the Qualtrics Survey Software (Qualtrics, 2005).

TABLE 1 Sociodemographic characteristics of the sample

	Mothers				Fathers			
	M	SD	Range	%	*M*	SD	Range	%
Age (years)	34.47	3.40	28.15–42.17		37.90	3.86	31.07–47.61	
Dutch nationality				91.4				84.2
Educational level[a]	7.65	.79	3–8		6.91	1.56	2–8	
Professional level[b]	8.98	1.50	3–10		8.15	2.08	2–10	
Work hours (per week)	26.6	12.5	0–50		37.75	6.27	24–60	
Full-time job				19.0				63.8
Part-time job				55.2				25.9
Unemployed				5.2				/
Housewife				6.9				/
Student				1.7				/
Maternity leave				6.9				/
Sick leave				3.4				/
Income[c]	4.28	1.76	1–7		5.40	1.30	3–7	

[a] ed with an 8-point scale from 1 (*primary education*) to 8 (*university*).

[b]Measured with a 10-point scale from 1 (*manual labor for which no education is required*) to 10 (*labor for which a university degree is required*).

[c]Measured with a 7-point scale from 1 (*<500 euros/month*) to 7 (*>5000 euros/month*). Sociodemographic information are missing for one mother (1.7%) and six fathers (10.3%).

2.3 | Procedures and measures

2.3.1 | Emotional communication

Infant emotional communication was assessed during separate two-minute face-to-face interactions with their mothers, fathers, and a (female) experimenter. A two- to three-minute sample of behavior is standard in the literature (e.g., Beebe et al., 2016; Cohn & Tronick, 1988), as it allows for predictions as accurate as observations of five-minute interactions (Ambady & Rosenthal, 1992). The order of the interaction partners was fully counterbalanced across families, within the infant gender. Parents were instructed to interact with their infant as they would typically do in their everyday life and were also informed that in case the infant experienced distress or tiredness, the observation could be interrupted at any time. Experimenters were instructed to be visually attentive and expressively positive with the infant, in line with the infant's emotional state. Infant-adult interactions occurred in a quiet room where no other person was present. In the (rare) circumstance separate rooms were not available, due to the structure of the house, experimenters and the other parent were situated in the same room but out of the infant's sight. The observations were video-recorded using a high-definition 360° Samsung camera, mounted in between the infant and the adult to get a split-screen output displaying both interaction partners simultaneously. The experimenters controlled the recording process from a separate room via a mobile phone connected to the camera, and the parents (and the older sibling) could participate in watching the ongoing interaction. Figure 1 displays the setting of the face-to-face interactions at four and eight months.

(a)   **(b)**
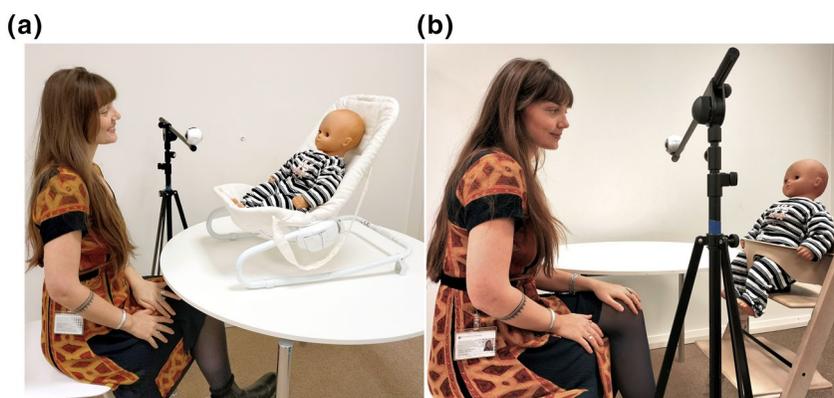
FIGURE 1 Settings of the face-to-face interactions at four and eight months. At four months (a) the infant was seated in an infant seat on the table, while at eight months (b) the infant was seated in a high chair next to the table. In between the adult and the infant is mounted the 360° Samsung camera

Behavioral coding system

Following Colonnesi et al. (2012)'s coding scheme for emotional communication, trained master students coded the interaction partners' gaze, facial expressions, and vocalizations. Behaviors were systematically coded at the microlevel, with an accuracy of up to 1/25th of a second, using The Observer Video Analysis Software XT 14.0 (Noldus, Wageningen). Gaze and facial expressions were coded as state events (i.e., duration in seconds), while vocalizations were coded as point events (i.e., frequency of occurrence), as in infants younger than six months the mean duration of vocalizations is less than 1 s (Yale et al., 2003). Behaviors from the same modality were defined in mutually exclusive categories, while behaviors from different modalities could overlap in time (i.e., co-occur). A graphical illustration of the microanalytic coding scheme is presented in Figure 2.

Gaze. Infant gaze direction was coded in three categories: "gaze at the partner", regardless of whether the gazing was focused on the partner's face or hands, "gaze elsewhere", when the infant's visual attention was not on the partner, or "gaze not visible", when the infant's eye region was not observable (e.g., covered or out of the camera's scope).

Facial expressions. Infant facial expressions were coded into four categories. "Positive facial expressions" refer to closed and opened smiles, with and without eye constrictions, and were identified by the infant's raising of the corners of the lips and cheeks. "Negative facial expressions" indicate frowns or sad/cry faces and were detected by a lowering of the corners of the lips, constrictions of the eye region, and opening of the mouth. "Neutral facial expressions" were coded when neither a positive nor a negative facial expression was displayed, as no muscle movement was visible or the muscle movements visible were not indicative of an emotion. In circumstances when the face was not visible, behaviors were categorized as "not codable facial expressions".

Vocalizations. Infant vocalizations were coded when constituting communicative bids. Vegetative and reflexive sounds, including hiccups, coughs, burps, sneezes, and so forth were thus not coded as vocalizations. When more vocalizations occurred within two consecutive seconds, they were coded as one occurrence. Positive and negative vocalizations were not coded separately as this distinction often yields unreliable coding. There is increasing evidence, however, that infant positive (e.g.,
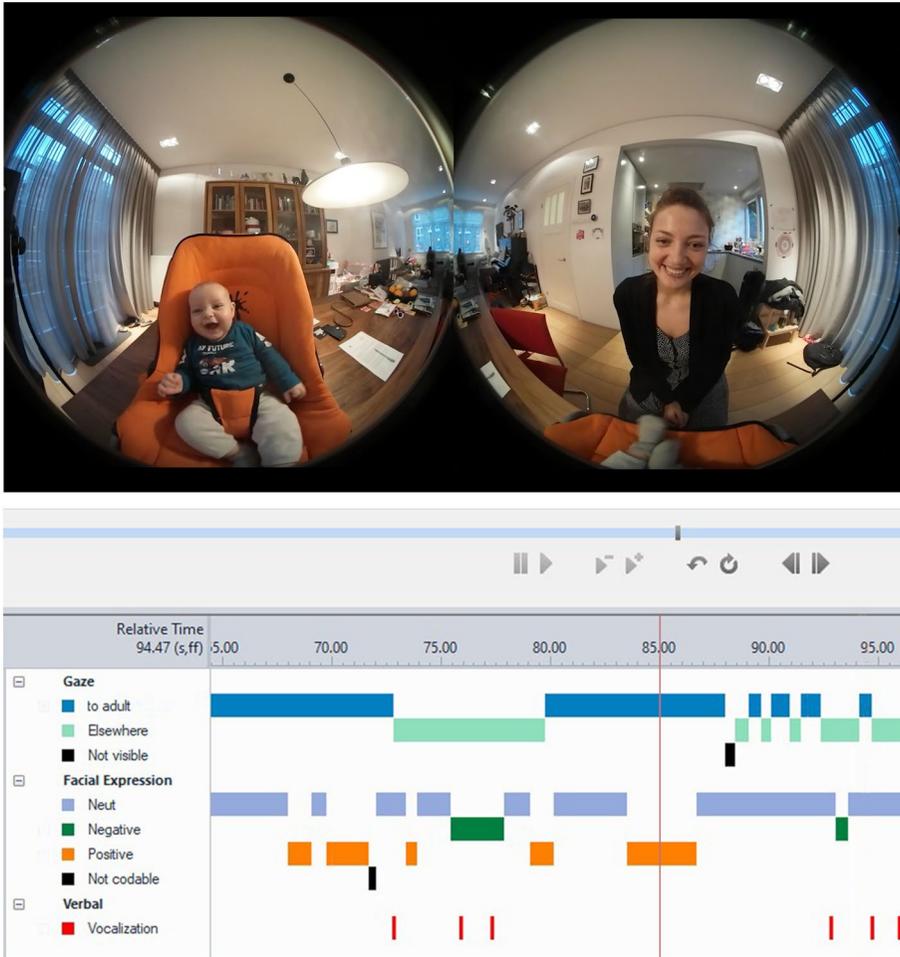
FIGURE 2   Microanalytic behavioral coding: Data visualization example

giggling, laughing), neutral (e.g., babbling), and negative (e.g., fussing, crying) vocalizations tend to occur in combination with specific facial expressions (Colonnesi et al., 2012). We thus examined infant vocalizations both comprehensively (i.e., positive, neutral, and negative vocalizations were aggregated) and separately for positively and negatively valenced vocalizations (i.e., vocalizations combined with a simultaneously occurring positive/negative facial expression). In the present study, negative facial expressions rarely occurred, M (SD) = 4.87% (8.57); see Table 2. When examining positive vocalizations, our analyses yielded a similar pattern of results to analyses examining all vocalizations. Consequently, we elected to report analyses examining all vocalizations.

Outcome variables

There was variability in video durations, M (SD) = 121.7 s (7.83). Therefore, for communication behaviors measured as durations, that is, infant visual engagement to the partner and positive and negative affect, we calculated the percentage of time the infant displayed a specific behavior. For behaviors measured as frequency of occurrence, that is, vocalizations, we calculated the frequency

TABLE 2 Descriptive statistics of infant emotional communication by interaction partner and age

Infant emotional communication	*M* (SE)					
	4 months			**8 months**		
	Mother	**Father**	**Stranger**	**Mother**	**Father**	**Stranger**
Gaze	80.46 (2.29)	77.43 (2.75)	81.80 (2.49)	67.94 (3.48)[a]	59.47 (3.32)[b]	75.45 (2.17)[c]
Smile	29.69 (3.40)	24.00 (2.79)	25.15 (3.09)	36.37 (3.26)[a]	28.19 (2.59)[b]	26.75 (3.48)[b]
Frown	6.53 (1.50)[a]	5.08 (1.26)[a]	1.54 (0.39)[b]	5.55 (1.42)	5.72 (1.31)	4.91 (1.60)
Vocalizations	5.20 (0.57)[a]	4.06 (0.49)	3.31 (0.46)[b]	5.47 (0.60)[a]	5.73 (0.59)[a]	2.48 (0.48)[b]

Note: Gaze and facial expressions are quantified as percentage of time, while vocalizations as frequency rate per minute. Mean values with different superscripts at a given age denote significant differences between interaction partners. Mean values underlined at a given interaction partner denote significant differences over time.

rate per minute. Missing data were rare (i.e., gaze not visible: $n = 6$ videos, *M* [SD] = 2.64% [.49]; facial expression not codable: $n = 30$ videos, *M* [SD] = 3.65% [1.49]).

Inter-rater reliability

A senior coder randomly selected and double coded the 15% of the observations (42 videos, 21 at each time measurement). Cohen's kappa coefficients at four and eight months were: .77 and .90 for gaze, .83 and .89 for facial expressions, and .81 and .76 for vocalizations. This level of inter-rater agreement in time speaks to the reliability of the coded data.

2.3.2 | Temperament

The Dutch version of the Infant Behavior Questionnaire (IBQ-R very short form; Putnam et al., 2014) was employed to measure infant temperament at four and eight months. The IBQ-R very short form consists of 37 items, which are measured on a Likert scale from 1 (*never*) to 7 (*always*); example item: "When introduced to an unfamiliar adult, how often did the baby cling to the parent?". Scores on items were averaged into three final scales, two of which were of interest in the present study: surgency and negative affectivity. As positive associations were found between maternal and paternal scores for surgency at four months ($r = .54$) and eight months ($r = .62$) as well as for negative affectivity at four months ($r = .32$) and eight months ($r = .54$), we computed averaged parental measures. Cronbach's alpha coefficients for surgency were .58 at four months and .62 at eight months, while Cronbach's alpha coefficients for negative affectivity were .74 at four months and .73 at eight months.

2.4 | Data analysis

2.4.1 | Analytic strategy

We used multilevel regression analyses to investigate contextual, developmental, and temperamental effects on infant emotional communication. Communicative behaviors with different interaction partners (mother, father, and stranger) at different ages (four and eight months) were nested within infants. A complete case would thus yield six level-1 observations. Infant temperament

variables (i.e., surgency and negative affectivity) were included as level-2 time-varying covariates. To facilitate interpretation of regression coefficients, we standardized all continuous variables and used binary coding for all indicator explanatory variables. Specifically, the stranger was the referent and the effects with mother and father were indicated; likewise, four months was the referent and the effects of the eight months were indicated. In addition, to explore differences between infant communication with mothers and fathers, we followed up the main analyses by reparametrizing the reference category as father. Maximum likelihood estimation was used to estimate all model parameters, which also included all level-1 covariances, without restriction. These unstructured covariances enabled us to freely estimate the associations between interaction partners over development. By interpreting these random effects via their standardized coefficients, we examined the extent to which infant behavioral patterns of emotional communication with strangers were associated with communication patterns with mothers and fathers. All analyses were performed in IBM SPSS 25.0 (IBM Corp, 2013).

Separate multilevel regression analyses were conducted for each of the infant communication variables. The model building procedure started with a model that included all main and interaction effects. We then excluded nonsignificant interaction effects one by one in a stepwise procedure, based on their p-values (Field, 2009). To safeguard against chance findings, we repeated the analyses with a forward-selection procedure, starting with a model that included all main effects and individually assessing the significance of additional interaction effects. The analyses yielded similar results, and we report the results of the analyses with the backward exclusion of interaction effects. Parallel analyses of infant multimodal communication (i.e., temporal co-occurrence of two and three communication modalities) are available upon request.

2.4.2 | Data processing

Six families (10% of the sample) lacked the four-month data, and five families (9% of the sample) lacked the eight month-data (i.e., home visits could not be scheduled). This created 33 missing observations (i.e., three for each home visit: with mother, father, and stranger). In addition, 3 four-month observations were unavailable due to recording problems, and 3 other eight-month observations were unavailable due to fathers' absence from home at the time of the data collection. An additional 20 observations were excluded due to infants' extreme fussiness: 5 interactions at four months (2 with mothers, 1 with fathers, and 2 with strangers) and 15 at eight months (5 with mothers, 4 with fathers, and 6 with strangers). One family consisted of two mothers; as our focus was on infant distinctive communication patterns with mothers and fathers, observations with the nonbiological mother were excluded. Accordingly, 287 (out of the potential 348) observations were coded and used in the final analyses. No differences in gender, age, and temperament were present between the completers and the noncompleter groups, t's range $= -1.09$–1.12; p's range $= .112$–$.737$. Outlier scores (i.e., z-scores exceeding ± 3.29) were replaced with scores one unit larger than the next most extreme score (Tabachnick & Fidell, 2013). A moderate degree of positive skewness was found for most of the infant communication variables. As statistical transformations did not substantially affect final results, we present analyses on the original data.

Parental temperament reports were lacking for eight children (14% of the sample). A nonsignificant Little's test showed that data were missing completely at random; χ^2 (90) $= 99.91$, $p = .223$. Multilevel analysis enables the use of all available information from the outcome variables, including

data from incomplete cases, resulting in unbiased parameter estimates and standard errors. However, complete data for the explanatory variables are required (Snijders & Bosker, 2011). Consequently, we imputed missing temperament data by means of the Expectation-Maximization estimation method (Graham, 2009), a maximum likelihood approach in which values are imputed in a way that does not affect means, variances, and covariances of all variables used in the procedure.

3 | RESULTS

3.1 | Preliminary analyses

Table 2 describes the infant emotional communication variables with mother, father, and stranger at four and eight months. Negative facial expressions rarely occurred, either with parents or with strangers, and were not modeled in the main analyses below. This results in three final outcome variables: gaze, smile, and vocalizations. Correlations between emotional communication variables at four and eight months are separately presented for mothers, fathers, and strangers in Appendix Tables A1 and A2. Table 3 describes the temperament variables and their intercorrelations over development. Infant temperamental surgency and negative affectivity were positively correlated between four and eight months, indicating temporal stability of the temperament constructs in infancy.

3.2 | Multilevel regression analyses

We describe and interpret the results of the final model for each communication modality (i.e., gaze, smile, and vocalization) in the subsections below. First, we compared the development of infant communication with mothers and fathers to infant communication with strangers (i.e., the reference category was the stranger). Second, we analyzed associations between temperamental positive and negative reactivity and infant communication, both as main effects and as interactions with partner. Third, we examined concurrent and longitudinal associations between infant communication with the stranger and each parent. We did this by analyzing the covariance matrix of the final models.

TABLE 3 Descriptive statistics and correlations for temperament variables

Infant temperament	M (SE)	Range	1.	2.	3.	4.
4 months						
1. Surgency	3.70 (.10)	2.10–5.46	-			
2. Negative affectivity	2.98 (.10)	1.57–4.46	−.05	-		
8 months						
3. Surgency	4.89 (.09)	2.69–6.41	.49*	−.06	-	
4. Negative affectivity	3.41 (.11)	1.71–5.08	−.08	.57*	.02	-

Note: Temperament scores are averaged between maternal and paternal reports. Scales are measured with a 7-point scale from 1 (*never*) to 7 (*always*).

*p < .001.

### 3.2.1 | Effects of partner differences, age, and temperament

Gaze

Overall, infant levels of partner-directed gaze were lower during interaction with fathers than with strangers, while no significant differences were found between mothers and strangers (see Table 4). Infant partner-directed gaze decreased between four and eight months (an age effect) and this effect was more pronounced with fathers than with strangers (an age by partner interaction effect; see Figure 3). With respect to temperament, negative affectivity was associated with lower levels of gaze (a main effect of negative affectivity), regardless of the identity of the interaction partner (interactions between negative affectivity and partner were not significant). Temperamental surgency was not associated with infant gaze.

TABLE 4 Effects of partner differences, age, and temperament on infant emotional communication

	Gaze		Smile		Vocalizations	
	B (SE)	*p*	*B* (SE)	*P*	*B* (SE)	*p*
Intercept	.41 (.11)	.001	−.12 (.12)	.331	−.19 (.12)	.124
Partner						
Mother (vs. Stranger)	−.18 (.12)	.153	.39 (.09)	.000	.58 (12)	.000
Father (vs. Stranger)	−.24 (.11)	.045	.04 (.12)	.708	.22 (.13)	.083
Mother (vs. Father)[a]	.27 (.12)	.026	.34 (.12)	.005	.14 (.13)	.277
Age						
8 months (vs. 4 months)	−.35 (.15)	.022	−.02 (.18)	.894	−.25 (.17)	.139
Temperament						
Surgency	.01 (.07)	.861	.19 (.09)	.031	.21 (.08)	.008
Negative affectivity	−.17 (.06)	.008	−.17 (.07)	.017	−.06 (.06)	.362
Parent × Age						
Mother (vs. Stranger) × 8 months (vs. 4 months)	\	\	\	\	\	\
Father (vs. Stranger) × 8 months (vs. 4 months)	−.53 (.19)	.009	\	\	.53 (.22)	.018
Parent × Temperament						
Mother (vs. Stranger) × Surgency	\	\	.25 (.09)	.009	\	\
Mother (vs. Stranger) × Negative affectivity	\	\	\	\	\	\
Father (vs. Stranger) × Surgency	\	\	\	\	\	\
Father (vs. Stranger) × Negative affectivity	\	\	\	\	\	\
Age × Temperament						
8 months (vs. 4 months) × Surgency	\	\	\	\	\	\
8 months (vs. 4 months) × Negative affectivity	\	\	\	\	\	\

Note: All numbers are standardized regression coefficients of the final multilevel regression models. These coefficients *B* can be interpreted as effect sizes *d* for the binary indicator variables (i.e., partner and age groups) and effect sizes *r* for the continuous variables (i.e., temperament). Underlined *p*-values denote statistical significance at alpha level .05.

[a]The coefficients of Mother (vs. Father) were derived from separate re-parametrized analyses with Father as the reference category.
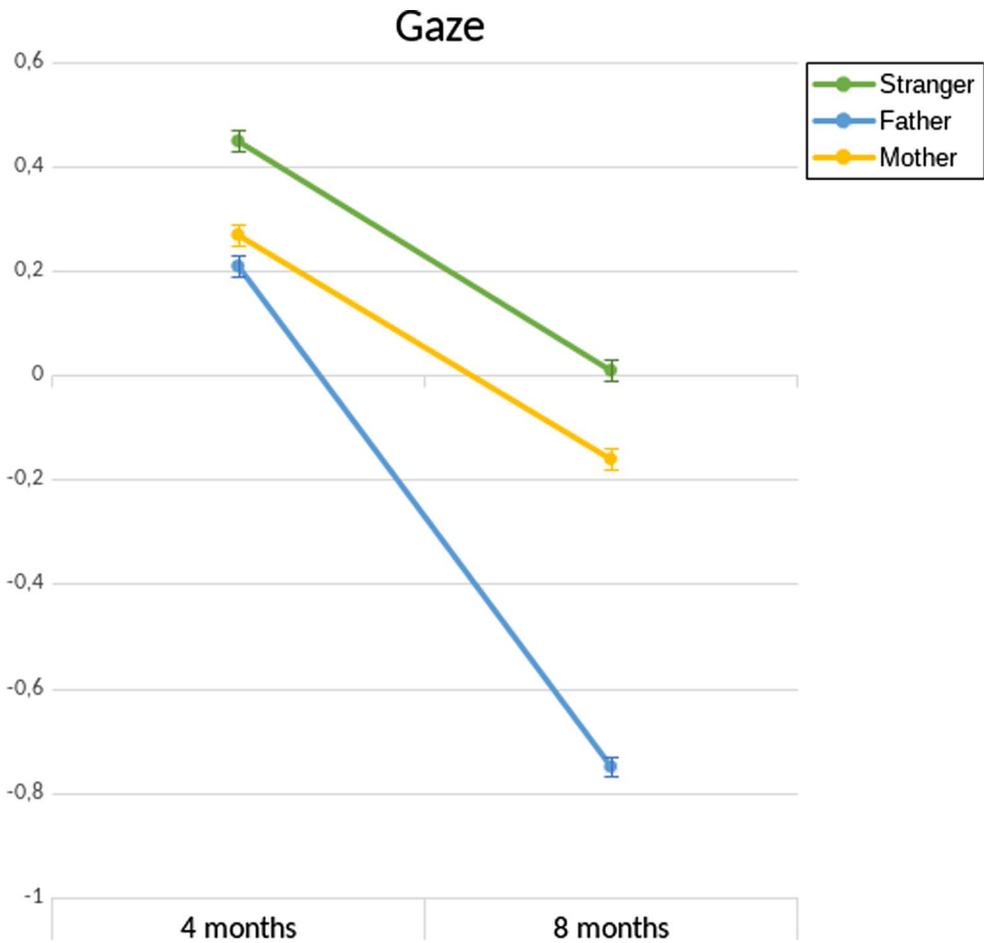
FIGURE 3 Infant visual engagement: Partner by age. The *Y* axis represents the standardized values of gaze (percentage of time)

Smile

Levels of smiling were higher during interaction with mothers than with strangers, while there were no differences in infant positive affect between interactions with fathers and strangers (see Table 4). As with gaze, there was an inverse effect of temperamental negative affectivity on smiling, indicating that infants who had higher levels of negative affectivity had lower levels of positive affect. In addition, temperamental surgency was associated with higher levels of smiling (a main effect of surgency), an effect that was more pronounced with mothers than with strangers (a significant interaction between surgency and partner, see Figure 4).

Vocalizations

Infants produced more vocalizations with mothers than with strangers (see Table 4). Vocalization frequency with fathers significantly differed from that with strangers at eight months (an age by partner interaction effect, see Figure 5). As with smiling, there was a main positive effect of temperamental surgency, indicating that infants who had higher levels of surgency also had higher vocalization frequency, regardless of the identity of the interaction partner (interactions between surgency
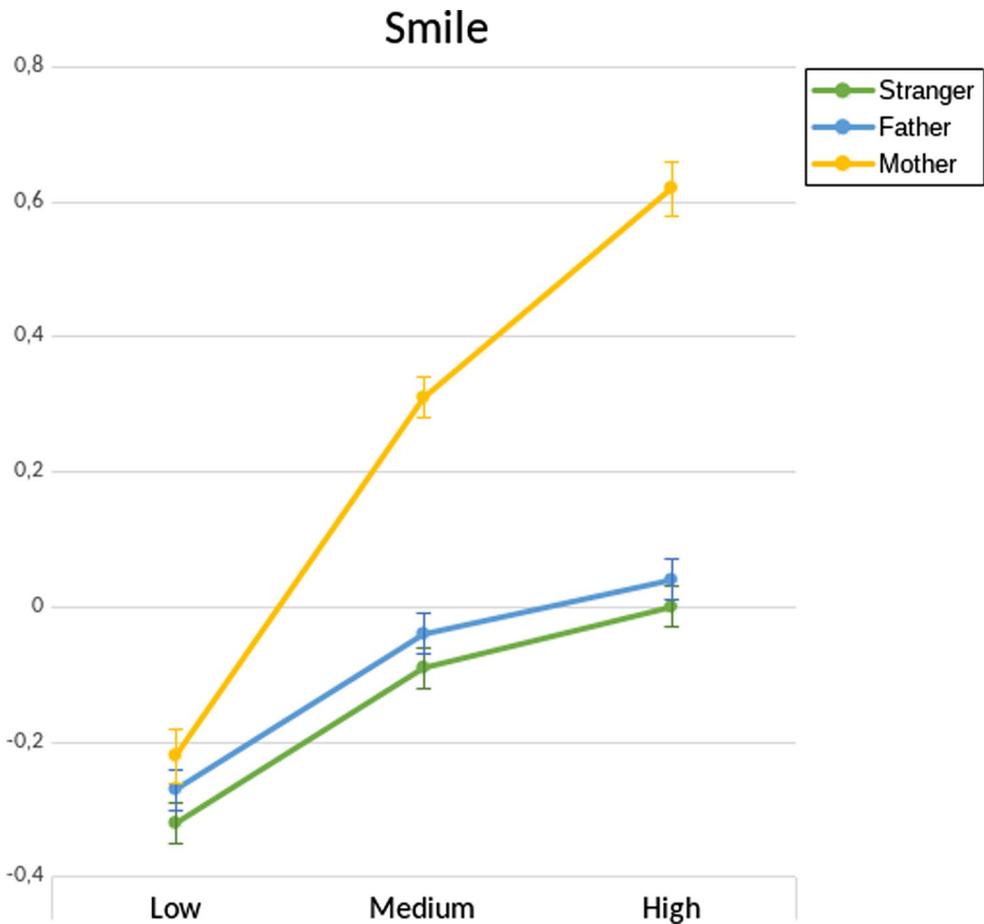
FIGURE 4 Infant positive affect: Partner by temperamental surgency. The *Y* axis represents the standardized values of smile (percentage of time). To facilitate interpretation, we divided the sample in three groups of about equal size (i.e., low, medium, high surgency)

and partner were not significant). Temperamental negative affectivity was not associated with infant vocalizations.

Mother versus father

Follow-up, reparametrized analyses did not indicate a difference in infant vocalization frequency between mothers and fathers, while infant levels of partner-directed gaze and positive affect were higher with mothers than with fathers (see Table 4).

3.2.2 | Associations between infant communication with parents and strangers

Gaze

At four months, infants who had higher levels of visual engagement with fathers also had higher levels of visual engagement with strangers (concurrent association, see Table 5). At eight months, levels of
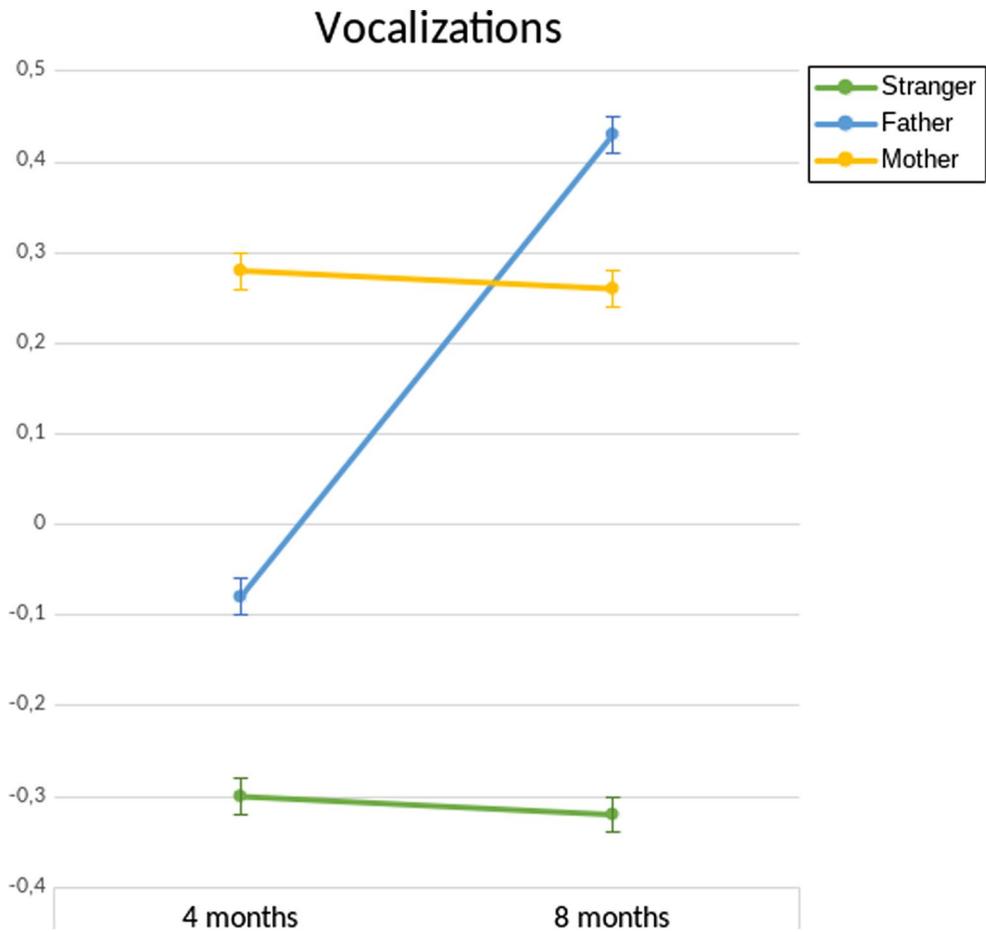
FIGURE 5 Infant vocalizations: Partner by age. The *Y* axis represents the standardized values of vocalizations (frequency rates per minute)

visual engagement with either parent were not associated with those with strangers, while there was a positive association between infant visual engagement displayed with mothers and fathers.

Smile

At four months, infants who had higher levels of smiling with mothers also had higher levels of smiling with strangers. At eight months, infants who had higher levels of smiling with mothers and fathers also had higher levels of smiling with strangers. Levels of smiling with mothers and fathers were also positively associated at eight months.

Vocalizations

At four months, infants who produced more vocalizations with fathers were also those who vocalized more with strangers. Higher vocalization frequency with mothers and fathers at four months was

TABLE 5 Associations between infant emotional communication with parents and strangers

	Mother-Stranger	Father-Stranger	Mother-Father
Concurrent Associations			
4 months			
Gaze	−.08	.56***	.22
Smile	.38**	.17	.22
Vocalizations	.26	.36**	.23
8 months			
Gaze	.13	.15	.29*
Smile	.44***	.36**	.29*
Vocalizations	.14	.18	.08
Longitudinal associations			
From 4 to 8 months			
Gaze	.12	.06	\
Smile	.02	−.24	\
Vocalizations	.38**	.42**	\

Note: Standardized coefficients of the random effects from the final multilevel regression models. Estimates are controlled for individual levels of temperamental surgency and negative affectivity.

*p < .05; **p < .01; ***p < .001.

associated with infant vocalization frequency with strangers at eight months (longitudinal association, see Table 5).

4 | DISCUSSION

Mean levels of visual, facial, and vocal communication differed by partner. Infants gazed longer at strangers than at fathers, exhibited less smiling to strangers than to mothers, and produced fewer vocalizations with strangers than with either parent. Differences in communication between strangers and mothers were evident at both ages, while differences in communication between strangers and fathers were moderated by infant age. Namely, infant visual engagement with strangers had a less pronounced decrease than visual engagement with fathers between four and eight months. Infant vocal communication with fathers increased with age, becoming significantly different from vocal communication with strangers at eight months. Temperamental surgency was associated with higher levels of positive affect and vocalizations with strangers and both parents (positive affect was particularly accentuated with mothers), while negative affectivity was associated with lower levels of visual engagement and positive affect. Levels of communication behavior with strangers were concurrently and longitudinally associated with communication with each parent, particularly fathers. Findings complement previous research on the development of infant communication with unfamiliar partners and provide new insights into interactions with fathers and the role of temperament in early social interactions.

4.1 | Infant communication with strangers versus mothers and fathers

4.1.1 | Visual engagement

Infants gazed longer at strangers than at fathers, probably because paternal interaction styles are characterized by active, physical play (e.g., Bögels & Phares, 2008; Paquette, 2004), which is associated with frequent but brief patterns of gaze (Aktar et al., 2017; Colonnesi et al., 2012; Forbes et al., 2004). Unlike previous studies, however, there were no significant differences in infant levels of visual engagement between strangers and mothers (e.g., Beebe et al., 2009; Bigelow, 1977, 1998; Iannou et al., 2021; Lin & Green, 2009). Young infants' visual engagement with unfamiliar partners has been often interpreted as a reflection of alertness (Beebe et al., 2009), indexing emotional states of wariness (Izard, 1977; Sroufe, 1977; Sroufe et al., 1974; Waters et al., 1975). The "stranger" in the current study was a young female experimenter, who was instructed to be visually attentive and expressively positive with the infant. Thus, it is possible that strangers' and mothers' interaction styles with the infant were similar and did not contribute to differences in infant visual behavior. Plausibly, it may be the infant's interest and curiosity triggered by the unfamiliar (female) adult that constitutes the underlying mechanism explaining infant visual engagement. Besides, the fact that in the present study social interactions were observed in the family's home, hence a familiar and safe environment, may have conditioned infants' visual patterns. Findings contribute to new data challenging the idea of a universal stranger wariness in infancy and emphasize the importance of intra- and interindividual variability as well as contextual factors that may predict variability in infant behavior (LoBue & Adolph, 2019; Solomon & Décarie, 1976).

4.1.2 | Positive affect

In line with previous findings (Beebe et al., 2009; Bigelow, 1998; but see Lin & Green, 2009), infants exhibited lower levels of smiling with strangers than with mothers. It is possible that higher levels of interaction caregiving on the part of infants' mothers, who were less likely to work outside the home than fathers (see Table 1), include repeated interactions characterized by affect sharing and positive arousal, which may help explain the current results (Bigelow, 1998; Bigelow & Rochat, 2006; Colonnesi et al., 2012; Tronick, 1989; but see Aktar et al., 2017). The fact that infant smiling levels between fathers and strangers did not differ significantly is intriguing. Both interactions with fathers and strangers tend to involve high levels of stimulation - active, physical play stimulation in the case of the father and novelty stimulation in the case of the stranger (Ferber, 2010), which might yield similar levels of infant positive emotional expressions. Future directions should compare the intensity and temporal dynamics of positive affect with strangers and fathers.

4.1.3 | Vocalizations

Consistent with prior evidence, infants produced less vocalizations when interacting with strangers than when interacting with mothers (Bigelow, 1998; Delack, 1976; Kurzweil, 1988; Sherrod, 1979; but see Beebe et al., 2009; Lin & Green, 2009). Likewise, infant vocalizations with strangers were also less frequent than with fathers at eight, but not four, months. All fathers in the current study were employed (64% full time; see Table 1) and in the Netherlands fathers receive only a few days of paternity leave after the child's birth. Thus, it may be argued that fathers' limited involvement in caregiving

affected the development of interaction routines and related vocal patterns of communication. These results suggest that infant vocal communication levels are a characteristic feature of the familiar, intimate bonds infants share with their parents.

4.2 | The contribution of temperament

Temperamental surgency and negative affectivity conditioned infant visual, facial, and vocal patterns of emotional communication, respectively, priming and tempering communication behaviors, in a theoretically coherent fashion (e.g., Laake & Bridgett, 2014; Nichols et al., 2005; Pérez-Pereira et al., 2016; Pratt et al., 2015). Children high in temperamental negative affectivity habitually experience high levels of distress and because of this they are often too overwhelmed to attend and learn relevant communication cues (Leve et al., 2013). Children displaying high levels of temperamental surgency, on the other hand, tend to elicit similar positive affect from interaction partners, thereby gaining access to a greater amount of social interactions than more introverted children (Laake & Bridgett, 2014). These infants may thus be enabled to strengthen interaction dynamics with the parent they spend most of their time with, hence the mother. The current study contributes to our understanding of the complex interplay of individual and contextual factors on infant expression of positive emotions (e.g., Aktar & Pérez-Edgar, 2020; Goldsmith et al., 1999), suggesting that temperament modulates infant partner-specific levels of positive affect already in the first half-year of life.

4.3 | Generalization of infant communication from mother and father to strangers

Our study presents the first empirical results relating to infant generalization of communication patterns from interactions with mothers and fathers to interactions with strangers (but see Beebe et al., 2009 for mother–stranger comparison), where generalization is intended as the display of "similar behavior toward discriminable entities" (Bornstein, 1985). Infant levels of visual engagement, positive affect, and vocalizations with strangers were congruent with communication behaviors with both parents, in and over time. The fact that associations were modest in strength but nevertheless pervasive and evident for each communication modality is compelling. At four months, infants' interactions with strangers and mothers had in common an emotional type of communication, characterized by similar levels of positive affect, while interactions with strangers and fathers shared a more attentional communication, characterized by similar levels of visual and vocal communication behaviors. At eight months, infants interacted with the strangers by exhibiting positive affect and vocalizations that were associated with (and parallel to those of) infant communication patterns with both mothers and fathers. Together, results not only corroborate the idea that infant communication with novel partners reflects communication patterns developed with parents (Beebe et al., 2009; Bigelow & Rochat, 2006; Watson, 1985) but also advance our current understanding of how infant interactions with mothers and fathers constitute distinctive templates for the infant's future interactions.

Possibly, infants' interactions between strangers and fathers shared more similarities than interactions between strangers and mothers because during interactions with their fathers, infants get challenged to new explorations and understandings, learning to stay focused and alert yet to take the risk (Kromelow et al., 1990; Möller et al., 2013; Raeburn, 2014; Yogman & Garfield, 2016). In this activation relationship with their father, infants get stimulated to explore the world and overcome obstacles, learning how to deal with unfamiliar situations such as encountering a stranger (Ferber, 2010;

Paquette & Bigras, 2010). Following this line of reasoning, fathers likely represent an intermediary person who is in between the familiar and safe mother on the one hand and the novel and potentially unsafe stranger on the other, whose function is of opening the child to the outside world (Bögels & Phares, 2008; Montague & Walker-Andrews, 2002; Paquette, 2004; Paquette & Bigras, 2010).

4.4 | Research implications

Children at risk of developing social-communicative delays often exhibit impairments in one—or more—modality of emotional communication (e.g., Cassel et al., 2007; Lambert-Brown et al., 2015; Merin et al., 2007). The findings of the present study provide unique insights into normative development of infant emotional communication with different social partners, which have implications for clinical practice, including implementation and advancement of screening tools, diagnosis, and intervention programs. Due to their novel nature, interactions with strangers may have the unique potential to elicit aspects of the infant communicative system that would normally remain hidden; hence, they may predict later socio-emotional adjustments over and beyond infant-parent interactions (Beebe et al., 2010; Jaffe et al., 2001).

Research toward a better understanding of infant interactions with strangers is also relevant in the context of parental depression. Depressed mothers tend to exhibit neutral and negative affect when interacting with their infant, which leads to similar communication behaviors in the infant (Aktar et al., 2017; Feldman et al., 2009; Forbes et al., 2004; Moore et al., 2001). These decreased levels of positive affectivity act as a central mechanism in the intergenerational transmission of depression and anxiety disorders, especially when they interact with genetic vulnerabilities, such as temperamental predispositions (Murray et al., 2009). Infant communication with strangers may thus have the potential to address whether parents' depression symptoms are reflected in the infant's interaction not only with the parent but also with a stranger, as a function of infant generalization of interaction difficulties (Beebe et al., 2009; Field et al., 1988, 2009).

The findings of the present study also implicate the key role played by temperamental dispositions during infancy. Both low levels of temperamental surgency as well as high levels of negative affectivity seem to entail disadvantages for infants' communicative development. Although preliminary, if supported by future studies, parental reports of their infant's temperament could be identified in clinical settings and used to target children at risk of social-communicative maladjustment (Davison et al., 2019). Parents could be informed about such risk in a probabilistic manner and provided with materials that may help to foster social communication in early childhood (Chow et al., 2018).

4.5 | Strengths, limitations, and future directions

Innovative aspects of this study include the participation of both mothers and fathers—which enabled us to identify distinctive patterns of differences and similarities between infant communication with strangers and each parent, and the adoption of a mixed-method design with longitudinal naturalistic observations, microanalytic coding of behavior across multiple communication modalities, and parental temperament reports. The majority of research to date has reported on infant interactions with strangers and mothers in laboratory settings (e.g., Beebe et al., 2009; Bigelow, 1998; Lin & Green, 2009). However, naturalistic studies, which employ observations in familiar and ecologically valid settings like the family's home, are critical to eliciting communication patterns that can be generalized to real-life situations (Cychosz et al., 2020; Tamis-LeMonda et al., 2017). This study also

underlines the potential of father and mother reports of infant temperament, while previous studies have tended to rely solely on mothers. Not only were maternal and paternal perceptions of infant temperamental surgency and negative affectivity congruent over time but they were also consistently associated with observed measures of infant communication behaviors across communication modalities.

The present study faces some limitations, which will be presently discussed along with suggestions for future research. To begin with, the fact that participants in the current study mostly consisted of highly educated, middle-class Dutch families limits the generalizability of findings. For instance, paternal involvement in caregiving is usually increased in families of middle- and high-socioeconomic status (Paquette & Bigras, 2010; Yeung et al., 2001). Further studies should therefore test across more heterogeneous backgrounds, ideally including comparisons between different cultural identities that rely on distinct social rules concerning emotional expressions (e.g., individualistic vs. community cultures; Otto et al., 2014).

A second limitation of this study concerns its moderate sample size, which nonetheless yielded abundant information through the infants' numerous repeated observations across social contexts of interactions and over time. In this regard, it is also worth noting that human manual microanalytic coding is undoubtedly a highly intensive and time-consuming procedure (Cohn & Kanade, 2007). Therefore, while on the one hand our study emphasizes the power of microanalysis in young infants, proving once again how relatively small amounts of nonverbal communication may generate high-density multimodal data that carry robust information (e.g., Beebe, 2006; Beebe et al., 2010; Colonnesi et al., 2012; Jaffe et al., 2001), on the other hand it also points out the importance of developing automatic coding systems suitable for few months old infants.

A third point of reflection concerns the fact that we analyzed infant emotional communication strictly in terms of facial behaviors, namely gaze, facial expressions, and vocalizations. In order to further enrich our knowledge about the development of the complex dynamics that characterize human communicative systems, future research should include investigations of additional preverbal communication modalities, such as bodily behaviors. Prior studies, for example, have examined the communicative features involved in movements like infant touch (e.g., sucking own fingers or touching the interaction partner; Beebe et al., 2010, 2016), posture stability (Fogel et al., 1999), and manual actions with objects (Yu & Smith, 2017).

Finally, our study examined the development of infant emotional communication from four to eight months of age. While it does represents a significant step forward in the understanding of infant interaction with familiar and unfamiliar interaction partners across the first and second half-year of life, additional time points would have the potential to identify nonlinear (e.g., quadratic or cubic) developmental trajectories. Moreover, it would be interesting if future research could investigate the extent to which infant partner-specific communication patterns independently and jointly contribute to the child's social-emotional development, comparing the magnitude of the predictive effects across the degrees of familiarity with the interaction partner.

5 | CONCLUSION

Interaction with strangers characterizes social life from infancy onwards. Understanding how infants adapt their communication behaviors as a function of the familiarity with the interaction partner—and identifying the factors that modulate individual differences in partner-specific communication—is central to advancing our knowledge of human socio-emotional development beyond the familial world. The current study presents evidence that during home-based face-to-face interactions, infants

gaze longer at strangers than at fathers, exhibit less smiling to strangers than to mothers, and produce fewer vocalizations with strangers than with either parent. Temperament contributed to individual differences in infant communication with strangers and both parents over development: infants higher in surgency expressed more positive affect and vocalizations while infants higher in negative affectivity exhibited less positive affect and visual engagement. Although infant emotional communication differed by partners, communication patterns with strangers shared similarities with each parent, particularly fathers. Insights into the early ontogenesis of communication with unfamiliar partners seem particularly relevant today, as the world population faces historically unprecedented, profound feelings of uncertainty toward whatever and whomever is perceived as different, thus strang-*er*.

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APPENDIX

T A B L E   A 1   Intercorrelations among infant emotional communication behaviors with mothers and fathers

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**
4 months								
1. Gaze	-	.42**	−.21	−.16	.10	.04	.06	.16
2. Smile	.24	-	−.36*	−.29*	.20	.15	−.16	−.01
3. Frown	−.09	−.33*	-	.43**	.04	−.14	.22	.18
4. Vocalizations	−.21	.06	.65**	-	−.06	.22	.08	−.09
8 months								
5. Gaze	.13	.03	.13	.25	-	.53**	.00	.01
6. Smile	.07	−.01	.09	.10	.45**	-	−.18	.01
7. Frown	−.15	−.01	−.07	.08	−.08	−.20	-	.44**
8. Vocalizations	.03	.06	−.16	.03	.24	.33*	.29*	-

Note: Bottom diagonal is with mothers; Top diagonal is with fathers.

*p < .05; **p < .01.

TABLE A2 Intercorrelations among infant emotional communication behaviors with strangers

	1.	2.	3.	4.	5.	6.	7.	8.
4 months								
1. Gaze	-							
2. Smile	.18	-						
3. Frown	−.17	−.14	-					
4. Vocalizations	−.28*	.38**	.23	-				
8 months								
5. Gaze	.05	.33*	−.07	−.12	-			
6. Smile	−.13	−.08	.06	.17	−.03	-		
7. Frown	.18	.02	−.10	−.09	.01	−.24	-	
8. Vocalizations	−.01	−.04	−.13	.06	.01	.23	.32*	-

*$p < .05$; **$p < .01$.