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Correlates of infant pointing frequency in the first year

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Abstract

This study examines the emergence of concurrent correlates of infant pointing frequency with the aim of contributing to its ontogenetic theories. We measured monthly from 8 to 12 months infants' ($N = 56$) index-finger pointing frequency along with several candidate correlates: (1) family socioeconomic status (SES), (2) mothers' pointing production, and (3) infants' point following to targets in front of and behind them. Results revealed that (1) infants increased their pointing frequency across age, but high-SES infants had a steeper increase, and a higher pointing frequency than low-SES infants from 10 months onward, (2) maternal pointing frequency was not associated with infant pointing frequency at any age, (3) infants' point following abilities to targets behind their visual fields was positively associated with their pointing frequency at 12 months, after pointing had already emerged around 10 months. Findings suggest that family SES impacts infants' pointing development more generally, not just through maternal pointing. The association between pointing and following points to targets behind, but not in front, suggests that a higher level of referential understanding emerges after, and perhaps through the production of pointing.

1 | CORRELATES OF INFANT POINTING IN THE FIRST YEAR

Infants start to communicate with gestures already before they produce their first words. Infants' use of the pointing gesture in particular is an important milestone in their communicative development that both predates and predicts their language skills (Colonnesi et al., 2010). Infants start to point conventionally with the index finger sometime between 8 and 15 months of age, on average at 11–12 months (Butterworth & Morissette, 1996; Camaioni et al., 2004; Cameron-Faulkner et al., 2015; Carpenter et al., 1998; Ruether & Liszkowski, 2023). The frequency with which they point, however, shows great individual variation (Liszkowski & Tomasello, 2011). Given that infants' pointing frequency is a strong predictor of infants' subsequent language development (Colonnesi et al., 2010), it is important to explain the differences in infants' pointing frequencies. One way to do so is to pinpoint the correlates of infant pointing frequency. Understanding correlates of early infant pointing, and the developmental timetable by which these correlates emerge, will advance theoretical claims about the ontogeny of pointing by adding to an empirical basis, and is a first step in developing informed interventions to promote infant pointing and subsequent language development.

Contemporary theories about how infant pointing emerges typically acknowledge a role of the social environment, however, they differ in their emphasis on child-external and child-internal forces (for overviews: Liszkowski & Rüther, 2021; Lock et al., 1990; Matthews et al., 2012). Social shaping accounts originally proposed that pointing emerges from a form of non-communicative pointing (Bates et al., 1975; Carpendale & Carpendale, 2010). The proposal was that caregivers respond to non-communicative behaviors as if they were communicative and somehow "shape" these early behaviors with unintended communicative effects into communicative pointing gestures. While caregiver interaction is a crucial element on this account, the precise process of the transformation of non-communicative behaviors to communicative pointing through reinforcement has remained less clear (Liszkowski & Rüther, 2021).

Another socialization variant, as reviewed by Liszkowski and Rüther (2021), emphasizes that parents model pointing behavior to their infants, who then mimic or imitate it (Lock et al., 1990; Rowe & Leech, 2019). Some accounts suggest that the latter entails a social-cognitive understanding that people behave with certain intentions and can intentionally direct others' attention to certain referents (Tomasello et al., 2007). According to this account, infants first need to understand that others refer to entities and events, for example, when they follow others' points. They can then understand that the points of their caregivers are communicative cues, which are intentionally produced to direct a recipient's attention to a referred entity, and imitate pointing by adopting the intentionality.

Recent research has focused on infants' earlier actual interactive behaviors and communicative attempts, like their vocalizing, reaching, giving, showing, and pointing, suggesting a developmental continuity in object-related communicative behaviors (Cameron-Faulkner et al., 2021; Choi et al., 2021; Salter & Carpenter, 2022). A recent synthesis of these claims and findings puts forth a social interaction account (Liszkowski & Rüther, 2021). This account holds that interactions, interactive behaviors, and their respective cognitions gradually increase in complexity through interactional experiences (from perceptual to cognitive, yielding an understanding of referential and communicative intentions, and a flexible use across situations). It suggests a common developmental process by which caregivers' object-directed interactions and their responsiveness to infants' early interactive object-directed behaviors lead to object-directed exchange, object-directed expectations, and a transformation toward a coordinating, anticipatory referential exchange, paving the way for distal referential communicative pointing. This interaction between infants and caregivers is of course not only unidirectional because caregivers respond to infants' behaviors (Olson & Masur, 2011, 2013), which in turn influences infants' communicative development (Olson & Masur, 2015). For instance, in a

study (Olson & Masur, 2015), mothers responded more often with object labels to infants' gestural bids compared to non-gestural bids, and only the responses to the gestural bids predicted infants' concurrent and subsequent vocabulary.

We derived three main variables from these theoretically informed accounts that should correlate with infants' pointing frequencies, which pertained to caregivers' use of pointing, infants' social-cognitive understanding of reference, and family socioeconomic status, which we introduce in the next sections. We aimed to examine correlations of these variables with pointing throughout the end of the first year and locate potential associations in the developmental timeline, potentially accounting for a gradual emergence of the associations. We benefitted from a longitudinal dataset that enabled cross-sectional analyses repeatedly over 5 months. Hence, this is the first study to examine at what particular age which particular variables might be associated with infants' pointing frequency.

1.1 | Point following

In line with a social cognition account, infants' ability to follow another's pointing may be associated with their own pointing (Matthews et al., 2012; Tomasello et al., 2007). In the literature, conventionally, simple point following tasks have been used to establish point following skills, when the experimenter captures the infant's attention and subsequently points to a target object to which the infant will then look, typically beginning around 9 months (Butterworth & Jarrett, 1991; Carpenter et al., 1998; Flom et al., 2004; Lempers, 1979). However, beyond a simple geometric mechanism of extrapolating a line of sight, a fuller representational, referential understanding of pointing has been assessed by tasks obstructing the line of sight from the infant to an object. This is because an obstructed perceptual line of sight requires the infant to form a cognitive expectation that a referent is intended by a point. This more complex level of referential understanding emerges a few months later than the simple point following, around 12 months. For example, infants follow targets outside of their visual field by 12 months (Deák et al., 2000), but not by 9 months (Flom et al., 2004). Further, recent studies with various methods show that infants at 12 months and older, but not at 8 months, expect a referent object following a point to an occluded site as revealed by their search behaviors and pupil dilations (Behne et al., 2005, 2012; Jartó & Liszkowski, 2021; Pätzold & Liszkowski, 2019; Rüther & Liszkowski, 2020).

There are mixed findings regarding correlations between pointing frequency and the different levels of point following. While some found concurrent correlations with a simpler point following at 12 months (Liszkowski & Tomasello, 2011), the Early Social Communication Scales (ESCS) study (Mundy et al., 2007) did not find concurrent correlations between initiating and responding to joint attention (which respectively includes but is not limited to producing pointing and following pointing to targets both within and outside the visual field) at 9, 12, 15 or 18 months. Two other studies found a predictive relation whereby infants' own production of pointing appears to enhance their simple point following. One showed that pointing frequency at 10 months predicted the point following skills (not distinguishing between simple vs. advanced point following) at 12 months (Ger et al., 2018). Another showed that infants' simple point following still improved with their own production of pointing between 12 and 16 months (Leung & Rheingold, 1981). Rüther and Liszkowski (2020) found a longitudinally predictive correlation between infants' pointing and their advanced pointing comprehension to occluded referents at 13 months but not earlier, and not in the reverse longitudinal direction. Liszkowski and Tomasello (2011) tested both simpler and higher levels of point following in relation to pointing at 12 months and found that simple point following concurrently correlated with the frequency of both index-finger and hand pointing frequency. However, only higher-level point

following correlated solely with index-finger pointing frequency, and with a descriptively higher correlation coefficient.

Previous studies reviewed above have not considered both a simpler and a higher level of point following in the same study while looking at it longitudinally (Ger et al., 2018; Leung & Rheingold, 1981; Rüther & Liszkowski, 2020). Therefore, we do not know how either level of point following develops. Further, studies did not consider multiple time points while looking at both levels (Liszkowski & Tomasello, 2011; Mundy et al., 2007). Therefore, we do not know particularly at what age(s) which level of point following is associated with point production and whether at any age one level is more strongly associated with point production than the other. During this period, it is yet to be more extensively studied whether and when point following with a simpler and a higher level of understanding of its function is associated with pointing frequency, and whether and when either level of point following is more strongly associated with pointing frequency. If a more complex level of reference understanding is required for pointing to emerge, as social cognition accounts may suggest (Tomasello et al., 2007), then we would expect correlations between pointing frequency and advanced point comprehension to emerge early. Conversely, as assumed by social interaction accounts of gradually emerging complexity (Liszkowski & Rüther, 2021), while simple point following should correlate with pointing frequency early, a correlation with more advanced point comprehension should emerge later, through increased social-interactional experiences (Rüther & Liszkowski, 2020).

1.2 | Caregiver pointing

The more caregivers point to objects for their infants, the more infants may produce pointing, perhaps because they will have more opportunities to observe and imitate the pointing of their caregivers, or because it reflects a more general increase in parents' communicativeness and responsiveness (Liszkowski & Rüther, 2021). In line with this, several studies have shown that caregiver and infant pointing are associated at an age window spanning 10–14 months (Liszkowski et al., 2012; Liszkowski & Tomasello, 2011; Rowe, 2000; Rowe & Goldin-Meadow, 2009). There is even some further evidence that this association is causal (Rowe & Leech, 2019) or at least directional (Ruether & Liszkowski, 2023; Salomo & Liszkowski, 2013), such that caregiver pointing leads to or predicts infant pointing. For instance, Rowe and Leech (2019) recruited families from diverse socioeconomic backgrounds. They found that irrespective of their background, training mothers to engage in more pointing activities with their infants at 10 months led to an increase in both their own and their infants' pointing frequency and pointing vocabulary (i.e., the number of different referents pointed at) at 12 months. Similarly, Marcos (1991) found that experimentally manipulating referential exchanges between caregivers and infants of 12–13 months of age led to an increase in infants' pointing frequency. Matthews et al. (2012) did not find an increase in 9- to 11-month-old infants' pointing frequency per se following training where parents pointed often for their infants but found an increase in infants' frequency of points that were accompanied by gaze alternation between the caregiver and the referent. They also found a cross-situational and longitudinal correlation between infant and caregiver pointing frequency. Together, the evidence seems to suggest that caregiver pointing enhances infant pointing frequency during referential exchanges.

1.3 | Family SES

Considering the diverse role of caregivers in infants' pointing development—be it through social shaping, modeling, or responsiveness—a strong candidate that may play a role in infants' pointing frequency which has received less attention in early infancy is the family socioeconomic status (SES). Family SES is known to be closely related to the development of crucial cognitive skills, such as language and executive functions, as young as 6 months of age (Lipina et al., 2005). Nevertheless, research on the role of family SES in early communicative development has been limited and inconclusive. In particular, some studies focused on initiating and/or responding to joint attention using the ESCS, which includes but is not limited to producing and responding to pointing gestures. Few such studies using the ESCS showed, surprisingly, that infants from a lower SES background responded more to joint attention (Abels & Hutman, 2015; Mundy et al., 2007). In contrast, the opposite pattern—higher SES infants showing better outcomes—was observed when looking at infants' initiation of joint attention using the ESCS (Abels & Hutman, 2015). Moreover, compared to infants from low-SES families, infants from high-SES families displayed a higher frequency of pointing in daily home interactions (Rowe & Goldin-Meadow, 2009) and a better ability in responding to more sophisticated cues in naturalistic play sessions (Reilly et al., 2021). Yet, in a laboratory free play session, no differences emerged between infants of low- and high-SES backgrounds in the frequency or duration of joint attention (Saxon & Reilly, 1998).

High-SES families may improve infants' pointing frequency by providing more sensitive and overall more responsive parenting for their infants. This assumption is based on research showing that high-SES families provide more sensitive parenting (Baydar & Akcinar, 2015; Koşkulu et al., 2021; Richman et al., 1992; Tamis-LeMonda et al., 2009), as well as greater quantity and quality of language input for their children (Hart & Risley, 1995; Vanormelingen & Gillis, 2016). This responsiveness may also apply to responding to infants' pointing. High-SES families may also provide more opportunities for their infants to imitatively point by pointing more often for them. In fact, at least one study showed that parent gesture mediates the relation between family SES and infant gesture at 14 months (Rowe & Goldin-Meadow, 2009). That is, higher SES parents indeed gesture more for their infants, which in turn leads their infants to also gesture more. Assessing family SES and caregiver pointing simultaneously earlier in the first year in relation to infant pointing frequency at a time closer to the time window of the emergence of infant pointing is essential to understanding the potential exclusive or mediated impact of these correlates.

1.4 | Present study

Given the robust link between infant pointing and language development, it is crucial to understand earlier correlates of infant pointing before language production proceeds. Previous research examined candidate factors like infants' social-cognitive abilities, in the form of their understanding of the pointing gesture, and the role of social environment, in the form of caregivers' pointing and responsivity, and to a lesser extent, caregivers' SES background. In the present study, we aimed to make contributions in three aspects. First, what is particularly necessary to be further researched is the developmental timeline of the particular associations, namely, when the measures emerge as correlates of the pointing frequency during the critical months of pointing emergence (i.e., 8–12 months). To fill this gap, we measured infants' pointing frequency and tested for relations to candidate variables each month between 8 and 12 months. Second, we took a closer look at the distinction between simpler (i.e., point following to objects in front) and more complex (i.e., point following to objects behind) levels

of understanding of pointing and situated it on this developmental timeline. Third, as there is only one prior study looking at SES background together with caregiver pointing, which tested 14-month-old infants (i.e., Rowe & Goldin-Meadow, 2009), we aimed to extend these findings to the first year of life and again situate these associations on the developmental timeline. To our knowledge, this is the first study to investigate the role of SES in the developmental trajectory of infants' pointing frequency.

In summary, the present study addressed some of the potential correlates of infants' pointing frequency within the first year of life. Specifically, we ask whether and at what age(s) between 8 and 12 months (1) infants' point following ability, (2) caregivers (mothers)' pointing frequency, and (3) family SES is related to infants' pointing frequency. We expected all three variables to be significantly and positively related to pointing frequency (for the SES as a binary predictor, we expected infants from high-SES families to point more frequently), and we expected the relation to get stronger by increasing age as the frequency of pointing gets more robust. For point following, we expected the more advanced ability to follow pointing behind the immediate visual field to be related more strongly to later pointing frequency compared to point following within the immediate visual field, reflecting a gradual increase in communicative complexity (Liszkowski & Rüther, 2021).

2 | METHOD

2.1 | Participants

Fifty-six infants (30 female) and their caregivers (all mothers) were tested each month when infants were between 8 and 12 months of age. The mean age of infants at the start of testing was 8.4 months (SD = 0.3, range = [7.8; 9.0]). The average days between each consecutive month of testing were 30.4 days (SD = 1.2). The mean age of mothers at the start of testing was 31.3 years (SD = 5.2, range = [21; 43]). Participants were recruited from Istanbul, Turkey. All the infants' parents lived together. Twenty-eight percent of mothers and 98% of fathers were working at the start of testing. Parents were asked to indicate their years of formal education: 15% of mothers and 4% of fathers completed primary education (5 years), 13% of mothers and 6% of fathers finished secondary education (8 years), 26% of mothers and 41% of fathers finished high school (12 years), 33% of mothers and 37% of fathers finished university (∼16 years), and 13% of mothers and 11% of fathers finished higher education (Master's or PhD level, ∼18–22 years), 2% of fathers did not complete any formal education.

There were a total of 46 missing data points emerging from 31 children (11 high SES) as some children had missing data at more than one age. Children with missing data were not completely excluded from the analyses, but only missing data points were excluded.

2.2 | Measures

2.2.1 | Family SES

To determine family socioeconomic status, we computed an SES index including maternal education, paternal education, the work status of both mothers and fathers, the monthly expenditure of the household, and the homeownership of the family, following Berzofsky et al. (2014) and Koşkulu et al. (2021). Maternal and paternal education was coded on a 5-point scale from 0: primary education to 5: higher education as described in the Participants section above. Mothers' and fathers' work

status was binary coded as 0: not working, and 1: working. The monthly household expenditure was coded on a 3-point scale as 0: 1200–3000 ₺[1] (44%), 1: 3000–5000 ₺ (29%), and 2: over 5000 ₺ (27%). The homeownership was binary coded as 0: not owning their home (66%), and 1: owning their home (34%). The total composite score ranged from 2 to 12 (median = 6). Based on this median value, families with a composite score of 6 and below were categorized into low SES ($n = 29$) and a score above 6 into high SES ($n = 27$).

2.2.2 | Point production

The decorated room paradigm (Liszkowski et al., 2012) was used to elicit pointing gestures from both, infants and parents. Mother-infant pairs were invited to a room where all four walls were decorated with a total of 21 items (see Figure 1). The only instruction given to parents was to spend 5 min in this room with their infant while carrying the infant in their arms and not to touch the objects on the walls (both themselves and their infants). Participants were recorded by four stationary video cameras situated at each corner of the ceiling. Using the annotation tool ELAN (Sloetjes & Wittenburg, 2008), which allows for synchronous playback of four videos and time-aligned annotations, we coded the pointing gestures of both, mothers and infants from these observations. Pointing gesture was defined as the extension of the arm and the index finger toward an item or location (Liszkowski & Tomasello, 2011). The coding was done by four coders. Eighteen percent of the videos were pseudo-randomly selected to include all 5 time points for calculating interrater reliability. Intraclass correlations were high among the four coders: Cronbach alphas ranged from 0.94 to 0.99.

2.2.3 | Point following

A point following paradigm, adapted from Mundy (2007), was used to assess infants' ability to follow a pointing toward its target. There were four differently colored target posters (50 × 70 cm) with different animal pictures (31 × 31 cm) on each. Two of the posters hung on the wall at 60°

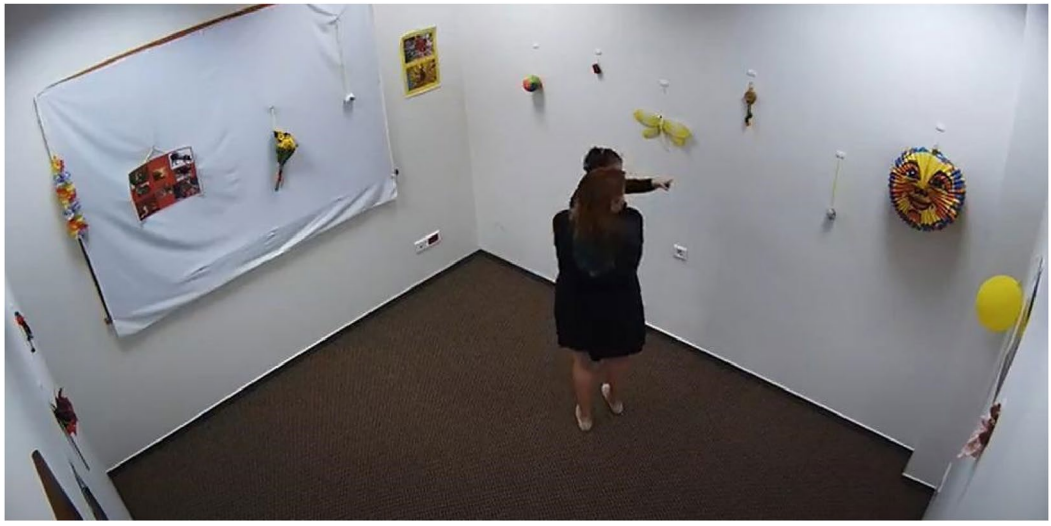

FIGURE 1 Snapshot from the decorated room paradigm.

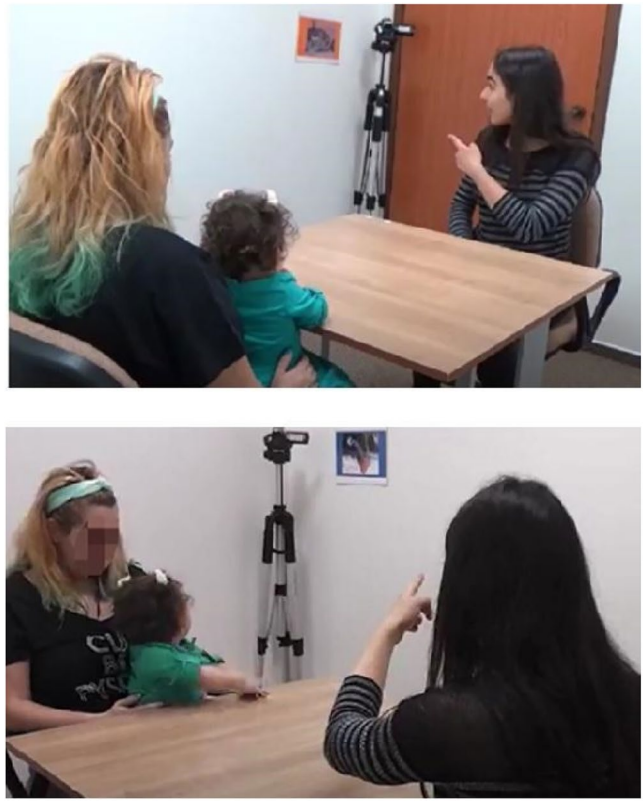

FIGURE 2 Snapshot from the point following paradigm. The picture above depicts the front trial and the picture below depicts the behind trial.

from the infants' midline to their left and right front (see Figure 2). These were within the immediate visual field of the infants (i.e., front trials). The other two posters hung on the wall at 150° from the infants' midline to their left and right behind. These were outside the immediate visual field of the infants (i.e., behind trials). The children sat at a table on their parent's lap across from the experimenter. In each trial, the experimenter first called the infants' name to attract their attention to herself, turned her head and entire torso toward a poster on one of the locations and pointed at it, and then said "Oh, look at that!" The trial order was counterbalanced such that half of the infants were tested in a clockwise order (front left, front right, behind right, and behind left) and the other half in a counterclockwise order (front right, front left, behind left, and behind right). For each of the four trials, infants' point following was scored as 1 if they succeeded in looking at the target object (i.e., the correct poster), and 0 if they failed to do so. For front trials, it was not sufficient for the infant to turn to the side of the correct poster to receive a score of 1, but strictly needed to look at the correct poster. For behind trials, they were given a score of 1 when they only turned their heads and searched in the correct location without specifically looking at the poster, considering motor limitations to turn their body or head all the way back in their given sitting position on their mothers' laps (see Deák et al., 2000). Trials were excluded when there was an experimental error or when no camera recording was available due to technical problems (a total of 7 trials from 5 infants were excluded). The final point following front and point following behind scores were each calculated as a percentage score by dividing the sum of each trial's score (0–2) by the total of valid trials (2 trials minus excluded, if any).

2.3 | Procedure

Infants and mothers were tested each month from 8 to 14 months and finally at 18 months, as part of a larger project conducted at Koç University, Istanbul, Turkey. For the present study, only data from the decorated room and point following paradigms, obtained between 8 and 12 months, were used. Before the study, one parent gave informed consent. The study was approved by the local ethics committee (Committee on Human Research at Koç University, Protocol no: 2012.048.IRB3.18) and all procedures were in line with the declaration of Helsinki.

2.4 | Data analysis

All analyses were carried out in R [Version 4.0.2] (R Core Team, 2020). The data and analysis script can be found at: https://osf.io/kmr4j/. We ran a linear mixed model with infant pointing frequency as the outcome, our candidate variables as fixed effects, and participants as random intercepts (letting the pointing frequency of infants vary). SES was a binary variable with low SES as the reference level; the remaining independent variables were continuous and were mean-centered, that is, the mean value was subtracted from each value. Mean centering was done for age because a value of 0 (e.g., age 0) is not meaningful, and for the other variables to set the interpretation of the coefficients to their mean value. We included age in interaction with every independent variable to model the influence of these variables throughout the age period we tested. Hence, we were able to examine (1) whether any candidate variable is significantly associated with infants' pointing frequency, and (2) whether that variable is significant all throughout the tested age period or only at a certain age or ages. We ran further mixed linear models or Wilcoxon signed-rank tests for post-hoc comparisons.

3 | RESULTS

Descriptive statistics and the distribution of (a) infant pointing frequency, (b) maternal pointing frequency, (c) infant point following scores (front), and (d) infant point following scores (behind), across all ages, can be seen in Table 1 and Figure 3, respectively. Note that in Figure 3 box plots are given for a and b whereas violin plots are given for c and d to illustrate the variability in the best way.

TABLE 1 Descriptive statistics of the variables.

	Mean (SD)[Range]				
Age in months	**8 M**	**9 M**	**10 M**	**11 M**	**12 M**
Infant pointing frequency	0.68 (1.61) [0–9]	0.89 (2.06) [0–12]	3.10 (7.02) [0–34]	6.53 (13.06) [0–58]	8.31 (9.94) [0–37]
Maternal pointing frequency	12.72 (12.88) [0–49]	15.98 (14.50) [0–62]	15.98 (14.26) [0–50]	14.60 (12.2) [0–43]	17.47 (13.85) [0–55]
Infant point following front (%)	0.63 (0.37) [0–1]	0.71 (0.39) [0–1]	0.80 (0.32) [0–1]	0.82 (0.32) [0–1]	0.93 (0.18) [0.5–1]
Infant point following behind (%)	0.13 (0.24) [0–1]	0.13 (0.30) [0–1]	0.20 (0.30) [0–1]	0.30 (0.40) [0–1]	0.31 (0.41) [0–1]

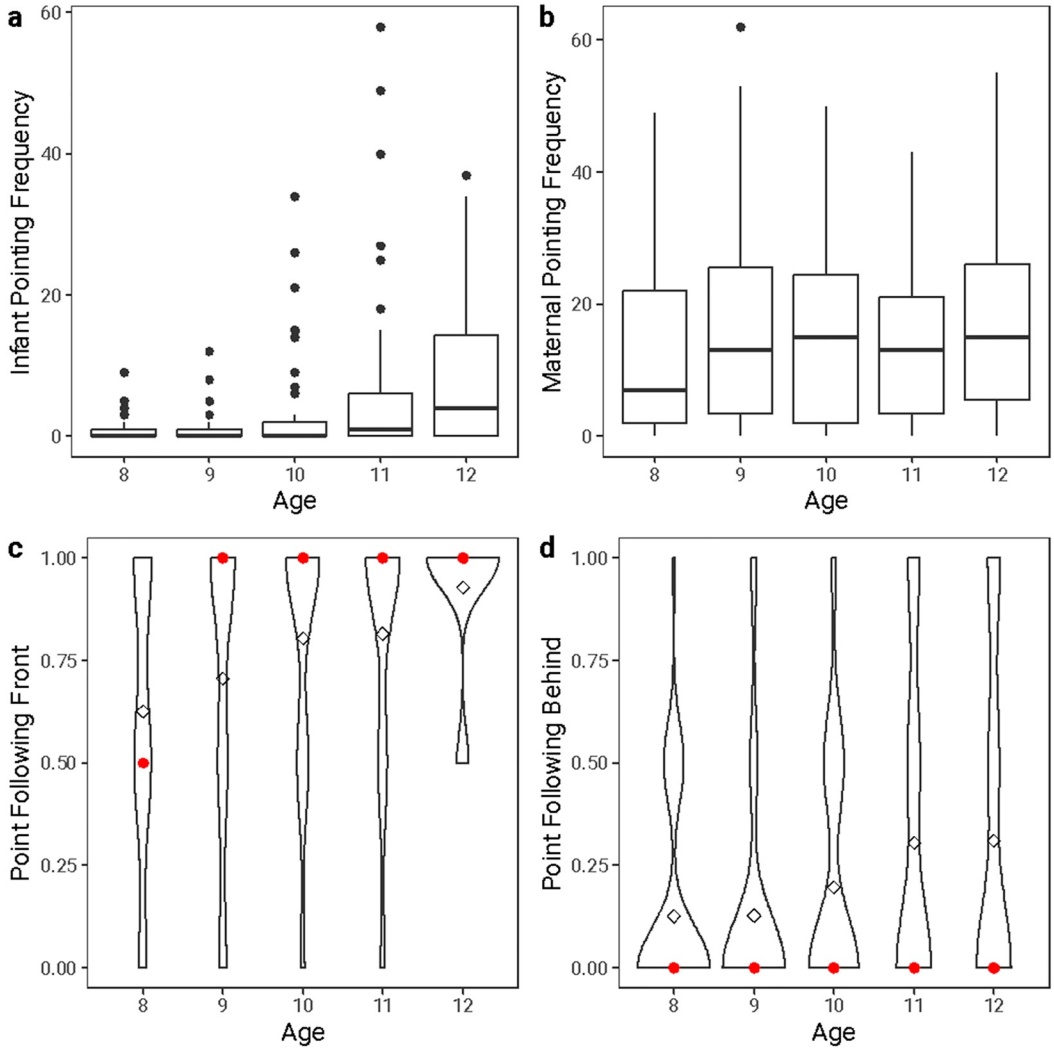

FIGURE 3 Distribution of the scores across infant age for (a) infant pointing frequency, (b) maternal pointing frequency, (c) infant point following front, and (d) infant point following behind. In c and d, filled dots and empty diamonds represent the median and mean values respectively.

Correlations between these variables in each month can be found in Appendix A (Table A1). We additionally determined the age of onset for infant pointing as the age at which the infant pointed more than once cumulatively up to that age. The age of onset for infant pointing (i.e., the age at which cumulative pointing frequency is above 1) was 8 months for 7 infants, 9 months for 9 infants, 10 months for 9 infants, 11 months for 8 infants, and 12 months for 9 infants. The remaining 14 infants did not point at all ($n = 9$; one of them did not attend the last two assessments) or only once ($n = 5$) cumulatively up to 12 months. The age of onset could be determined for 42 infants. Among these infants, the majority had the onset at or before 10 months ($n = 25$, 60% of infants), which we designated as the beginning of pointing.

The results of the linear mixed model are given in Table 2. A significant interaction between age and family SES (see Figure 4a), and between age and point following behind was revealed (see Figure 4b). No other effects were significant. We followed up on the interaction between age and family

TABLE 2 Fixed effects estimates of the linear mixed model analysis predicting infant pointing frequency.

Effect	*ß*	*SE*	*df*	*t*	*p*
Intercept	1.58	0.88	57.27	1.79	0.078
Age	0.46	0.46	189.83	1.01	0.314
SES	4.25	1.26	54.30	3.38	<0.001***
Point following front	−1.34	1.61	223.82	−0.83	0.407
Point following behind	4.65	1.56	220.49	2.99	0.003**
Maternal pointing	0.02	0.04	155.53	0.42	0.679
Age x SES	2.58	0.63	187.80	4.08	<0.001***
Age x point following front	−0.99	1.09	207.54	−0.91	0.363
Age x point following behind	2.32	1.02	207.20	2.28	0.024*
Age x maternal pointing	0.02	0.02	201.98	0.76	0.447

Note: The reference level of SES is low SES.

* < 0.05, ** < 0.01, *** < 0.001.

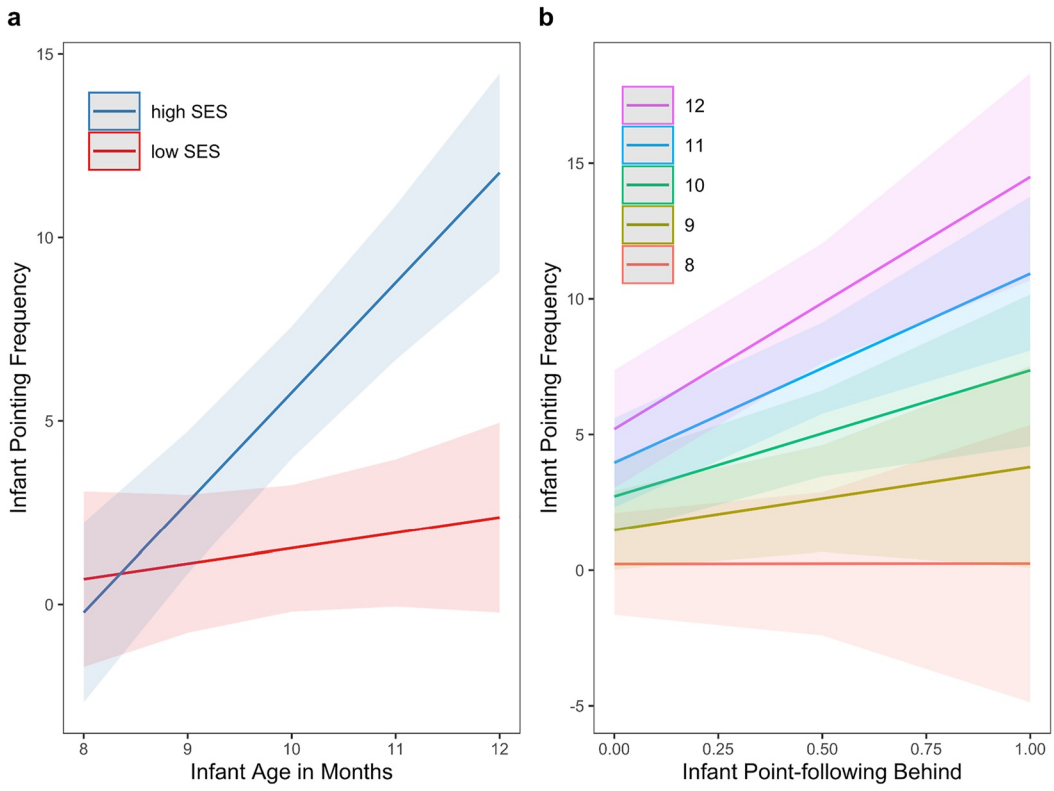

FIGURE 4 Interaction effect between (a) SES and age, and (b) age and point following behind.

SES with two further linear mixed models, that is, regressing age onto infants' pointing frequency separately in low-SES and high-SES infants. In both models, age significantly predicted pointing frequency, but with a larger slope in high-SES infants (see Table 3). Namely, 1-month increase in age was associated with 0.97 more pointing in low-SES and 3.35 more pointing in high-SES infants. Moreover, we compared low- and high-SES infants' pointing frequency separately at each age between

TABLE 3 Estimates of age in the linear mixed model analyses following up on age × SES interaction.

	ß	*SE*	*df*	*t*	*p*
Low SES					
Intercept	2.10	0.60	27.78	3.48	0.002**
Age	0.97	0.26	104.63	3.70	<0.001***
High SES					
Intercept	5.96	1.14	25.51	5.23	<0.001***
Age	3.35	0.55	98.39	6.07	<0.001***

Note: Estimates are given for the two separate models for low-SES (above) and high-SES (below) infants.
* < 0.05, ** < 0.01, *** < 0.001.

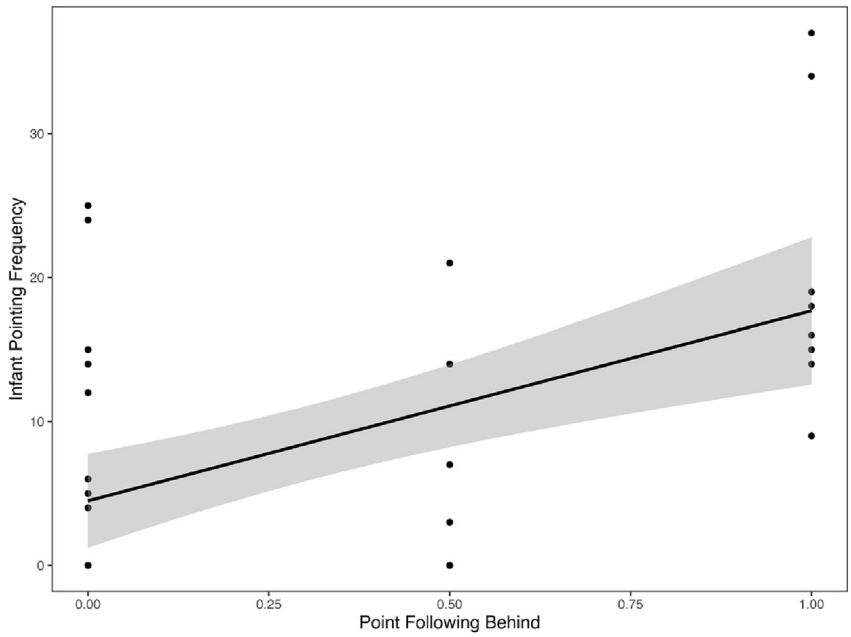

FIGURE 5 Relation between infants' point following behind and pointing frequency at 12 months.

8 and 12 months. Results showed that high-SES infants pointed more than low-SES infants at 10, 11 (*ps* < 0.05) and 12 months ($p < 0.01$).

We followed up on the interaction between age and point following behind with further linear mixed models regressing point following behind onto infants' pointing frequency separately in each age from 8 to 12 months. Point following behind was significantly related to pointing frequency only at 12 months ($ß = 13.20$, $SE = 3.16$, $t = 4.18$, $p < 0.001$; all other *p*s > 0.40). One more successful trial in following a target behind at 12 months was associated with 6.6 more pointing (Figure 5). Because there is no significant prediction by the point following to targets in the front at any month (i.e., simpler level of point following) but a significant prediction by the point following to targets in the back (i.e., higher level of point following) at 12 months, this suggests that the higher level of point following is the solely associated component of infants' pointing frequency, and only at 12 months.

Furthermore, given that SES was significantly related to infant pointing, but maternal pointing was not, we additionally examined three questions. First, does maternal pointing frequency change as a function of infant age and family SES? Second, is there a moderated relation between maternal

TABLE 4 Fixed effects estimates of the linear mixed model analysis predicting maternal pointing.

	β	*SE*	*df*	*t*	*p*
Intercept	12.01	2.04	54.24	5.90	<0.001***
Age	0.09	0.52	198.44	0.17	0.865
SES	6.69	2.94	54.42	2.28	0.027*
Age x SES	1.45	0.75	198.96	1.95	0.053

Note: The reference level of SES is low SES.

* < 0.05, ** < 0.01, *** < 0.001.

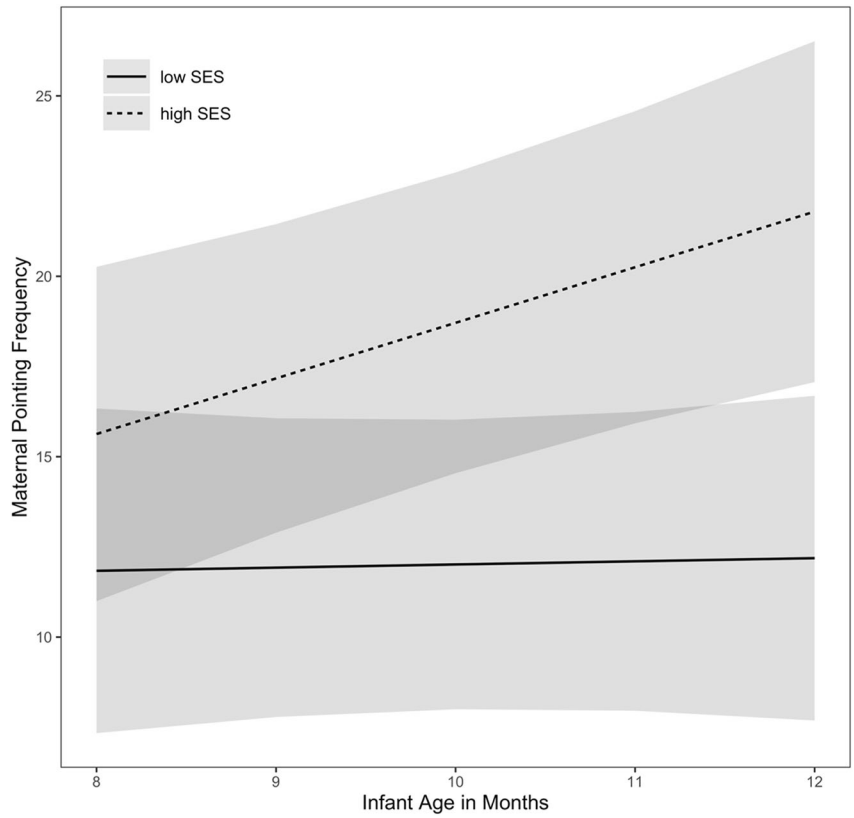

FIGURE 6 Maternal pointing frequency as a function of infant age and SES.

pointing and infant pointing through family SES? Third, is the age of onset of infants' index-finger pointing predicted by SES and maternal pointing frequency? For the first question, a mixed linear regression with maternal pointing frequency as the outcome variable, infant age, SES, and their interaction as the fixed effects showed that SES was significantly related to maternal pointing frequency independent of infant age (see Table 4). Namely, high-SES mothers pointed more often than low-SES mothers throughout the infant ages of 8–12 months (Figure 6). There was no significant effect of infant age indicating that mothers pointed equally frequently at each month when their infants were 8–12 months of age, for both high- and low-SES parents, although an interaction with SES approached significance. Because the interaction between age and SES on maternal pointing was approaching significance, we ran further analyses to check for the robustness of these patterns but

did not find sound statistical confirmation of an interaction effect (see Appendix B). For the second question, comparisons of mixed linear regression models to predict infant pointing from family SES, maternal pointing, and infant age as fixed effects, with and without the 3-way interaction, and 2-way interaction term between SES and maternal pointing showed that there was neither a significant 3-way interaction between family SES, maternal pointing, and infant age ($X2$ (1) = 0.93, $p = 0.334$) nor a significant 2-way interaction between family SES and maternal pointing ($X2$ (1) = 0.02, $p = 0.882$). This indicated that there was not a moderated relation between maternal pointing and infant pointing through family SES at any age. For the third question, we ran a linear regression analysis predicting the age of onset of infants' index-finger pointing from SES and maternal pointing frequency at the beginning of the longitudinal investigation (i.e., 8 months), and their interaction. We took the maternal pointing frequency at 8 months as the predictor because it has the most potential to influence the age of onset, which is already 8 months for some infants ($n = 7$). Moreover, because other analyses have shown that regardless of SES parents point about equally often at each infant age, the maternal pointing frequency at 8 months should be sufficiently representative of mothers' general tendency. Results yielded no significant prediction by either SES (Estimate = 0.60, $SE = 0.67$, $p = 0.375$) or maternal pointing frequency at 8 months (Estimate = −0.02, $SE = 0.02$, $p = 0.375$), or their interaction (Estimate = −0.06, $SE = 0.04$, $p = 0.171$).

Finally, because a previous study found that parents who pointed above the median at 12 months of infant age had infants who also pointed above the median (Liszkowski & Tomasello, 2011; Ruether & Liszkowski, 2023), we similarly categorized infants and mothers based on their median pointing frequency and calculated a Phi coefficient. At none of the months were the concurrent correlation coefficients significant (all Phi <0.24; ps > 0.153).

4 | DISCUSSION

We examined the development of pointing frequency in infants of diverse SES backgrounds, between the ages of 8 and 12 months. We tested whether and at what particular age(s) mothers' pointing frequency; family SES; and infants' point following skills would be related to infant pointing frequency. Our results showed that infants from both low- and high-SES families significantly increased their pointing frequency from 8 to 12 months. However, high-SES infants pointed more frequently than low-SES infants from the beginning of point emergence (i.e., the age at which most infants have started pointing), that is, starting from 10 months onwards and the increase was steeper for high-SES infants. Similarly, high-SES mothers pointed overall more than low-SES mothers, consistently from the beginning of the assessments at 8 months. However, maternal pointing frequency was not related to infant pointing frequency at any age, neither generally nor selectively for high-SES mothers. Finally, infants' point following was related to infant pointing frequency selectively for following the targets behind the infant, and the correlation emerged relatively late, 2 months after the average onset of pointing, at 12 months.

Surprisingly, we found no concurrent relations between maternal pointing and infant pointing at any age, and for either SES group. This contradicts some of the earlier findings that found significant concurrent relations between caregiver pointing frequency and infant pointing frequency within the age range of 10–14 months (e.g., Liszkowski et al., 2012; Liszkowski & Tomasello, 2011; Rowe, 2000; Rowe & Goldin-Meadow, 2009; Ruether & Liszkowski, 2023). This discrepancy is not likely to be explained by methodological differences in assessing pointing frequency since Liszkowski and colleagues (2011, 2012, 2023) used a similar decorated room paradigm as in the present study. A notorious methodological challenge may pertain to practicalities with coding and the common

ground of definitions and identification of index-finger pointing. For example, in the current sample, there were already several infants scored as pointing at 8 months, while the earliest onset in Ruether and Liszkowski (2023) was after 8 months, at 9 months, as often reported in the literature. While one possibility could also be differences in the cultural settings of the samples, it is also possible that caregiver pointing exerts an influence rather longitudinally than concurrently (see Ruether & Liszkowski, 2023). Liszkowski and Tomasello (2011) suggested that there was no direct copying of the pointing behavior between parent-infant dyads but rather that dyads engaged in a shared social practice of pointing together (Murphy & Messer, 1977). Indeed, parent and infant pointing that follow each other, rather than the absolute pointing frequencies of each party, seem to better capture parent-infant pointing as part of the proposed shared social practice (Liszkowski et al., 2012). Based on previous work (and due to statistical limitations), we modeled this association in the direction of caregiver pointing predicting infant pointing. Yet this association is likely bidirectional as infants not only imitate or learn from their parents' pointing but parents also respond to their infants' communicative bids and pointing. Moreover, parents typically verbalize when pointing, which may trigger more dynamic interactions with their infants. In our sample, the non-significant zero-order correlations between infant and mother pointing at any infant age (see Appendix A) suggest no concurrent relation in either direction. Yet future research with sufficiently powered data may take a closer look into longitudinal bidirectional and cross-lagged relations in episodes of joint pointing.

Regarding the relationship between SES and infant pointing, our findings paralleled and extended previous research such that infants from high-SES families pointed more frequently compared to the low-SES group even earlier than 14 months of age (cf., Rowe & Goldin-Meadow, 2009), already from the beginning (i.e., the onset of infant pointing at 10 months), and consistently at 10, 11, and 12 months. Our study contributes further to the literature with a novel finding that the growth in infants' pointing frequency from 8 to 12 months is steeper in the high-SES group than in the low-SES group. However, although high-SES mothers pointed more often than low-SES mothers in all ages between 8 and 12 months, there was no direct evidence for an influence of caregiver pointing frequency on infant pointing frequency. This finding suggests that SES may operate its effect on infant pointing through another mechanism than maternal pointing, suggesting against simple imitation accounts of pointing.

As an alternative mechanism, Liszkowski and Rüther (2021) discuss caregiver responsiveness, even to infants' earlier interactive behaviors, before they point, or the interactional style of mother-infant dyads. In line with the previous research, it is possible that higher-SES parents may be more responsive and less controlling toward their infants (Baydar & Akcinar, 2015; Richman et al., 1992; Tamis-LeMonda et al., 2009). Further, another recent study investigating a subset of the current sample in a free-play episode documented that compared to low-SES mothers, high-SES mothers were more sensitive, less controlling, cognitively more stimulating, and showed more positive affect (Koşkulu et al., 2021). They followed the attentional focus of their infants to a higher extent and provided more responsive behaviors when their infants pointed to an object. Parents' supportive attitudes and behaviors might increase the infants' tendency to engage with objects and point more since they are aware that they can receive a responsive reply in return for their pointing (Liszkowski & Rüther, 2021). A practical implication of the current findings is that it may not be sufficient to increase low-SES mothers' pointing for their infants, in order to increase their infant's pointing. More research is needed to explore whether parents' sensitive and controlling behaviors and their beliefs in growth mindsets (Rowe & Leech, 2019) play a role in the relationship between SES and infant pointing. Another important aspect that not be neglected given that SES had an influence on infant pointing from the beginning, is that SES has a heritability component (Hill et al., 2016), which may exert its influence from early on, initially perhaps even relatively independently from early socialization experiences.

In this vein, it is also possible that high-SES and low-SES mothers may have differed in how they perceived the pragmatic demands of the "semi-naturalistic" decorated room paradigm. Specifically, high-SES mothers in our study, who were college-educated, may have better recognized the referential nature of the decorated room and the desired referential behaviors than the low-SES mothers, who were not college-educated (Wei et al., 2022). This may have also played a role in the higher frequency of pointing of high-SES mothers. It is less clear from our current results how this may have also influenced infants' pointing. Nevertheless, it is worth replicating the current findings in future research in more naturalistic settings to eliminate any possible bias due to such task demands.

Infants' simple point following developed earlier and was more frequent than the more complex skill of comprehending reference to out-of-sight objects, which emerged around 12 months, but not much earlier. This finding is in line with recent findings (Jartó & Liszkowski, 2021; Pätzold & Liszkowski, 2019; Rüther & Liszkowski, 2020). Only the more advanced form of point comprehension, and only at 12 months of age, concurrently related to infants' pointing frequency, supporting previous findings of correlations between pointing and point comprehension to occluded objects at 12 months of age (Behne et al., 2012; Liszkowski & Tomasello, 2011; Rüther & Liszkowski, 2020).

Our results suggest that simple point following to targets within the visual field, which seems to be in place already at 8–9 months of age, is not related to how often infants point. The finding is at odds with an earlier study that found a correlation between infants' point following to targets and their index-finger pointing frequency at 12 months (Liszkowski & Tomasello, 2011; Ruether & Liszkowski, 2023); but overlaps with another study showing no correlations between initiating (includes point production) and responding (includes point following) to joint attention at 9 and 12 months (Mundy et al., 2007). The lack of a relation in our data may be related to the lack of variability in scores regarding infants' point following to objects in front. Our sample performed well above 50% in front trials from 8 to 12 months. A more sensitive measure of point following within the visual field, which captures more variation, may reveal relations to pointing frequency.

The finding that there was a correlation between pointing and the higher level of point comprehension at a later time point at 12 months supports the longitudinal finding that pointing predicts later emerging point comprehension to hidden objects (Rüther & Liszkowski, 2020). Accordingly, current findings are less compatible with a social cognition account if taken to postulate that a full-fledged comprehension of reference is necessary for pointing to emerge (see Tomasello et al., 2007). However, findings are compatible with the social interaction account of a gradual increase of complexity in communicative and social-cognitive development (Liszkowski & Rüther, 2021), suggesting that successful interactional experiences scale up the frequency and cognitive complexity of referential exchange (Ger et al., 2018; Leung & Rheingold, 1981; Rüther & Liszkowski, 2020).

In conclusion, our study shows that from as young as 10 months of age, family SES plays a role in how often infants produce pointing, as well as the growth in their pointing frequency between 8 and 12 months, with high-SES infants showing an advantage. The role of SES is not simply mediated through maternal pointing frequency, suggesting that other mechanisms might be at play such as the amount and/or nature of maternal responsive behavior, perhaps in combination with other genetic factors. Further, cognitive advances in referential understanding relate to a higher frequency of pointing. They are a later developmental outcome than pointing, likely of earlier object-directed interactions, but not causal to the initial use of pointing. Potential interventions to increase pointing (and later language) should adopt a differentiated focus on caregivers' interactional resources according to their SES and beliefs and go beyond simply enhancing caregiver pointing. Further, they should consider the child-internal level of cognitive reference comprehension. Current findings contribute to refining theoretical accounts of pointing, rendering strong notions of modeling, imitation,

and advanced social-cognitive reference comprehension less plausible, perhaps indicating a gradual increase of communicative complexity through object-directed social interactional experiences.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest with regard to the funding source for this study.

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FOOTNOTE

[1] It should be noted that the data for monthly household expenditure was collected before the hyperinflation period that Turkey went through between 2018 and 2023, thus the expenditure categorization does not reflect the current situation (Ipsos, 2022; Stoupos et al., 2023).

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APPENDIX A

TABLE A1 Correlation between the variables at each month from 8 to 12 months.

Variable	1	2	3	4
8 M				
1. Infant pointing frequency	1	-	-	-
2. Infant point following front	0.18	1	-	-
3. Infant point following behind	0.09	0.03	1	-
4. Caregiver pointing frequency	0.05	0.19	−0.02	1
5. SES	−0.19	−0.02	0.07	0.05
9 M				
1. Infant pointing frequency	1	-	-	-
2. Infant point following front	0.08	1	-	-
3. Infant point following behind	−0.12	0.11	1	-
4. Caregiver pointing frequency	0.27	0.18	0.02	1
5. SES	0.18	−0.06	0.14	0.27
10 M				
1. Infant pointing frequency	1	-	-	-
2. Infant point following front	0.13	1	-	-
3. Infant point following behind	0.07	0.22	1	-
4. Caregiver pointing frequency	0.11	0.22	−0.02	1
5. SES	0.29*	−0.17	−0.16	0.34*
11 M				
1. Infant pointing frequency	1	-	-	-
2. Infant point following front	−0.01	1	-	-
3. Infant point following behind	0.13	0.35*	1	-
4. Caregiver pointing frequency	0.20	0.14	0.03	1
5. SES	0.28	0.05	−0.25	0.37*
12 M				
1. Infant pointing frequency	1	-	-	-
2. Infant point following front	0.18	1	-	-
3. Infant point following behind	0.50***	0.14	1	-
4. Caregiver pointing frequency	0.19	−0.02	0.02	1
5. SES	0.45**	0.33*	0.03	0.22

Note: Correlations with SES (binary coded) are point-biserial correlations.

* < 0.05, ** < 0.01, *** < 0.001.

APPENDIX B

First, we ran two separate linear regression analyses predicting parents' pointing frequency from infant age for low-SES and high-SES parents. Infant age was not significantly predicting parents' pointing frequency in the low-SES group (Estimate = 0.13, $SE = 0.69$, $p = 0.858$) and did not reach conventional statistical significance level in the high-SES group (Estimate = 1.66, $SE = 0.96$, $p = 0.085$). Second, to test further whether mothers' pointing frequency in the two SES groups differed across age, we standardized mothers' pointing frequency and calculated an estimate of the slope of this trajectory via a simple linear regression for each parent (the estimate indicates the increase in pointing frequency in standard deviation unit as their infant ages 1 month older). This estimate did not significantly differ between low-SES ($M = 0.01$, $SE = 0.04$) and high-SES parents ($M = 0.08$, $SE = 0.05$) by a Welch t-test (t (48.8) = 1.03, $p = 0.307$). Third, we checked whether this trajectory estimate predicts infants' pointing frequency at 12 months and whether SES moderates this potential prediction, as a further test for our claim that SES likely imposes its influence on infant pointing not alone through parent pointing. We regressed infants' pointing frequency at 12 months onto SES, the trajectory estimate, and their interaction. Results revealed no significant interaction ($p = 0.994$) or no effect of the trajectory ($p = 0.775$). None of these additional analyses provides conclusive support for an interaction between SES, maternal pointing, and infant pointing.