Denise Ollas-Skogster

Temperament and Communicative Development in Early Childhood

Findings from the FinnBrain Birth Cohort Study

Åbo Akademi University

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Denise Ollas-Skogster

Abstract

Infants enter the world with a unique temperament and interact with their caregivers who have their own individual caregiving styles. Both temperament and caregiving quality shape the individual's early experiences and developmental environment. The foundation for communication skills is established during the first years of life through these interactions. Hence, gaining understanding of how infant temperament and caregiving quality are related to communicative development is warranted. Currently, the understanding of how different temperament traits are associated with the earliest communicative development, particularly preverbal communication, is limited. Further, the potential interplay between temperament and caregiving quality in relation to communicative development are poorly understood.

This thesis aimed to explore the roles of infant temperament and the combination of infant temperament and caregiving quality assessed as emotional availability as factors influencing infant and toddler communicative development, including preverbal communication.

The four studies within the thesis are part of the FinnBrain Birth Cohort Study. Language and communicative skills were assessed longitudinally in infancy (at 12 months in study I and 14 months in studies II-IV) and toddlerhood (at 30 months in studies II-IV) using parent reports of the CDI. Temperament was assessed both by parent report at 6 and 12 months of age (all studies, IBQ in study I and IBQ-R in II-IV) and by laboratory observation (Lab-TAB) at 8 months of age (studies II and III). Emotional availability as a measure of emotional caregiving quality was assessed by observations of free play at 8 months using the EAS (study III).

Higher infant positive emotionality, as reported by parents, was positively associated with communicative gesture use at 12 months (study I), overall communicative skills at 14 months (study III), and gesturing and receptive vocabulary at 14 months and expressive vocabulary at 30 months (study IV). Parent-reported self-regulation was positively related to infant gesturing in studies I, II and IV as well as to receptive and expressive vocabulary in study IV. However, similar associations were not found when self-regulation was assessed through observed gaze aversion in study II. Furthermore, temperamental negative emotionality did not have any significant association with communicative skills in any of the studies. Caregiver emotional availability was positively associated with 14-month communicative skills, but

no significant interactions between temperament traits and caregiver emotional availability in predicting communicative skills were found.

Taken together, and in line with previous research, the results indicate that infants with temperament profiles characterized by high parent-reported expression of positive emotions and extraversion, or high self-regulation tend to have a benefit in the development of early communicative skills. As a novel contribution, our findings suggest that these associations are particularly evident with gesturing. Regarding negative emotionality, our findings add to the inconclusive existing literature by suggesting that this trait does not appear to be related to communicative development at this age within this sample. Additionally, results show that high caregiver emotional availability is positively associated with infant communicative skills regardless of infant temperament. Finally, results indicate that reported and observed measures of temperament may have different associations with communicative development. This suggests that these methodologies may tap onto different aspects of temperament and should be used in combination for a more comprehensive perspective on temperament.

Results imply infant temperament is an individual factor to consider in the context of early communicative development. More specifically, awareness of traits of low positive emotionality/extraversion and low self-regulation as traits associated with less optimal communicative development is advised to ensure that all infants receive sufficient communicative input and scaffolding for optimal development. Furthermore, the results underscore the importance of caregiver emotional availability also from the communication development perspective.

Sammanfattning

Barn föds till världen utrustade med ett unikt temperament och interagerar med sina vårdnadshavare, som i sin tur bidrar med sitt sätt att ge omvårdnad. Både barnets temperament och vårdnadshavarnas omvårdnadskvalitet formar barnets tidiga erfarenheter och utvecklingsmiljö. Grunden till kommunikationsutvecklingen skapas under de första levnadsåren genom den här typen av interaktion. Därmed är det viktigt att förstå hur temperament under spädbarnstiden och omvårdnadskvalitet samverkar med utvecklingen av kommunikation och språk. I nuläget har vi bristande kunskap i hur olika temperamentsdrag samspelar med tidig kommunikationsutveckling, speciellt den förspråkliga utvecklingen. Vidare saknar vi kunskap om hur barnets temperament och vårdnadshavarnas omvårdnadskvalitet samspelar i relation till barnets kommunikationsutveckling.

Syftet med den här avhandlingen är att undersöka vilken roll spädbarnets temperament och kombinationen av barnets temperament och vårdnadshavarens omvårdnadskvalitet mätt som emotionell tillgänglighet spelar för utvecklingen av kommunikationsförmågan, inklusive förspråklig kommunikation, under spädbarns- och småbarnsåldern.

Alla fyra studier som avhandlingen innehåller är delar av FinnBrain-kohortstudien. Språk- och kommunikationsförmåga undersöktes longitudinellt i spädbarnsåldern (vid 12 månaders ålder i studie I och 14 månaders ålder i studie II-IV) och småbarnsåldern (vid 30 månaders ålder i studierna II-IV) med hjälp av föräldraskattningsformulären CDI. Barnens temperament bedömdes både genom föräldrarapport vid 6 och 12 månaders ålder (alla studier, formuläret IBQ i studie I och IBQ-R i studierna II-IV) och genom observation i laboratorium (LabTAB) vid 8 månaders ålder (studierna II och III). Emotionell tillgänglighet som ett mått på emotionell omvårdnadskvalitet bedömdes genom observation av fri lek vid 8 månaders ålder med instrumentet EAS (studie III).

Högre rapporterad positiv emotionalitet hos spädbarn hade ett positivt samband med användning av kommunikativa gester i 12-månadersåldern (studie I), sammantagen kommunikationsförmåga i 14-månadersåldern (studie III), gestanvändning och receptivt ordförråd i 14-månadersåldern, samt expressivt ordförråd i 30-månadersåldern (studie IV). Föräldrarapporterad självreglering hade positiva samband med gestanvändning i studierna I, II och IV, samt med receptivt och expressivt ordförråd i studie IV. Däremot hittades inte liknande samband då självreglering mättes genom observation av hur

barnet vände bort blicken från ett stimuli som orsakade frustration. Vidare hittades inga signifikanta samband mellan temperamentsdraget negativ emotionalitet och kommunikativa förmågor i någon av studierna. Vårdnadshavarens emotionella tillgänglighet hade ett positivt samband med barnets kommunikationsförmåga i 14-månadersåldern, men inga signifikanta interaktionseffekter mellan temperamentsdrag och emotionell tillgänglighet på kommunikationsförmågan hittades.

Sammantaget och i enlighet med tidigare forskning visar resultaten att barn vars föräldrar rapporterat temperamentsprofiler kännetecknade av hög grad av gladlynthet och utåtriktning eller hög självreglering verkar ha en fördel i sin tidiga kommunikationsutveckling. Våra resultat bidrar med ny kunskap genom att tyda på att temperament i spädbarnsåldern har speciellt tydliga samband med gestanvändning. Gällande de oklara tidigare forskningsresultaten gällande negativ emotionalitet tyder våra resultat på att det här temperamentsdraget inte har samband med kommunikationsutvecklingen inom det åldersspann som undersöktes i våra studier. Vidare tyder våra resultat på att högre emotionell tillgänglighet hos vårdnadshavare har ett positivt samband med kommunikationsförmågan oberoende av barnets temperament. Slutligen visar studierna att sambanden mellan temperament och kommunikationsutveckling ser olika ut beroende på om temperamentet bedöms genom föräldrarapport eller observation. Det här tyder på att de här metodologierna bedömer olika aspekter av temperamentet och bör användas i kombination för att ge en heltäckande uppfattning om barnets temperament.

Resultaten av avhandlingen visar att temperament är en individuell faktor hos barn som spelar roll för tidig kommunikationsutveckling. Mer specifikt är det värt att vara medveten om att lägre positiv emotionalitet/utåtriktning och lägre självreglering är kopplat till relativt svagare tidig kommunikations-förmåga. Detta för att kunna stöda och stimulera alla spädbarn på bästa möjliga sätt anpassat till deras temperament till optimal kommunikationsutveckling. Vidare betonar resultaten vikten av emotionell tillgänglighet hos vårdnads-havare även för att stöda kommunikationsutvecklingen.

List of original publications

I. Ollas, D., Rautakoski, P., Nolvi, S., Karlsson, H., & Karlsson, L. (2020). Temperament is associated with the use of communicative gestures in infancy. *Infant and Child Development, 29(3)*, e2166. https://doi.org/10.1002/icd.2166

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IV. Ollas-Skogster, D., Rautakoski, P., Kautto, A., Karlsson, H., Mainela-Arnold, E., Karlsson, L., & Nolvi, S. *Infant temperament predicts early communicative skills in the FinnBrain Birth Cohort Study* [preprint]. OSF. https://osf.io/3qmye_v1 *(submitted)*

This thesis is part of the FinnBrain Birth Cohort Study, which is responsible for cohort study design and collection of data used in the current thesis. The author has contributed to FinnBrain data collection as part of the PhD project by participating in coding of observational temperament data. The author was responsible for conducting statistical analyses in all studies while consulting with supervisors and co-authors of the respective studies. The author produced the first drafts of all manuscripts involved in the thesis and collaborated with the supervisors and other co-authors when making revisions resulting in the final articles.

Abbreviations

CDI	MacArthur-Bates Communicative Development Inventory
CDI-WG	MacArthur-Bates Communicative Development Inventory – Words and Gestures
CDI-WS	MacArthur-Bates Communicative Development Inventory – Words and Sentences
EA	Emotional Availability
EAS	Emotional Availability Scales
IBQ	Infant Behavior Questionnaire
IBQ-R	Infant Behavior Questionnaire – Revised
LabTAB	Laboratory Temperament Assessment Battery – Prelocomotor version
M3L	mean length of the child's three longest reported sentences calculated in morphemes
MLU	mean length of utterance
SEM	structural equation modeling
SES	socioeconomic status

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1. Introduction

Description of an interaction between a mother and a 14-month-old girl:

> The girl brings a book to the mother and opens it. They start reading together, one page at a time. The mother names the pictures in the book and the girl points out the corresponding pictures and adds own little comments in the form of sounds and gestures and a word here and there. When the book is finished, she goes to get the next one. After finishing that too, the mother moves away a bit and starts cleaning up toys. The girl becomes uneased left to herself, follows the mother and initiates playing with the toys handing them to the mother and making sounds. The mother comments: "Oh, here comes the cow! Did she get hungry again? Here's some hay!".

An interaction initialized in the same way between the same mother some years later with the 14-month-old little sister of the girl mentioned previously:

> The girl brings a book to the mother and opens it. They start reading together. The mother names pictures in the book, and the girl often looks at the corresponding pictures, but only points to the pictures she finds interesting to have the mother name them. The girl insists on turning pages at her own pace and becomes frustrated and objects loudly when the mother would like to finish a page before moving on. Having skipped a few pages, she leaves the book and moves on to explore something in the next room. The mother starts cleaning up some toys for a minute until she hears the girl climbing a chair and hurries to the other room commenting "Uh-oh, where have you climbed? Be careful, that's quite high! What are you looking at up there?"

Starting off identically, due to their temperament – defined as individual differences in emotional, motor, and attentional reactivity and self-regulation (Rothbart & Bates, 1998) – the interaction sequences took very different turns for the two children, as tends to be the case over a variety of everyday situations. They will spend different amounts of time engaged in activities – alone or in close contact with a caregiver – have different preferences for activities, hear different words, experience different interactional exchanges in different amounts, and elicit different reactions from the caregivers to their different behaviors. In other words, individual temperament traits seemingly influence the ways individual children interact with their caregivers and environment and the responses they elicit from others. Furthermore,

individual caregivers bring their own characteristics into the relationship and interaction with the child. Will this have consequences for the course of children's individual communicative development in infancy and toddlerhood?

One of the most eminent achievements of children during the first years is the development of the skills to interact and communicate with persons around them. Interaction is defined as a dynamic, reciprocal exchange between individuals (Merriam-Webster, n.d.). Interaction may or may not involve communication – defined as the sharing of a message between individuals using common symbols, signs, or behavior (Merriam-Webster, n.d.). Children become increasingly active interaction partners and develop communicative skills already during the first year. This development is the result of complex neurobiological and social processes acting together in constituting communicative development (Bloom, 1983).

Variability in language skills is high during the first years (e.g., Fenson et al., 1994). Explaining these differences is important in the light of preventing developmental delays. We need to gain awareness of what causes some children to excel in communicative development, whereas others struggle. Nevertheless, already in infancy, communicative skills, i.e., gesturing and emerging verbal skills, have some predictive value for later language skills (Bornstein et al., 2016; Hohm et al., 2007; Rantalainen, 2023; Rowe et al., 2008) although stability increases notably later in childhood (Bornstein et al., 2016). Consequently, the possibilities of nudging the development in a favorable direction may be at the highest at the earliest ages (Bornstein et al., 2016). Early communicative and language skills are related to many other developmental outcomes, such as later cognitive, academic, behavioral and language skills, for many years to come (Bleses et al., 2016; Kuhn et al., 2014; Law et al., 2009; Lee, 2011; Marchman & Fernald, 2008; Morgan et al., 2015; Vehkavuori et al., 2021). Thus, providing children with an adequate foundation for their communicative development is essential and should be in the interest of every caregiver and professional working with children. Communicative development happens in interpersonal interaction and is driven by an urge to share meanings with others (Bloom et al., 2001; Tomasello, 2015). Each individual enters the interaction and builds their communicative skills as active agents with their own intentions and motivation (Bloom et al., 2001).

Infants are born with predispositions that will influence their development from the very beginning. One individual trait present from the very beginning is temperament (Rothbart & Bates, 2006) –infants will already differ notably in how they act and express emotions in different situations (Gartstein &

Rothbart, 2003). Hence, individual temperament may play its own part in influencing the child's everyday life, experiences, and interactions, as described in the examples at the beginning of the chapter. Consequently, a link between infant temperament and developmental outcomes, including communicative development, seems reasonable. Awareness of temperament traits that potentially serve as protective or risk factors for communicative development facilitates preventing communicative and language delays. Indeed, associations between some temperament traits and language skills are reported in existing studies (e.g., Bloom & Capatides, 1987; Dixon & Smith, 2000; Kubicek & Emde, 2012; Slomkowski et al., 1992). However, gaps are evident in the literature regarding, for example, associations between temperament and preverbal gesturing, and the possible role of temperamental negative emotionality in early communicative development.

For the youngest children, the primary caregivers are usually the most frequent communication partners. This assigns them a key role in the children's communicative development since this development happens through interaction (Tomasello, 2015). Further, this emphasizes the importance of interaction quality in supporting communicative development. Caregivers differ in the way they respond to their child's signals – how sensitive, warm, supportive, and adaptive their responses are (Biringen, 2000). Where infant temperament is likely to influence the communicative output of the child, caregiving quality is likely to influence the communicative input the child receives and builds their communicative and language development on. Additionally, children with different temperaments may have their unique imprints on caregiving quality, and caregiving quality may influence the expression of temperament traits in the child (Putnam et al., 2002). Thereby, theoretically, different combinations of infant temperament profiles and caregiving qualities may result in different implications for the infant's communicative development. These theoretical interaction effects are, however, currently underexplored and poorly understood. Furthermore, the implications of emotional aspects of caregiving quality are overshadowed by more communicative perspectives on caregiving. Consequently, possible interrelations between emotional caregiving and temperament as predictors of communicative development are also unexplored.

This thesis aims to address gaps in the previous literature by exploring the relations between infant temperament, caregiving characteristics, and the development of early communicative skills up until the second year of life. It thereby aims to provide knowledge of how different innate temperament traits

in children tend to be related to early communicative development and how temperament traits and caregiving characteristics work together in predicting communicative outcomes.

2. Review of the literature

2.1. Early communicative development

A social urge to communicate our thoughts with other humans is hypothesized to drive language development according to several theories (Bloom, 1993; Tomasello, 2015). Starting from the very earliest moments, social interaction serves as a foundation for communicative development (Bloom, 1983). Before infants reach the stage of starting to use language, they develop several important communicative functions that are both functional means of communicating in themselves, as well as the basis of developing language skills (Tomasello, 2015). Communication can be considered as having three levels: a communicative *effect*, *inference* and *intention* (Gibb Harding, 1983).

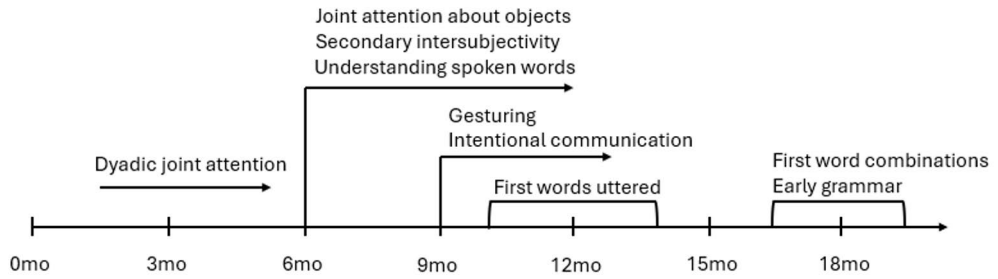
Furthermore, communication can be verbal, i.e., happen through the use of words, and nonverbal, using for example gaze, vocalizations, emotional expressions and gestures. The earliest communication utilizes vocalizations, gaze and emotional expressions (Salvadori et al., 2024). Even the very first acts of the infant, i.e., cries and kicks, can be considered communication since they have an *effect*: they elicit a response from the caregiver. During the first months the infant starts practicing dyadic joint attention and can have shared meanings with the caregiver through socioemotional expressions (Bloom, 1983; Salvadori et al., 2024). In these occurrences of joint attention and activity between the infant and caregiver, the acquisition of language skills starts (Bruner, 1975). The second level of communication reached is *inferential* communication, which involves at least one part of the dyad interpreting that an act has a communicative aim (Gibb Harding, 1983). For example, the infant moving towards a toy or looking at it while vocalizing is interpreted as inferential, i.e., a request for it, by the caregiver.

During the second half of the first year, joint attentional skills become more advanced and infants progress towards being able to share attention with others not only about themselves but about objects (Morales et al., 1998). They develop secondary intersubjectivity – the ability to share thoughts and goals with others (Trevarthen & Hubley, 1978). This also means they have reached a cognitive level where *intentional* communication is possible. Intentionality can be defined as anticipating a certain result of a chosen action and maintaining or adapting the action until the desired goal is reached (Bruner, 1973). Infants can, for example, intentionally request a toy by reaching for it while looking at the caregiver to convey the message that they want it (Gibb Harding, 1983). As

a consequence, a repertoire of instrumental communicative acts starts to appear – for example requesting something by pointing (Golinkoff, 1983). During the latter half of the first year, the infant starts showing signs of understanding verbal language and starts using gestures for intentional communication. Around one year of age, the first word is usually uttered (Fenson et al., 1994). A schematic overview of early communicative development is provided in Figure 1.

Figure 1

Overview of Early Communicative Development



Parallel with the emergence of secondary intersubjectivity, individual differences in communicative development become more evident (Golinkoff, 1983). The individual child's role as an intentional agent in acquiring language is also accentuated (Bloom et al., 2001), postulating that the development is best explained through the child's actions and cognition and driven by the child being engaged in the world surrounding them, motivating their effort to develop language. The concept of effort in learning language implies there is a competition for limited cognitive resources, and learning language requires some of these to be prioritized in this process (Bloom et al., 2001).

In sum, the development of nonverbal communication and verbal language share the same motives and early developmental underpinnings. In this thesis, the term communicative development is used as an umbrella term including early nonverbal and verbal communication. The development within these separate domains of communication will be elaborated further in the following chapters.

2.1.1. Gesturing

A gesture is a bodily movement used to express or emphasize an idea, emotion or attitude (Merriam-Webster, n.d.). Correlations between early gesturing and vocabulary are typically of similar size as those between expressive and receptive vocabulary (Cadime et al., 2017; Fenson et al., 1994; Schults et al., 2012). This has led to the conclusion that they are likely to share a developmental basis (Goldin-Meadow, 2007; Tomasello et al., 2007). The appearance of early gestures such as showing or giving around 10 months of age are the first evidence of intentional communication and shared intentionality (Fenson et al., 1994; Goodwyn et al., 2000; Tomasello et al., 2007). Use of gestures also indicate understanding of symbol use, i.e., that a gesture can represent an object or action in analogy with use of words (Goodwyn et al., 2000). Furthermore, the appearance of interactive actions and behaviors in play during the second half of the first year are signs of social interaction that is a prerequisite for communicative development (Bruner, 1975), and the accurate use of toys as representations of real world items is further evidence of having acquired symbol function (Fenson et al., 1976). Use of symbolic gestures, motorically more simple compared to producing speech, continue to play an important role after the onset of verbal speech in augmenting expression when the verbal vocabulary is still limited during the second year of life (Goodwyn et al., 2000).

Gesturing in the prelinguistic period is predictive of different language skills throughout childhood (Bavin et al., 2008; Iverson & Goldin-Meadow, 2005; Laakso et al., 1999; Määttä et al., 2016). Additionally, advances in the use of gesturing has been found to precede corresponding advances in verbal language during the first and second years of life (Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2005). The fact that interventions aimed at gesturing predict gains in verbal language (Choi & Rowe, 2021; Goodwyn et al., 2000) has also been interpreted as support of a causal influence of gesturing on verbal language development (Rowe et al., 2022). Gesturing and other non-verbal behaviors continue to be an important ingredient in communication throughout life (Goldin-Meadow, 2005).

The importance of nonverbal communication throughout life and the implications early nonverbal communication has for later verbal communication accentuates the importance of including nonverbal communication, such as gesturing, in the study of early communication development. Furthermore, since nonverbal communication emerges as an

expressive modality before the verbal expressive lexicon, it offers an opportunity to study expressive communication at an earlier age.

2.1.2. Verbal language development

The starting point of verbal language development, i.e., language using words, can be placed around the time the infant starts to understand spoken words. Children vary substantially regarding the pace at which they acquire language, and some stability of the core language skill, independent of background characteristics, can be found from late infancy up until adolescence in both children classified as having low and average-to-high language skills (Bornstein et al., 2016). This early stability motivates the study of the very earliest stages of language development in an attempt to uncover the factors influencing child language development trajectories.

Aside from studying core language skill, which is relevant in longitudinal settings (Bornstein et al., 2016), looking separately at different language domains short-term is warranted for gaining an understanding of early language development. Large discrepancies between receptive and expressive vocabulary are quite common in infancy. Understanding between 50 and 200 words without uttering a single one is not uncommon (Fenson et al., 1994). It is theorized that receptive and expressive language may rely on different cognitive resources and neural systems (Bates et al., 1995; Hickok, 2009). Consequently, the expressive and receptive domains may be differently related to personal and environmental factors. Thus, it is important to study both the receptive and expressive domains separately when uncovering such relations. The following chapters will describe the development of receptive and expressive vocabulary as well as factors hypothesized to relate to them.

2.1.2.1. Receptive vocabulary

Prior to using words expressively in the right sense of the word, the infant needs to understand them. According to recent research, infants are perceived to start to understand some common words starting already from 6 months of age (Bergelson & Swingley, 2015). By the age of 12 months, the mean receptive vocabulary was approximately 90-100 words according to the questionnaire Mac-Arthur-Bates Communication Development Inventories (CDI) in two Finnish samples, and two-three months later it had doubled (Lyytinen, 1999; Stolt et al., 2008). The estimated mean size of total receptive vocabulary is argued to be around 120 words at 12 months, and to reach nearly 600 words by the age of 18 months (Mayor & Plunkett, 2011). Apart from the strikingly

rapid growth, the enormous variability during this early period is also notable. (Fenson et al., 1994) report a 143-word difference between the 10th and 90th percentiles of the CDI at 10 months of age, whereas this difference had grown to 229 words by the age of 16 months.

Early receptive vocabulary is associated with development of different domains of language as well as pre-literacy and literacy later in childhood (Torppa et al., 2010; Vehkavuori et al., 2021; Vehkavuori & Stolt, 2019). Receptive skill in toddlerhood is considered a reliable predictor of later expressive vocabulary development (Fisher, 2017; Patrucco-Nanchen et al., 2019; Zambrana et al., 2014). Weak receptive vocabulary later in childhood has been associated with higher risk of problems with literacy, mental health and unemployment in adulthood (Law et al., 2009).

2.1.2.2. Expressive vocabulary

The first words are typically uttered around the first birthday, and initially the size of the expressive lexicon grows slowly, showing means of 4 words at 12 months and 19 words at 15 months in the CDI in a Finnish sample (Stolt et al., 2008). Towards the second half of the second year the expressive vocabulary however tends to grow at an accelerating rate, with CDI means of 76 words at 18 months and 342 words at 24 months (Stolt et al., 2008). Although variability is rather low until 12 months of age, from 13 months onward it increases substantially, similar to the case with receptive lexicon (Fenson et al., 1994). At 16 months the difference between the 10th and 90th percentiles in the CDI was 170 words (Fenson et al., 1994).

As the development of expressive lexicon lags behind receptive lexicon, parent reports succeed in depicting individual differences further into toddlerhood, up until the age of 30 months (Fenson et al., 1994). However, the estimated total vocabulary size differs substantially from the CDI-scores as the vocabularies grow, as the estimated means of total vocabulary are argued to be 158 words at 18 months, 599 words at 24 months and reach 1314 words by the age of 30 months (Mayor & Plunkett, 2011).

The size of toddler expressive lexicon has been found to predict later language development over different domains and development of preliteracy (Vehkavuori et al., 2021; Vehkavuori & Stolt, 2019) and literacy even years into school age (Bleses et al., 2016; Lee, 2011; Rescorla, 2005). Late emergence of expressive language in toddlerhood is associated with higher risk of slower acquisition of language throughout childhood (Rescorla, 2009; Rice et al., 2008).

2.1.2.3. Syntactical and morphological development

After some time of collecting vocabulary, typically during the latter half of the second year, toddlers start to combine words and add inflections to them, which is the starting point of syntax and morphology. The children in the earliest end of the distribution start acquiring grammar at 16-18 months of age, whereas those in the later end have typically stated acquiring at least some grammatical features by 30 months of age (Fenson et al., 1994). The first word combinations typically emerge around 18 months of age (Fenson et al., 1994). However, the grammatical development is not only age dependent, it is strongly associated with vocabulary development (Stolt et al., 2009). For example, nearly all children producing more than 100 words have started using word combinations (Stolt et al., 2009). At the age of 24 months, 89.5% of the children in a Finnish sample had started combining words into sentences. The mean number of morphemes in the three longest sentences (M3L) was 6.1 (*SD* 3.3). However, in the group with less than 51 words in their expressive vocabulary, M3L was 1.9, whereas in the group with a reported vocabulary of more than 400 words it was 8.9 (Stolt et al., 2009). Children with late emergence of expressive language in toddlerhood also tend to have weaker morphologic and syntactic skills over several years as compared to peers reaching expressive milestones at the expected age (Rescorla & Turner, 2015).

To conclude, the emergence of syntax and morphology is another milestone in communicative development adding new dimensions to what can be expressed. Although highly related to vocabulary development, it is a complementary dimension of verbal language with unique variability and therefore important to account for to comprehensively grasp toddler communicative skill.

2.1.3. Factors shaping communicative and language development

Communicative and language skills are linked to a large variety of outcomes throughout life, such as socioemotional skills, behavioral adjustment and academic achievement (Bornstein et al., 2013; Dubois et al., 2020; Hohm et al., 2007; Nærland, 2011; Petersen et al., 2013; Rescorla, 2009; Yew & O'Kearney, 2013). This creates an emphasis on the importance of creating the best possible circumstances for individual children to develop optimal communicative skills. As the previous chapters suggest, language and communication tend to develop roughly according to a set scheme. However, it is also noteworthy that variation

in level of acquisition between children at this early age is substantial (Fenson et al., 1994).

Thus far, the most commonly studied predictors of communicative development tend to be related to child sex, birth order, heredity, communication and language environment and socioeconomic status (SES) (Berglund et al., 2005; Hoff, 2006; Huttenlocher et al., 1991; Stromswold, 2001). A rich and diverse lexical environment, female sex, high SES background and firstborn status are commonly reported in association with stronger lexical development (Berglund et al., 2005; Fenson et al., 1994; Huttenlocher et al., 1991).

2.1.3.1. Environmental factors

The effect of SES is thought to act at least in part through influencing lexical environment, since more highly educated caregivers tend to use more diverse language and talk more to their children (Hoff, 2006). Infants learn language from interpersonal interaction rather than from overhearing language (Weisleder & Fernald, 2013) or from screens (Kuhl, 2010). Amount of conversational turns experienced has even been related to functional differences in the child's brain (Romeo et al., 2018). Apart from the aspects related to interactional quality, how the child's time is spent may also be of importance. For instance, activities such as shared book reading is often reported as nourishing language development (Dickinson et al., 2012), and is also subject to variations by family SES and caregiver values and beliefs (Phillips & Lonigan, 2009). In addition, communicative aspects such as maternal responsiveness to child verbal and non-verbal signals are positively related to how child communicative skills develop (Ger et al., 2018; Gros-Louis et al., 2014; Miller & Lossia, 2013; Tamis-Lemonda et al., 1998). In fact, caregiver communication quality is argued to be even more important than quantity of caregiver word use in predicting language development in toddlerhood (Hirsh-Pasek et al., 2015).

2.1.3.2. Individual factors

Among the most commonly studied individual child characteristics related to communicative development are sex (biological sex assigned at birth), hereditary factors and birth characteristics. Female infants are often reported to be slightly advantaged in early communication development (Wallentin, 2009). Genetic factors are found to contribute to several language domains throughout childhood (Verhoef et al., 2021). Furthermore, birth characteristics

such as low birth weight or gestational age at birth are known risk factors for communicative development (Zerbeto et al., 2015). In addition to the factors listed above, individual child characteristics theorized to influence engagement and effort in language development (Bloom et al., 2001) as well as interaction (Dixon & Smith, 2000) are important to account for in relation to communicative development. Being present from birth, temperament rises as a natural individual characteristic to explore in this context.

In summary, basic communicative skills, verbal and nonverbal, are acquired during the first years of life. Regularities can be observed between children in the order of communicative milestones reached, but the pace of reaching them and advancing skills is subject to substantial inter-individual variability. Factors contributing to this variability are not fully uncovered, and individual child characteristics and caregiving factors are among those in need of further exploration. Noteworthy is also that of the predictors of communicative development, caregiving quality and infant communicative environment are examples of ones that are open for intervention to scaffold development. Consequently, they possess the ability of being protective factors, which further underscores the importance of scientific evidence as a knowledge basis in the field. We need to know how different temperament traits are related to communicative development and what caregivers can do to scaffold this development in the best way for the individual child. The following chapters will provide more insight into what the concepts of temperament and caregiving quality embrace as background to explaining how they are theorized to relate to communicative development as well as review the current evidence for such relations is and what gaps are still present in the knowledge.

2.2. Temperament and communicative development

The concept of temperament refers to individual differences in emotional, motor and attentional reactivity and self-regulation (Rothbart & Bates, 1998). Temperament is innate and biologically based (Goldsmith et al., 1987; Rothbart & Bates, 2006) and refers to relatively stable individual dispositions (Putnam et al., 2001). This does, however, not mean it remains constant throughout an individual's life, but rather it is under the influence of maturation, experience and factors within the environment, this influence being most accentuated during the first years (Goldsmith et al., 1987; Rothbart & Bates, 2006). How temperament is expressed also depends on behaviors appearing as a consequence of development, such as starting to smile or gaining control over

executive attention (Rothbart & Bates, 2006). According to Rothbart's theory, infant temperament involves three dimensions: positive emotionality, negative emotionality and self-regulation (Gartstein & Rothbart, 2003). The temperament dimensions and their subscales are pictured in Table 1. Having influence over the individual's functioning and behavior from the very beginning, it is not surprising the dimensions of temperament have been studied in relation to different developmental outcomes, such as social skills, emotional and behavioral problems and executive functioning (Sanson et al., 2010; Ursache et al., 2013), language development being no exception.

Table 1

Temperament Dimensions and Subscales in Infancy as Assessed by the IBQ-R (Gartstein & Rothbart, 2003)

Temperament dimension	Subscales
Positive emotionality	approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level, perceptual sensitivity
Negative emotionality	sadness, distress to limitations, fear, falling reactivity
Self-regulation	low intensity pleasure, cuddliness/affiliation, duration of orienting, and soothability

In the light of language learning theories, temperament can be hypothesized to relate to communicative development through two different mechanisms. On the one hand, it is thought to influence quality and frequency of interaction between the infant and others, highlighted as an important prerequisite for language learning in the theories of (Bruner, 1975). On the other hand, it may influence the child's motivation and preferences as well as use of cognitive resources, highlighted as important factors in language development in Blooms theories on language development (Bloom et al., 2001). These two distinct theoretical explanations are divided as follows by Kubicek and Emde (2012): the "competition for resources theory", assuming higher positive or negative emotionality taxes cognitive resources available for communication and therefore are negatively related to communication development (Bloom & Capatides, 1987), and the "mutual facilitation perspective" suggesting emotionality may enhance communicative development by creating

interaction (e.g., Dixon & Smith, 2000). A third possibility is the mechanism being different for negative and positive emotionality, the "specific emotions perspective" (Kubicek & Emde, 2012). Note, however, that the temperamental dimension of self-regulation is not involved in these theoretical suggestions. Further, in addition to these theories assuming temperament affects communicative development, it is also proposed that communicative skills may affect the expression of temperament, that these relations may be bidirectional, or that some third, unknown variable may explain variation in both temperament and communicative skills (Conture et al., 2013). These possible mechanisms will be discussed below in more detail in relation to the temperamental dimensions respectively.

The existing empirical literature on relations between temperament traits and language or communication development fails to deliver clear conclusions of how the temperamental dimensions are related to language development, particularly regarding negative emotionality and self-regulation. Considering the importance of nonverbal communication skills as a foundation for communicative development (Goldin-Meadow, 2007) as well as their close relation to verbal language development (e.g., Määttä et al., 2016), the scarcity of studies involving relations between temperament and preverbal gesturing in favor of studies involving early vocabulary is conspicuous. Furthermore, parent report is the predominant method for assessing child temperament in the existing literature. The alternative, observational assessment, is utilized in notably fewer studies. Both methodologies come with their own strengths and weaknesses (see (Stifter et al., 2008) for a discussion), and consequently are recommended to be used in combination to yield a comprehensive conception of infant temperament (Stifter et al., 2008).

2.2.1. Positive emotionality and communicative development

The temperament dimension positive emotionality in infancy within Rothbart's theoretical framework contains the subscales approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level, and perceptual sensitivity as assessed in the Infant Behavior Questionnaire – Revised (IBQ-R; Gartstein & Rothbart, 2003, see Table 1). Infants typically begin to smile, vocalize, and move their bodies in response to faces and stimulating objects during the first 2-4 months, with these behaviors increasing steadily throughout the first year of life (Rothbart, 1986). Closer to the end of the first year behavioral inhibition develops, and thereby the individual differences on

the approach-dimension, both in social and non-social contexts, tend to become observable and somewhat stable over several years (Rothbart & Bates, 2006).

Positive emotionality has predominantly been reported to have positive associations with language development (Bruce et al., 2022; Dixon & Smith, 2000; Laake & Bridgett, 2014), as well as preverbal communication in a few studies (Bruce et al., 2022; Salvadori et al., 2024). The studies involving infants have had positive associations but with varying dimensions of communicative skills. We are aware of very few studies relating temperament and gesturing. Bruce et al. (2022) assessed associations between infant temperament and gesturing at 10 months of age, and found positive emotionality to positively associate with concurrent gesturing. Salvadori et al. (2024), on their part, found positive emotionality to strengthen the association between early socioemotional communication with the caregivers and later pointing, whereas the main effects of this temperament trait were more inconclusive (Salvadori et al., 2024).

As for studies of verbal language, Laake and Bridgett (2014) found mother-reported infant positive emotionality to predict expressive language at 14 months of age but found no relation to receptive language. Similarly, Bruce et al. (2022) found positive associations between parent-reported 10-month positive emotionality and 24-month expressive vocabulary, but the effect disappeared when the concurrent positive emotionality was accounted for. However, positive emotionality did not relate to expressive measures of mean length of utterance (MLU) or sentence complexity at neither 10 nor 24 months (Bruce et al., 2022). Oppositely, Morales et al. (2000) found correlations between parent-reported aspects of positive emotionality, such as smiling and laughter and activity level, to correlate with receptive language measures exclusively at 12 months. Kubicek and Emde (2012) found both a higher frequency of observed positive emotionality in earlier talkers compared to later talkers starting from the beginning of the second year of life until 30 months of age, but no difference in reported positive emotionality.

Observations of positive associations between positive emotionality align with theories emphasizing the essence of interaction in language development (Bruner, 1975), as high positive emotionality is thought to promote interaction and thus increasing the frequency of language stimulation and communication experience (Laake & Bridgett, 2014), whereas results favoring neutral emotional states may be seen as concurring better with the theory highlighting limited cognitive capacity (Bloom et al., 2001), as a neutral emotional state leaves more cognitive or attentional resources free for language learning

(Bloom & Capatides, 1987). Thus, the latter explanation is reminiscent of those of relations between self-regulation and communicative development described below. Alternatively, correlations between higher emotional expression and lower expressive language (Bloom & Capatides, 1987) may also be explained by modality – children who do not yet have the words for expressing their emotions will rely more on direct emotional expression.

2.2.2. Negative emotionality and communicative development

Negative emotionality in infancy consists of the subscales sadness, distress to limitations, fear, and falling reactivity in the IBQ-R (Gartstein & Rothbart, 2003, see Table 1). Already as newborns, infants express distress and some avoidance behaviors, which become more diverse as the ability to move develops (Rothbart, 2007). Anger or frustration starts to appear at 2-3 months of age, and expressions of fear/inhibition become distinct from general distress around 7-10 months (Rothbart, 2007). Fear is related to inhibition and avoidance, and thereby has an automatic, bottom-up regulatory component as well as a negative emotionality component (Rothbart, 2007).

Regarding the few studies on infant gesturing, Bruce et al. (2022) found a positive relation between concurrent reported negative emotionality and gesturing at 10 months, leading them to suggest higher emotional expression is related to more gesturing, perhaps due to higher motivation to initiate interaction or convey emotional information to an adult. On the contrary, Salvadori et al. (2024) found that negative emotionality had a dampening effect on the relations between early socioemotional communication with strangers and later referential gesturing, whereas the main effects of the trait on gesturing were more inconclusive.

Some studies utilizing both observational and reported assessments of temperament have found negative associations between negative emotionality and expressive language measures during the second year of life (Bloom & Capatides, 1987; Salley & Dixon, 2007). Also, Kubicek and Emde (2012) found evidence of higher negative emotionality from 15 to 30 months of age in later talkers compared to earlier talkers in both objective and reported temperament assessments. More specifically, higher objectively assessed fear and higher reported social fear and anger tended to be higher in the late talker group. On the contrary, Moreno and Robinson (2005) reported positive associations between high expression of negative emotions in an observational task at 8 months of age and receptive and expressive language at 30 months. Furthermore, associations of both directions with expressive lexicon have been

found in the same sample depending on age of assessment by Nozadi et al. (2013). An observational measure of anger reactivity at 18 months positively predicted expressive language at 30 months, whereas concurrent anger reactivity had negative associations with the same measure for boys (Nozadi et al., 2013). In comparison, in addition to their positive finding regarding negative emotionality and gesturing at 10 months, Bruce et al. (2022) reported negative associations between 10-month negative emotionality and sentence complexity at 24 months, whereas expressive vocabulary had no significant relations to this temperament trait. Neither did concurrent negative emotionality at 24 months relate to any dimension of expressive language.

Kubicek and Emde (2012) propose that the competition for resources between emotional and verbal expression may be true for negative emotions specifically, not positive emotionality. Consequently, toddlers higher in negative emotionality may be disadvantaged in communicative development due to designating more resources to emotional reactivity or regulation instead of communication. Further, Nozadi et al. (2013) argue relations between negative emotionality and language development may be age specific and that higher negative emotionality in infancy or early toddlerhood may be interpreted as an adaptive communicative expression. Expression of negative emotions may serve as motivation to communicate and be effective in initiating interaction in infancy (Bruce et al., 2022). Reversely, further into toddlerhood when self-regulation is typically more well developed, high negative emotionality may be more maladaptive in nature (Nozadi et al., 2013). Furthermore, child negative emotionality has been linked to lower maternal linguistic input and complexity (Vernon-Feagans et al., 2008).

In sum, existing studies fail to reach a conclusion regarding the nature of associations between negative emotionality and early communicative development and the proposed mechanisms behind eventual associations.

2.2.3. Self-regulation and communicative development

The subscales involved in the self-regulation factor describing emerging infant self-regulation in Rothbart's framework and the IBQ-R are low intensity pleasure, cuddliness/affiliation, duration of orienting, and soothability (Gartstein & Rothbart, 2003, see Table 1). Self-regulation in infancy consists of both the infant's own regulation as well as coregulation with the caregiver (Rothbart et al., 2004). Soothability and cuddliness/affiliation, in particular, are examples of regulation with caregiver involvement (Gartstein & Rothbart, 2003). The first appearing regulatory system early in infancy is based on

orienting attention (Rothbart et al., 2004), either by the infant themself or by the caregiver (Rothbart et al., 2011). Infants develop the ability to control their orienting to some extent by the age of 4 months (Rothbart et al., 2011). The second, more voluntary system, effortful control or more generally executive forms of attention, emerge late in infancy and refer to the ability to inhibit a dominant response in order to perform a subdominant response, detect errors and engage in planning (Rothbart et al., 2004; Rothbart & Bates, 2006). Effortful control continues to develop beyond school age (Rothbart & Bates, 2006). Self-regulation is linked to several developmental outcomes, such as socioemotional skills, school engagement and -achievement (Robson et al., 2020).

As early as at 3 months of age, a preference for social-oriented regulation has been linked to more coherent communication behaviors in an observational study by (Fuertes et al., 2024). Aspects of parent-reported self-regulation during the first year have been linked to early vocalizations (Gartstein et al., 2008), as well as receptive (Dixon & Smith, 2000; Morales et al., 2000) and expressive language (Dixon & Smith, 2000) including early syntax (Bruce et al., 2022; Spinelli et al., 2018) in infancy and toddlerhood. Specifically, attention to speech in infancy has been found to relate to better expressive vocabulary in toddlerhood in an experimental study Vouloumanos and Curtin (2014). However, not all studies have found significant associations. Kubicek and Emde (2012) found no difference in reported interest/persistence between earlier and later talkers during toddlerhood. Bruce et al. (2022) found no significant relation between reported 10-month orienting and gesturing, although they report associations between toddlerhood effortful control (the toddler equivalent of the self-regulation factor) and expressive vocabulary, mean length of utterance and sentence complexity.

Considering the nature of self-regulation directing and maintaining attention and regulating emotional states, it being related to communicative development is plausible. Self-regulation may influence how the child orients to and remains focused on communicative or language stimuli and interaction, as well as influence communicative experience through interaction, since infant regulation is characterized by strong caregiver involvement (Rothbart et al., 2004). Age of assessment is interesting in this context, considering the more advanced regulatory abilities start to develop only late in infancy (Rothbart & Bates, 2006) and are preceded by more primitive orienting abilities (Rothbart et al., 2004). As can be seen above, studies also show differing associations

depending on age of assessment. Thus far, our understanding of when self-regulation comes into play as a factor associated with communicative development, especially gesturing, and how these relations develop over the first years in limited.

To conclude, temperament has been studied in association with language development over the past years. However, studies have seldom involved the earliest expressive communication in the form of gesturing. The main focus has been on emotionality, both positive and negative, whereas self-regulation, particularly in the earliest days of the trait becoming observable, is relatively understudied. Thus, knowledge is scarce regarding when associations between self-regulation and communicative skills start to emerge and how they develop over the first years. Nevertheless, also regarding emotionality, both theoretical and empirical disagreement is evident. Whereas most studies report positive emotionality being positively associated with communicative skills (e.g., Bruce et al., 2022; Dixon & Smith, 2000; Laake & Bridgett, 2014) and both positive and negative associations between negative emotionality and communication are reported (Bloom & Capatides, 1987; Kubicek & Emde, 2012; Moreno & Robinson, 2005; Nozadi et al., 2013; Salley & Dixon, 2007), a third standpoint is that a tendency for neutral emotionality is most optimal for acquiring communicative skills (Bloom & Capatides, 1987). Namely, Bloom and Capatides (1987) found a positive correlation between observationally assessed time spent in neutral affect and early occurrence of the first words and vocabulary spurt. However, the state of neutral affect in the study was described as being alert, attentive and quiet, rather than an absence of emotion (Bloom & Capatides, 1987). Hence, the finding can be argued to relate to self-regulation as well.

On a final note, sample sizes have been small to moderate in existing studies, implying a need for larger studies to draw robust conclusions regarding smaller effects.

2.3. Caregiving quality

The most influential persons in a child's life during the first years are the primary caregivers. As the infant is very dependent on the caregivers fulfilling their needs, the caregivers' abilities to provide high-quality care for the child will have immense implications for several child developmental outcomes, which have been established in studies ranging over topics such as cognitive, motor, and psychosocial development and emotional competence (Britto et al.,

2017; Landry et al., 1997; Volling et al., 2002). Caregiving factors have been explored in the study of language and communication development as well. The term caregiving quality will be used in the present thesis as an overarching term including several aspects of caregiving quality. Sensitivity and responsiveness are two often-recurring concepts in the realm of caregiving. Sensitivity generally refers to caregivers' awareness of the child's signals and needs (Ainsworth et al., 2015), but different definitions and operationalizations are applied in different contexts. It has both been used as an umbrella term involving subdimensions of caregiving and as a subdimension of other caregiving concepts (see the next chapter). Responsiveness is typically considered to be the behavioral consequence of sensitivity – responding to the signals (Biringen & Easterbrooks, 2012). Definitions and operationalizations of caregiving behaviors differ across studies, and concepts can be weighted to different degrees on communicative and cognitive aspects, such as types of verbal responses and maintaining focus of interest, or emotional aspects such as positive emotionality, tone of voice and warmth (Landry et al., 1997; Taylor et al., 2009). Consequently, direct comparisons between studies are difficult to make. The theoretical framework for caregiving quality used within this thesis to be introduced in the next chapter is emotional availability (EA).

2.3.1. Emotional Availability as a framework for caregiving

In contrast to other concepts related to caregiving, emotional availability (EA) is an umbrella term that describes the emotional connection and relationship between caregiver and child, involving both positive and negative caregiving qualities pictured in four subscales: sensitivity, structuring, non-intrusiveness, and non-hostility (Biringen, 2000; Biringen & Easterbrooks, 2012; Saunders et al., 2015). Sensitivity refers to the adult's use of emotion and behavior in creating a positive and healthy connection with the child (Saunders et al., 2015). Structuring describes the adult's ability to create an age-appropriate learning context for the child that encourages their understanding, autonomy, and activity. The scale involves the adult's use of both verbal and non-verbal guidance. Non-intrusiveness involves the adult's ability to allow the child to take the lead and be independent in the situation and to withhold from unnecessary interference. Non-hostility is the adult's self-regulatory ability in the interaction with the child, leading to not expressing negative emotions or behaviors such as boredom, frustration, or aggression toward the child (Saunders et al., 2015). EA has been found to relate to developmental outcomes

such as emotion regulation, empathy, attachment and school readiness (Altenhofen et al., 2013; Biringen et al., 2005; Little & Carter, 2005; Moreno et al., 2008) in previous studies, but it occurs less frequently in studies of infant communication development. Compared to other measures of caregiving quality, EA is more comprehensive, emotionally focused and dyad-based (Saunders et al., 2015), but also shares several conceptual underpinnings with other measures of caregiving like sensitivity and responsiveness. Insofar, EA has been studied surprisingly little in the context of communicative development.

2.3.2. Caregiving quality and communicative development

As acknowledged in both usage-based (Tomasello, 2015) and intentionality (Bloom et al., 2001) theories of language development, language is acquired in interaction. For infants and toddlers, the most frequent interaction partners are the primary caregivers. Consequently, as interaction requires two parties, in addition to individual characteristics within the child, characteristics related to caregiving are of interest when studying factors influencing communicative development.

Since caregiving starts immediately after birth, the earliest preverbal communication is not to be neglected in the study of relations between caregiving quality and early communicative development. Nevertheless, similar to the case with temperament, literature covering relations between caregiving quality and preverbal communication development is rather scarce. The few examples of studies report positive associations between maternal sensitivity and infant intentional communication behaviors, such as gesturing, play behaviors and joint attention (Laakso et al., 1999; Paavola et al., 2006). Interestingly, in the study by Paavola et al. (2006), maternal sensitivity seemed to be more related to infant gesturing and symbolic behaviors than early verbal expressive skills. Bruce et al. (2022) did not find significant relations between caregiving and gesturing at 10 months of age. Conversely, higher infant gesturing directed towards the caregiver has been reported to be related to higher caregiver responsiveness (Vallotton, 2009).

In studies of early verbal language development, positive caregiving qualities are predominantly reported to be positively related to language development. Positive associations have been found between sensitivity/responsiveness and receptive (Frick et al., 2019; Laakso et al., 1999) and expressive (Frick et al., 2019; Leigh et al., 2011; Nozadi et al., 2013; Tamis-LeMonda et al., 2001) language skills in toddlerhood. However,

Rantalainen (2023) found no significant associations between maternal responsive utterances and child language skills in toddlerhood in a Finnish sample. The author theorized this could be due to the relatively high SES in the sample leading to overall high responsiveness.

Negative caregiving aspects are less frequently studied. Bruce et al. (2022) found negative associations between maternal intrusiveness and expressive vocabulary and early syntax in toddlerhood and an absence of associations with maternal sensitivity. Similarly, Rantalainen (2023) found negative associations between maternal intrusive directive utterances and child receptive language and communicative initiations in toddlerhood. This suggests negative caregiving aspects are also of importance in relation to communicative development. However, Laake and Bridgett (2018) found no main effects of intrusiveness on expressive or receptive language in infancy in their study. High caregiving quality is proposed to scaffold development by creating a positive learning environment, providing guidance and support (Landry et al., 1997). That is, since caregiving is based on interaction, which is in turn the basis of communicative development, intuitively these concepts are likely to be intertwined. High quality caregiving likely entails numerous interactional turns with linguistic or nonverbal communicative content adapted to the child's skill level and creates an encouraging context for communication (Leigh et al., 2011). In the majority of existing studies, caregiving quality has not been studied until early toddlerhood.

In sum, the current literature agrees caregiving quality is related to language development. However, as caregiving has been conceptualized and evaluated in various ways, it is difficult to distinguish which aspects of caregiving are of importance in the context of language and communication – verbal, emotional or both? Furthermore, associations between early non-verbal communication and caregiving quality are strikingly understudied considering their shared importance in the earliest years. Emotional caregiving quality in infancy as a contributor to early communication is seldom accounted for in previous work.

2.4. Temperament, caregiving quality and communicative development

Temperament influences the child's behavior and thereby development (Rothbart & Bates, 2006). Also, caregiving quality and caregiver-child interaction has important implications for several developmental domains

(Britto et al., 2017; Landry et al., 1997; Volling et al., 2002). To add still one dimension, child temperament and caregiving quality act together in shaping the relationship and child's growing environment, in that different temperamental characteristics elicit different parenting behaviors and affect how the child responds to different sorts of caregiving (Putnam et al., 2002). For example, temperament is theorized to influence how children respond to positive versus negative reinforcement (Rothbart & Bates, 2006). Both caregiver and child individual traits contribute to how the relationship is formed (Kochanska et al., 2004). Also, studies have concluded that caregiving quality is related to expression of temperament. For example, child self-regulation is positively related to caregiver EA (Frick et al., 2018; Kammermeier, 2022). Hence, caregiving may also support long-term communicative development through moderating expression of temperament traits. Additionally, parent ratings of child temperament tend to differ in different parts of the world, particularly for negative emotionality (Putnam et al., 2024). This is suggested to be due either to societies differing in how displays of negative emotions are regarded and thus shaping these expressions in children by responding to them differently. or to societal views influencing caregiver ratings of behavior (Putnam et al., 2024). In this line of thought, the interplay between caregiving and temperament in association with child communicative development may be culture dependent.

Consequently, it is plausible that different combinations of child temperament profiles and caregiving will lead to different communication experiences for the child and hence influence communicative development differently. Thus, it becomes relevant to account for both child temperament and caregiving quality when predicting child communicative development. This has, however, only been done in a handful of studies (Bruce et al., 2022; Gartstein et al., 2008; Karrass & Braungart-Rieker, 2003; Laake & Bridgett, 2018; Nozadi et al., 2013), insofar making it difficult to draw conclusions regarding any general tendencies. In the studies by Karrass and Braungart-Rieker (2003), Laake and Bridgett (2018) and Nozadi et al. (2013), interaction effects were found between caregiving quality and temperament in association with language skills, whereas only independent effects of temperament and caregiving quality on communicative skills was found in the studies of Bruce et al. (2022) and Gartstein et al. (2008).

Looking at individual temperament dimensions specifically, emotionality is best represented in the existing studies. At the infants' age of 14 months, Laake and Bridgett (2018) found that maternal support was associated with better

expressive language skills if the infant had higher positive emotionality. Additionally, maternal intrusiveness was negatively associated with expressive language when paired with high positive and negative emotionality, whereas for infants low in positive and negative emotionality, higher intrusiveness was associated with better infant expressive language skills (Laake & Bridgett, 2018). On the contrary, in another study in infancy, Karrass and Braungart-Rieker (2003) found that caregiver responsiveness was associated with better language skills for infants *low* in distress to novelty, an aspect of negative emotionality. Additionally, responsiveness was associated with better language skills in boys *lower* in smiling and laughter, an aspect of positive emotionality. Nozadi et al. (2013) found a sex-specific interaction effect between temperament and caregiving quality in association with expressive language in toddlerhood: higher maternal sensitivity was related to lower anger reactivity in boys, which in turn was associated with better language skills. Self-regulation has seldom been accounted for in studies of caregiving quality and temperament. This is surprising considering that early self-regulation in infancy is largely dependent on caregiver support (Rothbart et al., 2004), and known to affect parenting in general (Kiff et al., 2011), making it reasonable to assume they might interact in predicting communicative development. In the studies by Gartstein et al. (2008) and Bruce et al. (2022), however, aspects of orienting/self-regulation were associated with vocalizations in infancy and expressive skills in toddlerhood, but relations were found to be independent of caregiving factors.

Different explanations have been suggested for the different results. Laake and Bridgett (2018) conclude that higher infant emotionality of both negative and positive character is likely to elicit interaction, and supportive caregiving further adds to this positive chain of events. However, in contexts where the infant's emotionality is low and does not initiate interaction as much, caregiver intrusiveness, which is generally not considered a trait of positive caregiving, may instead drive interaction and thus lead to higher language input (Laake & Bridgett, 2018). For their opposite results, Karrass and Braungart-Rieker (2003) refer to the intentionality model of language development (Bloom et al., 2001), according to which emotional reactivity competes with resources for developing language and hence emotionally neutral states allow infants to make more use of language input from responsive caregivers (Karrass & Braungart-Rieker, 2003).

In sum, the existing literature on relations between caregiving quality, temperament and communicative development in infancy and toddlerhood is

scarce and contradictory. The studies we are aware of focus on selected areas of caregiving quality, most typically sensitivity/responsiveness and in some cases intrusiveness, predominantly involve emotionality-related temperament dimensions and varying measures of communication and language over different ages. EA offers a more comprehensive concept of caregiving quality, including non-intrusiveness and non-hostility (negative caregiving) in addition to sensitivity and structuring (positive caregiving), making it relevant to explore in this context.

2.4.1. Assessment of early communication skills, temperament and caregiving quality

The methodologies for assessing communicative skills, temperament and caregiving quality are based on a variety of underlying theoretical frameworks as well as practical constraints. Assessments of communicative skills and temperament can be divided into reported and observational measures, whereas caregiving quality is predominantly assessed observationally.

Infant and toddler communicative development is commonly studied utilizing parent reports, which rely on the knowledge of the child's most frequent communication partners. They were originally developed to gain a broader understanding of the communicative skill than the snapshot observational assessment provides (Fenson et al., 1994). Another advantage is that this methodology allows for collecting large samples. Parent reports of communication and language are generally in the form of checklists where caregivers choose the right alternatives based on observations of the child, for example if a certain communicative gesture or symbolic play behavior has been observed and how often, and which words their child is perceived to understand and heard to produce. Questionnaires can also involve questions regarding use of grammatical structures and syntax. One example is reporting the three longest sentences the child has been heard to produce (Fenson et al., 1994). From these sentences, a mean value of morphemes per sentence is calculated representing the maximum sentence length (M3L) (Fenson et al., 1994). Parent reports have generally been reported to have satisfactory reliability and validity (e.g., Bates et al., 1988; Fenson et al., 1994). At the earliest stages, reports yield quite an accurate estimation of total vocabulary size, whereas they soon begin to underestimate total vocabulary as the vocabulary size grows (Mayor & Plunkett, 2011). During the second year of life, ceiling effects start to occur in parent reports of gesturing and receptive

vocabulary, whereas expressive vocabulary becomes increasingly difficult to assess reliably using reports when typically developing children are approaching 30 months of age (Fenson et al., 1994).

In the case of child temperament, the use of parent reports versus laboratory-based observational assessments is an ongoing debate. Parent reports have the advantage of covering temperament over a longer period of time in naturalistic settings (Rothbart & Bates, 2006), whereas it is more prone to bias due to subjectivity of the reporter (Durbin & Wilson, 2012). In turn, observational assessment is more objective in nature and experimental episodes can be standardized and designed to elicit expressions of specific temperament traits, but it is restricted to shorter periods of time in less naturalistic settings offering lower ecological validity (Durbin et al., 2007). Some degree of disagreement also tends to occur in comparisons of parent-reported and observed measures of the same trait (Stifter et al., 2008). The reasonable conclusion seems to be that the different methodologies measure different aspects of temperament (Stifter et al., 2008), which may in turn have different relations to other phenomena, such as communicative development (Kubicek & Emde, 2012), and should thus be used in combination in order to provide a comprehensive overview of temperament.

As for caregiving quality, underlying theoretical differences and differing foci of interest in studies seem to have led to methodologies differing rather much between studies. More linguistically focused studies tend to use concepts of caregiver sensitivity or responsiveness to refer to communicative behaviors whereas studies in the field of psychology tend to attribute more emotional aspects of caregiving to similar concepts. Consequently, teasing out what exactly has been assessed in studies of caregiving quality and comparing studies has proven challenging. Observational assessment by trained coders of dyadic interaction either in naturalistic or laboratory settings is the predominant method of measuring caregiving quality.

3. Aims of the study

The overarching aim of the doctoral thesis was to explore the associations between temperament and communicative development during infancy and toddlerhood. The thesis complements prior research in several ways. First, focusing on the earliest phase of communicative development, involving preverbal communicative gesturing in addition to early verbal language, is uncommon in previous studies. Second, utilizing a combination of parent report and observational assessment of infant temperament provides a wider perspective on the temperament construct. Third, only a few studies in the field have been based on large cohort data. Fourth, taking caregiver emotional availability into account in the analysis of associations between temperament and communicative development is an important contribution to the narrow field of previous studies. A depiction of the associations between temperament, caregiving quality, and communicative development studied in the thesis can be found in Figure 2.

Aims of the specific studies:

Study I: To study relations between reported infant temperament traits (smiling and laughter, soothability, activity level, distress to limitations, fear, and duration of orienting) at 6 and 12 months and infant gesturing and receptive vocabulary at 12 months.

Research question: Are temperament traits associated with gesturing and receptive vocabulary in infancy?

Study II: To compare relations between objectively assessed (at 8 months) and reported (at 6 and 12 months) temperament traits (negative emotionality, fear, and self-regulation) in infancy and infant communicative skills at 14 months and toddler vocabulary at 30 months.

Research questions: Are infant negative emotionality, fear, and self-regulation associated with infant gesturing and receptive and expressive vocabulary and toddler vocabulary? Are possible associations similar when the same temperament traits are assessed objectively and by parent reports?

Study III: To analyze the role of caregiver emotional availability at 8 months as a predictor of communicative skills in infancy (14 months) and vocabulary in

toddlerhood (30 months) and explore possible moderation effects of infant temperament (at 6 and 12 months) on the relation between emotional availability and communicative development.

Research questions: Is caregiver emotional availability associated with infant communicative skills and toddler vocabulary? Are possible associations between caregiver emotional availability and child communicative skills moderated by child temperament?

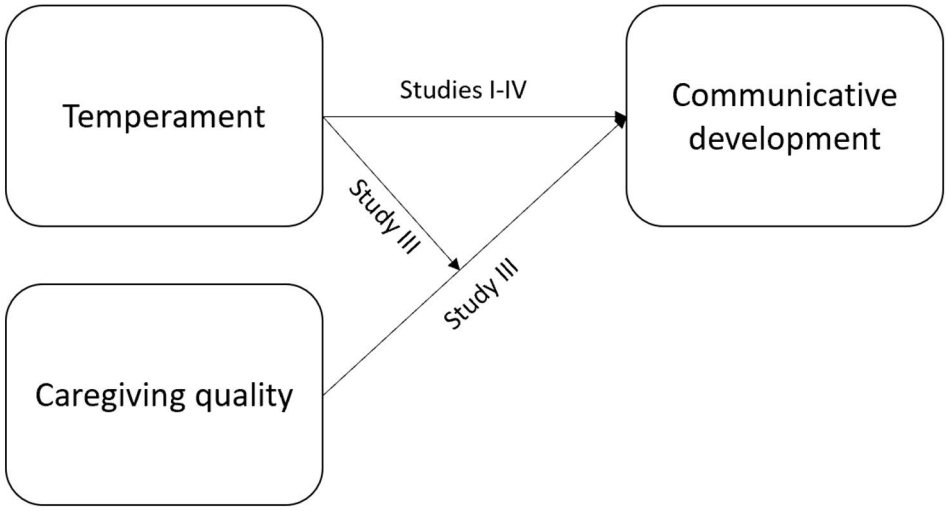
Study IV (an extension of study I): To examine relations between infant temperament (positive emotionality, negative emotionality, and self-regulation at 6 and 12 months) and infant communicative skills at 14 months and toddler language at 30 months in a larger cohort sample using a revised version of the parent report on temperament.

Research questions: Are temperament traits in infancy associated with infant gesturing, receptive and expressive vocabulary, and toddlerhood vocabulary and syntax? Can the results of Study I be replicated in a larger sample with language assessment extended into toddlerhood?

The hypotheses based on prior research were that infant positive emotionality and self-regulation would have positive associations with communicative skills. Formulating a directional hypothesis regarding negative emotionality and communicative development proved difficult due to contradictory previous findings.

Figure 2

Depiction of the Associations between Temperament, Caregiving Quality and Communicative Development Studied in the Thesis



4. Materials and methods

4.1. Study design

The research included in this thesis has been conducted within the FinnBrain Birth Cohort Study (Karlsson et al., 2018, https://sites.utu.fi/finnbrain/en/), including the pilot phase of the study for Study I (see Nolvi et al., 2016). The FinnBrain birth cohort study has the overarching aim of prospectively and multidisciplinarily studying the longitudinal influence of genetic and environmental factors on children, involving 3808 families from the Turku area and the Åland islands in Finland (Karlsson et al., 2018). A subset of families was recruited to the Focus Cohort and invited to participate in more extensive assessments, including laboratory visits for temperament and EA assessment. The FinnBrain project follows guidelines of the Declaration of Helsinki requiring caregivers of each participating child to give written informed consent before the child took part in assessment or data collection. Approval by the Ethics Committee of the Hospital District of Southwest Finland was granted for all study procedures.

4.2. Participants

The samples of studies I-IV are presented below. The sociodemographic characteristics of the samples are presented in Table 2.

4.2.1. Study I

The sample in study I was derived from the first phase of the FinnBrain study and included a sample of 91 families where the parents had completed questionnaires on infant temperament at 6 and 12 months and on communicative development at 12 months.

4.2.2. Studies II and III

The participants in studies II and III were participants of the focus cohort within the FinnBrain cohort. The focus cohort was selected based on different criteria, such as levels of prenatal stress and neurocognitive status, and this subsample took part in more extensive multidisciplinary follow-up including laboratory visits. Participants in study II were 183 infants, and the selection criteria was participation in the laboratory-based temperament assessment as

well as completion of at least the 14-month communication development parent report. Participants in study III were 151 infants selected based on the following criteria: participation in laboratory assessment of temperament and EA and completion of at least one of the communication parent reports at either 14 or 30 months.

4.2.3. Study IV

The samples in study IV were selected from the finalized FinnBrain cohort data based on completion of either the 14- or 30-month communication development parent report, which yielded samples of N_{14mo} = 1200 (sample with complete data on 14-month communicative development used in analyses involving this age point) and N_{30mo} = 1039 (sample with complete data on 30-month expressive vocabulary used in analyses involving this age point). The overlap between the samples was n = 789. Families reporting > 20% infant exposure to a language other than Finnish and infants born prematurely (at <37 gestational weeks) were excluded.

Table 2

Sociodemographic Characteristics for the Study Samples in the Thesis

	Study I (*N* = 91)		**Study II (*N* = 183)**		**Study III (*N* = 151)**		**Study IV (N_{14mo} = 1200)**		**Study IV (N_{30mo} = 1039)**	
	%	M (SD), range	%	M (SD), range	%	M (SD), range	%	M (SD), range	%	M (SD), range
Sex (female)	51		46		51		47		48	
Gestational age		39.6 (2.1), 31.0-42.3		40.0 (1.4), 35.7-42.3		40.0 (1.39), 35.7–42.3		40.0 (1.22), 37.0-42.6		40.0 (1.22) 37.0-42.4
Firstborn	64		62		64		52		54	
Monolingual family	82		72		72		100		100	
Maternal education										
High	49.5		40.4		39.7		39.8		37.8	
Mid	35.2		36.6		38.4		25.8		28.2	
Low	11.0		21.3		19.8		30.3		29.7	
Maternal age		29.8 (4.8), 19-42		30.9 (4.0), 21-44		31.2 (4.0), 21-44		30.8 (4.5), 18-45		30.9 (4.3), 18-45

Note. N_{14mo} = sample used in analyses involving 14-month communicative skills, N_{30mo} = sample used in analyses involving 30-month communicative skills, Sex = biological sex assigned at birth, Maternal education = maternal education level, Maternal age = maternal age at delivery. Only monolingual Finnish-speaking families (<20% exposure to language other than Finnish) were included in study IV.

4.3. Measures

The studies within the thesis involved both parent reports and observational assessment of infant temperament, laboratory-based assessment of caregiving quality and parent reports of infant and toddler communicative development. The measures used are described in the following chapters. An overview of them is provided in Figure 3.

4.3.1. Communicative development

In all studies, communicative development was assessed using the Finnish version of the parent report MacArthur-Bates Communicative Development Inventories (CDI, Fenson et al., 1994; Lyytinen, 1999), a widely used instrument considered valid and reliable (Fenson et al., 1994; Lyytinen, 1999). Additionally, a small number of CDI:s completed in Swedish (Eriksson & Berglund, 2002) were included in studies II and III. The infant version CDI – Words and Gestures (CDI-WG) was used at 12 months in study I and at 14 months in studies II-IV. In studies III and IV, the CDI-Words and Sentences (CDI-WS) was used for assessing 30-month expressive vocabulary (Study III and IV) and emerging morphosyntax (Study IV). Communicative gesturing was assessed via the Actions and gestures-section of the CDI - WG. Test reliability was assessed using Cronbach's α in studies I-II and McDonald's ω in studies III-IV. In Study I, a narrower conceptualization of communicative gesturing was applied, hence only the II A Communicative gestures was used. This section involves questions regarding use of gestures such as pointing, shaking head for "no" and waving goodbye (Cronbach's $\alpha = .65$). For the following studies, the entire Actions and gestures-section (II A-F) – which also includes the sections Games and routines, Actions with objects, Pretending to be a parent, and Imitating other adult actions – was used to assess communicative gesturing ($\alpha = .65$, McDonald's $\omega = .79$-83). This decision was supported by the fact that all subcategories assess behaviors theorized to underlie communicative development (Bates, 1979) and are closely interrelated (Fenson et al., 1994).

The CDI-WG allows for assessing both receptive and expressive vocabulary over different semantic categories in a checklist of common words. The reporter is instructed to check for each word whether the child is perceived to understand (i.e., receptive vocabulary, $\alpha = .93$- $.94$, $\omega = .96$-$.97$) or understand *and* produce (i.e., expressive vocabulary, $\alpha = .89$, $\omega = .89$) the specific word. Receptive vocabulary was used in all studies within the thesis (at 12 months in

study I and 14 months in studies II-IV). Expressive vocabulary at 14 months was used in study II and III. For study III, all CDI-WG scales were used to create a latent variable. From the CDI-WS at 30 months we used measures of expressive vocabulary (studies II-IV, α = .95, ω = .99) and mean length of the three longest reported utterances counted as morphemes (M3L, study IV).

As the CDI:s are culturally dependent they are validated and standardized for each language. Hence, the Finnish and Swedish CDI-WG contains different amounts of words and behaviors in the checklists. To combine both Finnish and Swedish questionnaires, percentage scores of the vocabularies were used in studies II and III. Studies I and IV involved only Finnish versions of the CDI.

4.3.2. Temperament

The thesis involves infant temperament assessment both by parent report (studies I-IV) and via objective laboratory observations (studies II and III), which will be described in respective sections below.

4.3.2.1. Parent reports of infant temperament

The Infant Behavior Questionnaire (IBQ, Rothbart, 1981) was used in study I, and the short form of the revised version Infant Behavior Questionnaire-Revised (Gartstein & Rothbart, 2003; Putnam et al., 2014) in studies II-IV. Both versions are questionnaires based on the same theoretical framework by Rothbart. The earlier IBQ-version yields estimations of six temperament subscales: duration of orienting (α = .80-.82), distress to limitations (α = .80-.84), soothability (α = .66-.80), smiling and laughter (α = .82), activity level (α = .83-.83) and fear (α = .55-73) (Rothbart, 1981), whereas the revised version includes 14 subscales loading onto three broader temperament dimension factors: positive emotionality (ω = .85-.89), negative emotionality (ω = .80-.89) and self-regulation (ω = .82-.87) (Gartstein & Rothbart, 2003; Putnam et al., 2014). The questionnaires instruct the parent to choose the alternative best describing frequency of certain behaviors expressing temperament traits in the infant during the past week in a selection of everyday situations on a 7-point scale from "never" to "always". All six subscales of the IBQ were used in study I, whereas the factors of the IBQ-R were used in studies II-IV (all factors in studies III and IV, only negative emotionality and self-regulation in study II), as well as the subscale fear in studies II and III (α = 0.80–0.81, ω = 0.83–0.84).

4.3.2.2. Observational temperament assessment

The observational temperament assessment at 8 months of age was based on a selection of episodes from the standardized Laboratory Temperament Assessment Battery Prelocomotor version (Goldsmith & Rothbart, 1999) designed to elicit behaviors picturing specific temperament traits. Episodes chosen for the study were Blocks, measuring duration of attention (intercorrelation between subscales: $r = .30$, inter-rater reliability: Cohen's $\kappa = .72–.79$), Masks measuring expressions of fear ($r = .45–.78$, $\kappa = .73–.83$) and Gentle Arm Restraint by parent measuring overall negative emotionality ($r = .48–.84$, $\kappa = .62–.79$). In addition to the original purpose, the arm restraint episode was used for assessing infant self-regulation by gaze aversion (inter-rater $r = .78–.95$) Episodes were videotaped and infant behaviors were coded by trained graduate and postgraduate students, including the author of the current thesis. Inter-rater reliability was calculated for 10% of the sample and remained at an acceptable level for all episodes.

4.3.3. Caregiving quality

Study III involves laboratory assessment of parent-child interaction utilizing the Emotional Availability Scales (EAS, Biringen, 2008). The assessment was carried out when the child was 8 months of age and is based on a 20-minute free play situation in the laboratory between the infant and mother, which was videotaped and coded by two trained coders. The coding results in estimates of interaction quality on a 7-point scale on four subscales: sensitivity, structuring, non-intrusiveness and non-hostility. Inter-rater reliability was assessed for 10% of the sample. Intraclass correlation coefficients were as follows: sensitivity .80, structuring .72, non-intrusiveness .85 and non-hostility .70. Consensus ratings were negotiated by the coders in cases of disagreement.

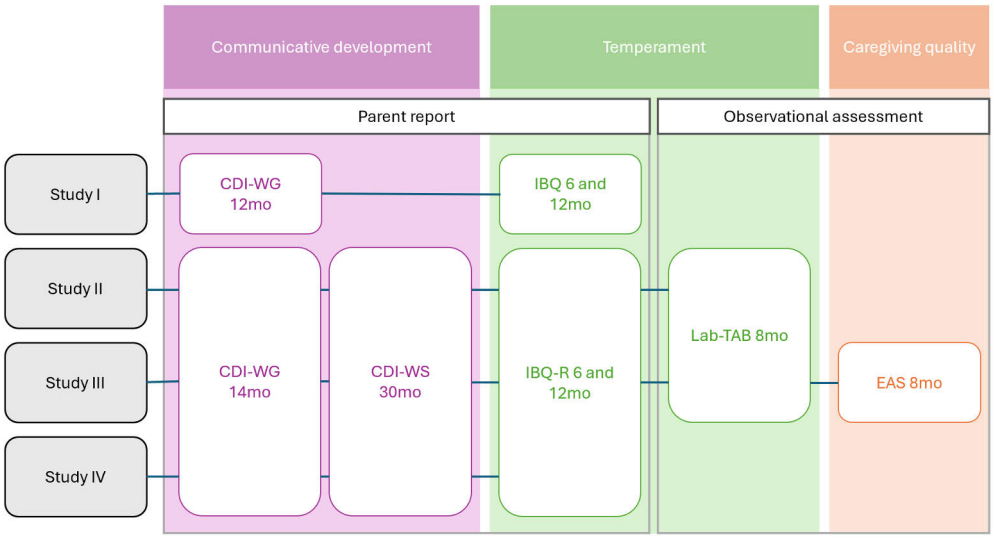
4.3.4. Covariates

Variables picturing background factors known to be related to infant communicative development (Berglund et al., 2005; Hoff-Ginsberg, 1998; Sohr-Preston & Scaramella, 2006; Zerbeto et al., 2015) were chosen as covariates in the analysis in order to control for confounding factors. The chosen covariates were child biological sex assigned at birth, maternal education level, number of siblings and gestational age, as well as maternal psychological distress in studies II-IV. Data on child gestational age and sex was obtained from the wellbeing services county of Southwest Finland (VARHA) records. Mothers

self-reported educational level during pregnancy and the number of siblings at different age points, of which the data from infant age 12 months primarily was used and completed with an earlier report if missing. A composite score for maternal psychological distress was created combining standardized self-reported measures of depressive symptoms using the Edinburgh Postnatal Depression Scale (EPDS, Cox et al., 1987) at 12 months postpartum and the anxiety subscale from the Symptom Checklist – 90 (SCL-90, Derogatis et al., 1973) at 6 months postpartum. Maternal vocabulary score from the Wechsler Adult Intelligence Scale – Fourth Edition Verbal Comprehension subscale (WAIS-IV VCI, Wechsler, 2012) was used as a proxy for maternal language skill in study III.

Figure 3

Overview of Measures Utilized in Studies I-IV



4.4. Statistical analyses

Descriptive statistics and zero-order correlations were calculated in IBM SPSS statistics versions 24-29 in studies I-III, as was regression analyses for studies I-II. For study IV, the analyses were carried out in R (v4.3.2, R Core Team, 2023). Additionally, in study III structural equation models were built using Mplus (v8.7 ,Muthén & Muthén, 1998-2017). *P*-values under .05 were considered statistically significant.

4.4.1. Study I

Two outliers were excluded from the receptive vocabulary variable. The distribution of the receptive vocabulary variable was improved by logarithm transformation, whereas the communicative gesturing sum variable could not be improved. Both were, however, considered close enough to a normal distribution to use parametric tests (Lumley et al., 2002). Pearson correlation coefficients were used for zero-order correlation analyses. Next, standard linear regression analyses were used to explore the variances explained by temperament variables in the communication dimensions. Variables were added manually and stepwise with covariates in the first step and temperament traits added in the next.

4.4.2. Study II

Square root transformation was used to improve normality in 14-month receptive vocabulary and 30-month expressive vocabulary. Gesture use was normally distributed. Zero-order correlations were calculated using Pearson correlation coefficient. Study II also utilized regression analyses to explore the associations between negative emotionality, self-regulation and communicative development. Standard linear regression analyses were used for the models where communicative gestures at 14 months, receptive lexicon at 14 months and expressive lexicon at 30 months were used as continuous outcomes. The expressive lexicon at 14 months was skewed towards zero and could not be improved by transformation, and hence was recoded into extreme groups as follows: a low expressive vocabulary group consisting of the infants with no words in their expressive vocabulary (n = 29), a high expressive vocabulary group of corresponding size consisting of the infants with the highest amount of reported spoken words (n = 30), whereas the remaining infants were designated to an intermediate expressive vocabulary group (n = 124). These groups were used as the outcome variable in multinomial logistic regression analysis to investigate the influence of negative emotionality and self-regulation on group designation. The Benjamini-Hochberg false discovery rate procedure was used at an alpha level $p < .05$ to correct for multiple comparisons.

4.4.3. Study III

In study III, the same transformations as in study II were used to improve the distribution of response variables. Spearman's correlation coefficient was used

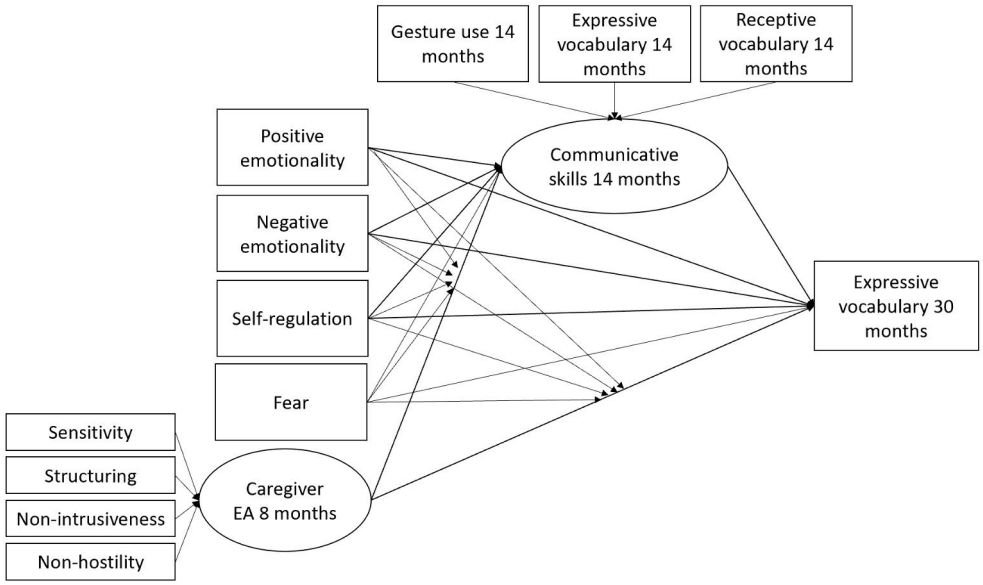
for calculating zero-order correlations since not all variables were normally distributed. Structural equation modeling (SEM) was used to explore associations between EA, temperament traits, covariates and communicative development. Due to non-normality of some variables, maximum likelihood estimation with robust standard errors was used. Creating a latent variable from different measures depicting core language skill is argued to give a purer estimate of language (Bornstein et al., 2016). The Benjamini-Hochberg false discovery rate procedure (alpha level < .05) was used to correct for multiple comparisons. First, a basic model of associations between EA and communicative skills was created. The model initially included a latent EA-variable consisting of the four EA-subscales and a latent communication variable consisting of gesturing, receptive and expressive vocabulary at 14 months as well as an observed variable for expressive vocabulary at 30 months. Paths between the EA-latent variable and both assessment points for communication were tested. Non-significant paths were removed to improve model fit. The model with best fit indices was chosen as basic model for further analyses (Hu & Bentler, 1999).

Next, moderation of temperament traits on the association between EA and communicative skills was tested by including interaction terms consisting of the EA-latent variable and each of the temperament traits. Separate interaction terms were created for all temperament traits (reported traits at 6 and 12 months and observed traits at 8 months) and tested separately in the basic model along with the corresponding main effects and all selected covariates. Paths were tested with 14-month communicative skills and 30-month vocabulary separately. Next, a log-likelihood ratio test with scaling correction factors (Satorra & Bentler, 2010) was used to compare model fit of possible models with significant interaction terms and the corresponding null models (i.e., the basic model with covariates but without the interaction term). A significant improvement of model fit according to the log-likelihood ratio test from including the interaction term was the criterion for regarding a moderation effect as significant (Maslowsky et al., 2015). Possible significant interaction terms were to be included in the final model. Finally, a final model was created by adding all temperament traits (reported traits at 6 and 12 months and observed traits at 8 months), covariates and possible significant interaction effects as predictors of 14-month communication and 30-month vocabulary to the basic model and stepwise removing non-significant paths until reaching models with acceptable fit. Possible competing models were to be compared by chi square difference testing using the Satorra-Bentler scaled

chi square (Satorra & Bentler, 2010). The theoretical path model to be tested is described in Figure 4.

Figure 4

Theoretical Path Model to be Tested in Study III (N = 151)



Note. The original figure can be found in Study III.

4.4.4. Study IV

Gesture use, M3L and all temperament variables were considered normally distributed by visual inspection. Receptive vocabulary was skewed but approached a normal distribution by square root transformation. Consequently and considering the large sample size (Lumley et al., 2002), these variables were considered suitable for use in hierarchical linear regression analysis. Expressive vocabulary was skewed due to an expected ceiling effect (Fenson et al., 1994) and did not resemble a normal distribution after transformation. Zero-order correlations were calculated using Spearman's rank order correlation coefficient. Due to a moderate amount of data being missing and not meeting MCAR-assumptions (Jakobsen et al., 2017) missing data was imputed using multiple imputations prior to use in regression models. Ten imputations using chained equations (MICE) was used (van Buuren & Groothuis-Oudshoorn, 2011). Two separate datasets with complete data on 14-

month receptive (N = 1200) and 30-month expressive (N = 1039) vocabulary were imputed. Continuous covariates correlating with any of the response variables at a level > .20 were added to regression models. In the first step of the model building, covariates (child sex, maternal education level and psychological distress score) were introduced. Continuous predictors were *z*-scored before being added to models. In the following step, temperament traits were added one by one in separate models to avoid multicollinearity. Lastly, all possible sex x temperament trait interaction effects were explored. Due to 30-months expressive vocabulary having a non-normal distribution, to avoid using it as dependent variable, temperament traits were modeled as a function of expressive vocabulary and covariates in linear regression models to yield conceptually equal results in a mathematically robust manner. Benjamini-Hochberg *p*-values with alpha level <.05 were calculated to correct for multiple comparisons per hypothesis.

5. Results

5.1. Descriptive statistics

Distributions for the study variables are presented in Tables 3-6. Distributions of the communicative development assessed by the CDI-WG and CDI-WS are presented in Table 3.

Table 3

Distributions for Communicative Development in Studies I-IV

Measure	Mean (SD), range			
	Study I	Study I	Study III	Study IV
CDI-WG 12/14mo[a]				
Communicative gestures (section II A)	10 (3), 0-17			
Actions and gestures (section II A-F)				36.0 (8.8), 6-63
Receptive vocabulary		72 (53), 1-210		121.7 (72.6), 0-336
Communicative gestures (section II A-F, % of total score)		55.0 (12.1), 9.0-87.9	54.6 (13.2), 9.1-87.9	
Receptive vocabulary (% of total score)		37.5 (20.1), 1.8-91.3	36.7 (19.4), 1.8-91.3	
Expressive vocabulary (% of total score)		3.3 (4.2), 0-26	2.8 (4.1), 0-35.5	
CDI-WS 30 mo				
Expressive vocabulary				409.4 (158.0), 0-594
Expressive vocabulary (% of total score)		71.2 (25.4), 4.6-100	71.1 (24.7), 2.0-100	
M3L				8.3 (3.4), 1-30

[a] CDI-WG was administered at 12 months in study I and at 14 months in studies II-IV.

Note. Study I: N = 91, study II: N = 183, study III: N = 151, study IV: N_{14mo} = 1200 and N_{30mo} = 1039. In studies I and IV, CDI raw scores were used and are reported in the table. In studies II and III % of the total score was used in order to be able to combine Finnish and Swedish versions of the CDI

In study I, based in the first phase of the FinnBrain-study, temperament was assessed by the IBQ, yielding measures on six temperament subscales. The distribution of these subscales are depicted in Table 4.

Table 4

Distributions for Temperament Assessed by the IBQ in Study I (N = 91)

Measure (theoretical range)	**Mean (SD), range**	
	6 months	**12 months**
Activity level (1-7)	4.55 (.81), 2.06-6.53	4.47 (.79), 2.18-6.41
Fear (1-7)	2.44 (.71), 1.07-4.27	2.65 (.63), 1.33-4.57
Duration of orienting (1-7)	3.22 (.93), 1.09-6.27	3.04 (.92), 1.18-5.80
Smiling and laughter (1-7)	4.74 (.92), 3.00-7.00	5.17 (.74), 3.33-6.60
Soothability (1-7)	4.87 (.83), 2.10-6.50)	5.05 (.79), 2.89-6.67
Distress to limitations (1-7)	3.34 (.74), 1.92-5.44	3.70 (.77), 2.22-5.85

In the consecutive studies based on data from the actual FinnBrain cohort sample, the revised IBQ-R form was used for temperament assessment. The distributions for the factors and subscale used in studies II-IV as well as the temperament dimensions measured observationally in episodes from the LabTAB in studies II and III are presented in Table 5.

Table 5

Distributions for Temperament Traits in Studies II (N = 183), III (N = 151) and IV (N_{14mo} = 1200 and N_{30mo} = 1039)

Measure (theoretical range)	Mean (SD), range		
	Study II	Study III	Study IV[a]
IBQ-R 6 months (1-7)			
Positive emotionality		4.6 (.8), 2.5-6.3	4.7 (.7), 2.5-6.6
Negative emotionality	2.9 (.8), 1.4-5.0	3.0 (.8), 1.5-5.0	3.0 (.8), 1.2-6.5
Self-regulation	5.3 (.6), 3.4-6.6	5.3 (.6), 3.4-6.6	5.3 (.6), 3.0-7.0
Fear	2.4 (1.1), 1.0-5.7	2.6 (1.2), 1.0-6.0)	
IBQ-R 12 months (1-7)			
Positive emotionality		5.1 (.6), 3.6-6.3	5.1 (.6), 3.2-6.5
Negative emotionality	3.2 (.7), 1.6-5.5	3.3 (.7), 1.6-4.8	3.3 (.7), 1.5-5.5
Self-regulation	5.1 (.6), 3.4-6.3	5.0 (.7), 3.1-6.3	5.0 (.6), 2.4-6.7
Fear	3.0 (1.2), 1.0-6.3	2.9 (1.2), 1.0-6.3	
LabTAB 8 months			
Negative emotionality (0-11)	4.4 (1.9), .05-8.3	4.5 (2.0), .5-8.2	
Self-regulation (0-60)	21.0 (9.9), 0-50	21.7 (10.3), 0-54	
Fear (0-14)	3.5 (2.1), 0-10	3.7 (2.3), 0-21.1	
Attentiveness (0-5)	3.7 (.5), 2.1-4.7	3.7 (.6), .8-4.7	

[a] Study IV included two subsamples used in different analyses (based on availability of 14 month and 30 month communication variables) for which multiple imputation was carried out, but for the sake of brevity only non-imputed descriptive statistics for the sample used in analyses with 14-month communicative development are reported here as *M* and *SD* were identical between the imputed and non-imputed as well as 14-month and 30-month samples and range varied by ≤ .5.

In study III, caregiving quality was assessed using the EAS. Subscale distributions are presented in Table 6.

Table 6

Distributions for EAS at 8 Months in Study III (N = 151)

Scale (theoretical range)	Mean (SD), range
Sensitivity (1-7)	5.3 (1.3), 2-7
Structuring (1-7)	5.0 (1.5), 2-7
Non-intrusiveness (1-7)	5.7 (2.0), 1-7
Non-hostility (1-7)	6.1 (1.0), 3-7

5.2. Positive emotionality and communicative development

In study I, the subscale Smiling and laughter, considered a part of the positive emotionality temperament trait had a positive association with infant communicative gesturing (B = 0.98, [95% CI 0.04-1.92], p = .04), accounting for 4% of the variance respectively. In study III, positive emotionality was the only infant temperament trait to significantly predict communicative skills in the SEM alongside caregiving quality and infant sex as the other significant predictors (see Figure 6).

In study IV, the results of linear regression analyses also showed positive associations between the infant temperament traits of positive emotionality and all communicative skills except M3L. More specifically, positive emotionality at 6 and 12 months of age was positively associated with gesturing at 14 months (B for positive emotionality at 6 months = 2.89[2.40-3.39], p <.001, and at 12 months = 3.09[2.56-3.61], p <.001). The same traits were also positively associated with receptive vocabulary at 14 months (B for positive emotionality at 6 months = 0.79[0.58-0.99], p <.001, and at 12 months = 0.76[0.54-0.97], p <.001,), as well as with expressive vocabulary at 30-months (B for vocabulary as a predictor of positive emotionality at 6 months = 0.08[0.04-0.13], p <.001, and at 12 months = 0.10[0.06-0.14], p <.001)[1]. See Figures 2-4 in study IV for visualizations of the associations. Positive emotionality explained most of the variance in gesturing (10 and 11%), whereas values were more modest for the language outcomes (4-5% of receptive vocabulary and 1-3% for 30-month expressive vocabulary).

5.3. Negative emotionality and communicative development

In study II, infants with higher negative emotionality assessed observationally more likely belonged to high expressive vocabulary group than the intermediate group (B =−0.18, p = .04, Benjamini-Hochberg p-value = .52, $\Delta Cox\&Snell R^2$ = .03), but the finding did not remain statistically significant after correcting for multiple comparisons. Reported and observed negative emotionality had modest and non-significant correlations. No additional main effects of negative emotionality or the subscale of fear were found in any of the

[1] Due to the non-normal distribution of 30-month expressive vocabulary, models were built with positive emotionality as the dependent variable and vocabulary and covariates as predictors as an analytically equivalent option to analyze the conceptual association between infant temperament and toddlerhood expressive vocabulary

studies within the thesis, neither when assessed observationally nor by parent report.

However, infant sex by 6-month negative emotionality interaction effects had significant associations with receptive vocabulary at 14 months (B = -0.55[-0.97—0.14], p = .009, corrected p = .039, ΔR^2 = .00) and 30-month expressive vocabulary (B = -0.16[-0.25—0.06], p < .001, corrected p = .005, ΔR^2 = .01). Both effects suggested that negative emotionality at 6 months was negatively associated with language skills in girls only, whereas boys higher in this trait at 6 months tended to have larger expressive vocabularies at 30 months. However, although statistically significant, these effects explained only marginal amounts of variance in the communicative skills.

5.4. Self-regulation and communicative development

Two of the subscales measured in study I considered to be aspects of self-regulation showed associations with communicative gesturing in infancy. More specifically, 6-month Soothability (B = 1.06[0.32-1.80], p < .01) was longitudinally associated with use of communicative gestures at 12 months and accounted for 7% of the variance, whereas concurrently at 12 months, gesturing was associated with Duration of orienting (B = .70[0.06-1.34], p = .03), accounting for 4% of the variance.

In study II, self-regulation was assessed both by parent report and observationally. The corresponding reported and observed measures showed modest and statistically non-significant correlations. Regression analyses showed that self-regulation by gaze aversion negatively predicted receptive vocabulary at 14 months (B =−.03[-0.05—0.00], p = .02, Benjamini-Hochberg p-value = .06, ΔR^2 = .02), and infants using more gaze aversion were more likely to belong to the no words- and intermediate expressive vocabulary groups than the high vocabulary group (intermediate vs. high: B =.05, p = .04, Benjamini-Hochberg p-value = .06 and high vs. no words: B =−.07, p = .04, Benjamini-Hochberg p-value = .08, $\Delta Cox\&Snell R^2$ = .04). In turn, reported self-regulation at 6 and 12 months positively predicted gesturing (B =3.12[0.26-5.99], p = .03, Benjamini-Hochberg p-value = 0.10, ΔR^2 = .02 and B =5.48[2.51-8.47], p = .00, Benjamini-Hochberg p-value = .01, ΔR^2 = .07) and 6-month self-regulation positively predicted receptive vocabulary (B =0.49[0.09-0.88], p = 0.02, Benjamini-Hochberg p-value = 0.10, ΔR^2 = .03). Thus, the only finding to survive correction for multiple comparisons was 12-month reported self-regulation predicting gesturing. Observations of infant attentiveness,

considered a part of the self-regulation trait, had no significant associations with any communicative skill.

In study III, no significant associations with self-regulation assessed either by parent report or observation and communicative skills at 14 months or expressive vocabulary at 30 months were found in the SEM including EA, temperament traits and covariates (see Figure 6).

In study IV, the results of linear regression analyses showed positive associations between self-regulation and all communicative skills except M3L. That is, self-regulation at 6 and 12 months was positively associated with gesturing at 14 months of age (*B* for self-regulation at 6 months = 1.90[1.38-2.42], p <.001, and at 12 months = 2.40[1.87-2.94], p <.001). This trait was also positively associated with receptive vocabulary at 14 months (*B* for self-regulation at 6 months = 0.54[0.32-0.76], *p* <.001, and at 12 months = 0.61[0.39-0.82], *p* <.001), as well as with 30-month expressive vocabulary (*B* for vocabulary as a predictor of self-regulation at 6 months = 0.05[0.01-0.09], *p* <.001, and at 12 months = 0.06[0.02-0.10], *p* <.001)[2]. See Figures 2-4 in Study IV for visualizations of the associations. Self-regulation at 6 and 12 months positively predicted 14-month gesturing (explained 4 and 6% of the variance), receptive vocabulary (explained 2 and 3% of the variance) and expressive vocabulary (explained 0-1% of the variance).

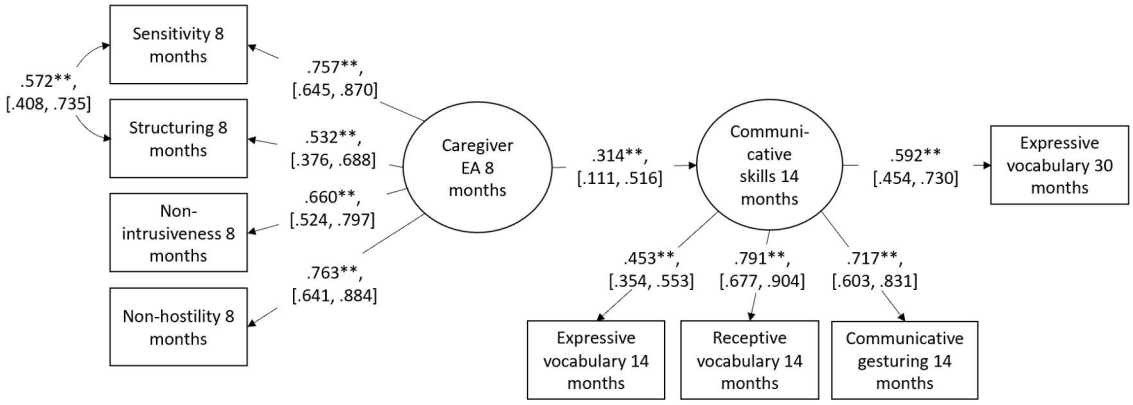
5.5. Emotional availability, temperament, and communicative development

In study III, SEM was used to model associations between caregiving quality assessed as EA and communicative skills in infancy and expressive vocabulary in toddlerhood. The basic model of the associations with the best fit is depicted in Figure 5. The model with one latent variable comprising all EA-scales had better fit than one with separate latent variables for positive (sensitivity and structuring) and negative (non-intrusiveness and non-hostility) parenting. EA at 8 months was not directly associated with 30-month vocabulary but had an indirect effect on 30-month vocabulary through 14-month communication (β = 0.19, *p* = .003).

[2] Due to the non-normal distribution of 30-month expressive vocabulary, models were built with self-regulation as the dependent variable and vocabulary and covariates as predictors as an analytically equivalent option to analyze the conceptual association between infant temperament and toddlerhood expressive vocabulary

Figure 5

Basic Path Model Describing Associations between Emotional Availability and Communicative Development

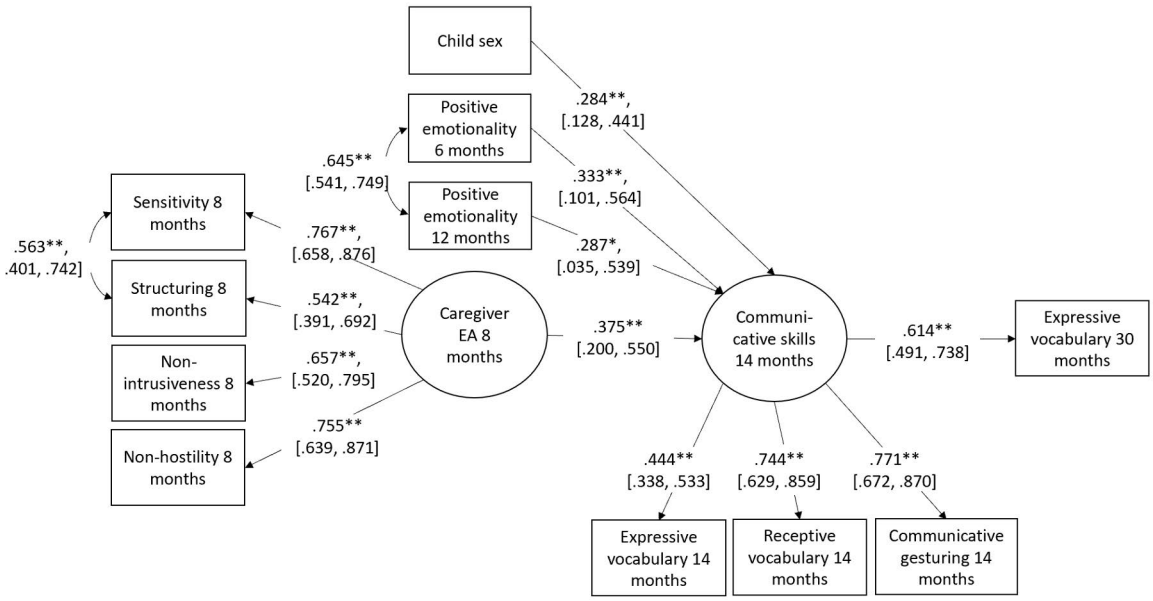


Note. $\chi^2(18) = 13.6$, $p = .757$, *RMSEA* = .00, *CFI* = 1.00, *TLI* = 1.00, *SRMR* = .03. Standardized coefficients. $^{**}p < .01$. The original figure can be found in Study III.

The tests of interaction effects between EA and temperament traits in study III showed no effects that remained significant after correcting for multiple comparisons. Results thus indicated that EA was associated with early communication development regardless of infant temperament. The final model was created by including all temperament traits and covariates as predictors of 14-month communicative skills in the model and then removing non-significant predictors until acceptable fit was achieved. Competing models of acceptable fit were compared using Satorra-Bentler chi square difference test. The best fitted final model involving paths with significant main effects is depicted in Figure 6.

Figure 6

Final Path Model Describing Associations between Emotional Availability, Infant Temperament, Covariates, and Communicative Development in Study III (N = 151)



Note. $\chi^2(39) = 46.3$, p = .1978, RMSEA = .04, CFI = .98, TLI = .98, SRMR = .05. Standardized coefficients. *$p < .05$, **$p < .01$. The original figure can be found in Study III.

5.6. Summary of the main results

A summary of the associations between infant temperament and early communicative skills found in the studies within the thesis is presented in Figure 7. Results suggested that positive emotionality was the infant temperament trait most strongly associated with communicative development in infancy and toddlerhood, showing significant positive relations over several measurements and different studies. Parent-reported self-regulation (or its facets) also presented positive associations with several communicative outcomes. However, observed self-regulation by gaze aversion showed a modest negative association with receptive and expressive vocabulary in infancy. Observational and parent reported temperament seem to have different relations to communicative development. Negative emotionality was not associated with communicative development in our studies. Finally,

caregiving quality assessed as EA was positively associated with communication skills in infancy and indirectly with toddlerhood expressive vocabulary through its relationship with infant communication. Additionally, this association was found regardless of infant temperament, since no interaction effects between temperament and EA in relation to communication development were found. The strongest associations between temperament and communicative development were found with infant gesturing, an outcome scarcely studied in previous literature. An overview of the associations between infant temperament, caregiver EA and early communicative skills found is provided in Figure 8.

Figure 7

Summary of the Associations between Temperament and Communicative Skills Found in the Thesis

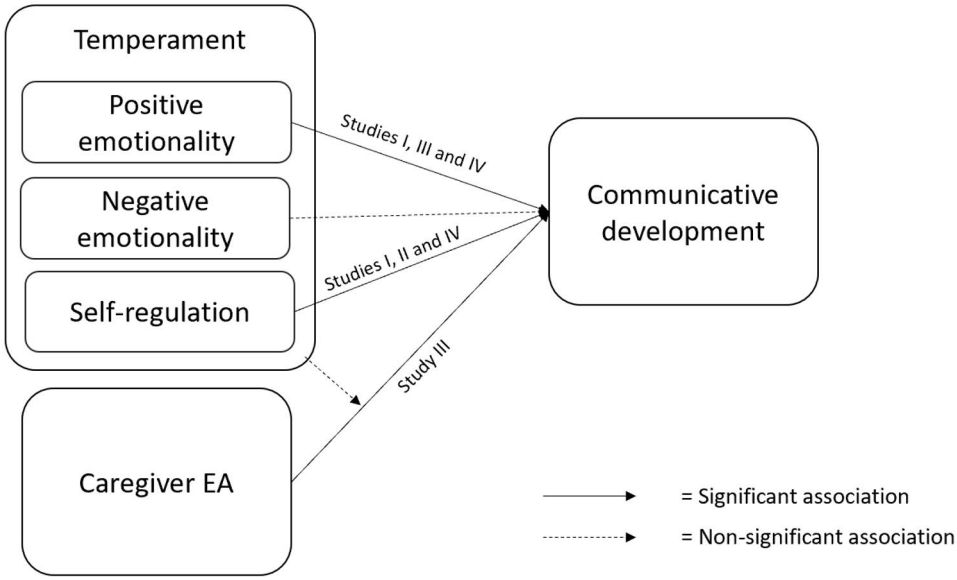
Temperament trait	Study	Gesturing 12/14 months[a]	Receptive vocabulary 14 months	Expressive vocabulary 14 months[b]	Communicative skills 14 months	Expressive vocabulary 30 months	M3L 30 months
Positive emotionality (reported)	I[c]	12 months					
	III				6 months 12 months		
	IV	6 months 12 months	6 months 12 months			6 months 12 months	
Negative emotionality (reported)	I						
	II						
	III						
	IV						
Negative emotionality (observed)	II			8 months[f]			
	III						
Self-regulation (reported)	I	6 months[d] 12 months[e]					
	II	6 months[f] 12 months	6 months[f]				
	III						
	IV	6 months 12 months	6 months 12 months			6 months 12 months	
Self-regulation (observed)	II		8 months[f]	8 months[f]			
	III						

Positive association:
Weak/tentative positive association:
Negative association:
Weak/tentative negative association:
No significant association:
Not applicable:

Note. Months reported within the table refer to the age at which temperament was assessed. M3L = mean length of 3 longest utterances.
[a] gesturing reported at 12mo in study I and 14mo in studies II-IV
[b] based on logistic regression with vocabulary divided into groups with high, intermediate and low expressive vocabulary at 14 months
[c] positive emotionality assessed by subscale *Smiling and laughter*
[d] self-regulation assessed by subscale *Soothability*
[e] self-regulation assessed by subscale *Duration of orienting*
[f] association did not survive correction for multiple comparisons

Figure 8

Summary of the Associations between Infant Temperament, Caregiver EA, and Communicative Development Found in the Thesis



6. Discussion

The overarching aim of the current thesis was to study the associations between infant temperament and infant and toddler communicative development. Additionally, the thesis aimed to explore the role of emotional caregiving quality (EA) and possible moderation effects between temperament and EA in relation to early communicative development. Based on prior research we hypothesized that infant positive emotionality and self-regulation would have positive associations with communicative skills, whereas previous findings regarding negative emotionality made it difficult to formulate a directional hypothesis regarding the trait. Further, we hypothesized caregiver EA would be positively associated with communicative development and that its implications may differ depending on infant temperament.

The general hypotheses above were mainly supported by our findings, as we found compelling evidence of positive emotionality being positively associated with several communicative domains over infancy and toddlerhood. Moreover, parent-reported self-regulation was positively associated with several communicative domains. We did not find evidence of infant negative emotionality being associated with communicative development. Further, we found a positive association between caregiving quality assessed as EA and communicative development as hypothesized. However, contrary to our hypothesis, we did not find evidence of interaction effects between caregiver EA and any temperament trait as predictors of communicative skills. Overall, our results suggest temperament and caregiver EA are independently related to communicative development in infancy. Findings are discussed in the following chapters.

6.1. Positive emotionality

The relation between temperament and communicative development with most robust evidence in previous studies seems to be the positive association between positive emotionality and communicative skills (e.g., Bruce et al., 2022; Dixon & Smith, 2000; Laake & Bridgett, 2014). As expected, it was significantly associated with communicative skills in the current thesis as well. More specifically, smiling and laughter, an aspect of positive emotionality, was associated with communicative gesturing at 12 months in study I. Further, infant positive emotionality had a significant association with 14-month total

communication in study III. Finally, positive emotionality was significantly related to most communicative measures in study IV.

Positive emotionality had the largest effect sizes in the studies and was the only temperament trait that remained a significant predictor of communicative skills in the SEM-model, alongside other temperament traits in study III. This indicates that positive emotionality may be the most prominent temperament trait contributing to communicative development. Explaining how positive emotionality may relate to communicative development seems rather straightforward based on in theories emphasizing the social interactional basis for language development (Bruner, 1975; Tomasello, 2015), as well as individual factors related to effort and engagement contributing to the process (Bloom et al., 2001). The trait of positive emotionality contains dimensions of extraversion, and hence is linked to seeking out and enjoying social interaction, simultaneously increasing communicative and language input (Laake & Bridgett, 2014). In other words, since infants rely on interaction partners to develop communicative and language skills, behaviors and tendencies that result in interaction and communication with others are likely to support this development. Initially, Bloom and Capatides (1987) theorized a more neutral emotional state would be optimal for language development due to allowing more cognitive resources to be focused on language. However, positive emotionality may instead primarily serve as motivation to allocate resources to communication, thus supporting communicative development more than neutral emotional tendencies. Later in childhood, as verbal language becomes more advanced, the links with verbal language may become stronger. As nonverbal communication is rarely assessed in older children, finding studies comparing relations between positive emotionality and nonverbal and verbal communication at later ages is difficult.

In the context of positive emotionality/extraversion and communication, the discussion of underlying ability versus expression needs to be introduced. Fenson and colleagues attribute some of the differences in early vocabulary to possibly adhere to the infant being "cautious" in trying to produce words (Fenson et al., 1994, p.64). Being socially cautious, i.e., less extroverted, may indeed influence how expressive the child is. Consequently, the level of positive emotionality may, to some degree, be more related to the *expression* of communicative skills than the underlying skill itself. Parent reports are probably less affected by the level of child extraversion, but even in the most primary relationship, the level of extraversion may relate to how eager the child is to display what communicative skills they have acquired. Future

studies could utilize measures of language and communication that are less dependent on interpersonal interaction, such as eye tracking or brain imaging.

6.2. Negative emotionality

In contrast to the case with positive emotionality, the role of negative emotionality in the context of communicative development is debated. Results of opposite directions as well as null findings are reported in the literature. Our studies combined arrive at the conclusion that negative emotionality does not seem to be significantly related to communicative development in our sample. Nevertheless, in study II, higher infant negative emotionality assessed observationally showed a trend for positive associations with infant expressive vocabulary. Although the finding did not survive correction for multiple comparisons, infants higher in negative emotionality initially seemed more likely to belong to the high expressive vocabulary group than to the intermediate group. Further, for fear specifically, no significant associations were found in either the observed or reported condition at any of the age points, but the coefficients were positive.

Studies suggest that infant/early toddlerhood negative emotionality and communication tend to be positively related, whereas the direction of associations changes in toddlerhood (Bruce et al., 2022; Nozadi et al., 2013). This shift is attributed to expression of negative emotions serving as communicative expressions or motivation to communicate when accompanied by limited verbal skills in infancy, whereas it is less adaptive in toddlerhood when verbal expressive skills are available (Bruce et al., 2022; Nozadi et al., 2013). It, however, remains unknown when this hypothetical shift occurs. Assuming there is a shift in the direction of how negative emotionality associates with communicative development, slight differences in age of assessment in our sample may possibly explain the lack of significant findings. As for gesturing, the explanation for the differences between our study and that of Bruce et al. (2022) may lie in the definition of gesturing. Namely, they used only the communicative gestures section of the CDI, whereas we included the sections involving actions with objects and symbolic play behaviors. It is possible that negative emotionality in infancy is related on a higher level to communicative gestures specifically, i.e., gestures likely used for requesting support from an adult. Hence associations may not have reached significance with the wider conceptualization of gesturing additionally involving actions with objects and symbolic play used by us.

Evidence for emerging associations between vocabulary and self-regulation grows stronger over childhood as vocabulary becomes more advanced (Vallotton & Ayoub, 2011), suggesting the ability to verbally express emotions develops over several years. In analogy, if associations between negative emotionality and communicative development change in direction longitudinally, this could also be assumed to happen over the course of several years. If associations are expected to become negative at the age typically developing children tend to be able to express negative emotions verbally, this probably occurs outside of the age range studied here. This could, in turn, explain such findings being missing in our studies. However, positive associations between negative emotionality and communicative skills are often explained by the fact that negative emotionality entails a higher need to communicate for regulatory purposes (Bruce et al., 2022). Consequently, another possibility is that this association is reflected in the association between self-regulation and communicative skills instead in our studies.

Perhaps more likely, differences when comparing our findings to others may also be due to sample characteristics. The FinnBrain sample is of relatively high psychosocial wellbeing and SES, and caregiver EA was relatively high throughout the sample. High parental stress is related to perceptions of higher negative emotionality in infants (Räikkönen et al., 2006). Thus, better caregiver wellbeing may result in less variance in the report of negative emotionality, dampening its possible associations with communicative development. High negative emotional reactivity in previous studies is argued to both drive interaction by initiating coregulation (Bruce et al., 2022), but also to have negative associations with communicative development by the aroused state not allowing as much focus on communication and language input (Bloom & Capatides, 1987). If both arguments hold place, the positive and negative effects may balance each other out. According to the hypothesis of negative emotionality being related to communicative development through its influence on caregiver-infant interaction, possible relations will reasonably depend on caregiver factors such as SES, wellbeing, and EA. However, also the possible negative consequences of negative emotionality taxing attentional resources may be diminished by high-quality caregiving helping the child regulate their emotions and providing communicative input in the process. This will be discussed further in chapter 6.4.

Furthermore, apart from sample characteristics, societal factors may also play a part in associations being missing in our sample. On a global level, parent ratings of negative emotionality in children was the lowest in Finland and the

other Nordic countries (Putnam et al., 2024). These differences may be due either to parents rating temperament differently or to actual temperamental differences between children from different parts of the world (Putnam et al., 2024). Both explanations could, however, explain negative emotionality not being related to communicative development in our sample. Relatively low negative emotionality may simply not influence communication, or parents not perceiving emotional expressions as particularly negative may be less likely to be influenced in their interaction with the infant by these expressions.

Lastly, significant, but weak, associations between sex by 6-month negative emotionality and 14-month receptive and 30-month expressive vocabulary emerged in study IV. These associations suggested negative emotionality was negatively associated with vocabulary in girls only. As the interaction effect explained only 0-1% of the variance in vocabulary, it is of little clinical relevance. However, theoretically these tentative associations suggest sex differences in associations between early infancy negative emotionality and later communicative development could warrant further exploration.

To conclude, our results combined do not indicate any aspect of negative emotionality in infancy being either a risk or protective factor for infant or toddler communicative development in our relatively low risk sample.

6.3. Self-regulation

Early self-regulation reported by parents has been linked to dimensions of communicative development, such as early vocalizations and receptive and expressive language skills, in some previous research (Bruce et al., 2022; Dixon & Smith, 2000; Gartstein et al., 2008; Morales et al., 2000; Spinelli et al., 2018). However, not all studies have found such associations (Kubicek & Emde, 2012). Uncertainty remains regarding when associations between emerging self-regulatory ability and different communicative skills start to emerge and whether such associations can be found also when self-regulation is assessed observationally.

Positive associations between reported emerging self-regulation and communicative development are a robust finding in the thesis, as duration of orienting and soothability in study I was associated with 12-month gesturing, the self-regulation factor trait in study II was associated with 14-month gesturing and 6- and 12-month self-regulation was significantly positively related to most communicative outcomes in study IV.

Results from study II show that the relations between self-regulation and communicative skills depend on mode of assessment. Observed self-regulation by gaze aversion showed a tendency of being negatively related to receptive and expressive lexicon, whereas self-regulation assessed by parents was associated with higher use of preverbal gesturing, as well as a tendency for higher receptive vocabulary. These results may suggest fine-grained aspects of self-regulation and the general self-regulation dimension have different associations with vocabulary. Namely, gaze aversion is a narrower measure of use of orienting to regulate distress, whereas the reported self-regulation is based on assessment of different sorts of infant orienting and regulation over a variety of situations. As is argued in the literature, observed and reported temperament measures do not always fully agree (Freund, 2019; Stifter et al., 2008) and may represent different underlying constructs of temperament. The observational assessment episodes used in the study are designed to elicit expression of a specific temperament trait and are standardized, with minimal opportunities for parent-infant interaction. Thus, self-regulation by gaze aversion may be interpreted as an avoidant, non-social regulatory strategy, and high use of this strategy may not be supportive of communicative development. This hypothesis needs further exploration in future research.

Also unexpectedly, observed attentiveness did not significantly relate to any communicative skill in study II, although it has been linked to communicative development in some previous work in infants. However, those studies have typically used parent reports of attentiveness (Gartstein et al., 2008). Possibly the social aspect could explain this lack of findings, too. The episode we used for observational attentiveness assessment is based on the infant playing independently with minimal adult involvement. This particular sort of attentiveness in non-social play is less likely to support communicative development. In sum, the subdimensions of the temperament trait self-regulation in infancy (e.g., social vs. independent regulatory strategies and attentiveness) need further exploration to gain understanding of how they independently relate to communicative development.

Whereas our findings regarding specific aspects of self-regulation are less easily interpreted, the findings regarding parent-reported overall self-regulation consistently show positive associations with communicative skills. When using parent report, self-regulation is assessed over a longer period of time in the child's natural environment. This viewpoint on self-regulation is perhaps most naturally associated with communicative development. It depicts the child's typical everyday functioning and is likely to reflect the

coregulation of the child and parent, which will probably carry over into parent reports of temperament. That is, high reported infant self-regulation is likely to be accompanied by well-functioning parent-child coregulation (Rothbart et al., 2004), which in turn relies on interaction supporting communicative development. In addition, in suggested theories, successfully regulated emotions is linked to a more optimal state for acquiring communicative skills in improving cognitive focus on communicative input (Bloom & Capatides, 1987).

Taken together, the findings suggest that overall self-regulation assessed by parents in natural settings is positively related to some measures of language development starting from the first half of the first year of life, but especially to gesturing. The contradictory findings of observationally assessed self-regulation imply further studies are needed to gain better understanding of how different fine-grained aspects of self-regulation in infancy are related to early communicative development.

6.4. Emotional availability

Positive associations between caregiving factors and child communication development have rather consistently been reported in existing literature (Frick et al., 2019; Leigh et al., 2011; Nozadi et al., 2013; Paavola et al., 2006; Tamis-LeMonda et al., 2001). The findings of the current thesis add to this literature by finding associations utilizing the EA-framework emphasizing the emotional, rather than communicative, aspects of caregiving. More specifically, the results of study III show that caregiving quality assessed as EA in infancy was positively associated with communicative skills at 14 months of age. In other words, high caregiver EA, including the constructs of sensitivity, structuring, non-intrusiveness and non-hostility, is related to stronger communicative skills.

Our results suggest that an emotional view of caregiving quality using the EA-framework can explain variance in communicative development without explicitly assessing caregiver language dimensions. Parallels can be drawn between the scaffolding taking place in the EA-scale structuring and scaffolding evident in concepts of child-directed speech (Rowe, 2012) and parental gesturing as support of language development (Choi & Rowe, 2021), with the obvious exception that structuring is independent of parent language. However, higher EA is likely to be accompanied by higher quality and/or quantity of caregiver communicative input as well. That is, a high-EA caregiving

context serves as a platform for caregiver-child interaction which is likely to involve different kinds of joint acts supporting communication development. In comparison, Rantalainen (2023), who studied associations between maternal responsive utterances found, to their surprise, that maternal use of verbal fillers, with little semantic content, was positively associated with child language skills in toddlerhood. This led the author to conclude these fillers and other maternal behaviors conveying interest and warmth may suffice to encourage interaction and thus support language development although not having rich language content themselves (Rantalainen, 2023). However, these results do not warrant claiming the positive associations adhere solely to emotional dimensions of caregiving.

Furthermore, it is also worth noting that we used caregiver EA as a continuous measure. In comparison, Paavola et al. (2006), who used a categorical variable for maternal sensitivity, found no difference in communicative skills between adequately and highly sensitive mothers. This suggests no additional advantage of higher maternal sensitivity beyond the threshold of adequate. Further research is needed to examine whether the same applies to EA and to gain a deeper understanding of the interplay between different levels of EA and infant communicative development.

In addition to studies involving different measures of caregiving quality, often involving some degree of caregiver communication, the importance of caregiver communication and language use specifically has also been documented in research (Ger et al., 2018; Gros-Louis et al., 2014; Huttenlocher et al., 1991; Miller & Lossia, 2013; Tamis-Lemonda et al., 1998), as well as dyadic measures of conversation turns (Fields-Olivieri et al., 2024). As the studies we are aware of, including our own, provide measures of either caregiver language use or caregiving quality or a mix within the same measure, the field of research is yet to provide explanations of which aspects of parenting are related to communicative development and how.

EA assessed at 8 months was not directly associated with 30-month expressive vocabulary but had an indirect effect through 14-month communicative skills. In other words, the direct association between EA in infancy and expressive vocabulary in toddlerhood did not reach statistical significance, likely due to the relatively long time passing between assessments. However, the finding of an indirect effect can be interpreted as early EA supporting early communicative skills, and these relatively stronger early skills serve as a good foundation for building vocabulary in toddlerhood. Additional EA assessments in toddlerhood would be needed in order to analyze

possible longitudinal changes in the relationship between EA and communicative development.

In the same structural equation model as EA, temperamental positive emotionality was also significantly related to communicative skills. However, contrary to previous proposals (e.g., Laake & Bridgett, 2018), we found no evidence for any temperament trait interacting with caregiver EA in terms of communicative development. Thus, caregiver EA contributed to communicative development regardless of infant temperament traits. This may be due to the emotional view within the caregiving measure applied. Perhaps child temperament is more linked to parental communication and language input. That is, a parent possibly has more verbal and gestural communication with, for example, a child with high positive emotionality showing interest in interacting, whereas the emotional undertone and warmth in the relationship is more likely to be similar also in cases where the child expresses less positive emotionality. Additionally, positive emotionality may particularly elicit more communicative input from persons other than the primary caregivers. That is, the communicative behavior of more unfamiliar persons may be more affected by how keen the infant is to communicate as compared to the communicative habits of their caregivers. Communicating with a variety of speakers has been found to have positive associations with language development (Rost & McMurray, 2009).

On a related note, another possible explanation for missing moderation effects is sample characteristics. In this relatively low psychosocial risk sample, few mothers displayed behaviors raising concern in interacting with their children. Associations between child temperament and caregiving have been shown to depend on sample characteristics. For example, negative emotionality in children is associated with less supportive caregiving behavior in lower SES families, whereas opposite relations are seen in high SES contexts (Paulussen-Hoogeboom et al., 2007). If the same phenomenon can be generalized to EA, it is likely only the positive associations are represented in our high-SES, high-EA sample. That is, high-EA mothers are less likely to react to their infants' expressions of, for example, negative emotions or dysregulation in ways that could hinder communicative development, such as ignoring them or becoming overtly frustrated. Possibly moderation effects of temperament on caregiving are visible only in samples where some individuals show highly problematic caregiving behaviors with their children.

As discussed concerning negative emotionality in chapter 6.2., societal and cultural factors associated with the ratings of temperament may also partially

underlie the lack of some hypothesized associations. That is, parents rate their children's temperament differently in different parts of the world, and different temperament traits are perceived differently in different cultures (Putnam et al., 2024). For instance, Finnish parents tend to rate their children relatively high on self-regulation and low on negative emotionality (Putnam et al., 2024). This may also have implications for the interplay between temperament and caregiving factors; caregivers in different parts of the world may be influenced differently in their caregiving quality by their child's temperament. For example, high levels of a specific temperament trait in an infant may be regarded as a good or bad quality depending on culture. This, in turn, is likely to affect how infants high in such a trait are interacted with in different cultural settings (Chen, 2018). Further, cultural differences are also present in how caregivers communicate with their children (Hoff, 2006). This has implications, for example, for how much, and about what, caregivers communicate with their children. This, in turn, is found to relate to the course of early communicative development (for a review, see Hoff, 2006). Insofar, culture-dependent relations between caregiving, temperament and communicative development are, however, poorly understood and require further study with multi-national samples.

In summary, study III provides evidence indicating that parental EA in infancy is positively associated with communicative skills at 14 months. This indicates that high caregiver EA contributes to laying a strong foundation for communicative development. In our sample, we did not find evidence of infant temperament moderating the association between EA and communicative development, suggesting caregiver EA is related to communicative development regardless of infant temperament.

6.5. Gesturing is more strongly related to temperament than verbal skills

Generally, across our studies, relations between infant temperament and communicative skills were the strongest with 14-month gesturing as compared to verbal measures. More specifically, the association between positive emotionality and gesturing in infancy was stronger than with verbal language outcomes in both study I and IV. The reason for positive emotionality being most related to higher use of gesturing and symbolic play behaviors assessed in the CDI-WG gesturing scales could be that modalities for expressions of positive emotionality and gesturing are more closely linked than emotional

expression and verbal skills at this age. Hence, positive emotionality and the approach tendencies it involves are perhaps most conveniently and easily expressed as gesturing and engaging in play with caregivers at this age.

Further, self-regulation in studies I and IV also had the strongest associations with gesturing. The only other study we are aware of investigating early self-regulation and gesturing (Bruce et al., 2022) did not find reported self-regulation to relate to 10-month gesturing. This is surprising since self-regulation in our studies had the most robust and strong relations with gesturing compared to the verbal outcomes. However, relations to early vocalizations and receptive and expressive language are frequently reported in the literature(Bruce et al., 2022; Dixon & Smith, 2000; Gartstein et al., 2008; Morales et al., 2000; Spinelli et al., 2018). The early assessment of self-regulatory abilities in our study may explain the relatively weaker associations with later verbal outcomes. Self-regulatory skills undergo tremendous maturation and development during the first years (Rothbart & Bates, 2006), which may explain why earlier measures of the dimension have limited explanatory value for later outcomes. Involving later measures of self-regulation would be necessary to evaluate longitudinal change in associations. The maturation perspective does, however, not explain why we found associations of very early self-regulation with infant gesturing whereas (Bruce et al., 2022) did not. The explanation may lie in the 2-4-month gap between measures of gesturing in these two studies. Gesturing does develop significantly between the age of 10 months when it was assessed by (Bruce et al., 2022) and 12 (study I) or 14 (study II and IV) months when it was assessed in our studies. The first intentional communicative gestures have recently started to emerge at 10 months (Fenson et al., 1994; Goodwyn et al., 2000; Tomasello et al., 2007). Consequently, by the age of 12 or 14 months, when gesturing has developed further, inter-individual variability is significantly larger and subtle effects of self-regulation are more likely found.

In sum, our findings combined imply that preverbal gesturing is the dimension of emerging communicative skills most clearly linked to infant temperament. Comparing this finding to other studies proves difficult since very few have studied gesturing, and the assessment points do not match. For example, Bruce et al. (2022) did not assess gesturing and verbal skills concurrently, and hence effect sizes are not comparable. However, considering gesturing precedes expressive language (Iverson & Goldin-Meadow, 2005), it reaches larger variability by the age of 14 months. Furthermore, early caregiving factors have been found to relate to infant gesturing and symbolic

behaviors over and above early verbal expressive skills in the study by Paavola et al. (2006), possibly suggesting early nonverbal communication is particularly sensitive to both caregiving and infant temperamental factors. Additionally, as a modality, gesturing is based on bodily expression similar to many aspects of temperament (Rothbart & Bates, 1998). Combined, these facts may explain how gesturing and temperament are particularly interrelated. The compelling evidence of prelinguistic communication, including gesturing, being associated with language development throughout childhood (Bavin et al., 2008; Iverson & Goldin-Meadow, 2005; Kuhn et al., 2014; Laakso et al., 1999; Määttä et al., 2016) further emphasizes the importance of this finding.

6.6. Theorized mechanisms behind associations

Most of the literature seems to explain associations between temperament traits and communicative skills through mechanisms of infant temperament influencing communicative development (e.g., Bloom & Capatides, 1987; Bruce et al., 2022; Laake & Bridgett, 2014). In relation to the classification of theories by Kubicek and Emde (2012), our findings support the "mutual facilitation perspective" for positive emotionality and self-regulation since these traits were associated with relatively better communicative skills. We found no support for the "competition for resources theory" suggested by Bloom and Capatides (1987) as no negative associations were found. Regarding negative emotionality, our results indicate this trait is not related to communicative development at all, at least not in our samples. This could be interpreted as supporting the "specific emotions perspective" in the sense that different temperamental emotionality displayed different associations, although not in the sense of negative emotionality being negatively associated with communicative development as originally suggested by Kubicek and Emde (2012).

Further, Kubicek and Emde (2012) argue that emotional expression can be considered a form of communication and that the mutual facilitation theory aligns with the current understanding of different modalities of communication supporting the development of one another rather than competing. For example, visual communication by symbols or signs is found to support the development of verbal language (Millar et al., 2006; Schlosser & Wendt, 2008), and children are found to have the capacity to successfully learn more than one language simultaneously (Hoff & Core, 2013).

In the same vein, higher communication of emotions can be considered supportive of developing verbal communication (Kubicek & Emde, 2012). This theoretical explanation is compelling, at least in the case of positive emotionality in our results. Verbal expression of emotions develops over the entire childhood period and mainly outside the developmental window studied here (Nook et al., 2020; Streubel et al., 2020; Wellman et al., 1995). Associations between language and self-regulation start to emerge in toddlerhood (Vallotton & Ayoub, 2011) and continue to associate with emotional regulation and understanding during school age (Streubel et al., 2020). Consequently, corresponding associations between negative emotionality and verbal language may be expected only later in childhood. That is, high expression of infant positive emotionality/extraversion may drive overall communication, whereas negative emotionality may primarily drive communication related to the specific emotion at hand. In infancy and toddlerhood, these negative emotions are typically expressed nonverbally.

Furthermore, in the suggested theoretical associations between emotionality and communicative development, a third temperament trait, self-regulation, is part of the explanation. At least for negative emotionality, it is suggested that the motive for communication caused by the emotion is regulation – typically coregulation with the caregiver. In studies involving the self-regulation temperament trait, it is possible this suggested phenomenon is instead seen as associations between self-regulation and communicative skills, as in our studies. The question of why some studies have found associations with negative emotionality and/or self-regulation and communicative development aspects in different combinations, and others have not, is puzzling and remains to be answered in future research.

However, other interpretations of causality are also possible, as suggested by Conture et al. (2013). It may be that communicative skills influence the expression of temperament traits, that associations are bidirectional, or actually explained by some third variable (Conture et al., 2013). For example, strong communicative skills may encourage approach behavior/extraversion or good ability to focus attention on communication, whereas poor communication may lead to a higher expression of negative emotions. However, bidirectional associations are rarely studied longitudinally in the literature. One exception is self-regulation and language, where bidirectional associations are reported in several studies (see Hanno & Surrain, 2019 for a review). However, language skills are argued to predict self-regulatory ability more strongly at later ages, which is explained by language becoming a tool for

self-regulation (e.g., through private speech) only after reaching a certain level of complexity (Vallotton & Ayoub, 2010). In the same vein, it is possible that temperament, present from birth, has more influence on communicative development in the very early years. Comparisons of these hypotheses of the direction of effects should be further explored in future longitudinal studies to gain a deeper understanding of the mechanisms behind the associations found. Especially regarding positive and negative emotionality, bidirectional associations with communicative development are rather unexplored in the literature.

Lastly, another theoretical question lacking an answer in the literature is whether temperamental traits primarily relate to underlying communicative ability or to the expression of these abilities. That is, are emotionally positive and well-regulated infants perceived to gesticulate, talk, and understand words at a higher level because of having stronger skills in these domains, or do their temperaments make these skills more observable to adults? Corresponding findings of associations between temperament and language in older children do not answer the question of skill versus expression either. Associations between temperament and language have been found up until school age also based on standardized language tests (Slomkowski et al., 1992). Such tests preclude the possibility of subjective biases as the underlying mechanisms as in parent reports. However, even standardized tests are still subject to temperamental effects on the children's achievement in the test situation with an unfamiliar adult. DeThorne et al. (2011) studied associations between temperament and language measures derived from speech samples and found that temperament was associated with language measures only when they were derived from the whole sample, not when they were based on standardized sample lengths or mean lengths of utterances. Hence, the authors interpret that associations with temperament in this context are caused by temperament traits impacting talkativeness (DeThorne et al., 2011). We only used parent reports of communicative skills in our studies, but the fact that associations between reported versus observed self-regulation and communicative skills differed does not allow us to rule out "common source bias" (DeThorne et al., 2011) in our findings of significant associations between parent-reported temperament and child communication. However, infant use of verbal language has been found to be associated with the amount of language input from the environment (Dailey & Bergelson, 2023). Thus, an alternative mechanism explaining our results could be temperament traits resulting in more talkativeness supporting further language development by resulting in

more language input according to this "talking to talkers"-hypothesis (Dailey & Bergelson, 2023).

6.7. Limitations and directions for future research

The studies incorporated in the thesis present some limitations, which, together with some tentative results, suggest ideas and directions for future studies.

Firstly, although the sample of the entire FinnBrain Birth Cohort Study is large, the available data for analyses incorporating laboratory assessment carried out in the subset of the sample involved in the focus cohort can lack statistical power to detect small effects. On the other hand, considering the relatively small effect sizes of some results reaching statistical significance in the studies with smaller samples, the effects failing to do so due to lack of power are most likely too small to be considered of clinical significance.

Temperament in infancy and toddlerhood changes as a result of maturation making some of the traits observable only over time and others becoming more advanced (Goldsmith et al., 1987; Rothbart & Bates, 2006). In addition to the longitudinal measures over infancy and combination of reported and observed traits in our studies, expanding the perspective into at least toddlerhood would add valuable information of how associations may change over time. This would also enhance the understanding of directionality of associations between temperament and communication. The development of longitudinal trajectory data for temperament is planned for the FinnBrain data in the near future. Utilizing these data will add a new dimension to the understanding of temperamental associations with communicative development over time.

Similarly, the limited scope of this thesis led us to focus primarily on communicative skills in infancy, with only partial consideration of toddlerhood. A longer-term perspective on communicative development would provide valuable insights. Additionally, the use of CDI-WS at 30 months of age is a limitation, as ceiling effects for expressive lexicon begin to emerge (Fenson et al., 1994). More broadly, relying solely on parent reports of communicative skills can also be considered a limitation.

Given that the strongest associations between temperament and communicative development in this thesis were found for nonverbal communication – specifically gesturing – further research on this topic is warranted. Future studies could explore these relations using observational assessment of nonverbal communication to mitigate potential "common source

bias" (DeThorne et al., 2011). Additionally, continuing the assessment of associations between temperament and nonverbal communication past the transition to verbal language would enhance the understanding of how relations between temperament and verbal versus nonverbal communication develop. Trajectories for longitudinal language development involving observational and standardized assessments are being constructed in the FinnBrain study. Future studies will utilize trajectories of both temperament and communicative development to better understand their relationship throughout childhood.

As discussed earlier, the extraversion-dimension of positive emotionality may influence communicative expressiveness. Extraverted children might be less inclined to communicate regardless of underlying communicative skills, leading to underestimation of communicative skills. This issue is probably less pronounced in parent reports compared to assessment by an unfamiliar person. Still, utilization of less behaviorally dependent measures of language and communication, such as eye tracking or brain imaging, could provide valuable insights in this context.

Future research should integrate both observational and reported assessments of temperament over extended periods of time to better understand how fine-grained and overarching concepts of temperament relate to different communicative outcomes and how these relations evolve over time. This was only done in one study within the thesis, and observational assessment of positive emotionality was not included. The reasons for discrepancies between reported and observational assessments of corresponding temperament traits remain unclear and warrant further investigation. Additionally, the reliance on parent reports for both temperament and communicative development may introduce "common source bias" (DeThorne et al., 2011).

Future studies on the associations between caregiving quality, child temperament and communicative development should aim to disentangle the influence of emotional caregiving factors from language input factors by accounting for both dimensions within the same study. Additionally, future studies could adopt a broader focus on caregiving. In families with two primary caregivers, both should be involved in the assessment of caregiving quality to provide a more comprehensive understanding of the child's caregiving environment. Furthermore, studies could consider other frequent interaction partners, as some temperament traits may have broader implications for communication beyond the primary caregiving context.

6.8. Clinical implications

The clearest clinical implication of our combined study results is the role of positive emotionality, self-regulation, and EA in the development of communicative skills. The positive association between positive emotionality and early communicative skills suggests that children lower in this trait—who express positive emotions and approach tendencies less frequently—may be at risk of developing a relatively weaker early foundation for communicative development. Similarly, infants with lower self-regulation may benefit from an extra effort to support them in regulating and maintaining interactional attention. For example, this could mean helping them engage in interaction and adapting communicative situations to make them more enjoyable.

Our findings also highlight the importance of gesturing in the context of temperament and communicative development, as both infant positive emotionality and self-regulation seemed to be particularly related to gesturing. Given that early gesturing is a predictor of later language development (Bavin et al., 2008; Iverson & Goldin-Meadow, 2005; Laakso et al., 1999; Määttä et al., 2016), it is important to acknowledge the role of temperament and to provide individualized support for the development of gesturing alongside verbal language.

Caregiver awareness of the nature of temperament and its relation to communicative development may enhance their understanding of their infant's behavior. For example, caregivers may respond differently to an infant withdrawing from an intense social activity or frequently shifting focus of attention during play if they attribute these behaviors to temperament rather than to, for example, themselves, the child's development, or an active choice by the child. When recognizing these behaviors as temperament-driven and acknowledging the importance of stimulating communicative development, caregivers are more likely to continue engaging, communicating, and scaffolding joint activities. Additionally, caregivers can adapt interactions to better suit the infant's individual temperament, creating communication opportunities that are suitable and enjoyable for the child. For instance, a child who is easily overwhelmed in novel or socially intense situations may benefit from opportunities to interact in a calm environment with a familiar adult. Likewise, a child with lower self-regulation may require gentle scaffolding to help them focus on interactive activities, with adjustments made to sustain their engagement.

The previously discussed importance of individually adapted enjoyable interactions for stimulating communicative development aligns closely with findings on the role of caregiver EA in this context. Beyond the traditional psychological emphasis on the importance of caregiver EA, our results suggest the emotional quality of interaction assessed within the EA-construct is not to be neglected in the context of communication and language development either. Thus, in addition to highlighting the value of high-quality and frequent verbal and gestural input, it is equally important to emphasize that communication should be an enjoyable experience for the infant. A key factor in fostering both engaging communicative activities and successful therapeutic alliances is ensuring that the child perceives the adult as supportive, warm, and genuinely interested in them and their expressions. The adult's ability to create enjoyable interactions, demonstrate interest in the child's experiences, and adapt activities to the child's skill level and interests plays a vital role in communicative development. Speech-language pathologists should be mindful of these aspects both in guiding families and in their direct work with clients.

In the same vein, therapists and healthcare workers involved with families and infants may be advised to be aware of temperament's role in communication development and consider it in both their direct work with young children and their guidance for caregivers. At a societal level, investing in resources to support families and provide early interventions when needed is well justified by the vast research showing the importance of strong early communicative skills for various adaptive long-term outcomes (Bornstein et al., 2013; Dubois et al., 2020; Hohm et al., 2007; Nærland, 2011; Petersen et al., 2013; Rescorla, 2009; Yew & O'Kearney, 2013).

By highlighting the connection between caregiver EA and early communicative development, the current research indicates caregiver EA is also an aspect to consider in preventive work and interventions aimed at supporting early communicative development. Furthermore, these findings also add to the evidence of the importance of society supporting families on a more general level, since EA is linked to family psychosocial and socioeconomical wellbeing (Stack et al., 2012).

7. Conclusions

The present thesis provides a description of how temperament in infancy is related to early communication and language development. Especially high positive emotionality and self-regulation seem to be positively associated with communicative skills. In addition, caregiver EA in infancy is positively associated with communicative development regardless of infant temperament. In other words, all infants seem to benefit from high caregiver EA when developing communicative skills. Infants lower in temperamental positive emotionality and self-regulation may, however, benefit from additional caregiver stimulation for communication and language development adapted to their individual temperament for optimal communicative development.

Let us return to the little girls in the introduction. The first girl preferred to read the book from beginning to end, following the adult's lead, and actively sought adult company from both her caregivers and others. This behavior creates many communication and language learning opportunities, and it is rather effortless for adults to provide plenty of communicative stimuli. The other little girl, having stronger own visions on the course of play, a shorter attention span for activities, and enjoying playing on her own to a larger degree may not as efficiently encourage adults to interact with her and stimulate her communicative development. The little girls are, however, not alone on their journey acquiring communicative skills. Interacting with both girls, adults can respond in different ways and thus influence the course and enjoyability of the situation. During book reading, the adult may name the pictures in order and ask closed-ended questions and become slightly annoyed when the child loses interest and moves to the next toy, and move on themselves to clean up toys. Alternatively, the adult may follow the child's lead when reading, showing interest in which pictures capture the child's attention and name and ask open-ended questions regarding them, encouraging any response from the child. When the child starts to lose interest in reading, maybe they can find a similar toy tractor as the ones depicted in the book and continue playing with that?

To conclude, infants come into the world equipped with different temperaments, of which some traits seem to support communicative development more than others. However, acquiring a well-functioning ability to communicate with those around us is equally important for all of us. Infants cannot develop communication on their own. The results of the current thesis suggest that we as caregivers can support communicative development for all

infants by being supportive, warm, and enjoyable interaction partners. Infants with lower positive emotionality and self-regulation may benefit from more explicit effort in stimulating communicative development in ways enjoyable to them. Considering the overwhelming amount of advice and recommendations new parents encounter, I am pleased to arrive at the following recommendation for supporting communicative development based on the results of the thesis: Spend time with your child engaged in each other and communicative activities you both enjoy.

References

Ainsworth, M. D. S., Blehar, M. C., Waters, E., & Wall, S. N. (2015). *Patterns of attachment: A psychological study of the strange situation*. Psychology Press.

Altenhofen, S., Clyman, R., Little, C., Baker, M., & Biringen, Z. (2013). Attachment security in three-year-olds who entered substitute care in infancy. *Infant Mental Health Journal*, *34*(5), 435–445. https://doi.org/10.1002/imhj.21401

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/doi:10.18637/jss.v067.i01

Bates, E. (1979). On the evolution and development of symbols. In E. Bates (Ed.), *The Emergence of Symbols* (pp. 1–32). Academic Press. https://doi.org/10.1016/B978-0-12-081540-1.50007-7

Bates, E., Bretherton, I., & Snyder, L. S. (1988). *From first words to grammar: Individual differences and dissociable mechanisms*. Cambridge University Press.

Bates, E., Dale, P. S., & Thal, D. (1995). Individual differences and their implications for theories of language development. In P. Fletcher & B. MacWhinney (Eds.), *The Handbook of Child Language* (pp. 95–151). Blackwell Publishing Ltd. https://doi.org/10.1111/b.9780631203124.1996.00005.x

Bavin, E. L., Prior, M., Reilly, S., Bretherton, L., Williams, J., Eadie, P., Barrett, Y., & Ukoumunne, O. C. (2008). The Early Language in Victoria Study: Predicting vocabulary at age one and two years from gesture and object use. *Journal of Child Language*, *35*(3), 687–701. https://doi.org/10.1017/S0305000908000726

Bergelson, E., & Swingley, D. (2015). Early word comprehension in infants: Replication and extension. *Language Learning and Development*, *11*(4), 369–380. https://doi.org/10.1080/15475441.2014.979387

Berglund, E., Eriksson, M., & Westerlund, M. (2005). Communicative skills in relation to gender, birth order, childcare and socioeconomic status in 18-month-old children. *Scandinavian Journal of Psychology*, *46*(6), 485–491. https://doi.org/10.1111/j.1467-9450.2005.00480.x

Bernier, A., Carlson, S. M., & Whipple, N. (2010). From External Regulation to Self-Regulation: Early Parenting Precursors of Young Children's Executive Functioning. *Child Development*, *81*(1), 326–339. https://doi.org/10.1111/j.1467-8624.2009.01397.x

Biringen, Z. (2000). Emotional availability: Conceptualization and research findings. *American Journal of Orthopsychiatry*, *70*(1), 104–114. https://doi.org/10.1037/h0087711

Biringen, Z. (2008). *Emotional availability (EA) scales manual, 4th edition. Part 1: Infancy/ early childhood version (child age: 0–5 years).* [Unpublished manuscript].

Biringen, Z., & Easterbrooks, M. A. (2012). Emotional availability: Concept, research, and window on developmental psychopathology. *Development and Psychopathology*, *24*(1), 1–8. https://doi.org/10.1017/S0954579411000617

Biringen, Z., Skillern, S., Mone, J., & Pianta, R. (2005). Emotional availability is predictive

of the emotional aspects of children's "school readiness." *Journal of Early Childhood and Infant Psychology*, *1*, 81–98.

Bleses, D., Makransky, G., Dale, P. S., Højen, A., & Ari, B. A. (2016). Early productive vocabulary predicts academic achievement 10 years later. *Applied Psycholinguistics*, *37*(6), 1461–1476. https://doi.org/10.1017/S0142716416000060

Bloom, L. (1983). Discussion of continuity and discontinuity, and the magic of language development. In R. M. Golinkoff (Ed.), *The transition from prelinguistic to linguistic communication*. Psychology Press.

Bloom, L. (1993). *The transition from infancy to language: Acquiring the power of expression*. Cambridge University Press.

Bloom, L., & Capatides, J. B. (1987). Expression of affect and the emergence of language. *Child Development*, *58*(6), 1513–1522. https://doi.org/10.2307/1130691

Bloom, L., Tinker, E., & Scholnick, E. K. (2001). The intentionality model and language acquisition: Engagement, effort, and the essential tension in development. *Monographs of the Society for Research in Child Development*, *66*(4), i–101.

Bornstein, M. H., Hahn, C.-S., & Putnick, D. L. (2016). Long-term stability of core language skill in children with contrasting language skills. *Developmental Psychology*, *52*(5), 704–716. https://doi.org/10.1037/dev0000111

Bornstein, M. H., Hahn, C.-S., & Suwalsky, J. T. D. (2013). Language and internalizing and externalizing behavioral adjustment: Developmental pathways from childhood to adolescence. *Development and Psychopathology*, *25*(3), 857–878. https://doi.org/10.1017/S0954579413000217

Britto, P. R., Lye, S. J., Proulx, K., Yousafzai, A. K., Matthews, S. G., Vaivada, T., Perez-Escamilla, R., Rao, N., Ip, P., Fernald, L. C. H., MacMillan, H., Hanson, M., Wachs, T. D., Yao, H., Yoshikawa, H., Cerezo, A., Leckman, J. F., & Bhutta, Z. A. (2017). Nurturing care: Promoting early childhood development. *The Lancet*, *389*(10064), 91–102. https://doi.org/10.1016/S0140-6736(16)31390-3

Bruce, M., McFayden, T. C., Ollendick, T. H., & Bell, M. A. (2022). Expressive language in infancy and toddlerhood: The roles of child temperament and maternal parenting behaviors. *Developmental Psychobiology*, *64*(6), e22287. https://doi.org/10.1002/dev.22287

Bruner, J. S. (1973). Organization of early skilled action. *Child Development*, *44*(1), 1–11. https://doi.org/10.2307/1127671

Bruner, J. S. (1975). The ontogenesis of speech acts. *Journal of Child Language*, *2*(1), 1–19. https://doi.org/10.1017/S0305000900000866

Cabrera, N. J., Shannon, J. D., & Tamis-LeMonda, C. (2007). Fathers' influence on their children's cognitive and emotional development: From toddlers to pre-k. *Applied Developmental Science*, *11*(4), 208–213. https://doi.org/10.1080/10888690701762100

Cadime, I., Silva, C., Santos, S., Ribeiro, I., & Viana, F. L. (2017). The interrelatedness between infants' communicative gestures and lexicon size: A longitudinal study. *Infant Behavior and Development*, *48*, 88–97. https://doi.org/10.1016/j.infbeh.2017.05.005

Caspi, A., & Roberts, B. W. (2001). Personality development across the life course: The argument for change and continuity. *Psychological Inquiry*, *12*(2), 49–66. https://doi.org/10.1207/S15327965PLI1202_01

Chen, X. (2018). Culture, temperament, and social and psychological adjustment.

Developmental Review, *50*, 42–53. https://doi.org/10.1016/j.dr.2018.03.004

Choi, B., & Rowe, M. L. (2021). A parent gesture intervention as a means to increase parent declarative pointing and child vocabulary. *Infancy*, *26*(5), 735–744. https://doi.org/10.1111/infa.12418

Conture, E. G., Kelly, E. M., & Walden, T. A. (2013). Temperament, speech and language: An overview. *Journal of Communication Disorders*, *46*(2), 125–142. https://doi.org/10.1016/j.jcomdis.2012.11.002

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression. *British Journal of Psychiatry*, *150*(6), 782–786. https://doi.org/10.1192/bjp.150.6.782

Dailey, S., & Bergelson, E. (2023). Talking to talkers: Infants' talk status, but not their gender, is related to language input. *Child Development*, *94*(2), 478–496. https://doi.org/10.1111/cdev.13872

Davison, L., Warwick, H., Campbell, K., & Gartstein, M. A. (2019). Infant temperament affects toddler language development. *Journal of Education and E-Learning Research*, *6*(3), 122–128. https://doi.org/10.20448/journal.509.2019.63.122.128

Derogatis, L. R., Lipman, R. S., & Covi, L. (1973). SCL-90: An outpatient psychiatric rating scale - preliminary report. *Psychopharmacology Bulletin*, *9*(1), 13–28.

DeThorne, L. S., Deater-Deckard, K., Mahurin-Smith, J., Coletto, M.-K., & Petrill, S. A. (2011). Volubility as a mediator in the associations between conversational language measures and child temperament. *International Journal of Language & Communication Disorders*, *46*(6), 700–713. https://doi.org/10.1111/j.1460-6984.2011.00034.x

Dickinson, D. K., Griffith, J. A., Golinkoff, R. M., & Hirsh-Pasek, K. (2012). How reading books fosters language development around the world. *Child Development Research*, *2012*(1), 602807. https://doi.org/10.1155/2012/602807

Dixon, W., & Smith, P. (2000). Links between temperament and language acquisition. *Merrill-Palmer Quarterly*, *46*, 417–440.

Dubois, P., St-Pierre, M.-C., Desmarais, C., & Guay, F. (2020). Young adults with developmental language disorder: A systematic review of education, employment, and independent living outcomes. *Journal of Speech, Language, and Hearing Research*, *63*, 3786–3800. https://doi.org/DOI: 10.1044/2020_JSLHR-20-00127

Durbin, C. E., Hayden, E. P., Klein, D. N., & Olino, T. M. (2007). Stability of laboratory-assessed temperamental emotionality traits from ages 3 to 7. *Emotion*, *7*(2), 388–399. https://doi.org/10.1037/1528-3542.7.2.388

Durbin, C. E., & Wilson, S. (2012). Convergent validity of and bias in maternal reports of child emotion. *Psychological Assessment*, *24*(3), 647–660. https://doi.org/10.1037/a0026607

Enders, C. K. (2011). Analyzing longitudinal data with missing values. *Rehabilitation Psychology*, *56*(4), 267–288. https://doi.org/10.1037/a0025579

Eriksson, M., & Berglund, E. (2002). *Instruments, scoring manual and percentile levels of the Swedish Early Communicative Development Inventory, SECDI* (FoU-Rapport No. 17). Institutionen för pedagogik, didaktik och psykologi.

Feldman, R. (2007). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, *16*(6), 340–345. https://doi.org/10.1111/j.1467-8721.2007.00532.x

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J. (1994). Variability

in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i–185. https://doi.org/10.2307/1166093

Fenson, L., Kagan, J., Kearsley, R. B., & Zelazo, P. R. (1976). The developmental progression of manipulative play in the first two years. *Child Development*, *47*(1), 232–236. https://doi.org/10.2307/1128304

Fields-Olivieri, M. A., Thinzar, C. E., Roben, C. K. P., & Cole, P. M. (2024). Toddler negative affectivity and effortful control: Relations with parent-toddler conversation engagement and indirect effects on language. *Infant Behavior and Development*, *74*, 101912. https://doi.org/10.1016/j.infbeh.2023.101912

Fisher, E. L. (2017). A systematic review and meta-analysis of predictors of expressive-language outcomes among late talkers. *Journal of Speech, Language, and Hearing Research*, *60*(10), 2935–2948. https://doi.org/10.1044/2017_JSLHR-L-16-0310

Freund, J.-D. (2019). Early temperament in parental report and scientific observation. *Early Child Development and Care*, *189*(14), 2318–2333. https://doi.org/10.1080/03004430.2018.1450252

Frick, M. A., Forslund, T., & Brocki, K. C. (2019). Does child verbal ability mediate the relationship between maternal sensitivity and later self-regulation? A longitudinal study from infancy to 4 years. *Scandinavian Journal of Psychology*, *60*(2), 97–105. https://doi.org/10.1111/sjop.12512

Frick, M. A., Forslund, T., Fransson, M., Johansson, M., Bohlin, G., & Brocki, K. C. (2018). The role of sustained attention, maternal sensitivity, and infant temperament in the development of early self-regulation. *British Journal of Psychology*, *109*(2), 277–298. https://doi.org/10.1111/bjop.12266

Fuertes, M., Almeida, R., Martelo, I., Barbosa, M., & Beeghly, M. (2024). It's you and me: Infants' cross-modal communicative signals and mother-infant interactive behavior predict infant regulatory patterns in the still-face paradigm at 3 months. *Infant Behavior and Development*, *75*, 101930. https://doi.org/10.1016/j.infbeh.2024.101930

Gartstein, M. A., Crawford, J., & Robertson, C. D. (2008). Early markers of language and attention: Mutual contributions and the impact of parent–infant interactions. *Child Psychiatry and Human Development*, *39*(1), 9–26. https://doi.org/10.1007/s10578-007-0067-4

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*, *26*(1), 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8

Ger, E., Altınok, N., Liszkowski, U., & Küntay, A. C. (2018). Development of infant pointing from 10 to 12 months: The role of relevant caregiver responsiveness. *Infancy*, *23*(5), 708–729. https://doi.org/10.1111/infa.12239

Gibb Harding, C. (1983). Setting the stage for language acquisition: Communication development in the first year. In R. M. Golinkoff (Ed.), *The Transition From Prelinguistic To Linguistic Communication* (pp. 93–113). Psychology Press. https://doi.org/10.4324/9780203781128

Goldin-Meadow, S. (2005). *Hearing gesture: How our hands help us think*. Harvard University Press.

Goldin-Meadow, S. (2007). Pointing sets the stage for learning language—And creating language. *Child Development*, *78*(3), 741–745. https://doi.org/10.1111/j.1467-8624.2007.01029.x

Goldsmith, H. H., & Rothbart, M. K. (1999). *The Laboratory Temperament Assessment Battery (LAB-TAB, Prelocomotor Version, Edition 3.1)*. University of Wisconsin Press.

Golinkoff, R. M. (1983). The preverbal negotiation of failed messages: Insights into the transition period. In R. M. Golinkoff (Ed.), *The Transition From Prelinguistic To Linguistic Communication*. Psychology Press.

Goodwyn, S. W., Acredolo, L. P., & Brown, C. A. (2000). Impact of symbolic gesturing on early language development. *Journal of Nonverbal Behavior*, *24*(2), 81–103. https://doi.org/10.1023/A:1006653828895

Götz, A., Altuntas, E., Kalashnikova, M., Best, C., & Burnham, D. (2024). Shaping linguistic input in parent-infant interactions: The influence of the Infant's temperament. *Infancy*, *n/a*(n/a). https://doi.org/10.1111/infa.12629

Gros-Louis, J., West, M. J., & King, A. P. (2014). Maternal responsiveness and the development of directed vocalizing in social interactions. *Infancy*, *19*(4), 385–408. https://doi.org/10.1111/infa.12054

Guedes, C., & Cadima, J. (2022). The bidirectional interplay between self-regulation and expressive vocabulary during toddlerhood. *Developmental Psychology*, *58*(9), 1652–1664. https://doi.org/10.1037/dev0001062

Hanno, E., & Surrain, S. (2019). The direct and indirect relations between self-regulation and language development among monolinguals and dual language learners. *Clinical Child and Family Psychology Review*, *22*(1), 75–89. https://doi.org/10.1007/s10567-019-00283-3

Harrell, F. (2024). *Hmisc: Harrell miscellaneous* (Version 5.2-0) [Computer software]. https://CRAN.R-project.org/package=Hmisc

Hickok, G. (2009). The functional neuroanatomy of language. *Physics of Life Reviews*, *6*(3), 121–143. https://doi.org/10.1016/j.plrev.2009.06.001

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., Yust, P. K. S., & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071–1083. https://doi.org/10.1177/0956797615581493

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002

Hoff, E., & Core, C. (2013). Input and language development in bilingually developing children. *Seminars in Speech and Language*, *34*, 215–226. https://doi.org/10.1055/s-0033-1353448

Hoff-Ginsberg, E. (1998). The relation of birth order and socioeconomic status to children's language experience and language development. *Applied Psycholinguistics*, *19*(4), 603–629. https://doi.org/10.1017/S0142716400010389

Hohm, E., Jennen-Steinmetz, C., Schmidt, M. H., & Laucht, M. (2007). Language development at ten months. *European Child & Adolescent Psychiatry*, *16*(3), 149–156. https://doi.org/10.1007/s00787-006-0567-y

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and

gender. *Developmental Psychology*, *27*(2), 236–248. https://doi.org/10.1037/0012-1649.27.2.236

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science*, *16*(5), 367–371. https://doi.org/10.1111/j.0956-7976.2005.01542.x

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials – A practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 162. https://doi.org/10.1186/s12874-017-0442-1

Kammermeier, M. (2022). *The role of maternal emotional availability and attachment in child emotion regulation* [Doctoral dissertation, Ludwig-Maximilians-Universität München]. Electronic Theses of LMU Munich.

Karlsson, L., Tolvanen, M., Scheinin, N. M., Uusitupa, H.-M., Korja, R., Ekholm, E., Tuulari, J. J., Pajulo, M., Huotilainen, M., Paunio, T., Karlsson, H., & FinnBrain Birth Cohort Study Group. (2018). Cohort profile: The FinnBrain Birth Cohort Study (FinnBrain). *International Journal of Epidemiology*, *47*(1), 15–16j. https://doi.org/10.1093/ije/dyx173

Karrass, J., & Braungart-Rieker, J. M. (2003). Parenting and temperament as interacting agents in early language development. *Parenting*, *3*(3), 235–259. https://doi.org/10.1207/S15327922PAR0303_03

Kiff, C. J., Lengua, L. J., & Zalewski, M. (2011). Nature and nurturing: Parenting in the context of child temperament. *Clinical Child and Family Psychology Review*, *14*(3), 251–301. https://doi.org/10.1007/s10567-011-0093-4

Kochanska, G., Friesenborg, A. E., Lange, L. A., & Martel, M. M. (2004). Parents' personality and infants' temperament as contributors to their emerging relationship. *Journal of Personality and Social Psychology*, *86*(5), 744–759. https://doi.org/10.1037/0022-3514.86.5.744

Komsi, N., Räikkönen, K., Pesonen, A.-K., Heinonen, K., Keskivaara, P., Järvenpää, A.-L., & Strandberg, T. E. (2006). Continuity of temperament from infancy to middle childhood. *Infant Behavior and Development*, *29*(4), 494–508. https://doi.org/10.1016/j.infbeh.2006.05.002

Kubicek, L. F., & Emde, R. N. (2012). Emotional expression and language: A longitudinal study of typically developing earlier and later talkers from 15 to 30 months. *Infant Mental Health Journal*, *33*(6), 553–584. https://doi.org/10.1002/imhj.21364

Kuhl, P. K. (2007). Is speech learning 'gated' by the social brain? *Developmental Science*, *10*(1), 110–120. https://doi.org/10.1111/j.1467-7687.2007.00572.x

Kuhl, P. K. (2010). Brain mechanisms in early language acquisition. *Neuron*, *67*(5), 713–727. https://doi.org/10.1016/j.neuron.2010.08.038

Kuhn, L. J., Willoughby, M. T., Wilbourn, M. P., Vernon-Feagans, L., & Blair, C. B. (2014). Early communicative gestures prospectively predict language development and executive function in early childhood. *Child Development*, *85*(5), 1898–1914. https://doi.org/10.1111/cdev.12249

Laake, L. M., & Bridgett, D. J. (2014). Happy babies, chatty toddlers: Infant positive affect facilitates early expressive, but not receptive language. *Infant Behavior and Development*, *37*(1), 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006

Laake, L. M., & Bridgett, D. J. (2018). Early language development in context: Interactions between infant temperament and parenting characteristics. *Early Education and Development*, *29*(5), 730–746. https://doi.org/10.1080/10409289.2018.1436366

Laakso, M.-L., Poikkeus, A.-M., Katajamäki, J., & Lyytinen, P. (1999). Early intentional communication as a predictor of language development in young toddlers. *First Language, 19*(56), 207–231. https://doi.org/10.1177/014272379901905604

Landry, S. H., Smith, K. E., Miller-Loncar, C. L., & Swank, P. R. (1997). Predicting cognitive-language and social growth curves from early maternal behaviors in children at varying degrees of biological risk. *Developmental Psychology*, *33*(6), 1040–1053. https://doi.org/10.1037/0012-1649.33.6.1040

Law, J., Rush, R., Schoon, I., & Parsons, S. (2009). Modeling developmental language difficulties from school entry into adulthood: Literacy, mental health, and employment outcomes. *Journal of Speech, Language & Hearing Research*, *52*(6), 1401–1416. https://doi.org/10.1044/1092-4388(2009/08-0142)

Lee, J. (2011). Size matters: Early vocabulary as a predictor of language and literacy competence. *Applied Psycholinguistics*, *32*(1), 69–92. https://doi.org/10.1017/S0142716410000299

Leigh, P., Nievar, M. A., & Nathans, L. (2011). Maternal sensitivity and language in early childhood: A test of the transactional model. *Perceptual and Motor Skills*, *113*(1), 281–299. https://doi.org/10.2466/10.17.21.28.PMS.113.4.281-299

Little, C., & Carter, A. S. (2005). Negative emotional reactivity and regulation in 12-month-olds following emotional challenge: Contributions of maternal–infant emotional availability in a low-income sample. *Infant Mental Health Journal*, *26*(4), 354–368. https://doi.org/10.1002/imhj.20055

Lobo, F. M., & Lunkenheimer, E. (2020). Understanding the parent-child coregulation patterns shaping child self-regulation. *Developmental Psychology*, *56*(6), 1121–1134. https://doi.org/10.1037/dev0000926

Lüdecke, D. (2018). ggeffects: Tidy data frames of marginal effects from regression models. *Journal of Open Source Software*, *3*(26), 776. https://doi.org/10.21105/joss.00772

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2002). The importance of the normality assumption in large public health data sets. *Annual Review of Public Health*, *23*(1), 151–169. https://doi.org/10.1146/annurev.publhealth.23.100901.140546

Lyytinen, P. (1999). *Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä [A method for assessing early communication and language]*. The Child Research Center of the University of Jyväskylä and the Niilo Mäki institute.

Määttä, S., Laakso, M.-L., Ahonen, T., Tolvanen, A., Westerholm, J., & Aro, T. (2016). Continuity from prelinguistic communication to later language ability: A follow-up study from infancy to early school age. *Journal of Speech, Language, and Hearing Research*, *59*(6), 1357–1372. https://doi.org/10.1044/2016_JSLHR-L-15-0209

Marchman, V. A., & Fernald, A. (2008). Speed of word recognition and vocabulary knowledge in infancy predict cognitive and language outcomes in later childhood. *Developmental Science*, *11*(3), F9–F16.

https://doi.org/10.1111/j.1467-7687.2008.00671.x

Maslowsky, J., Jager, J., & Hemken, D. (2015). Estimating and interpreting latent variable interactions: A tutorial for applying the latent moderated structural equations method. *International Journal of Behavioral Development*, *39*(1), 87–96. https://doi.org/10.1177/0165025414552301

Mayor, J., & Plunkett, K. (2011). A statistical estimate of infant and toddler vocabulary size from CDI analysis. *Developmental Science*, *14*(4), 769–785. https://doi.org/10.1111/j.1467-7687.2010.01024.x

Merriam-Webster. (n.d.a). Communication. In *Merriam-Webster.com dictionary*. Merriam-Webster. https://www.merriam-webster.com/dictionary/communication

Merriam-Webster. (n.d.b). Gesturing. In *Merriam-Webster.com dictionary*. Merriam-Webster. https://www.merriam-webster.com/dictionary/gesturing

Merriam-Webster. (n.d.c). Interaction. In *Merriam-Webster.com dictionary*. Merriam-Webster. https://www.merriam-webster.com/dictionary/interaction

Millar, D. C., Light, J. C., & Schlosser, R. W. (2006). The impact of augmentative and alternative communication intervention on the speech production of individuals with developmental disabilities: A research review. *Journal of Speech, Language, and Hearing Research*, *49*(2), 248–264. https://doi.org/10.1044/1092-4388(2006/021)

Miller, J. L., & Lossia, A. K. (2013). Prelinguistic infants' communicative system: Role of caregiver social feedback. *First Language*, *33*(5), 524–544. https://doi.org/10.1177/0142723713503147

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Neal, R., & Schwartz, H. K. (2000). Gaze following, temperament, and language development in 6-month-olds: A replication and extension. *Infant Behavior and Development*, *23*(2), 231–236. https://doi.org/10.1016/S0163-6383(01)00038-8

Morales, M., Mundy, P., & Rojas, J. (1998). Following the direction of gaze and language development in 6-month-olds. *Infant Behavior and Development*, *21*(2), 373–377. https://doi.org/10.1016/S0163-6383(98)90014-5

Moreno, A. J., Klute, M. M., & Robinson, J. L. (2008). Relational and individual resources as predictors of empathy in early childhood. *Social Development*, *17*(3), 613–637. https://doi.org/10.1111/j.1467-9507.2007.00441.x

Moreno, A. J., & Robinson, J. L. (2005). Emotional vitality in infancy as a predictor of cognitive and language abilities in toddlerhood. *Infant and Child Development*, *14*(4), 383–402. https://doi.org/10.1002/icd.406

Morgan, P. L., Farkas, G., Hillemeier, M. M., Hammer, C. S., & Maczuga, S. (2015). 24-month-old children with larger oral vocabularies display greater academic and behavioral functioning at kindergarten entry. *Child Development*, *86*(5), 1351–1370. https://doi.org/10.1111/cdev.12398

Muthén, L. K., & Muthén, B. O. (1998). *Mplus User's Guide* (Eighth edition). Muthén & Muthén.

Nærland, T. (2011). Language competence and social focus among preschool children. *Early Child Development and Care*, *181*(5), 599–612. https://doi.org/10.1080/03004431003665780

Nolvi, S., Karlsson, L., Bridgett, D. J., Pajulo, M., Tolvanen, M., & Karlsson, H. (2016). Maternal postnatal psychiatric symptoms and infant temperament affect early mother-infant bonding. *Infant Behavior and*

Development, *43*, 13–23. https://doi.org/10.1016/j.infbeh.2016.03.003

Nook, E. C., Stavish, C. M., Sasse, S. F., Lambert, H. K., Mair, P., McLaughlin, K. A., & Somerville, L. H. (2020). Charting the development of emotion comprehension and abstraction from childhood to adulthood using observer-rated and linguistic measures. *Emotion*, *20*(5), 773–792. https://doi.org/10.1037/emo0000609

Nozadi, S. S., Spinrad, T. L., Eisenberg, N., Bolnick, R., Eggum-Wilkens, N. D., Smith, C. L., Gaertner, B., Kupfer, A., & Sallquist, J. (2013). Prediction of toddlers' expressive language from maternal sensitivity and toddlers' anger expressions: A developmental perspective. *Infant Behavior and Development*, *36*(4), 650–661. https://doi.org/10.1016/j.infbeh.2013.06.002

Ollas, D., Rautakoski, P., Nolvi, S., Karlsson, H., & Karlsson, L. (2020). Temperament is associated with the use of communicative gestures in infancy. *Infant and Child Development*, *29*(3), e2166. https://doi.org/10.1002/icd.2166

Ollas-Skogster, D., Korja, R., Yada, A., Mainela-Arnold, E., Karlsson, H., Bridgett, D. J., Rautakoski, P., Karlsson, L., & Nolvi, S. (2025). Maternal emotional availability supports child communicative development regardless of child temperament—Findings from the FinnBrain Birth Cohort Study. *Infancy*, *30*(1), e12649. https://doi.org/10.1111/infa.12649

Ollas-Skogster, D., Rautakoski, P., Bridgett, D., Kataja, E.-L., Karlsson, H., Karlsson, L., & Nolvi, S. (2023). Associations between observed and reported infant negative affectivity, fear and self-regulation, and early communicative development—Evidence from the FinnBrain Birth Cohort Study. *Infancy*, *28*(2), 410–434. https://doi.org/10.1111/infa.12508

Ollas-Skogster, D., Rautakoski, P., Kautto, A., Karlsson, H., Mainela-Arnold, E., Karlsson, L., & Nolvi, S. *Infant temperament predicts early communicative skills in the FinnBrain Birth Cohort Study.* [Preprint]. OSF. https://osf.io/3qmye_v1

Özçalışkan, Ş., & Goldin-Meadow, S. (2005). Gesture is at the cutting edge of early language development. *Cognition*, *96*(3), B101–B113. https://doi.org/10.1016/j.cognition.2005.01.001

Paavola, L., Kemppinen, K., Kumpulainen, K., Moilanen, I., & Ebeling, H. (2006). Maternal sensitivity, infant co-operation and early linguistic development: Some predictive relations. *European Journal of Developmental Psychology*, *3*(1), 13–30. https://doi.org/10.1080/17405620500317789

Patrucco-Nanchen, T., Friend, M., Poulin-Dubois, D., & Zesiger, P. (2019). Do early lexical skills predict language outcome at 3 years? A longitudinal study of French-speaking children. *Infant Behavior and Development*, *57*, 101379. https://doi.org/10.1016/j.infbeh.2019.101379

Paulussen-Hoogeboom, M. C., Stams, G. J. J. M., Hermanns, J. M. A., & Peetsma, T. T. D. (2007). Child negative emotionality and parenting from infancy to preschool: A meta-analytic review. *Developmental Psychology*, *43*(2), 438–453. https://doi.org/10.1037/0012-1649.43.2.438

Petersen, I. T., Bates, J. E., D'Onofrio, B. M., Coyne, C. A., Lansford, J. E., Dodge, K. A., Pettit, G. S., & Van Hulle, C. A. (2013). Language ability predicts the development of behavior problems in children. *Journal of Abnormal Psychology*, *122*(2), 542–557. https://doi.org/10.1037/a0031963

Peterson, E. R., Waldie, K. E., Mohal, J., Reese, E., Atatoa Carr, P. E., Grant, C. C., & Morton, S.

M. B. (2017). Infant Behavior Questionnaire–Revised Very Short Form: A new factor structure's associations with parenting perceptions and child language outcomes. *Journal of Personality Assessment*, *99*(6), 561–573. https://doi.org/10.1080/00223891.2017.1287709

Phillips, B. M., & Lonigan, C. J. (2009). Variations in the home literacy environment of preschool children: A cluster analytic approach. *Scientific Studies of Reading*, *13*(2), 146–174. https://doi.org/10.1080/10888430902769533

Putnam, S., Ellis, L., & Rothbart, M. (2001). The structure of temperament from infancy through adolescence. In A. Eliasz & A. Angleitner (Eds.), *Advances in Research on Temperament* (pp. 165–182). Pabst Science Publishers.

Putnam, S. P., Helbig, A. L., Gartstein, M. A., Rothbart, M. K., & Leerkes, E. (2014). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. *Journal of Personality Assessment*, *96*(4), 445–458. https://doi.org/10.1080/00223891.2013.841171

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development*, *17*(4), 387–405. https://doi.org/10.1002/icd.582

Putnam, S. P., Sanson, A. V., & Rothbart, M. K. (2002). Child temperament and parenting. In M. H. Bornstein (Ed.), *Handbook of parenting* (2nd ed, pp. 255–277). Erlbaum.

Putnam, S. P., Sehic, E., French, B. F., Gartstein, M. A., & Lira Luttges, B. (2024). The Global Temperament Project: Parent-reported temperament in infants, toddlers, and children from 59 nations. *Developmental Psychology*, *60*(5), 916–941. https://doi.org/10.1037/dev0001732

R Core Team. (2023). *R: A language and environment for statistical computing* (Version 4.3.2) [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

Räikkönen, K., Pesonen, A.-K., Heinonen, K., Komsi, N., Järvenpää, A.-L., & Strandberg, T. E. (2006). Stressed parents: A dyadic perspective on perceived infant temperament. *Infant and Child Development*, *15*(1), 75–87. https://doi.org/10.1002/icd.431

Rantalainen, K. (2023). *Early language development: Relationships with social-emotional/behavioural development and maternal interaction* [Doctoral dissertation]. University of Oulu.

Reck, C., Van Den Bergh, B., Tietz, A., Müller, M., Ropeter, A., Zipser, B., & Pauen, S. (2018). Maternal avoidance, anxiety cognitions and interactive behaviour predicts infant development at 12 months in the context of anxiety disorders in the postpartum period. *Infant Behavior and Development*, *50*, 116–131. https://doi.org/10.1016/j.infbeh.2017.11.007

Rescorla, L. (2005). Age 13 language and reading outcomes in late-talking toddlers. *Journal of Speech, Language, and Hearing Research*, *48*(2), 459–472. https://doi.org/10.1044/1092-4388(2005/031)

Rescorla, L. (2009). Age 17 language and reading outcomes in late-talking toddlers: Support for a dimensional perspective on language delay. *Journal of Speech, Language, and Hearing Research*, *52*(1), 16–30. https://doi.org/10.1044/1092-4388(2008/07-0171)

Rescorla, L., & Turner, H. L. (2015). Morphology and syntax in late talkers at age 5. *Journal of Speech, Language, and Hearing Research*,

58(2), 434–444. https://doi.org/10.1044/2015_JSLHR-L-14-0042

Rice, M. L., Taylor, C. L., & Zubrick, S. R. (2008). Language outcomes of 7-year-old children with or without a history of late language emergence at 24 months. *Journal of Speech, Language, and Hearing Research*, *51*(2), 394–407. https://doi.org/10.1044/1092-4388(2008/029)

Robson, D. A., Allen, M. S., & Howard, S. J. (2020). Self-regulation in childhood as a predictor of future outcomes: A meta-analytic review. *Psychological Bulletin*, *146*(4), 324–354. https://doi.org/10.1037/bul0000227

Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., & Gabrieli, J. D. E. (2018). Beyond the 30-million-word gap: Children's conversational exposure is associated with language-related brain function. *Psychological Science*, *29*(5), 700–710. https://doi.org/10.1177/0956797617742725

Rost, G. C., & McMurray, B. (2009). Speaker variability augments phonological processing in early word learning. *Developmental Science*, *12*(2), 339–349. https://doi.org/10.1111/j.1467-7687.2008.00786.x

Rothbart, M., Ellis, L. K., & Posner, M. (2004). Temperament and self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 357–370).

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*, 569–578.

Rothbart, M. K. (1986). Longitudinal observation of infant temperament. *Developmental Psychology*, *22*(3), 356–365. https://doi.org/10.1037/0012-1649.22.3.356

Rothbart, M. K. (2007). Temperament, development, and personality. *Current Directions in Psychological Science*, *16*(4), 207–212. https://doi.org/10.1111/j.1467-8721.2007.00505.x

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology, vol. 3: Social, emotional, and personality development* (pp. 105–176). Wiley.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology* (Vol. 6). John Wiley & Sons, Inc.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, *1*(1), 2–7. https://doi.org/10.1111/j.1750-8606.2007.00002.x

Rothbart, M. K., Sheese, B. E., Rueda, M. R., & Posner, M. I. (2011). Developing mechanisms of self-regulation in early life. *Emotion Review*, *3*(2), 207–213. https://doi.org/10.1177/1754073910387943

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development*, *83*(5), 1762–1774. https://doi.org/10.1111/j.1467-8624.2012.01805.x

Rowe, M. L., & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science*, *12*(1), 182–187. https://doi.org/10.1111/j.1467-7687.2008.00764.x

Rowe, M. L., Özçalışkan, Ş., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language*, *28*(2), 182–199. https://doi.org/10.1177/0142723707088310

Rowe, M. L., Raudenbush, S. W., & Goldin-Meadow, S. (2012). The pace of vocabulary growth helps predict later vocabulary skill. *Child Development*, *83*(2), 508–525. https://doi.org/10.1111/j.1467-8624.2011.01710.x

Rowe, M. L., Wei, R., & Salo, V. C. (2022). Early gesture predicts later language development. In A. Morgenstern & S. Goldin-Meadow (Eds.), *Gesture in language* (pp. 93–112). American Psychological Association. https://www.jstor.org/stable/j.ctv249sgdf.7

Rubin, D. B. (1976). Inference and missing data. *Biometrika*, *63*(3), 581–592. https://doi.org/10.2307/2335739

Salley, B. J., & Dixon, W. E. (2007). Temperamental and joint attentional predictors of language development. *Merrill-Palmer Quarterly (Wayne State University. Press)*, *53*(1), 131–154.

Salvadori, E. A., Colonnesi, C., Oort, F. J., & Messinger, D. S. (2024). Predicting pointing from early socioemotional communication with mothers, fathers, and strangers through the lens of temperamental reactivity. *Developmental Psychology*. https://doi.org/10.1037/dev0001671.supp

Sanson, A., Hemphill, S. A., Yagmurlu, B., & McClowry, S. (2010). Temperament and social development. In P. K. Smith & C. H. Hart (Eds.), *The Wiley-Blackwell Handbook of Childhood Social Development*. John Wiley & Sons.

Satorra, A., & Bentler, P. M. (2010). Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika*, *75*(2), 243–248. https://doi.org/10.1007/s11336-009-9135-y

Saunders, H., Kraus, A., Barone, L., & Biringen, Z. (2015). Emotional availability: Theory, research, and intervention. *Frontiers in Psychology*, *6*. https://www.frontiersin.org/articles/10.3389/fpsyg.2015.01069

Schlosser, R. W., & Wendt, O. (2008). Effects of augmentative and alternative communication intervention on speech production in children with autism: A systematic review. *American Journal of Speech-Language Pathology*, *17*(3), 212–230. https://doi.org/10.1044/1058-0360(2008/021)

Schults, A., Tulviste, T., & Konstabel, K. (2012). Early vocabulary and gestures in Estonian children. *Journal of Child Language*, *39*(3), 664–686. https://doi.org/10.1017/S0305000911000225

Slomkowski, C. L., Nelson, K., Dunn, J., & Plomin, R. (1992). Temperament and language: Relations from toddlerhood to middle childhood. *Developmental Psychology*, *28*(6), 1090–1095. https://doi.org/10.1037/0012-1649.28.6.1090

Snijders, V. E., Bogicevic, L., Verhoeven, M., & van Baar, A. L. (2020). Toddlers' language development: The gradual effect of gestational age, attention capacities, and maternal sensitivity. *International Journal of Environmental Research and Public Health*, *17*(21), Article 21. https://doi.org/10.3390/ijerph17217926

Sohr-Preston, S. L., & Scaramella, L. V. (2006). Implications of timing of maternal depressive symptoms for early cognitive and language development. *Clinical Child and Family Psychology Review*, *9*(1), 65–83. https://doi.org/10.1007/s10567-006-0004-2

Spinelli, M., Fasolo, M., Shah, P. E., Genovese, G., & Aureli, T. (2018). The influence of early temperament on language development: The moderating role of maternal input. *Frontiers in Psychology*, *9*. https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01527

Stack, D. M., Serbin, L. A., Girouard, N., Enns, L. N., Bentley, V. M. N., Ledingham, J. E., & Schwartzman, A. E. (2012). The quality of the mother–child relationship in high-risk dyads: Application of the Emotional Availability Scales in an intergenerational, longitudinal study. *Development and Psychopathology*, *24*(1), 93–105. https://doi.org/10.1017/S095457941100068X

Stifter, C. A., Willoughby, M. T., & Towe-Goodman, N. (2008). Agree or agree to disagree? Assessing the convergence between parents and observers on infant temperament. *Infant and Child Development*, *17*(4), 407–426. https://doi.org/10.1002/icd.584

Stolt, S., Haataja, L., Lapinleimu, H., & Lehtonen, L. (2008). Early lexical development of Finnish children: A longitudinal study. *First Language*, *28*(3), 259–279. https://doi.org/10.1177/0142723708091051

Stolt, S., Haataja, L., Lapinleimu, H., & Lehtonen, L. (2009). Associations between lexicon and grammar at the end of the second year in Finnish children. *Journal of Child Language*, *36*(4), 779–806. https://doi.org/10.1017/S0305000908009161

Streubel, B., Gunzenhauser, C., Grosse, G., & Saalbach, H. (2020). Emotion-specific vocabulary and its contribution to emotion understanding in 4- to 9-year-old children. *Journal of Experimental Child Psychology*, *193*, 104790. https://doi.org/10.1016/j.jecp.2019.104790

Stromswold, K. (2001). The heritability of language: A review and metaanalysis of twin, adoption, and linkage studies. *Language*, *77*(4), 647–723.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development*, *72*(3), 748–767. https://doi.org/10.1111/1467-8624.00313

Tamis-Lemonda, C. S., Bornstein, M. H., Kahana-Kalman, R., Baumwell, L., & Cyphers, L. (1998). Predicting variation in the timing of language milestones in the second year: An events history approach. *Journal of Child Language*, *25*(3), 675–700. https://doi.org/10.1017/S0305000998003572

Taylor, N., Donovan, W., Miles, S., & Leavitt, L. (2009). Maternal control strategies, maternal language usage and children's language usage at two years. *Journal of Child Language*, *36*(2), 381–404. https://doi.org/10.1017/S0305000908008969

Tomasello, M. (2015). The usage-based theory of language acquisition. In E. L. Bavin & L. R. Naigles (Eds.), *The Cambridge Handbook of Child Language* (2nd ed., pp. 89–106). Cambridge University Press. https://doi.org/10.1017/CBO9781316095829.005

Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development*, *78*(3), 705–722. https://doi.org/10.1111/j.1467-8624.2007.01025.x

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities*, *43*(4), 308–321. https://doi.org/10.1177/0022219410369096

Trevarthen, C., & Hubley, P. (1978). Secondary intersubjectivity: Confidence, confiding and acts of meaning in the first year. In A. Lock (Ed.), *Action, gesture and symbol: The emergence of language* (pp. 183–229). Academic Press.

Ursache, A., Blair, C., Stifter, C., & Voegtline, K. (2013). Emotional reactivity and regulation in infancy interact to predict executive functioning in early childhood. *Developmental Psychology*, *49*(1), 127–137. https://doi.org/10.1037/a0027728

Vallotton, C., & Ayoub, C. (2011). Use your words: The role of language in the development of toddlers' self-regulation. *Early Childhood Research Quarterly*, *26*(2), 169–181. https://doi.org/10.1016/j.ecresq.2010.09.002

Vallotton, C. D. (2009). Do infants influence their quality of care? Infants' communicative gestures predict caregivers' responsiveness. *Infant Behavior and Development*, *32*(4), 351–365. https://doi.org/10.1016/j.infbeh.2009.06.001

Vallotton, C. D., & Ayoub, C. C. (2010). Symbols build communication and thought: The role of gestures and words in the development of engagement skills and social-emotional concepts during toddlerhood. *Social Development*, *19*(3), 601–626. https://doi.org/10.1111/j.1467-9507.2009.00549.x

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*(3), 1–67. https://doi.org/10.18637/jss.v045.i03

Vehkavuori, S.-M., Kämäräinen, M., & Stolt, S. (2021). Early receptive and expressive lexicons and language and pre-literacy skills at 5;0 years – A longitudinal study. *Early Human Development*, *156*, 105345. https://doi.org/10.1016/j.earlhumdev.2021.105345

Vehkavuori, S.-M., & Stolt, S. (2019). Early lexicon and language skills at 42 months. *Clinical Linguistics & Phonetics*, *33*(9), 854–868. https://doi.org/10.1080/02699206.2019.1584721

Verhoef, E., Shapland, C. Y., Fisher, S. E., Dale, P. S., & St Pourcain, B. (2021). The developmental origins of genetic factors influencing language and literacy: Associations with early-childhood vocabulary. *Journal of Child Psychology and Psychiatry*, *62*(6), 728–738. https://doi.org/10.1111/jcpp.13327

Vernon-Feagans, L., Pancsofar, N., Willoughby, M., Odom, E., Quade, A., & Cox, M. (2008). Predictors of maternal language to infants during a picture book task in the home: Family SES, child characteristics and the parenting environment. *Journal of Applied Developmental Psychology*, *29*(3), 213–226. https://doi.org/10.1016/j.appdev.2008.02.007

Volling, B. L., McElwain, N. L., Notaro, P. C., & Herrera, C. (2002). Parents' emotional availability and infant emotional competence: Predictors of parent-infant attachment and emerging self-regulation: Journal of Family Psychology. *Journal of Family Psychology*, *16*(4), 447–465. https://doi.org/10.1037/0893-3200.16.4.447

Vouloumanos, A., & Curtin, S. (2014). Foundational tuning: How infants' attention to speech predicts language development. *Cognitive Science*, *38*(8), 1675–1686. https://doi.org/10.1111/cogs.12128

Wallentin, M. (2009). Putative sex differences in verbal abilities and language cortex: A critical review. *Brain and Language*, *108*(3), 175–183. https://doi.org/10.1016/j.bandl.2008.07.001

Wechsler, D. (2012). *WAIS IV esitys- ja pisteytyskäsikirja [WAIS IV Manual]*. Hogrefe Psykologien Kustannus Oy [Psychological corporation].

Wei, T., & Simko, V. (2021). *R package "corrplot": Visualization of a correlation*

matrix (Version 0.92) [Computer software]. https://github.com/taiyun/corrplot

Weisleder, A., & Fernald, A. (2013). Talking to children matters: Early language experience strengthens processing and builds vocabulary. *Psychological Science*, *24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Wellman, H. M., Harris, P. L., Banerjee, M., & Sinclair, A. (1995). Early understanding of emotion: Evidence from natural language. *Cognition and Emotion*, *9*(2–3), 117–149. https://doi.org/10.1080/02699939508409005

Yew, S. G. K., & O'Kearney, R. (2013). Emotional and behavioural outcomes later in childhood and adolescence for children with specific language impairments: Meta-analyses of controlled prospective studies. *Journal of Child Psychology and Psychiatry*, *54*(5), 516–524. https://doi.org/10.1111/jcpp.12009

Zambrana, I. M., Pons, F., Eadie, P., & Ystrom, E. (2014). Trajectories of language delay from age 3 to 5: Persistence, recovery and late onset. *International Journal of Language & Communication Disorders*, *49*(3), 304–316. https://doi.org/10.1111/1460-6984.12073

Zerbeto, A. B., Cortelo, F. M., & C. Filho, É. B. (2015). Association between gestational age and birth weight on the language development of Brazilian children: A systematic review. *Jornal de Pediatria*, *91*, 326–332. https://doi.org/10.1016/j.jped.2014.11.003

Appendix: Original publications

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BRIEF REPORT

Temperament is associated with the use of communicative gestures in infancy

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Abstract

Temperament is important to consider when investigating factors influencing communicative development in infancy. Existing research supporting the assumption that temperament and verbal language development are interrelated covers mainly verbal development in toddlerhood onward, but few studies focus on these relations in infancy. The present study of 91 infants from a general population pregnancy cohort in Finland used parent reports to investigate associations between temperament and the development of preverbal gesturing and receptive vocabulary in infancy. We found that infant temperament explained a substantially larger proportion of the variance in expressive communicative gesturing compared to receptive vocabulary. High *Duration of orienting* and *Soothability*, indicators of orienting/regulation capacity, and higher positive emotionality were found to be favourable for the use of communicative gestures. These temperament characteristics might promote interaction and thus advance communicative development. Knowledge on associations between infant temperament and communicative development is important in supporting outcomes in children with temperament characteristics possibly less favourable for communication development.

Highlights

- The aim is to investigate how temperament traits relate to gesture use and receptive vocabulary in infants.
- Temperament was assessed at 6 and 12 months and receptive vocabulary and gesture use at 12 months using parental reports.
- Temperament was found to relate to communicative development in infancy, and to use of communicative gestures in particular.

KEYWORDS

communicative development, gestures, infant, language development, temperament, vocabulary

1 | INTRODUCTION

The trajectories of communicative development in young children are diverse, and part of this variability is reportedly explained by child temperament traits (e.g., Prior et al., 2008; Usai, Garello, & Viterbori, 2009). Communicative development starts long before the first word is uttered in the form of preverbal gesturing and receptive vocabulary. In order to understand and support communicative development trajectories over the course of life, it is of great importance to explore specifically the earliest relations between the different domains of temperament and the characteristics of emergent communicative development. However, currently, very few studies have focused on these detailed aspects when examining the early phases of temperament and communicative development.

Temperament refers to individual differences in emotional, motor and attentional reactivity, and self-regulation (Rothbart & Bates, 1998) and is assumed to have a biological foundation, but it is also modifiable throughout life due to experience, maturation and environmental factors (Goldsmith et al., 1987; Rothbart & Bates, 2006). Infant temperament is commonly seen to include three broader dimensions: positive emotionality/surgency, negative affect, and orienting/regulation, the latter usually referring to the emerging self-regulation abilities (Gartstein & Rothbart, 2003).

Moderate stability in temperament traits is displayed across both parent reports and observational studies even in young children (Dyson et al., 2015; Kopala-Sibley, Olino, Durbin, Dyson, & Klein, 2018; Putnam, Rothbart, & Gartstein, 2008). However, some traits and especially dimensions of self-regulation also develop and show inter-individual change across development. This is explained as happening because some traits, for instance, fearfulness (Braungart-Rieker, Hill-Soderlund, & Karrass, 2010) and duration of orienting, do not become prominent until the latter half of the first year (Rothbart, Sheese, & Posner, 2007), and might not be fully observable until the end of the first year of life. Moreover, the behavioural expression of certain temperament dimensions may change along the development (Caspi & Roberts, 1999; Rothbart & Bates, 2006). As a result, associations between temperament and other developmental outcomes, like communicative development, which also rapidly changes across infancy and toddlerhood, may vary across early childhood. This emphasizes the need to study these specific associations at the earliest ages and to follow them up in a longitudinal setting (Holmboe, Bonneville-Roussy, Csibra, & Johnson, 2018). For example, positive emotionality has been found to correlate with expressive vocabulary in toddlerhood (e.g., Laake & Bridgett, 2014), but there is currently no research published on whether positive emotionality already contributes to infant expressive gesturing.

Investigation of the factors influencing communicative development is, in turn, important, as early verbal and nonverbal communication skills are associated with several developmental outcomes later in life, such as cognitive

skills, executive functioning, language skills, and school performance (e.g., Hohm, Jennen-Steinmetz, Schmidt, & Laucht, 2007; Kuhn, Willoughby, Parramore Wilbourn, Wernon-Feagans, & Blair, 2014). Hence, communicative development in infancy plays an important role in laying the foundation for later developmental outcomes, emphasizing the importance of studying different factors associated with it. However, despite the importance of early communicative skills and existing evidence that child temperament traits, such as positive emotionality, self-regulation, and attentiveness, may be intertwined with language development (e.g., Garello, Viterbori, & Usai, 2012; Moreno & Robinson, 2005; Salley & Dixon, 2007), relatively few studies have focused on the relations between temperament and language development in infancy. To our knowledge, no studies have scoped the relations between temperament traits and gesturing. In the current study, we extend the current research by studying the association between temperament in early (at 6 months) and late (at 12 months) infancy and preverbal communication at 12 months of age.

1.1 | Communicative development

Children develop verbal language at different rates and display large variability in language (e.g. Fenson et al., 1994). However, the rank-order stability in language skills is shown to be moderate to strong from 1 year of age to at least school age (Bornstein, Hahn, & Haynes, 2004). Infants' receptive vocabularies are usually substantially larger than their expressive ones, and before the first word is uttered, they usually understand many (Fenson et al., 1994). Moreover, even before they speak their first words, infants communicate with others using vocalizations and nonverbal communication such as gestures. The first gestures usually emerge after the age of 6 months (Bates & Dick, 2002), whereas the first word is usually uttered closer to the time of the first birthday (Barrett, 1995). Hence, at the age of 12 months, gesturing is, for most infants, a more developed mode of expressive communication than verbal language. Since the use of gestures has had a head start and reached a higher level of use and thereby higher variability at the age of 12 months, we argue that focusing on gesturing instead of produced words is preferable when studying expressive communication in this age group. Gesturing is assumed to form a foundation upon which verbal language skills can be built (Goldin-Meadow & Wagner Alibali, 2013). Infant use of gestures predicts concurrent emerging expressive vocabulary (Kuvač Kraljević, Cepanec, & Šimleša, 2014), and later verbal language skills (Kuhn et al., 2014). Gesturing also reportedly predicts later vocabulary size better than the early use of expressive words (Rowe & Goldin-Meadow, 2009).

1.2 | Relations between temperament and language

As part of the work investigating factors influencing communicative development, a growing number of studies have looked at temperament as a predictor of language outcomes. Accordingly, studies involving older children have found that temperament traits such as duration of orienting or high attentiveness and high positive emotionality, in addition to executive control, are positively associated with language skills (Garello et al., 2012; Salley & Dixon, 2007).

Existing research has also emphasized the need to differentiate between aspects of language, as different domains of early temperament traits may relate differentially to expressive and receptive language. For example, Smith Watts et al. (2014) found behavioural inhibition (shyness), which is an aspect related to fearfulness and negative emotionality, to be negatively associated with expressive, but not receptive, language at 14, 20, and 24 months of age. A handful of studies conducted in infants have, so far, found similar relations between temperament and language as those conducted in older children. For instance, Morales et al. (2000) found that higher infant activity level, attentiveness, soothability, and positive emotionality at the age of 6 months were associated with better receptive language skills at the age of 12 months. In another study, emotional vitality, comprising the infant's higher expression of both positive and negative emotionality, assessed at 8 months positively predicted expressive language skills at 30 months (Moreno & Robinson, 2005). Positive emotionality at 10 months also predicted expressive, but not receptive, language skills at 14 months in a study by Laake and Bridgett (2014). However,

Molfese et al. (2010) found that more difficult temperament, a temperament type typically referring to higher expressions of negative affect, predicted larger total vocabulary size, including both receptive and expressive vocabulary, at 12 months. To conclude, results regarding the relationship between temperament and language development in infancy are relatively few and inconclusive, but similarly to studies with focus on older children point out the need to study receptive and expressive language separately. Moreover, it can be argued whether emergent infant expressive language skills show enough variability in early toddlerhood, since the expressive vocabulary at 1 year of age often ranges between no words at all to just above 20 (e.g., Paavola, Kunnari, Moilanen, & Lehtihalmes, 2005) and the distribution tends to be skewed towards 0 (Fenson et al., 2000). Notably, none of the studies listed have considered the use of communicative gestures, which show more variability in infancy and early toddlerhood.

Several mechanisms underlying the relations between temperament and language have been indicated. First, it is suggested that temperament influences the quantity and quality of interaction with others, as well as the ability to acquire linguistic information from the environment. That is, children high in positive emotionality and outgoingness may encourage other people to interact with them and thereby get more linguistic stimulation (Laake & Bridgett, 2014). Moreover, it is proposed that temperament might add to other skills beneficial for language development; for instance, children high in attentiveness and executive control may better be able to absorb linguistic stimuli thanks to their ability to focus attention on them (Usai et al., 2009). However, given the relatively few longitudinal follow-ups and the possible change in both temperament and language development during infancy, the exact relations between these two remain unknown.

1.3 | The present study

Previous research on the associations between temperament and communicative development has focused primarily on receptive and expressive verbal skills in older children, leaving a knowledge gap concerning the links between temperament and infant preverbal communication, such as use of gestures. In all, research on the associations between temperament in infancy and the earliest stages of communication development remains relatively scarce, which limits our understanding of how best to support communicative development in children with different temperamental traits in early life.

The aim of our study was to address these gaps in the literature by investigating how temperament traits assessed at 6 and 12 months of age relate to gesture use and receptive vocabulary at 12 months. Gesture use and receptive vocabulary were chosen as measures of communicative development because they are already reliably measurable in infancy. The hypothesis based on earlier studies was that higher infant orienting/regulation capacity measured by infant *Duration of orienting* and *Soothability*, and a higher level of positive emotionality measured by *Smiling and laughter*, would correlate positively with preverbal language skills at the age of 12 months.

2 | METHODS

2.1 | Participants

The participants in the study comprised 91 families from South-Western Finland with a child born between June 2010 and August 2011, who had participated in the first phase of the FinnBrain Birth Cohort Study (see, e.g., Nolvi et al., 2016). The first phase of the study had involved 203 families, of which the selected 91 had returned all three questionnaires used in this study. The study was approved by the Ethics Committee of the Hospital District of Southwest Finland. Most of the participating families (84.6%) lived in a city. Of the infants, 46 (50.5%) were girls and 45 (49.5%) were boys. The mean length of gestation at birth was 39.6 weeks (Mdn 40, *SD* 2.1, range 31.0–42.3, information missing in three cases, 3.3%). Most of the children (n = 81, 89.0%) were born full term, whereas seven (7.7%) were born preterm (<37 gestational weeks). There were no significant differences in receptive vocabulary or

temperament between preterm and full-term infants. However, preterm infants used significantly fewer communicative gestures (preterm M = 7.9, SD = 2.9, full-term M = 10.3, SD = 2.8, $t(86) = 2.2$, $p = .03$, $d = .85$). All children were included in the further analyses, but gestational weeks were included as a covariate in the regression analyses involving gesture use.

Most of the families, (75, 82.4%), were monolingual, and three (3.3%) had not provided sufficient information about the language or languages spoken by the parents. There were 13 (14.3%) bilingual families (Finnish–Swedish or Finnish–other language); in nine of these, the mother spoke Finnish with the child. No significant differences between monolingual and bilingual infants in receptive vocabulary, use of communicative gestures or temperament were found. Thereby, both monolingual and bilingual families were included in the further analyses.

The mean age of the mother at delivery was 29.8 years (Mdn 30, SD 4.8, range 19–42, information missing in four cases). Of the mothers, 45 (49.5%) had a university education (bachelor's degree/master's degree/licentiate/doctorate), 32 (35.2%) had a mid-level education (college-level training/polytechnic degree), and 10 (11.0%) had a low education level (school-level training/high school/vocational course/no education). Over half of the infants (63.7%) were firstborns, the rest (36.3%) having one sibling or more. None of the infants were twins. Effects of birth order on language and educational outcomes have been discussed in the literature with different conclusions (e.g., Barclay, 2018). In contrast to previous research showing that being a firstborn might be advantageous for language development through having the caregivers' undivided attention (Berglund, Eriksson, & Westerlund, 2005), the groups of children with and without siblings did not differ significantly from one another for any of the measured parameters in our sample.

2.2 | Data collection and measures

Infant temperament was assessed twice using the Infant Behavior Questionnaire (IBQ) (Rothbart, 1981), first when the child was 6 months old and later at 12 months old. The IBQ contains 94 items regarding the infant's behaviour in different situations during the past week, for example, “After sleeping, how often did the baby fuss or cry immediately?” The questions are answered on a 7-point scale where 1 stands for “never” and 7 for “always.” Six subscales describing different temperament traits of the child were derived from the 94 items of the IBQ. These subscales are *Activity level*, *Smiling and laughter*, *Distress and latency to approach sudden/novel stimuli*, *Distress to limitations*, *Soothability*, and *Duration of orienting*. *Activity level* refers to the infant's level of gross motor activity. *Smiling and laughter* refers to how much the infant tends to smile and laugh in different situations and can be considered a dimension under Positive emotionality. *Distress and latency to approach sudden/novel stimuli* refers to fearfulness or the need for time to adapt when encountering new or sudden stimuli. *Distress to limitations* is the tendency to cry, fuss or otherwise show distress in the following situations: waiting for food, refusing food, being in a confining position or place, being dressed or undressed, or not being able to access an object of interest; these two can be considered to fall under the dimension of negative emotionality. Moreover, the scale of *Soothability* refers to how effectively soothing techniques used by a caretaker or the infant serve in reducing crying, fussing or other displays of distress, and *Duration of orienting* describes the length of time the infant tends to vocalize and look at or interact with the same object, provided no sudden changes in stimulation occur (Rothbart, 1981, p. 573); both are considered to reflect early orienting/regulation ability. These subscales demonstrated acceptable to good internal consistency in the present study: *Activity level* (Cronbach's α = .82 and .83), *Smiling and laughter* (α = .82 for both time points), *Distress and latency to approach sudden/novel stimuli* (α = .55 and .73), *Distress to limitations* (α = .80 and .84), *Soothability* (α = .66 and .80), and *Duration of orienting* (α = .80 and .82).

Communicative development was measured using the Finnish version of the MacArthur-Bates Communicative Development Inventories (CDI) (Fenson et al., 1994; Lyytinen, 1999). The CDI was filled out by the parents when the infant was 12 months old. All families, both bilingual and monolingual, received the CDI in Finnish and the questionnaires were completed by the mothers. The sections selected for this study were receptive vocabulary (α = .94) and use of communicative gestures (α = .65). The assessment of receptive vocabulary is based on checklists of words in different semantic categories, where parents tick boxes for whether the parent perceives the infant to understand the word in

question. The maximum score is 380. The assessment of use of communicative gestures is based on a gesture checklist (CDI Part II Section A: First communicative gestures), which includes the first communicative gestures such as pointing, waving goodbye and nodding to say "yes." The later sections of Part II in the CDI (Games and routines, Actions with objects, Pretending to be a parent, and Imitating other adult actions) were not included as they were not considered to assess purely communicative gesturing. The parent chooses between the alternatives "does not use," "uses sometimes," and "uses often" for each gesture listed. The maximum score is 20 (Fenson et al., 1994; Lyytinen, 1999).

2.3 | Data analysis

The data were analysed using IBM SPSS statistics 24. *p*-Values below .05 were considered statistically significant. The IBQ subscales were normally distributed. Two outliers were removed from the analyses involving the receptive vocabulary variable in the CDI, since they were unlikely to be realistic, nearly reaching the maximum score on the receptive vocabulary scale (see, e.g., the Finnish CDI norms by Lyytinen (1999), where the highest points in receptive vocabulary were 263/380). The communicative gestures sum variable was not normally distributed ($D(91) = .13$, $p = .001$, skewness = −.61) and the distribution could not be improved by using logarithm transformation. For the receptive vocabulary, a more normal distribution was accomplished by conducting a logarithm transformation ($D(89) = .10$, $p = .03$, skewness = −1.21) in comparison to the original variable ($D(89) = .11$, $p = .01$, skewness = .80). Both variables, although deviating from normality, were considered to be close enough to normal distribution and suitable for use with parametric tests and regression analyses due to the relative robustness of these tests (see Lumley, Diehr, Emerson, & Chen, 2002). To investigate zero-order correlations between temperament and communication measures, Pearson correlation coefficients were used. Further, standard linear regression with sets of variables entered manually in predetermined steps was used to discover how much of the variance in communicative development could be explained by variations in the temperamental traits. Thereby, infant gender and maternal education were included in the analysis as covariates due to their previously reported associations with language development (Harrison & McLeod, 2010; Prior et al., 2008). Length of gestation at birth was included as a covariate, as prematurely born children differed significantly from full-term children regarding use of communicative gestures. These covariates, maternal educational level, length of gestation, and child gender, were entered in the first step and temperament variables in the second step of the analyses. Collinearity statistics throughout the models were low (VIF <2.00), indicating that it was adequate to include different temperament traits in the same model.

3 | RESULTS

The descriptive information for the CDI is displayed in Table 1. Many infants already understood a large number of words and used several communicative gestures at the age of 12 months. There were no significant differences regarding receptive vocabulary between girls and boys (girls $M = 70$, $SD = 54.2$, boys $M = 74$, $SD = 51.6$, $t(87) = -.02$, $p = .98$, $d = .00$). The use of communicative gestures, however, was higher in girls ($M = 11$, $SD = 2.42$) than in boys ($M = 9$, $SD = 3.01$), $t(87) = 3.96$, $p = .001$, $d = 82$. The descriptive information for temperament variables at both 6 and 12 months of age is displayed in Table 2. *Distress and latency to approach sudden/novel stimuli*, *Smiling and laughter*, and *Distress to limitations* all increased significantly between the ages of 6 and 12 months (Table 2). Additionally, there were differences between genders on the temperament scales. At 6 months of age, boys were rated higher in *Smiling and laughter*, whereas at 12 months girls were rated higher in *Distress and latency to approach sudden/novel stimuli* (see Tables 3 and 4). The temperament dimensions were interrelated at both 6 and 12 months, and the correlation coefficients ranged from modest to moderate (Table 5).

The correlations between temperament and receptive vocabulary and communicative gesturing are presented in Table 6. *Soothability* at 6 months correlated positively with the use of communicative gestures at 12 months. Moreover, *Duration of orienting* at 12 months correlated positively with the use of both receptive vocabulary and

TABLE 1 Descriptive statistics for the CDI communication variables and a *t* test with effect size Cohen's *d* of differences between genders (*N* = 91)

	Whole sample (N = 91)					*Girls (n = 46)*					*Boys (n = 45)*					*Difference between genders*		
Measure	*M*	*Mdn*	*SD*	*SE*	*Range*	*M*	*Mdn*	*SD*	*SE*	*Range*	*M*	*Mdn*	*SD*	*SE*	*Range*	*t*(87)	*p*	*d*
Receptive vocabulary[a]	72	59	53	5.6	1–210	70	50	54	8.1	6–210	74	64	52	7.8	1–195	−.02	.98	.00
Communicative gestures	10	10	3	0.3	0–17	11	11	2	0.4	6–17	9	9	3	0.3	0–14	3.96	.00	.82

[a]*n* = 89, 45 girls and 44 boys for receptive vocabulary since two outliers were removed.

TABLE 2 Descriptive statistics for the IBQ scales at ages 6 and 12 months and a *t* test with effect size Cohen's *d* of differences between assessment points (*N* = 91)

	6 months					12 months					Difference between 6 and 12 months		
Scale (1–7)	*M*	*Mdn*	*SD*	*SE*	*Range*	*M*	*Mdn*	*SD*	*SE*	*Range*	*t*(90)	*p*	*d*
Activity level	4.55	4.65	0.81	0.09	2.06–6.53	4.47	4.44	0.79	0.08	2.18–6.41	−2.00	.44	.10
Distress and latency to approach sudden/novel stimuli	2.44	2.45	0.71	0.07	1.07–4.27	2.65	2.63	0.63	0.07	1.33–4.57	−2.51	.02	.31
Duration of orienting	3.22	3.27	0.93	0.10	1.09–6.27	3.04	3.09	0.92	0.10	1.18–5.80	1.92	.06	.19
Smiling and laughter	4.74	4.80	0.92	0.10	3.00–7.00	5.17	5.21	0.74	0.08	3.33–6.60	−5.58	.00	.52
Soothability	4.87	5.00	0.83	0.09	2.10–6.50	5.05	5.00	0.79	0.08	2.89–6.67	−1.85	.07	.22
Distress to limitations	3.34	3.30	0.74	0.08	1.92–5.44	3.70	3.63	0.77	0.08	2.22–5.85	−4.68	.00	.48

communicative gestures at 12 months, and *Smiling and laughter* at 12 months correlated positively with the use of communicative gestures at 12 months.

The regression analyses on 6-month temperament and the communicative outcomes receptive vocabulary and communicative gesturing at 12 months are shown in Table 7. Temperament at 6 months accounted for a higher proportion of the variance in gesture use compared to receptive vocabulary at the age of 12 months. After accounting for the variation of length of gestation and child gender, *Soothability*, an aspect of orienting/regulation capacity, significantly predicted use of communicative gestures, and accounted for 7% of the variance. None of the temperament traits at 6 months predicted receptive vocabulary at 12 months.

Regression analyses for concurrent assessments of temperament and receptive vocabulary and communicative gesturing at 12 months showed that after accounting for the variance of child gender and duration of gestation, infant temperament traits *Duration of orienting*, an aspect of orienting/regulation capacity, and *Smiling and laughter*, an aspect of positive emotionality, had a significant positive contribution to the variance in use of communicative gestures (Table 8). Both temperamental dimensions accounted for 4% of the variance in the use of communicative gestures. None of the temperament traits significantly contributed to the variance in receptive vocabulary.

TABLE 3 Descriptive statistics for the IBQ scales separately for girls and boys at age 6 months and a *t* test with effect size Cohen's *d* of differences between genders (*N* = 91)

	6 months												
	Girls (*n* = 46)					Boys (*n* = 45)					Difference between genders		
Scale (1–7)	*M*	Mdn	*SD*	*SE*	Range	*M*	Mdn	*SD*	*SE*	Range	*t*(89)	*p*	*d*
Activity level	4.42	4.53	0.84	0.12	2.06–6.18	4.68	4.76	0.77	0.12	3.06–6.53	−1.56	.12	.33
Distress and latency to approach sudden/novel stimuli	2.47	2.53	0.73	0.11	1.07–4.27	2.40	2.29	0.70	0.10	1.14–4.00	.43	.67	−.09
Duration of orienting	3.09	3.23	0.92	0.14	1.09–4.55	3.35	3.30	0.93	0.14	1.70–6.27	−1.34	.18	.28
Smiling and laughter	4.55	4.68	0.92	0.14	3.00–6.60	4.94	4.87	0.89	0.13	3.00–7.00	−2.00	.05	.42
Soothability	4.76	4.75	0.84	0.12	2.10–6.11	4.98	5.00	0.82	0.12	3.13–6.50	−1.29	.20	.27
Distress to limitations	3.21	3.11	0.66	0.10	1.94–5.44	3.46	3.50	0.80	0.12	1.92–5.15	−1.55	.12	.33

Abbreviation: IBQ, Infant Behavior Questionnaire.

TABLE 4 Descriptive statistics for the IBQ scales separately for girls and boys at age 12 months and a *t* test with effect size Cohen's *d* of differences between genders (*N* = 91)

	12 months												
	Girls (*n* = 46)					Boys (*n* = 45)					Difference between genders		
Scale (1–7)	*M*	Mdn	*SD*	*SE*	Range	*M*	Mdn	*SD*	*SE*	Range	*t*(90)	*p*	*d*
Activity level	4.40	4.41	0.84	0.12	2.18–5.93	4.54	4.50	0.73	0.11	3.14–6.41	−.88	.38	.18
Distress and latency to approach sudden/novel stimuli	2.78	2.69	0.60	0.09	1.73–4.57	2.51	2.56	0.64	0.10	1.33–4.20	2.05	.04	−.42
Duration of orienting	2.95	3.09	0.85	0.13	1.18–5.55	3.12	3.09	0.99	0.15	1.27–5.80	−.87	.39	.18
Smiling and laughter	5.03	5.08	0.72	0.11	3.33–6.60	5.31	5.47	0.74	0.11	3.60–6.57	−1.89	.06	.40
Soothability	4.97	4.84	0.74	0.11	3.50–6.50	5.13	5.22	0.84	0.12	2.89–6.67	−.98	.33	.21
Distress to limitations	3.69	3.63	0.77	0.11	2.22–5.85	3.70	3.61	0.79	0.12	2.31–5.20	−.10	.92	.02

Abbreviation: IBQ, Infant Behavior Questionnaire.

4 | DISCUSSION

Mapping out factors influencing early communicative development is essential to gain the knowledge needed to support children's communicative development from the very beginning of life, even before the first words are uttered. Although there is previous research on the relations between different domains of temperament and language

TABLE 5 Correlations between temperament dimensions

	Activity level	Distress and latency to approach sudden/novel stimuli	Duration of orienting	Smiling and laughter	Soothability	Distress to limitations
6 months						
Activity level		−.02	.13	.29**	.16	.30**
Distress and latency to approach sudden/novel stimuli			.25*	−.08	−.09	.15
Duration of orienting				.30**	.28**	−.10
Smiling and laughter					.44**	−.04
Soothability						−.00
12 months						
Activity level		.35**	.16	.04	.15	−.07
Distress and latency to approach sudden/novel stimuli			−.13	−.30	−.10	.37**
Duration of orienting				.35**	.20	−.03
Smiling and laughter					.35**	−.20
Soothability						−.25

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

TABLE 6 Correlations between temperamental traits at 6 and 12 months of age and receptive vocabulary and communicative gestures at 12 months of age

	Temperament 6 months		Temperament 12 months	
	Receptive vocabulary 12 months	Communicative gestures 12 months	Receptive vocabulary 12 months	Communicative gestures 12 months
Activity level	.12	.15	−.03	.16
Distress and latency to approach sudden/novel stimuli	.20	.17	.02	.09
Duration of orienting	.02	.16	.22*	.29**
Smiling and laughter	.13	.09	.10	.32**
Soothability	.10	.28**	.15	.12
Distress to limitations	.07	−.05	−.00	−.02

Note: $n = 89$, 45 girls and 44 boys for receptive vocabulary since two outliers were removed.
*$p < .05$; **$p < .01$.

development, the knowledge on these relations in infancy is still scarce, and the infant-specific domain of preverbal gesturing is to our knowledge unexplored. The aim of the present study was to examine whether infant temperament across the first year of life and use of communicative gestures and receptive vocabulary at 1 year of age are interrelated. The hypotheses were that higher infant orienting/regulation, measured as *Duration of orienting* and *Soothability*, and positive emotionality, measured as *Smiling and laughter*, would be positively associated with communicative development already at the ages of 6 and 12 months. We found that the indicators of infant self-regulation at

TABLE 7 Summary of regression analysis for temperament at 6 months of age and receptive language and use of communicative gestures at 12 months of age

	Receptive vocabulary					Communicative gestures				
	B	*SE B*	*β*	*p*	Δ R^2	*B*	*SE B*	*β*	*p*	Δ R^2
Model 1					.03					.22
Constant	.16	1.11				.96	5.68			
Maternal educational level	.12	.15	.09	.42		−.07	.42	−.02	.87	
Length of gestation	.03	.02	.15	.19		.32	.14	.23	.02*	.05
Child gender	−.04	.10	−.04	.71		−2.38	.58	−.41	<.01**	.17
Model 2					.07					.12
Constant	−.45	1.18				−5.97	5.90			
Maternal educational level	.16	.15	.12	.29		.20	.42	.05	.64	
Length of gestation	−.02	.03	.10	.41		.29	.14	.21	.04*	.04
Child gender	−.06	.10	−.07	.55		−2.70	.58	−.46	<.01**	.19
Activity level	.05	.07	.10	.45		.46	.39	.12	.24	
Distress and latency to approach sudden/novel stimuli	.13	.08	.21	.10		.46	.44	.11	.30	
Duration of orienting	−.04	.06	−.09	.49		.31	.34	.10	.36	
Smiling and laughter	.05	.06	.11	.42		−.26	.37	−.08	.48	
Soothability	.05	.07	.10	.42		1.06	.37	.30	.01**	.07
Distress to limitations	.01	.08	.02	.87		−.03	.41	−.01	.95	

Note: Adjusted R^2 for receptive language in the first step = −.01 and adjusted R^2 = −.02 for the last step, adjusted R^2 for communicative gestures in the first step = .19 and for the last step adjusted R^2 = .26. *N* = 89, 45 girls and 44 boys for receptive vocabulary since two outliers were removed.
*p < .05; **p < .01.

6 months (*Soothability*) and at 12 months (*Duration of orienting)* and positive emotionality (*Smiling and laughter*) at 12 months were positively related to the use of gestures at 12 months of age.

Thus, our hypotheses were in many respects supported by the results, as most temperament dimensions which were expected to be central for communicative development correlated with the use of communicative gestures. In accordance with the hypotheses, we found that positive emotionality, represented by the scale *Smiling and laughter* in the IBQ, was positively associated with the use of gestures. As use of gestures is a mode of expressive communication comparable to expressive vocabulary, we argue that these findings concur with those of Laake and Bridgett (2014), who found that positive emotionality at 8 months predicted expressive, but not receptive, vocabulary in 14-month-olds, and with the findings of Moreno and Robinson (2005), who found a relation between 8-month *Smiling and laughter* and expressive language at 30 months. Laake and Bridgett (2014) suggest that infants high in positive emotionality use their emerging expressive communicative skills more effectively to elicit interaction compared to peers lower in this dimension. It is also likely that infants with a tendency to happiness generally encourage adults to interact with them to a larger extent compared to infants with more negative emotionality. This greater amount of interaction with others and the received language stimuli, in turn, scaffold further communicative development, since we know children learn language and communication in interaction and not by simply overhearing conversations (Weisleder & Fernald, 2013), and the same is likely true for the development of gesturing. This interpretation points to a need to explicitly provide infants lower in positive emotionality with a sufficient amount of interaction and communicative stimulation, even though they may not elicit this behaviour from adults as efficiently as peers higher in this temperament dimension. Another interpretation for these findings could be that higher positive emotionality, an

TABLE 8 Summary of regression analysis for temperament variables at 12 months and receptive language and use of communicative gestures at 12 months (N = 91)

	Receptive vocabulary					Communicative gestures				
	B	*SE B*	*β*	*p*	Δ R^2	*B*	*SE B*	*β*	*p*	Δ R^2
Model 1					.03					.22
Constant	.16	1.11				.96	5.68			
Maternal educational level	.12	.15	.09	.42		−.07	.42	−.02	.87	
Length of gestation	.03	.02	.15	.19		.32	.14	.23	.02*	.05
Child gender	−.04	.10	−.04	.71		−2.38	.58	−.41	<.01**	.17
Model 2					.05					.16
Constant	−.22	1.26				−7.82	6.06			
Maternal educational level	.13	.15	.10	.41		.09	.40	.02	.83	
Length of gestation	.02	.03	.11	.36		.28	.14	.20	.04*	.04
Child gender	−.06	.10	−.07	.56		−2.88	.56	−.49	<.01**	.22
Activity level	−.02	.07	−.04	.77		.69	.38	.19	.07	
Distress and latency to approach sudden/novel stimuli	.00	.09	.00	.99		.28	.49	.06	.58	
Duration of orienting	.09	.06	.17	.16		.70	.32	.22	.03*	.04
Smiling and laughter	.02	.09	.03	.81		.98	.47	.23	.04*	.04
Soothability	.06	.07	.10	.42		.01	.39	.00	.98	
Distress to limitations	.04	.08	.07	.60		−.03	.41	−.01	.94	

Note. Adjusted R^2 for receptive language in the first step = −.01 and adjusted R^2 = −.04 for the last step, adjusted R^2 for communicative gestures in the first step = .19, and adjusted R^2 = .31 for the second step. N = 89, 45 girls and 44 boys for comprehended words since two outliers were removed.
*p < .05; **p < .01.

aspect of temperament related to later extraversion, in itself increases the tendency to use communicative gestures, regardless of the underlying capacity to gesture as compared to infants lower in positive emotionality.

Moreover, the indicators of higher self-regulation such as higher *Soothability* at 6 months and higher *Duration of orienting*, a measure of attentiveness, at 12 months predicted gesture use at 12 months. These results correspond to previous research reporting positive relations between self-regulatory abilities or attentiveness, and language skills in infancy and toddlerhood (Dixon & Smith, 2000; Karrass & Braungart-Rieker, 2003; Morales et al., 2000; Salley & Dixon, 2007; Usai et al., 2009). There are several alternative explanations for these findings. Infants with longer duration of orienting may have stronger language skills than their peers due to their better ability to pay attention to interaction and language spoken around them, which increases the amount of opportunities for communication and language learning. It is also possible that longer duration of orienting enables infants to engage in longer interactions with caretakers, again enhancing learning to communicate.

It was unexpected that no associations between temperament and receptive vocabulary were found in the current study, although temperament has been found to predict receptive vocabulary in previous studies carried out on infants (Morales et al., 2000) and older children (Garello et al., 2012). This suggests that temperament is especially related to the preverbal communicative ability, i.e., gesturing, in infancy. This is possibly specific to this young age group and the communicative abilities observable in them. Perhaps use of communicative gestures shows greater variability at 12 months than earlier in infancy and is thus easier for mothers to assess compared to receptive vocabulary. Another possibility in light of the limited research literature is that temperament simply associates more strongly with the expressive use of communicative gestures than with receptive vocabulary in the

earliest stages of communicative development. Since gesturing is argued to share developmental underpinnings with verbal language (Goldin-Meadow & Wagner Alibali, 2013), parallels could be drawn between our findings of temperament being related exclusively to expressive communicative gesturing, and previous research reporting similar findings regarding expressive verbal language. These studies, such as those by Laake and Bridgett (2014) and Smith Watts et al. (2014), also found temperament to relate differently to expressive and receptive language.

For most temperament traits, the associations between temperament and receptive vocabulary and gesturing differed depending on the timing of temperament assessment. This was in itself expected, as we know that temperament in infancy undergoes changes due to maturation, and some dimensions only become observable later in life. One possibility is that some traits also become more important in the interactions with the environment during the first year of life and related to the development of other skills (Rothbart et al., 2007). This could be the case with *Smiling and laughter*, which was associated with use of gestures only when assessed at 12 months. This might be related to the developmental increase in expressions of positive emotionality during late infancy (Gartstein & Rothbart, 2003), also observed in the current study.

Similarly, *Duration of orienting*, reflecting early orienting/regulation capacity and attentiveness, did not have any significant correlations with communicative skills when assessed at 6 months, but did do so at 12 months. This may be attributable to the emergence of executive attention skills and the consequent increase in variations of this dimension during the second half of the first year of life (Rothbart et al., 2007). In contrast, *Soothability* predicted the use of communicative gestures only at the age of 6 months but no longer at 12 months. These patterns fit with the earlier reports of *Soothability* showing less stability or even decreasing throughout the first year of life (Gartstein & Rothbart, 2003; Putnam et al., 2008; Rothbart, 1981).

The correlations between temperament dimensions observed in our study correspond to those of earlier studies and indicate that the IBQ temperament dimensions are independent, but that some traits tend to coexist somewhat. Temperament dimensions showed some modest or moderate intercorrelations in our study (r = .00–.44, p = .00–.88). For instance, in line with earlier studies (Gartstein & Rothbart, 2003; Komsi et al., 2006), dimensions of positive emotionality and self-regulation (*Smiling and laughter*, *Soothability*, *Duration of orienting*) were positively correlated at both time points. Similarly, dimensions of negative emotionality (*Distress and latency to approach sudden/novel stimuli* and *Distress to limitations*) correlated at 12 months but not at 6 months, which may reflect the age-normative later emergence of fearful behaviours (Gartstein et al., 2010; Putnam & Stifter, 2005) measured by distress to latency in this study. Activity level was correlated with both dimensions of negative and positive emotionality, a finding also previously reported in the literature (Kochanska, Coy, Tjebkes, & Husarek, 1998; Komsi et al., 2006).

In addition to temperament, the covariates child gender and length of gestation also remained significant predictors of infant gesture use. Gesture use presented with a significant gender difference; that is, girls had a slightly higher level of gesture use than boys. This resembles previous findings showing that female infants tend to have significantly larger expressive lexicons than male infants (e.g., Stolt, Haataja, Lapinleimu, & Lehtonen, 2008). Similarly, the infants born prematurely used relatively fewer gestures compared to full-term infants, but the effect size was modest. Prematurity as a risk factor for language delay has been established in previous research (e.g., Jansson-Verkasalo et al., 2004), but the modest difference in the small prematurely born group in this sample could also be explained by the discrepancy between these infants' chronological and corrected age, since their gesture use was assessed at 12 months of chronological age.

There are some limitations to our study. One is the use of maternal reports in the assessment of temperament and communicative behaviour. The used instruments have, however, been shown to be reliable in several studies (e.g., Feldman et al., 2005; Fenson et al., 1994; Fenson et al., 2000; Lyytinen, 1999), which correspond to observed temperament (Kochanska, Murray, & Coy, 1997) and provide information that might not be observed during laboratory visits (Gartstein & Marmion, 2008). In the case of bilingual families (n = 13), the instructions for the CDI lacked information on whether to take into account only the language used with the parent doing the assessment or both languages when assessing vocabulary, which may have led to parents using different approaches. However, in 9 of the 13 bilingual families, the mother spoke Finnish, which was therefore probably the stronger

language for these infants; hence we believe this deficiency to be of little significance in the data. Moreover, information on parent–infant interaction might shed more light on possible mechanisms of the associations between temperament and communication and should be considered in future studies. Since the temperament traits become more stable as children grow older, and the relation between temperament and communicative development changes as the children mature, it would be important to assess the same children later to investigate the nature of this change. It would also be interesting to involve more extensive exploration of possible differences between genders in future research.

5 | CONCLUSIONS

In the current study, temperament traits reflecting early self-regulatory abilities and positive emotionality were related to communicative development in infancy, specifically to the use of communicative gestures at 12 months of age. It is plausible that temperamental characteristics encouraging interaction with the infant, such as high positive emotionality and self-regulation, are associated with favourable communicative development. The results implicate the need to consider that certain temperamental traits, such as short duration of orienting or low positive emotionality, may entail a disadvantage for communicative development in infancy, and to provide all infants with the sufficient amount of communicative stimulation regardless of temperament.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

Barclay, K. J. (2018). The birth order paradox: Sibling differences in educational attainment. *Research in Social Stratification and Mobility*, *54*, 56–65. https://doi.org/10.1016/j.rssm.2018.02.001

Barrett, M. (1995). Early lexical development. In P. Fletcher, & B. MacWhinney (Eds.), *The handbook of child language* (pp. 362–392). Malden, MA: Blackwell Publishing.

Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology*, *40*, 293–310. https://doi.org/10.1002/dev.10034

Berglund, E., Eriksson, M., & Westerlund, M. (2005). Communicative skills in relation to gender, birth order, childcare and socioeconomic status in 18-month-old children. *Scandinavian Journal of Psychology*, *46*, 485–491. https://doi.org/10.1111/j.1467-9450.2005.00480.x

Bornstein, M. H., Hahn, C.-S., & Haynes, O. M. (2004). Specific and general language performance across early childhood: Stability and gender considerations. *First Language*, *24*, 267–304. https://doi.org/10.1177/0142723704045681

Braungart-Rieker, J. M., Hill-Soderlund, A. L., & Karrass, J. (2010). Fear and anger reactivity trajectories from 4 to 16 months: The roles of temperament, regulation, and maternal sensitivity. *Developmental Psychology*, *46*, 791–804. https://doi.org/10.1037/a0019673

Caspi, A., & Roberts, B. W. (1999). Personality continuity and change across the life course. In L. A. Pervin, & O. P. John (Eds.), *Handbook of personality psychology: Theory and research* (2nd ed.) (pp. 300–326). New York, NY: Guilford Press.

Dixon, W. E. Jr., & Smith, P. H. (2000). Links between early temperament and language acquisition. *Merrill-Palmer Quarterly*, *46*, 417–440.

Dyson, M. W., Olino, T. M., Durbin, C. E., Goldsmith, H. H., Bufferd, S. J., Miller, A. R., & Klein, D. N. (2015). The structural and rank-order stability of temperament in young children based on a laboratory-observational measure. *Psychological Assessment*, *27*, 1388–1401. https://doi.org/10.1037/pas0000104

Feldman, H. M., Dale, P. S., Campbell, T. F., Colborn, D. K., Kurs-Lasky, M., Rockette, H. E., & Paradise, J. L. (2005). Concurrent and predictive validity of parent reports of child language at ages 2 and 3 years. *Child Development*, *76*, 856–868. https://doi.org/10.1111/j.1467-8624.2005.00882.x

Fenson, L., Bates, E., Dale, P., Goodman, J., Reznick, P. S., & Thal, D. (2000). Variability in early communicative development: Don't shoot the messenger. *Child Development*, *71*, 323–328. https://doi.org/10.2307/1166093

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*, 1–185.

Garello, V., Viterbori, P., & Usai, M. C. (2012). Temperamental profiles and language development: A replication and an extension. *Infant Behavior and Development*, *35*, 71–82. https://doi.org/10.1016/j.infbeh.2011.09.003

Gartstein, M. A., Bridgett, D. J., Rothbart, M. K., Robertson, C., Iddins, E., Ramsay, K., & Schlect, S. (2010). A latent growth examination of fear development in infancy: Contributions of maternal depression and the risk for toddler anxiety. *Developmental Psychology*, *46*, 651–668. https://doi.org/10.1037/a0018898

Gartstein, M. A., & Marmion, J. (2008). Fear and positive affectivity in infancy: Convergence/discrepancy between parent-report and laboratory-based indicators. *Infant Behavior and Development*, *31*, 227–238. https://doi.org/10.1016/j.infbeh.2007.10.012

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*, *26*, 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8

Goldin-Meadow, S., & Wagner Alibali, M. (2013). Gesture's role in speaking, learning, and creating language. *Annual Review of Psychology*, *64*, 257–283. https://doi.org/10.1146/annurev-psych-113011-143802

Goldsmith, H. H., Buss, A. H., Plomin, R., Rothbart, M. K., Thomas, A., Chess, S., … McCall, R. B. (1987). Roundtable: What is temperament? Four approaches. *Child Development*, *58*, 505–529. https://doi.org/10.2307/1130527

Harrison, L. J., & McLeod, S. (2010). Risk and protective factors associated with speech and language impairment in a nationally representative sample of 4- to 5-year-old children. *Journal of Speech, Language, and Hearing Research*, *53*, 508–529. https://doi.org/10.1044/1092-4388(2009/08-0086)

Hohm, E., Jennen-Steinmetz, C., Schmidt, M. H., & Laucht, M. (2007). Language development at ten months—Predictive of language outcome and school achievement ten years later? *European Child and Adolescent Psychiatry*, *16*, 149–156. https://doi.org/10.1007/s00787-006-0567-y

Holmboe, K., Bonneville-Roussy, A., Csibra, G., & Johnson, M. H. (2018). Longitudinal development of attention and inhibitory control during the first year of life. *Developmental Science*, *21*, e12690. https://doi.org/10.1111/desc.12690

Jansson-Verkasalo, E., Valkama, M., Vainionpää, L., Pääkkö, E., Ilkko, E., & Lehtihalmes, M. (2004). Language development in very low birth weight preterm children: A follow-up study. *Folia Phoniatrica et Logopaedica*, *56*, 108–119. https://doi.org/10.1159/000076062

Karrass, J., & Braungart-Rieker, J. M. (2003). Parenting and temperament as interacting agents in early language development. *Parenting: Science and Practice*, *3*, 235–259. https://doi.org/10.1207/S15327922PAR0303_03

Kochanska, G., Coy, K. C., Tjebkes, T. L., & Husarek, S. J. (1998). Individual Differences in Emotionality in Infancy. *Child Development*, *69*, 375–390. https://doi.org/10.1111/j.1467-8624.1998.tb06196.x

Kochanska, G., Murray, K., & Coy, K. C. (1997). The development of self-regulation in the first four years of life. *Child Development*, *68*, 263–277. https://doi.org/10.2307/1131849

Komsi, N., Räikkönen, K., Pesonen, A.-K., Heinonen, K., Keskivaara, P., Järvenpää, A.-L., & Strandberg, T. E. (2006). Continuity of temperament from infancy to middle childhood. *Infant Behavior and Development*, *29*, 494–508. https://doi.org/10.1016/j.infbeh.2006.05.002

Kopala-Sibley, D. C., Olino, T., Durbin, E., Dyson, M. W., & Klein, D. N. (2018). The stability of temperament from early childhood to early adolescence: A multi-method, multi-informant examination. *European Journal of Personality*, *32*, 128–145. https://doi.org/10.1002/per.2151

Kuhn, L. J., Willoughby, M. T., Parramore Wilbourn, M., Wernon-Feagans, L., & Blair, C. B. (2014). Early communicative gestures prospectively predict language development and executive function in early childhood. *Child Development*, *85*, 1898–1914. https://doi.org/10.1111/cdev.12249

Kuvač Kraljević, J., Cepanec, M., & Šimleša, S. (2014). Gestural development and its relation to a child's early vocabulary. *Infant Behavior and Development*, *37*, 192–202. https://doi.org/10.1016/j.infbeh.2014.01.004

Laake, L. M., & Bridgett, D. (2014). Happy babies, chatty toddlers: Infant positive affect facilitates early expressive, but not receptive language. *Infant Behavior and Development*, *37*, 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2002). The importance of the normality assumption in large public health data sets. *Annual Reviews of Public Health*, *23*, 151–169. https://doi.org/10.1146/annurev.publheath.23.100901.140546

Lyytinen, P. (1999). *Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä. Jyväskylän yliopiston Lapsitutkimuskeskus ja Niilo Mäki instituutti. [A method for assessing early communication and language. University of Jyväskylä Child Research Centre and the Niilo Mäki Institute]*. Jyväskylä, Finland: Niilo Mäki Säätiö.

Molfese, V. J., Rudasill, K. M., Beswick, J. L., Jacobi-Vessels, J. I., Ferguson, M. C., & White, J. M. (2010). Infant temperament, maternal personality, and parenting stress as contributors to infant developmental outcomes. *Merrill-Palmer Quarterly*, *56*, 49–79. https://doi.org/10.1353/mpq.0.0039

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Neal, R., & Schwartz, H. K. (2000). Gaze following, temperament, and language development in 6-month-olds: A replication and extension. *Infant Behavior and Development*, *23*, 231–236. https://doi.org/10.1016/S0163-6383(01)00038-8

Moreno, A. J., & Robinson, J. A. L. (2005). Emotional vitality in infancy as a predictor of cognitive and language abilities in toddlerhood. *Infant and Child Development*, *14*, 383–402. https://doi.org/10.1002/icd.406

Nolvi, S., Karlsson, L., Bridgett, D. J., Pajulo, M., Tolvanen, M., & Karlsson, H. (2016). Maternal postnatal psychiatric symptoms and infant temperament affect early mother-infant bonding. *Infant Behavior and Development*, *43*, 13–23. https://doi.org/10.1016/j.infbeh.2016.03.003

Paavola, L., Kunnari, S., Moilanen, I., & Lehtihalmes, M. (2005). The functions of maternal verbal responses to prelinguistic infants as predictors of early communicative and linguistic development. *First Language*, *25*, 173–195. https://doi.org/10.1177/0142723705050341

Prior, M., Bavin, E. L., Cini, E., Reilly, S., Bretherton, L., Wake, M., & Eadie, P. (2008). Influences on communicative development at 24 months of age: Child temperament, behaviour problems, and maternal factors. *Infant Behavior and Development*, *31*, 270–279. https://doi.org/10.1016/j.infbeh.2007.11.001

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development*, *17*, 387–405. https://doi.org/10.1002/ICD.582

Putnam, S. P., & Stifter, C. A. (2005). Behavioral approach-inhibition in toddlers: Prediction from infancy, positive and negative affective components, and relations with behavior problems. *Child Development*, *76*, 212–226. https://doi.org/10.1111/j.1467-8624.2005.00840.x

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*, 569–578. https://doi.org/10.2307/1129176

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon, & N. Eisenberg (Eds.), *Handbook of child psychology, vol. 3: Social, emotional, and personality development* (pp. 105–176). New York, NY: Wiley.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon, R. M. Lerner, & N. Eisenberg (Eds.), *Handbook of child psychology, vol. 3: Social, emotional, and personality development* (pp. 99–166). Hoboken, NJ: Wiley.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks and genes. *Child Development Perspectives*, *1*, 2–7. https://doi.org/10.1111/j.1750-8606.2007.00002.x

Rowe, M. L., & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science*, *12*, 182–187. https://doi.org/10.1111/j.1467-7687.2008.00764.x

Salley, B. J., & Dixon, W. E. Jr. (2007). Temperamental and joint attentional predictors of language development. *Merrill-Palmer Quarterly*, *53*, 131–154. https://doi.org/10.1353/mpq.2007.0004

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing Alternative Hypotheses Regarding the Association Between Behavioral Inhibition and Language Development in Toddlerhood. *Child Development*, *85*, 1569–1585. https://doi.org/10.1111/cdev.12219

Stolt, S., Haataja, L., Lapinleimu, H., & Lehtonen, L. (2008). Early lexical development of Finnish children: A longitudinal study. *First Language*, *28*, 259–279. https://doi.org/10.1177/0142723708091051

Usai, M. C., Garello, V., & Viterbori, P. (2009). Temperamental profiles and linguistic development: Differences in the quality of linguistic production in relation to temperament in children of 28 months. *Infant Behavior and Development*, *32*, 322–330. https://doi.org/10.1016/j.infbeh.2009.04.001

Weisleder, A., & Fernald, A. (2013). Talking to children matters: Early language experience strengthens processing and builds vocabulary. *Psychological Science*, *24*, 2143–2152. https://doi.org/10.1177/0956797613488145

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RESEARCH ARTICLE

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Associations between observed and reported infant negative affectivity, fear and self-regulation, and early communicative development—Evidence from the FinnBrain Birth Cohort Study

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Abstract

Self-regulation and language are intertwined abilities, but the nature of their relations in early childhood when both skills are still emerging is insufficiently understood. Our knowledge of the relations between early negative affectivity and preverbal and verbal communicative development is still limited. Further, observed and reported temperament capture how aspects of temperament operate in different settings but are rarely used in parallel in studies examining early language. During the period of rapid development, longitudinal studies are needed to identify early risk factors

for delayed communicative development. We studied relations between aspects of emerging self-regulation and negative affectivity using both observations at 8 months and mother-reports at 6 and 12 months, and communicative development measured by gesturing and vocabulary at 14 and vocabulary at 30 months in 183 children. Mother-reported self-regulation was related to a higher use of communicative gestures and observed self-regulation by gaze aversion to poorer receptive and expressive vocabulary at 14 months, but neither was significantly associated with vocabulary at 30 months. We found little evidence for associations between negative affectivity and fear in infancy and communicative development. Our findings highlight different aspects of self-regulation as both potential risk and protective factors for communicative development. Mixed results indicate a need for a more detailed examination of different strategies of self-regulation in different conditions and developmental stages to yield a deeper understanding of the relations between self-regulation in infancy and communicative development.

1 | INTRODUCTION

During the first year of life, infants start to communicate using preverbal gestures and sounds and start to develop a receptive vocabulary. From around the first birthday, communication is enriched by a growing expressive vocabulary. Early communicative skills thus include both preverbal communicative gesturing as well as expressive and receptive vocabulary. It is known that strong communicative skills in infancy predict adaptive outcomes in language skills and academic achievement during childhood and adolescence (Hohm et al., 2007), and even in adulthood (Taanila et al., 2005). Inter-individual variability is also very large at this early stage. Therefore, supporting children's communicative development from the very beginning of life is of importance. Further, it is pivotal to understand the underlying factors influencing communicative development in order to support it comprehensively. Although existing work has pointed to the importance of some factors, such as parental child-directed speech (e.g., Newman, Rowe, & Bernstein, 2016), in support of language development, much less work has focused on the role of early emotionality and self-regulation.

Temperament refers to inter-individual differences in emotional, motor, and attentional reactivity and self-regulation (Rothbart & Bates, 1998). Temperament traits have a biological foundation, but experience, maturation, and environmental factors modify them over the life course (Goldsmith et al., 1987; Rothbart & Bates, 2006). According to Rothbart's psychobiological theory, infant temperament consists of three dimensions: positive emotionality/surgency, negative affectivity, and orienting/regulation (Gartstein & Rothbart, 2003). Extant literature presents relatively consistent and robust findings on positive emotionality/surgency being positively related to language development in infants and

toddlers (Garello et al., 2012; Laake & Bridgett, 2014; Moreno & Robinson, 2005; Prior et al., 2008), and is arguably due to this temperament dimension promoting interaction leading to increased communication opportunities (Laake & Bridgett, 2014). However, in striving to prevent weak communicative skills, temperament traits associated with a risk of communicative development problems are also of importance to be aware of, as these may be indicative of a need to stimulate communicative development explicitly.

Negative affectivity is a trait linked with several negative developmental outcomes, such as psychopathology (Buss, 2011; Edwards & Hans, 2015; Pérez-Edgar & Fox, 2005) However, findings regarding negative affectivity and communicative development have been inconsistent. Many studies have reported that high negative affectivity is linked with poorer language development (Bloom & Capatides, 1987; Kubicek & Emde, 2012; Pérez-Pereira, Fernández, Resches, & Luisa Gómez-Taibo, 2016; Salley & Dixon, 2007). In the same vein, low overall affectivity (including both positive and negative affect) has been positively related to language skills in some studies (Bloom & Capatides, 1987; Noel et al., 2008). However, Moreno and Robinson (2005) found that high expression of negative emotions at 8 months of age positively predicted expressive language at 30 months. Furthermore, Nozadi et al. (2015) found that the relations between observationally assessed negative affectivity and language development depended on child age. More specifically, higher levels of anger reactivity at 18 months predicted better expressive language skills at 30 months of age for both genders, whereas poorer expressive language was predicted by concurrent higher anger reactivity for boys. This led the authors to conclude that the same temperament dimension may have differential associations with language development depending on child age. Moreno and Robinson (2005) argue that, similar to positive emotionality, displays of negative affectivity may also serve as support for interaction and create learning opportunities since displaying negative emotions often initiates interaction with an adult. In addition to expressions of frustration and arousal, negative emotions, such as anger, can also be signs of eagerness to reach a goal, which gives the child motivation to communicate the need for assistance in achieving the goal (Moreno & Robinson, 2005). Regardless of the possible positive associations between the tendency for negative affectivity and language skills, Bloom and Capatides (1987) argue that negative affectivity taxes the attentional resources available for language learning, and therefore a more neutral emotional state is more optimal for language learning. Finally, it has been hypothesized that anger expressions in early toddlerhood, when verbal expression is still limited, may be an adaptive communicative strategy (Robinson & Acevedo, 2001), whereas high anger expressions in later toddlerhood, when regulatory abilities are more developed, may be indicative of weaker regulatory abilities (Nozadi et al., 2015).

Separately from other negative emotions, the associations between fear and language have been less frequently studied in infancy and toddlerhood, with the direction of findings being inconsistent across studies. Some suggest that high fear is associated with poorer language skills starting at 15 months of age (Kubicek & Emde, 2012), whereas others have found positive relations between the two domains during the first year (Peterson et al., 2017). Robinson and Acevedo (2001), on the other hand, report that high fear at 6–9 months was inversely related to language skills at 2 years in infants with low reliance on the mother in the assessment situation, whereas fearful infants with high reliance on the mother tended to have stronger language skills. Theories about the mechanisms underlying the relation between fear and language development are similar to those regarding anger and general negative affectivity. Namely, negative relations are explained using the competition for resources-theory, thus, the infants with higher need to regulate fear have less resources for acquiring language skills (Kubicek & Emde, 2012). Positive relations, in turn, are suggested to result from fear creating a need to communicate distress to the caregiver and consequently resulting in the caregiver scaffolding communicative development (Peterson et al., 2017). To conclude, the existing studies

report mixed results regarding both negative emotionality and fear and communicative development in infancy and toddlerhood. Hence, more research is needed in this age group. In line with other research showing that better early self-regulation predicts adaptive development (McClelland et al., 2007; Trentacosta & Shaw, 2009; Ursache et al., 2013; Valiente et al., 2003), the orienting/regulation temperament trait or other closely related concepts of emerging self-regulation, such as attentional orienting (Nigg, 2017), are typically positively associated with language development. These associations have, however, been scarcely studied in infancy, and the few existing studies have predominantly utilized parent reports of self-regulation. For example, Gartstein et al. (2008) found that orienting persistence and perceptual sensitivity, which are specific aspects of regulation, in 6- to 12-month-olds positively predicted emerging language in the form of vocalizations. Additionally, Dixon and Smith (2000) found attentional control, also an aspect of early regulation skills, to positively predict both expressive and receptive language in infancy/toddlerhood. Parent reports typically assess general self-regulation, including several strategies in a variety of situations over a longer period of time. In an experimental design focusing strictly on attention rather than overall self-regulation, Vouloumanos and Curtin (2014) found that attention to verbal stimuli at 12 months positively predicted expressive speech at 18 months, whereas overall attentiveness did not. It is believed that, similar to affectivity, good capacity for self-regulation increases chances for interaction with others (Gartstein et al., 2008). More effective emotion regulation and the ability to focus attention on others may encourage interaction and lead to more occasions for learning communicative behaviors. Hence, it may be important to specify the type of self-regulation studied, as the attentional strategies differ in the degree they involve turning to another person for support, and consequently, more social regulatory strategies may have stronger associations with communicative development compared to strategies such as gaze aversion. This has been done in very few studies, and we have not come across any previous studies where, for example, gaze aversion, which is the earliest form of self-regulation (Rothbart et al., 2011), and communicative development have been studied.

Especially later in childhood, self-regulation is thought to have a bidirectional relationship with language skills (Bohlmann et al., 2015). Namely, language is a tool for self-regulation and, thereby, stronger language predicts more advanced self-regulation, but good self-regulatory capacity also provides better prerequisites for language development (Bohlmann et al., 2015). Bohlmann et al. (2015) hypothesize that language as a tool for self-regulation may become increasingly important during the preschool years when vocabulary grows substantially, whereas the influence of self-regulation on language learning may be stronger in infancy and early childhood, when vocabulary is still limited. Gartstein et al. (2008) argue, however, that even in infancy, emerging vocalizations may serve as a regulatory strategy to call for adult attention when needed. Also worth noting when discussing relations between negative affectivity and communicative development is that the infant's preferred strategy for self-regulation when experiencing negative emotions may influence the association between negative affectivity/fear and communicative skills. More specifically, avoidant regulation behaviors such as gaze aversion, in instances where it means looking away from the communication partner, may reduce exposure to communication stimuli. This points to the need to study negative emotionality and self-regulation together in the same condition, which has, to our knowledge, not been done previously.

In addition to the inconsistencies and paucity of research regarding negative affectivity and self-regulation as predictors of infant language development, there are several gaps in the literature that limit our understanding of the topic. First, some studies report temperament dimensions to be related to receptive language skills (Morales et al., 2000), whereas others have found relations with expressive language only (Laake & Bridgett, 2014). This distinction is important to make since, for example, weak early receptive vocabulary is a stronger risk factor for problems with later reading acquisition compared to expressive vocabulary (Psyridou et al., 2018). Although several studies assess

infant temperament in relation to later language, language assessments are often carried out during the latter half of the second year of life or later. It has been argued that since rank-order stability in language skills is typically reached by the age of two or 3 years, it is particularly important to study the influence of personality and environmental factors on the very earliest language development where inter-individual variability is still high (Laake & Bridgett, 2018). Additionally, the findings suggesting that the same temperament trait may relate differently to language development at different stages of infancy/toddlerhood (Nozadi et al., 2015) highlight the need for longitudinal studies over this developmental period. This also puts more emphasis on the early forms of communication, such as gesturing, which is very scarcely studied. Previous research has found that infant temperament is related to gesturing to a much higher degree than to early receptive language skills. More specifically, higher infant orienting/regulation and positive emotionality predicted higher use of gestures at 12 months of age (Ollas et al., 2020). We also know that gestures typically appear before the first words are uttered and predict later verbal language development (Iverson & Goldin-Meadow, 2005). This underscores the need to further explore this dimension of communication when studying relations between temperament and infant communicative development, which is done in the present study.

Third, the majority of existing studies have used parent reports as the method of temperament assessment, and only a few have utilized observed temperament assessment. In the few studies that have employed both parent-report and laboratory observations of temperament, results have differed somewhat between the assessment modalities. For example, in the study by Kubicek and Emde (2012) parents reported that late talkers showed more anger, whereas no differences were found in laboratory-assessed anger proneness. However, higher fear in late talkers was detected using both observation and parent reports (Kubicek & Emde, 2012). Mixed findings in studies employing both approaches to temperament assessment are notable, as parent reports are sometimes argued to be less objective and under the influence of factors such as parent personality, sensitivity, attitudes, own childhood experiences, and psychiatric symptoms (Durbin et al., 2007; Durbin & Wilson, 2012; Leerkes & Crockenberg, 2003). However, parent reports also have some advantages; for instance, a familiar person assessing child characteristics over a longer period of time across a wider range of situations (Rothbart & Bates, 2006). Laboratory assessments, on the other hand, offer the opportunity for more objective assessment in a standardized setting designed to elicit specific emotions and reactions, but the novel situations with their short durance may limit ecological validity (Durbin et al., 2007) and influence child reactivity (Stifter et al., 2008). As both assessment methods have their strengths and weaknesses and possibly tap into different aspects of temperament, it is recommended to use them in combination (Stifter et al., 2008). The current study uses both mother-reports of temperament at 6 and 12 months of age and observational temperament assessment at 8 months of age, which gives more comprehensive information.

To summarize, although several studies have reported associations between aspects of temperament and language development, literature is lacking consensus especially regarding temperament traits that are possible risk factors for early communicative development. Results differ regarding negative affectivity as a predictor of language outcomes early in life with both positive and negative associations reported. Findings are inconsistent and somewhat dependent on the mode of assessment. The knowledge of the relations between emerging self-regulation and communicative development is also limited and has predominantly been acquired using parent reports. There is also controversy regarding which dimensions of language development seem to be more strongly related to child temperament, and relations between temperament and preverbal communicative skills have been overlooked. Furthermore, the significance of child age in determining the relationship between temperament and communicative development is still poorly understood. In the current study, we address these gaps by focusing on infant negative affectivity and aspects of emerging self-regulation during

the first year of life, assessed using observations and parent-reports, as predictors of early communicative development.

More specifically, the aim of the study is to investigate the relations between negative affectivity and emerging self-regulation and communicative development, both preverbal gestural communication and expressive and receptive language skills at 14 and 30 months of age. We address the limitations of most existing studies by using both observations at 8 months and mother-reports at 6 and 12 months of age when assessing temperament. In light of the mixed findings reported previously, we expected negative affect and fear to be associated with communicative outcomes, but we did not set a specific direction for our hypothesis. Based on prior research, including our study on a different Finnish sample (Ollas et al., 2020), our hypotheses were that higher emerging self-regulation, measured as higher mother-reported emerging regulatory ability and longer observed duration of attention, would be positively related to communicative skills, especially expressive communication. However, the hypothesis for self-regulation by gaze aversion was based on prior research on other aspects of self-regulation only, since there was no research on this specific regulation aspect and communicative development available, and thus, the research question was partially exploratory.

In order to control for confounding variables, factors known to potentially relate to language development were chosen as covariates in the analyses. These variables were maternal postpartum psychological distress, child gender, gestational age at birth, maternal education level, and number of siblings (Berglund et al., 2005; Briggs-Gowan et al., 1996; Durbin & Wilson, 2012; Harrison & McLeod, 2010; Hoff & Tian, 2005; Prior et al., 2008; Reck et al., 2018; Sohr-Preston & Scaramella, 2006; Zerbeto et al., 2015).

2 | METHOD

2.1 | Participants

The participants were 183 families from the FinnBrain Birth Cohort Study. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Joint Ethics Committee of the University of Turku and the Hospital District of Southwest Finland. The study sample was selected from those families who participated in the laboratory visits for temperament observation and had returned the CDI-questionnaire on communicative development at least at 14 months. These families belonged primarily to the Focus cohort of the FinnBrain Birth Cohort Study, which is a subsample recruited initially for a case-control follow-up of mothers with high and low reports of prenatal stress and in which the families take part in more extensive multidisciplinary assessments during infancy and early childhood (Karlsson et al., 2018). Families from the current sample did not differ significantly from the entire cohort concerning maternal age (t (6412) = −0.029, p = 0.98), psychological distress (EPDS: t (2435) = 1.43, p = 0.15, SCL-90: t (2432) = 1.18, p = 0.24) or family income (χ^2 (8) = 4.91, p = 0.77). The parents in the current sample, however, tended to have a higher education level (χ^2 (2) = 32.0, p = 0.00). The demographic characteristics of the families in the current sample are presented in Table 1. Monolingualism was defined according to the criterion that the child is exposed to the mother tongue more than 80% of the time. Most typically, the national languages of Finland, Finnish and Swedish, are used in bilingual families. The bi- and monolingual groups did not differ significantly from each other on any of the communication measures according to independent samples t-tests, hence all participants were included in the study. The Finnish version of the

TABLE 1 Demographic characteristics of the sample ($N = 183$)

	Mean, (*SD*) or %, range
Gender, girl	46%
Primiparous	62%
One sibling	29%
≥2 siblings	9%
Gestational age at delivery	40.0 (1.39), 35.7–42.3
Monolingual family	72.4%
Bilingual family	7.5%
Data missing regarding bilingualism	20.1%
Maternal educational level	
University degree	40.4%
Polytechnic degree	36.6%
Vocational training/9-year compulsory school (one case)	12.0%
High school	9.3%
Maternal age at delivery	30.9 (4.0), 21–44
Paternal age at delivery	32.1 (4.9), 23–48

CDI-questionnaire was filled out by all families except five—these five families used the Swedish version of the measure. Since the maximum scores in the Finnish and Swedish versions of the questionnaire are not equal, the percentage of the total score for each individual was used in the analyses.

2.2 | Procedures

Families were recruited in maternal welfare clinics at gestational week 12. Background information regarding the families was collected using questionnaires at gestational week 14 and supplemented with information from later data points when needed. The questionnaire data on maternal anxiety was collected at 3 and 6 months postpartum, and on depressive symptoms at 3, 6, and 12 months postpartum. Mother-reports on infant temperament were collected at 6 and 12 months of age, and postal or electronic questionnaires regarding child communicative development were sent to the families when the child was 14 and 30 months old. Additionally, information regarding child gender and gestational age at birth from the maternity ward was retrieved from the Finnish National Birth Register (www.thl.fi). At 8 months, the families were invited to a laboratory visit at the FinnBrain research site in Turku, where experimental temperament observations were carried out by trained psychologists or advanced psychology master's students.

2.3 | Measures

2.3.1 | Temperament

Observed Temperament. Temperament observations were conducted at 8 months of age using the Laboratory Temperament Assessment Battery Prelocomotor version (Lab-TAB; Goldsmith & Rothbart, 1999), which is a standardized battery for assessing child temperament as a reaction to

different stimuli (Planalp et al., 2017). Aspects of infant negative affectivity were assessed using two episodes, Gentle Arm Restraint by Parent (Overall negative affectivity) and Masks (Fear). Likewise, aspects of infant emerging self-regulation were assessed using two episodes, Blocks (Duration of attention) and Gentle Arm Restraint by Parent (Gaze aversion). The Lab-TAB episodes were presented to all infants/dyads in the same order. In each observation episode, an assessment of caregiver behavior/interference was additionally calculated for each temperament episode (0 = very inefficient parent behavior, does not follow instructions, 1 = parent mildly deviates from instructions, and 2 = parent behaves as instructed) and controlled for in all the analyses with the respective temperament outcome. Coding was carried out by trained graduate and postgraduate students (2–4 coders depending on the episode). Inter-rater reliability was performed on 10% of the full sample participating in the visits.

Fear was assessed during the episode Masks, which is a fear-eliciting episode where the infant is presented with four different masks in order of increasing intensity and likelihood of eliciting a fear response. The episode lasted for 1−1.5 min, or 1,5−2 min with instructions from the experimenter included. Each of the four masks was presented separately to the child for 10 s, and these presentations were coded into two 5 s epochs each. The following behaviors as a response to the presentation of each mask were coded: escape behaviors (0–3), facial fear (0–3), bodily fear (0–3), and distress vocalizations (0–5) ($r = 0.45$–0.78). We used the sum score for total fear, consisting of the standardized scores for the fear responses. The episode showed good inter-rater reliability (Cohen's kappa 0.73–0.83).

Task orientation/attentiveness was assessed using the Blocks episode, where the infant is given a set of blocks to play with and manipulate during a 3-min episode with minimal involvement from the caregiver. The whole episode, including instructions from the experimenter, lasted for approximately 4 min and was coded in 10-s epochs divided into three sets of one minute each. The following behaviors were coded[1]: intensity of facial interest (0–2) and duration of looking (0–3), from which a standardized sum score was calculated (intercorrelation $r = 0.30$). The episode showed adequate inter-rater reliability (Cohen's $K = 0.72$–0.79).

Finally, overall negative affectivity and emergent self-regulation were assessed using the Arm Restraint episode. In this episode, the infant is presented with an interesting toy, and after the infant has started to play with the toy, the mother grabs and gently holds the infant's arms for two 30-s trials, preventing the infant from reaching the toy. Both 30-s trials are coded in 5-s epochs. The total duration of the episode was 2 min, or 3 min including instructions from the experimenter. The following behaviors were coded: intensity of facial anger (0–3), intensity of facial sadness (0–3) and intensity of distress vocalizations (0–5). A negative affect sum score was calculated based on these three indicators ($r = 0.48$–0.84). Inter-rater reliability was adequate (Cohen's $K = 0.62$–0.79). The Arm Restraint episode was also used for assessing self-regulation by gaze aversion, which is one of the earliest forms of self-regulation evident in infancy (Rothbart et al., 2011). Gaze aversion was coded as seconds looking away from the toy, either around the room or at the parent, during the episodes. We used a sum score of total gaze aversion in seconds during each 5-s epoch (0–5). The epochs were the same as for the assessment of negative affectivity. The reliability of the measure was adequate (inter-rater $r = 0.78$–0.95). Gaze aversion was not divided into social and non-social as the assessment situation was not originally designed for this purpose and hence not optimal for this, with the parent sitting behind the child and not always with the eyes visible on the videotape.

Reported Temperament. The Infant Behavior Questionnaire—Revised (IBQ-R) (Gartstein & Rothbart, 2003) was used for parent reports of infant temperament. The Finnish version of the instrument has been used in several studies and its reliability and predictive validity have been at

[1]One of the indicators, manipulation, was left out of the sum score because it showed very low inter-individual variability between the infants.

least at the same level as other translations (Gaias et al., 2012; Komsi et al., 2006). The questionnaire was completed by the mother twice, when the infants were aged 6 and 12 months. The IBQ-R is a parent-report of infant temperament where the parent rates the occurrence of certain infant behaviors and reactions in different everyday situations during the past week on a seven-point scale from *never* to *always*. Three broader factor scores, Surgency/Extraversion (Cronbach's $\alpha = 0.89–0.91$), Negative Affectivity ($\alpha = 0.85–0.87$), and Orienting/Regulation ($\alpha = 0.82–0.84$) are obtained (Gartstein & Rothbart, 2003). Negative Affectivity contains subscales Sadness ($\alpha = 0.74–0.78$), Distress to limitations ($\alpha = 0.68–0.74$), Fear ($\alpha = 0.80–0.81$), and Falling reactivity ($\alpha = 0.73–0.75$). Orienting/Regulation is an indicator of emerging self-regulation composed of subscales Low intensity pleasure ($\alpha = 0.75–0.78$), Cuddliness ($\alpha = 0.71–0.76$), Duration of orienting ($\alpha = 0.80–0.84$), and Soothability ($\alpha = 0.79$) (Gartstein & Rothbart, 2003). To match the observed temperament assessments, in this study we used the factors Negative Affectivity and Orienting/Regulation, as well as the specific Fear-subscale form the IBQ-R-questionnaires to match the observed Fear episode.

2.3.2 | Communicative development

Communicative development was assessed using the Finnish and Swedish versions of the MacArthur-Bates Communication Development Inventories—Words and gestures for infants (CDI-I) (Eriksson & Berglund, 2002; Fenson, 1994; Lyytinen, 1999) at 14 months and the CDI—Words and sentences for toddlers (CDI-T) at 30 months (Eriksson & Berglund, 2002; Fenson, 1994; Lyytinen, 1999). The CDI, including the currently used translations, has been shown to be a valid parent-report for assessing early communication and language development (Eriksson & Berglund, 2002; Fenson, 1994; Lyytinen, 1999). We used the sum scores for actions and gestures, receptive vocabulary and expressive vocabulary at 14 months, and for expressive vocabulary at 30 months. The CDI is a checklist of different communicative behaviors and words. The actions and gestures section involves lists of the first communicative gestures, games and routines, actions with objects, pretending to be a parent, and imitating other adult actions. For the communicative gestures, the parent checks whether the infant uses the gesture often, sometimes or not at all. For the remaining actions and gestures, the use is assessed on a yes/no-basis. We used the sum score for the total use of gestures. Regarding vocabulary, the instrument contains words in different semantic categories, and the parent fills out whether the infant understands or understands and uses a certain word in the 14-month version, giving separate sum scores for receptive and expressive vocabulary, and understands *and* uses in the 30-month version, resulting in one sum score for expressive vocabulary (Fenson, 1994; Lyytinen, 1999).

2.3.3 | Covariates

Maternal postpartum psychological distress is associated with both less adaptive communicative outcomes and maternal rating of child behavior (Briggs-Gowan et al., 1996; Durbin & Wilson, 2012; Reck et al., 2018; Sohr-Preston & Scaramella, 2006). For the purpose of controlling for this type of distress, the Edinburg Postnatal Depression Scale (EPDS) at 12 months postpartum (Cox et al., 1987) and the anxiety subscale of the Symptom Checklist—90 (SCL-90, Derogatis, Lipman, & Covi, 1973) at 6 months postpartum were used. For one participant, who had not completed the 6-month SCL-90-questionnaire, the score from the same questionnaire at 3 months postpartum was used. The sum scores for EPDS and SCL-90 were standardized and summed into a postnatal psychological distress composite score, which was used as a continuous covariate in analyses.

In addition, since also previously reported to relate to language development, child gender, gestational age at birth, maternal education level, and number of siblings were used as covariates in all models (Berglund et al., 2005; Harrison & McLeod, 2010; Hoff & Tian, 2005; Prior et al., 2008; Reck et al., 2018; Sohr-Preston & Scaramella, 2006; Zerbeto et al., 2015). Maternal educational level was self-reported during the first trimester of pregnancy. Educational level was coded as a categorical variable with four categories: high school-level, vocational training, polytechnic degree, or university degree. One mother had completed only the 9-year compulsory education and was added to the vocational training group. Information regarding the number of siblings was reported by the mother when the child was 12 months, and the information was completed by the same data from the 3-month postpartum assessment in instances where the 12-month answer was missing and used as a continuous variable in analyses.

2.4 | Data analysis

The data was analyzed using IBM SPSS 25. Missing data was imputed using multiple imputation (10 imputations) using the MCMC protocol. Data was missing for the variables: maternal postnatal psychological distress, 6- and 12-month reported temperament measures, use of communicative gestures, 30-month vocabulary, and maternal educational level. Data was missing in 19.7% of cases for 30-month vocabulary, 11.5%–12% of cases for 12-month reported temperament, and less than 10% of cases for the other measures. According to Little's MCAR test, data was missing at random (chi-square = 104.39, $DF = 133$, $p = 0.97$).

Gesture use was normally distributed, whereas expressive and receptive vocabularies at 14 months and vocabulary at 30 months were not. The 14-month receptive vocabulary score and the 30-month vocabulary score were improved by square root transformation. The transformed 30-month vocabulary score was not normally distributed according to the tests (D (183) = 0.08, $p = 0.005$, skewness = −0.39) but was still regarded as resembling a normal distribution to a degree that allows use of parametric tests and regression analyses (see Lumley et al., 2002). Further, as not many children produce a high number of words around their first birthday, the expressive vocabulary sum score at 14 months was expectedly skewed toward zero and could not be improved by transformation. Hence, we used a categorical version of the variable with groups of low, intermediate, and high expressive vocabulary. The low-vocabulary group represented the children with no words in use at 14 months ($n = 29$), and the large expressive vocabulary group consisted of a same sized group of infants with the highest scores on expressive vocabulary ($n = 30$), and the remaining infants ($n = 124$) were assigned to the intermediate-level group. The data did not contain any outliers extreme enough to require actions.

First, the Pearson correlation coefficient was used for analyzing zero-order correlations between variables. Standard linear regression analysis with manual stepwise entering of variables using the general linear model command was used for analyzing the effects of temperament traits on gestures and receptive vocabulary at 14 months and expressive vocabulary at 30 months. Correspondingly, the influence of temperament traits on expressive vocabulary groups (small, intermediate, and large vocabulary) was analyzed using multinomial logistic regression analysis. The first step of each model included the covariates (child gender, maternal educational level, gestational age at birth, number of siblings, and maternal postpartum psychological distress score), and the second step included the temperament trait in focus. Temperament traits were entered in individual models to avoid collinearity. Additionally, negative affectivity was included in the regression model with observed emerging self-regulation by gaze aversion in order to test whether gaze aversion had an independent effect or was dependent on the level of negative affectivity during the episode. Finally, the p-values in the regression

models were corrected for multiple comparisons per each hypothesis using the Benjamini-Hochberg procedure with an alpha level $p < 0.05$.

3 | RESULTS

Descriptive statistics for the Lab-TAB, IBQ-R, and CDI are displayed in Table 2.

3.1 | Zero-order associations between measures

3.1.1 | Communicative outcomes

Zero-order Pearson correlations between measures are displayed in Table 3. The correlations between communicative measures at 14 and 30 months were moderate to strong, both concurrently and longitudinally.

3.1.2 | Temperament traits

Correlations between observed and mother-reported temperament traits are displayed in Table 3. First, there was a modest negative association between observed emerging self-regulation and observed

TABLE 2 Descriptive statistics for the measures used in the study

Measure (theoretical range)	*M* (*SD*) original data	*M* (*SD*) imputed data	Range
Observed temperament (Lab-TAB)			
Negative affectivity	4.4 (1.9)	4.4 (1.9)	0.5–8.3
Fear	3.5 (2.1)	3.5 (2.1)	0–10
Task orientation/attentiveness	3.7 (0.5)	3.7 (0.5)	2.1–4.7
Emerging self-regulation	21.0 (9.9)	21.0 (9.9)	0–50
Mother-reported temperament (IBQ-R)			
At 6 months (0–7)			
Negative affectivity	2.9 (0.8)	2.9 (0.8)	1.4–5.0
Fear	2.4 (1.1)	2.4 (1.1)	1.0–5.7
Emerging self-regulation	5.3 (0.6)	5.3 (0.6)	3.4–6.6
At 12 months (0–7)			
Negative affectivity	3.2 (0.7)	3.3 (0.7)	1.6–5.5
Fear	3.0 (1.2)	3.0 (1.3)	1.0–6.3
Emerging self-regulation	5.1 (0.6)	5.1 (0.6)	3.4–6.3
Communicative development (CDI) (0%–100%)			
Gesture use 14 months	55.0 (12.1)	55.1 (12.3)	9.0–87.9
Expressive vocabulary 14 months	3.3 (4.2)	3.3 (4.2)	0–26
Receptive vocabulary 14 months	37.5 (20.1)	37.5 (20.1)	1.8–91.3
Expressive vocabulary 30 months	71.2 (25.4)	71.1 (25.2)	4.6–100

TABLE 3 Zero-order correlations between measures in the study

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Receptive vocabulary															
2. Gesture use	0.51**														
3. Vocabulary 30 months	0.46**	0.40**													
Observed temperament 8 months															
4. Fear	0.05	0.15*	0.11												
5. Negative affectivity	0.11	0.03	0.05	0.04											
6. Emerging self-regulation	−0.16*	−0.07	−0.10	−0.08	−0.17*										
7. Task orientation/ attentiveness	−0.07	−0.05	−0.08	−0.04	0.11	−0.12									
Reported temperament 6 months															
8. Fear	0.06	0.08	0.09	0.07	0.08	−0.01	−0.01								
9. Negative affectivity	0.01	−0.03	0.04	0.13	0.09	−0.06	−0.01	0.55**							
10. Emerging self-regulation	0.19*	0.17*	0.05	−0.11	−0.02	−0.16*	−0.05	0.05	−0.12						
Reported temperament 12 months															
11. Fear	0.06	0.04	0.08	0.11	0.04	0.05	−0.03	0.41**	0.27**	0.00					
12. Negative affectivity	0.01	0.01	0.05	0.06	−0.01	0.02	−0.11	0.26**	0.53**	−0.06	0.59**				
13. Emerging self-regulation	0.16*	0.32**	0.06	−0.06	0.09	−0.12	0.03	0.02	−0.11	0.54**	0.04	−0.10			
14. Postnatal psychological distress	−0.16*	−0.14	−0.11	0.05	0.04	−0.07	−0.02	0.05	0.23**	−0.09	0.14	0.36**	−0.16*		
15. Gestational age	0.19*	0.18*	0.15	0.07	0.08	−0.09	0.10	0.09	0.15	−0.04	−0.00	−0.01	0.09	−0.04	
16. Number of siblings	−0.11	0.10	−0.18*	0.04	−0.07	−0.12	0.06	0.07	−0.01	0.00	0.11	0.06	0.06	−0.09	−0.08

*$p < 0.05$, **$p < 0.01$.

negative affectivity, but other observed temperament traits at 8 months were not significantly interrelated. Mother-reported fear, negative affectivity, and emerging self-regulation at 6 months in general showed moderate to high correlations with the corresponding traits at 12 months of age. Reported emerging self-regulation at 6 months was modestly negatively correlated with observed emerging self-regulation at 8 months. Other observed and mother-reported temperament traits did not correlate significantly.

3.1.3 | Covariates, temperament, and communicative development

Maternal postpartum psychological distress showed a modest negative correlation with receptive vocabulary at 14 months. Gestational age at delivery was modestly positively associated with both 14-month communicative outcomes, receptive vocabulary, and gesture use. The number of siblings was negatively associated with the 30-month vocabulary. In turn, postpartum psychological distress was positively correlated with reported negative affectivity at both 6 and 12 months, but not with observed negative affectivity. Maternal distress also had a modest negative correlation with 12-month emerging self-regulation.

3.1.4 | Bivariate associations between observed and reported temperament and communicative development

The associations between temperament and communicative development are also shown in Table 3. Observed fear showed a modest positive correlation with gesture use at 14 months. Observed self-regulation correlated negatively with receptive vocabulary at 14 months. Mother-reported self-regulation at both 6 and 12 months of age correlated positively with gesture use and receptive vocabulary at 14 months of age but not with vocabulary at 30 months of age. Other observed or reported temperament traits were not related to communicative development outcomes.

3.2 | The Regression Analyses for observed temperament at 8 Months and communicative development at 14 and 30 months

Regression analyses for observed temperament and communicative development measures are reported in Tables 4 and 5.

3.2.1 | Gesture use at 14 months

None of the observed temperament traits negative affectivity, fear, emerging self-regulation, nor task orientation/attentiveness significantly predicted gesture use at 14 months (see Table S1 in the Supplement).

3.2.2 | Receptive vocabulary at 14 Months (Table 4)

Use of gaze aversion in a distress-provoking situation negatively predicted receptive vocabulary at 14 months, indicating higher emerging self-regulation by gaze aversion was related to lower receptive

TABLE 4 Summary of regression analyses for observed temperament at 8 Months and receptive vocabulary at 14 Months

	B (95% CI)	*SE B*	*p*	Partial eta sqared	Adjusted R^2
Covariates					0.06
Intercept	−2.26 (−9.16–4.65)	3.52	0.52	0.00	
Child gender	0.05 (−0.43–0.52)	0.24	0.85	0.00	
Number of siblings	−0.17 (−0.54–0.19)	0.19	0.36	0.01	
Gestational age	0.21 (0.04–0.38)	0.09	**0.02**	0.03	
Maternal education level (reference: University degree)					
High school	−1.02 (−1.90 to −0.15)	0.45	**0.02**	0.03	
Vocational training	−0.13 (−0.90–0.63)	0.39	0.73	0.00	
Polytechnic degree	−0.12 (−0.65–0.42)	0.27	0.67	0.00	
Maternal postnatal psychological distress	−0.15 (−0.27 to −0.02)	0.06	**0.02**	0.03	
Observed temperament traits					
Negative affectivity	0.06 (−0.04–0.15)	0.05	0.25	0.01	0.06
Fear	0.04 (−0.26–0.33)	0.15	0.81	0.00	0.06
Emerging self-regulation	−0.03 (−0.05 to −0.00)	0.01	**0.02**	0.03	0.08
Task orientation/attentiveness	−0.11 (−0.41 - 0.19)	0.15	0.49	0.00	0.14

Note: Adjusted R^2 reported for the whole model. The same covariates were used in all models, but in the interest of saving space only temperament traits were reported in models. Significant *p*-values are bolded.

vocabulary scores. Correcting for multiple comparisons led to this finding being marginally above the significance level (Benjamini-Hochberg *p*-value = 0.06). There were no significant associations between observed negative affectivity, fear or task orientation/attentiveness, and receptive vocabulary at this age.

3.2.3 | Expressive vocabulary at 14 Months (Table 5)

Emerging self-regulation by gaze aversion was also associated with expressive vocabulary, as infants higher in self-regulation more likely belonged to the no-words group and the intermediate expressive vocabulary group when compared to the high expressive vocabulary group. After correcting for multiple comparisons, the *p*-values were just above the significance level (Benjamini-Hochberg *p*-values = 0.06 and 0.08). Additionally, negative affectivity significantly explained expressive vocabulary at 14 months, with infants higher in negative affectivity being more likely to belong to the high expressive vocabulary group than to the intermediate group. After adjusting for multiple comparisons, the *p*-value for the comparison of high versus intermediate vocabulary groups was no longer significant (Benjamini-Hochberg *p*-value = 0.52). *Fear* or task orientation/attentiveness did not relate significantly to vocabulary group membership.

3.2.4 | Vocabulary at 30 months

Emerging self-regulation by gaze aversion at 8 months was no longer significantly associated with the 30-month vocabulary. Neither were there any other significant associations between negative affectivity, fear, or task orientation/attentiveness and vocabulary at 30 months (see Table S2 in the Supplement).

TABLE 5 Summary of multinomial logistic regression analyses for observed temperament and low, intermediate and high expressive vocabulary at 14 Months

	Intermediate group versus no words-group				Intermediate group versus high expressive vocabulary group				High expressive vocabulary group versus no words-group				Cox & snell
	B	SE B	OR (95% CI)	*p*	B	SE B	Or (95% CI)	*p*	B	SE B	Or (95% CI)	*p*	R^2
Covariates													0.10
Intercept	−4.20	5.95		0.48	7.81	6.49		0.23	−12.02	8.09		0.14	
Child gender (reference: Girl)	−1.19	0.47	0.30 (0.12–0.79)	**0.02**	0.09	0.42	1.09 (0.48–2.47)	0.84	−1.28	0.59	0.28 (0.09–0.89)	**0.03**	
Number of siblings	0.22	0.35	1.24 (0.63–2.45)	0.53	−0.09	0.32	0.91 (0.49–1.71)	0.77	0.31	0.43	1.37 (0.58–3.20)	0.47	
Gestational age	0.17	0.15	1.19 (0.88–1.59)	0.26	−0.16	0.16	0.85 (0.62–1.16)	0.31	0.33	0.20	1.40 (0.94–2.07)	0.10	
Maternal education level (reference: University degree)													
High school	−1.49	0.70	0.23 (0.06–0.89)	**0.03**	1.15	1.10	3.15 (0.36–27.25)	0.30	−2.64	1.21	0.07 (0.01–0.76)	**0.03**	
Vocational training	−0.75	0.66	0.47 (0.13–1.72)	0.26	0.67	0.80	1.94 (0.41–9.35)	0.41	−1.42	0.96	0.24 (0.04–1.60)	0.14	
Polytechnic degree	−0.35	0.53	0.70 (0.25–1.99)	0.51	0.27	0.45	1.30 (0.54–3.14)	0.56	−0.62	0.64	0.54 (0.16–1.88)	0.33	
Maternal postnatal psychological distress	0.08	0.11	1.08 (0.87–1.35)	0.48	0.03	0.12	1.03 (0.82–1.29)	0.82	0.05	0.15	1.06 (0.79–1.41)	0.72	
Observed temperament traits													
Negative affectivity	−0.00	0.09	1.00 (0.84–1.18)	0.97	−0.18	0.09	0.84 (0.71–0.99)	**0.04**	0.18	0.11	1.19 (0.96–1.48)	0.11	0.13
Fear	0.08	0.28	1.08 (0.62–1.88)	0.78	−0.12	0.26	0.88 (0.54–1.45)	0.63	0.20	0.35	1.22 (0.62–2.41)	0.57	0.12
Emerging self-regulation	−0.02	0.02	0.98 (0.94–1.02)	0.29	0.05	0.02	1.05 (1.00–1.10)	**0.04**	−0.07	0.03	0.93 (0.88–0.99)	**0.02**	0.14
Attention	−0.12	0.29	0.89 (0.50–1.58)	0.69	−0.00	0.27	1.00 (0.59–1.71)	0.99	−0.12	0.37	0.89 (0.43–1.82)	0.74	0.12

Note: Cox & Snell R^2 reported for the whole model. The same covariates were used in all models, but in the interest of saving space only temperament traits were reported in models. Reference groups are underlined in the table. Significant *p*-values are bolded.

3.2.5 | Sensitivity analysis with negative affectivity as a covariate

When adding negative affectivity to the models with emerging self-regulation by gaze aversion, results stayed essentially the same (receptive vocabulary at 14 months: $B = -0.03$, $p = 0.04$, use of communicative gestures at 14 months: $B = -0.04$, $p = 0.69$, expressive vocabulary at 14 months: intermediate expressive vocabulary group vs. no words-group: $B = -0.02$, $p = 0.28$, intermediate vs. high: $B = 0.02$, $p = 0.07$, high vs. no words: $B = -0.07$, $p = 0.03$, expressive vocabulary 30 months: $B = -0.03$, $p = 0.11$), leading us to conclude that the relation between gaze aversion and communicative skills was independent from the level of negative affectivity during the episode.

3.3 | The Regression Analyses for Mother-reported Temperament at 6 and 12 Months and Communicative Development at 14 and 30 Months

Summaries of regression analyses on mother-reported temperament and communicative skills are presented in Table 6. None of the temperament traits significantly predicted group membership of low or high expressive vocabulary at 14 months, hence these logistic regressions are reported in the Supplement (Table S3).

3.3.1 | Gesture use at 14 Months (Table 6)

Emerging self-regulation at 6 and 12 months was positively related to gesturing. After adjusting for multiple comparisons, the *p*-value for 12-month emerging self-regulation remained significant, whereas for 6-month emerging self-regulation it did not (Benjamini-Hochberg *p*-values = 0.01 and 0.10). Negative affectivity and fear showed no significant associations with gesturing.

TABLE 6 Summary of regression analyses for mother-reported temperament at 6 and 12 Months and use of gestures and receptive vocabulary at 14 Months

	***B* (95% CI)**	***SE B***	***p***	**Partial eta sqared**	**Adjusted R^2**
Use of gestures					
Reported temperament traits					
Negative affectivity 6 months	−0.77 (−3.23–1.69)	1.25	0.54	0.00	0.07
Fear 6 months	0.61 (−0.97–2.20)	0.81	0.45	0.00	0.08
Emerging self-regulation 6 months	3.12 (0.26–5.99)	1.46	**0.03**	0.03	0.10
Negative affectivity 12 months	0.20 (−2.68–3.08)	1.46	0.89	0.00	0.07
Fear 12 months	0.18 (−1.43–1.79)	0.83	0.82	0.00	0.07
Emerging self-regulation 12 months	5.48 (2.51–8.47)	1.52	**0.00**	0.08	0.15
Receptive vocabulary					
Reported temperament traits					
Negative affectivity	0.03 (−0.31–0.36)	0.17	0.88	0.00	0.06
Fear 6 months	0.09 (−0.12–0.30)	0.11	0.42	0.00	0.06
Emerging self-regulation 6 months	0.49 (0.09–0.88)	0.20	**0.02**	0.03	0.09
Negative affectivity 12 months	0.13 (−0.26–0.52)	0.20	0.50	0.00	0.06
Fear 12 months	0.11 (−0.12–0.34)	0.12	0.34	0.01	0.07
Emerging self-regulation 12 months	0.34 (−0.07–0.75)	0.21	0.11	0.02	0.07

Note: Adjusted R^2 reported for the whole model. Significant *p*-values are bolded.

3.3.2 | Receptive vocabulary at 14 Months (Table 6)

Self-regulation was positively associated with receptive vocabulary when assessed at 6 months, but no longer at 12 months. After adjusting for multiple comparisons, the *p*-value for 6-month emerging self-regulation was no longer significant (Benjamini-Hochberg *p*-value = 0.10). Negative affectivity and fear were found to have no significant relation with receptive vocabulary.

3.3.3 | Vocabulary at 30 months

Self-regulation, which was related to communicative skills at 14 months, was no longer associated with vocabulary at 30 months of age (see Table S4 in the Supplement). Neither negative affectivity nor fear showed any relation with vocabulary at this age.

4 | DISCUSSION

Many studies agree that positive emotionality/surgency is positively related to language development, but there is much less conclusive results regarding which temperamental dimensions are potential risk factors for early communicative development. The aim of the study was to investigate the relations between infant negative affectivity and emerging self-regulation and communicative development, as previous results differ regarding these dimensions of temperament in particular. Additionally, of the few studies of relations between temperament and language development in infants, we are not aware of other research groups involving preverbal gesturing as a measure of communicative development, although it is a very important communication modality in this age group. We assessed both preverbal gestural communication at 14 months of age and expressive and receptive language skills at 14 and 30 months of age, and utilized both observations and mother-reports of temperament in our setting. In light of existing literature and our previous results from the first phase of the FinnBrain-study (Ollas et al., 2020), our hypotheses were that dimensions of higher emerging self-regulatory abilities (assessed by mother-reported orienting and regulation and observed attentiveness and gaze aversion in a distress-provoking situation) would be positively related to communicative skills, especially expressive verbal and gestural communication, and that similar relations would be found using both observed and reported temperament in the analyses. Given the mixed previous findings, we did not set any direction for the hypothesis regarding negative affectivity and fear, but hypothesized these traits would be associated with communicative development.

In line with our hypotheses, mother-reported orienting/regulation, an indicator of emerging self-regulation, was positively related to gesturing at 14 months (Dixon & Smith, 2000; Gartstein et al., 2008). Surprisingly, observed attentiveness did not relate significantly to any communicative skill. We found weak support for the hypothesis that higher levels of observed negative affectivity would predict better expressive language, since infants higher in negative affectivity were more likely to belong to the high expressive vocabulary group than to the intermediate group, but this finding did not remain significant after multiple comparisons correction. This was also the only result supporting this hypothesis. Further, we found no significant relations with neither observed nor reported fear and communicative outcomes at 14 and 30 months of age.

4.1 | Self-regulation and communicative development

Regarding self-regulation, the strongest association found was between mother-reported self-regulation at 12 months and communicative gesturing at 14 months of age. There were also associations between

self-regulation and receptive vocabulary, but these did not remain significant after correcting for multiple comparisons. This corresponds well with our previous findings in a different sample (Ollas et al., 2020). We are not aware of any prior studies looking into self-regulation and preverbal gesturing. Suggested mechanisms behind relations between self-regulation and language in previous studies are that better infant emerging self-regulation supports interaction and leads to an increase in chances for communicative learning when the infant can more easily focus on the communicative experiences. Higher emerging self-regulation and orienting can also be interpreted as a higher interest in communication, which may lead to others communicating more with the infant (Dixon & Smith, 2000; Gartstein et al., 2008). Finally, better regulatory ability may have a positive influence by leaving more attentional resources to spend on interpersonal interaction rather than on the regulation of actions and negative affective states (Salley & Dixon, 2007). Although these theories are based on verbal language, it is plausible that the same mechanisms can be applied to preverbal gesturing. The fact that the strongest association in the current study was found between the concurrent self-regulation at 12 months and gesturing at 14 months of age, and not with the verbal language outcomes, was interesting. We had similar findings in another Finnish sample of 12-month-olds where we found aspects of mother-reported self-regulation and positive emotionality to predict infant gesturing over and above verbal language (Ollas et al., 2020). Our findings suggest that gesturing is the communicative skill most influenced by self-regulatory capacity at this early age. As an expressive modality, gesturing typically precedes expressive vocabulary (Iverson & Goldin-Meadow, 2005) and presents larger variability at this age, which may explain why it shows stronger associations with self-regulation compared to expressive vocabulary. Interestingly, whereas the predictive power of early expressive vocabulary is debated (Duff et al., 2015), early gesturing is reported to predict later language development (Kuhn et al., 2014; Rowe & Goldin-Meadow, 2009), making the current findings interesting also from the larger perspective of childhood. More studies are needed to explore whether similar results can be found in other populations as well.

Although using self-regulation by gaze aversion was partially an exploratory study question as no previous similar studies have been conducted, it was surprising that we found a negative association between observed emerging self-regulation and language outcomes. This pattern of associations, although not significant after correcting for multiple comparisons, was observed in terms of two different language outcomes, receptive and expressive vocabulary, whereas reported self-regulation was most clearly associated with gesturing. The maternal report and observations capture different aspects of self-regulatory ability, which is supported by the fact that observed emergent self-regulation by gaze aversion at 8 months was also modestly negatively correlated with reported emerging self-regulation at 6 months. The aspects of self-regulation beneficial for communicative development may be better reflected in parent-reported self-regulation than in the observations of self-regulatory behaviors. Instead, the frequent use of gaze aversion may reflect a more avoidant regulatory strategy that is independent of parental scaffolding in distress-provoking conditions. Thus, infants using this strategy may regulate through means that are not as beneficial for communicative development. Parallels can be drawn to the finding by Robinson and Acevedo (2001) where high fear was positively related to language when accompanied by high reliance on the mother, but the opposite was true when reliance on the mother was low. The fact that the model did not change when adding negative affectivity indicates that the use of gaze aversion is related to language skills independent of the level of emotional reactivity. Interestingly, the negative relations between gaze a version, a behavioral marker of emotion regulation, were found only with the verbal communication outcomes, not with gesturing. These preliminary results have to be treated with caution, but they point to a need to further confirm the findings and study different aspects of self-regulation at different child age points as these may have individual contributions to the development of communicative skills.

The lack of associations between observed attentiveness and communicative outcomes was also unexpected. Vouloumanos and Curtin (2014) studied associations between experimentally observed attentiveness at 12 months and expressive skills at 18 months and found that attention to linguistic stimuli positively predicted language skills, but overall attentiveness did not. Similarly, it is possible that the method used for observed task orientation/attentiveness assessment used in our setting does not pick up this dimension since the task involves as little interaction and communication as possible and is mainly about visual attention. Conversely, the mother-reported emerging self-regulation factor contains both dimensions of attentiveness and emotional self-regulation across several everyday situations, so it may better tap into dimensions that support interaction and communicative development related to emotion regulation and attentiveness in communication situations. However, we are not aware of other studies employing the same measure of attentiveness as in the current study, so more research is needed to draw conclusions on the patterns observed.

4.2 | Negative affectivity, fear, and communicative development

Previous studies have reported inconsistent findings regarding associations between negative affectivity and language skills, including both positive associations (e.g., Molfese et al., 2010) and negative associations (e.g., Kubicek & Emde, 2012) and no significant main effects at all (Karrass & Braungart-Rieker, 2003; Laake & Bridgett, 2018). Our findings were in line with the latter, as we found no robust evidence for either observed or reported negative affectivity playing a role in language development in our study. However, a finding that did not survive multiple comparison correction, higher negative affectivity in the observed condition significantly associated with infants belonging to the high expressive vocabulary group rather than the intermediate expressive vocabulary group. Furthermore, the regression coefficients, although not statistically significant, between higher negative affectivity and communicative outcomes were positive. Thus, our findings rather hint toward infant negative affectivity having a positive contribution to communicative development instead of being harmful for this development. This interpretation would also be in line with the previous notion that in younger children, specifically anger, has been reported to be positively related to language (Nozadi et al., 2013). Particularly in the observational assessment condition negative affect is a reactive response to being limited from a desired action, which can be interpreted as a way of communicating the distress to the adult when verbal expression is not yet possible (Nozadi et al., 2013; Stifter & Fox, 1990). To summarize, we found no evidence of higher negative affectivity being a risk factor for communicative development.

Previous findings regarding infant fear have also been contradictory, as both positive associations in infancy (Peterson et al., 2017) and negative associations from 15 to 30 months of age (Kubicek & Emde, 2012) have been reported. In our study, the relations did not reach significance, but the coefficients observed in our study were positive. This pattern may reflect the relatively lower power and the possibility that the associations may emerge in larger samples. Further, the associations may be dependent on the context. More specifically, fear expressions in distress-provoking contexts that serve the purpose of initiating interaction with the caregiver may influence communicative development positively (Robinson & Acevedo, 2001). However, since no clear associations were found in the current study, future studies should continue studying negative affectivity as a determinant of language in different contexts.

4.3 | Observed and reported temperament

The use of observed and reported temperament can be seen as both a strength and a weakness in the current study. It is a strength as both methodologies have seldom been used in the same study when

exploring associations between temperament and communicative development. However, unfortunately, the time points for observational and reported assessment did not overlap entirely in our sample, decreasing the degree to which they can be directly compared. Generally, the corresponding observed and reported temperament traits showed low intercorrelations, which is not surprising as it is well known from previous research that correspondence between observational and reported temperament assessment, especially regarding negative emotionality, is not always high (Freund, 2019; Stifter et al., 2008). Thus, the low intercorrelations in the current study are unlikely to result from the 2-month time difference between the first mother-report and the laboratory assessment. Observed and reported temperament traits also displayed differing associations with communicative outcomes. This supports the view that they assess different aspects of the temperament. In a laboratory setting, it is possible to standardize the situations assessed and try to elicit specific, low-frequency emotions and reactions, and the observers are more objective (Durbin et al., 2007). Laboratory assessments are, however, novel situations for the infant, which may lead to lower ecological validity (Durbin et al., 2007) and affect infant reactions, for example, by heightening negative reactivity (Stifter et al., 2008). During observational assessment, the infant and adult are not allowed to interact freely, in contrast to the situations assessed when using parent-reports, which may also shape the infant responses. Since infant self-regulation is dependent on caregiver support (Feldman, 2007) and the expression of dimensions of temperament also depends on caregiver actions and the environment, assessing temperament independently is naturally difficult for parents, and parent-reports inevitably lack objectivity to some extent (Durbin & Wilson, 2012; Leerkes & Crockenberg, 2003). The involvement of interaction aspects in the reported measures may in fact explain their stronger associations with communicative skills. Our findings converge with the prior reports in supporting the view that both assessment modalities may have independent associations with early childhood communicative development (Kubicek & Emde, 2012) and should be utilized simultaneously to understand the relations between temperament and language development.

4.4 | Limitations and directions for future research

There are several strengths in the current study. One is studying relations between temperament and communicative development longitudinally during the first years of life, a time period when the expression of temperament traits comes online and develops (Braungart-Rieker et al., 2010; Caspi & Roberts, 2001; Rothbart et al., 2007), and the first communicative behaviors become observable and then develop at a fast pace (Fenson, 1994). Due to the rapid changes in temperament and communicative development during this time period, this is a particularly interesting time period to explore.

However, there are also important limitations to consider. One is the above-mentioned discussion regarding the use of observed and reported temperament assessment. Furthermore, although being quite large compared to other studies that have considered associations between early temperament and language, the current sample size may still have affected the statistical power and led to smaller, but yet conceptually interesting effects not reaching significance. Second, although both the communication development (Fenson, 1994) and temperament (Gartstein & Rothbart, 2003) assessment instruments have been shown to be reliable and also have advantages as compared to observatory assessments (Gartstein & Marmion, 2008), it is not possible to rule out that the relations between reported temperament and communicative outcomes may be due to rater bias, since ratings of both temperament and communicative skills were made by the same person. Hence, parent perceptions, for example, positive versus negative perceptions of the child, could influence ratings on both instruments. However, the present study used both observed and reported temperament to examine the study

questions, which effectively attenuates this limitation. One additional limitation related to the observational temperament assessment was that no observation technology other than video recording from the front of the infant was used to code gaze aversion in the observational self-regulation task, and it was not possible to add technology at a later stage. Future studies focusing on gaze aversion should routinely use such technologies when available.

Third, since the theory is that temperament traits influence communicative development through influencing the quality and quantity of infant-adult interaction (e.g., Moreno & Robinson, 2005), it would be optimal to involve assessment of parent-child interaction in studies of these relations as well. For example, Karrass and Braungart-Rieker (2003) argue that the influence of negative affectivity may depend on how the parent responds to the emotion. Thus, if they isolate the child in order to help them calm down, interaction is disrupted, but more effective soothing by talking to the child, interaction continues. Hence, knowledge of the quality of mother-infant interaction would be valuable in understanding these relations, and this is included in our plans for future research.

Fourth, it is important to take into consideration that, while measures have been taken to make the current sample as representative as possible for the Finnish sample, there may be cultural differences concerning communication, temperament, and economic factors that this study has not managed to control for, reducing the generalizability to other populations.

5 | CONCLUSION

The results of the current study indicated that higher mother-reported self-regulation was positively associated with preverbal gesturing at 14 months, explaining 15% of the variance. As a preliminary finding, observed self-regulation by gaze aversion at 8 months was linked with poorer receptive and expressive vocabulary. This indicates self-regulation is important to take into consideration as a risk/protective factor for early communicative development, but different aspects of or strategies for self-regulation may have different relations to the different dimensions of communication. No clear associations between negative affectivity or fear and early communicative development were detected in this study. Our findings also support the view that the association between temperament and communicative development depends on the age at which the traits are assessed. More longitudinal research is needed to yield a deeper understanding of these relations and to improve the understanding of the risk factors of early language development.

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CONFLICT OF INTEREST

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REFERENCES

Berglund, E., Eriksson, M., & Westerlund, M. (2005). Communicative skills in relation to gender, birth order, childcare and socioeconomic status in 18-month-old children. *Scandinavian Journal of Psychology*, *46*(6), 485–491. https://doi.org/10.1111/j.1467-9450.2005.00480.x

Bloom, L., & Capatides, J. B. (1987). Expression of affect and the emergence of language. *Child Development*, *58*(6), 1513–1522. https://doi.org/10.2307/1130691

Bohlmann, N. L., Maier, M. F., & Palacios, N. (2015). Bidirectionality in self-regulation and expressive vocabulary: Comparisons between monolingual and dual language learners in preschool. *Child Development*, *86*(4), 1094–1111. https://doi.org/10.1111/cdev.12375

Braungart-Rieker, J. M., Hill-Soderlund, A. L., & Karrass, J. (2010). Fear and anger reactivity trajectories from 4 to 16 months: The roles of temperament, regulation, and maternal sensitivity. *Developmental Psychology*, *46*, 791–804. https://doi.org/10.1037/a0019673

Briggs-Gowan, M. J., Carter, A. S., & Schwab-Stone, M. (1996). Discrepancies among mother, child, and teacher reports: Examining the contributions of maternal depression and anxiety. *Journal of Abnormal Child Psychology*, *24*(6), 749–765. https://doi.org/10.1007/BF01664738

Buss, K. A. (2011). Which fearful toddlers should we worry about? Context, fear regulation, and anxiety risk. *Developmental Psychology*, *47*(3), 804–819. https://doi.org/10.1037/a0023227

Caspi, A., & Roberts, B. W. (2001). Personality development across the life course: The argument for change and continuity. *Psychological Inquiry*, *12*(2), 49–66. https://doi.org/10.1207/S15327965PLI1202

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression - development of the 10-item edinburgh postnatal depression scale. *British Journal of Psychiatry*, *150*(6), 782–786. https://doi.org/10.1192/bjp.150.6.782

Derogatis, L. R., Lipman, R. S., & Covi, L. (1973). SCL-90: An outpatient psychiatric rating scale - preliminary report. *Psychopharmacology Bulletin, 9*(1), 13–28.

Dixon, W. E., & Smith, P. H. (2000). Links between early temperament and language acquisition. *Merrill-Palmer Quarterly*, *46*, 417–440. http://www.jstor.org/stable/23093739

Duff, F. J., Nation, K., Plunkett, K., & Bishop, D. V. M. (2015). Early prediction of language and literacy problems: Is 18 months too early? *PeerJ*, *3*, e1098. https://doi.org/10.7717/PEERJ.1098/SUPP-1

Durbin, C. E., & Wilson, S. (2012). Convergent validity of and bias in maternal reports of child emotion. *Psychological Assessment*, *24*(3), 647–660. https://doi.org/10.1037/a0026607

Durbin, C. E., Hayden, E. P., Klein, D. N., & Olino, T. M. (2007). Stability of laboratory-assessed temperamental emotionality traits from ages 3 to 7. *Emotion*, *7*(2), 388–399. https://doi.org/10.1037/1528-3542.7.2.388

Edwards, R. C., & Hans, S. L. (2015). Infant risk factors associated with internalizing, externalizing, and co-occurring behavior problems in young children. *Developmental Psychology*, *51*(4), 489–499. https://doi.org/10.1037/A0038800

Eriksson, M., & Berglund, E. (2002). Instruments, scoring manual and percentile levels of the Swedish Early Communicative Development Inventory, SECDI (FoU-Rapport 17). Institutionen för pedagogik, didaktik och psykologi.

Feldman, R. (2007). Parent-infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, *16*(6), 340–345. https://doi.org/10.1111/j.1467-8721.2007.00532.x. http://www.jstor.org/stable/20183232

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*, 1–185.

Freund, J. D. (2019). Early temperament in parental report and scientific observation. *Early Child Development and Care*, *189*(14), 2318–2333. https://doi.org/10.1080/03004430.2018.1450252

Gaias, L. M., Räikkönen, K., Komsi, N., Gartstein, M. A., Fisher, P. A., & Putnam, S. P. (2012). Cross-cultural temperamental differences in infants, children, and adults in the United States of America and Finland. *Scandinavian Journal of Psychology*, *53*(2), 119–128. https://doi.org/10.1111/J.1467-9450.2012.00937.X

Garello, V., Viterbori, P., & Usai, M. C. (2012). Temperamental profiles and language development: A replication and an extension. *Infant Behavior and Development*, *35*(1), 71–82. https://doi.org/10.1016/j.infbeh.2011.09.003

Gartstein, M. A., & Marmion, J. (2008). Fear and positive affectivity in infancy: Convergence/discrepancy between parent-report and laboratory-based indicators. *Infant Behavior and Development*, *31*(2), 227–238. https://doi.org/10.1016/j.infbeh.2007.10.012

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior and Development*, *26*(1), 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8

Gartstein, M. A., Crawford, J., & Robertson, C. D. (2008). Early markers of language and attention: Mutual contributions and the impact of parent-infant interactions. *Child Psychiatry and Human Development*, *39*(1), 9–26. https://doi.org/10.1007/s10578-007-0067-4

Goldsmith, H. H., Buss, A. H., Plomin, R., Rothbart, M. K., Thomas, A., Chess, S., Hinde, R. A., & McCall, R. B. (1987). Roundtable: What is temperament? Four approaches. *Child Development*, *58*, 505–529. https://doi.org/10.2307/1130527

Harrison, L. J., & McLeod, S. (2010). Risk and protective factors associated with speech and language impairment in a nationally representative sample of 4- to 5-year-old children. *Journal of Speech, Language, and Hearing Research*, *53*(2), 508–529. https://doi.org/10.1044/1092-4388(2009/08-0086)

Hoff, E., & Tian, C. (2005). Socioeconomic status and cultural influences on language. *Journal of Communication Disorders*, *38*(4), 271–278. https://doi.org/10.1016/j.jcomdis.2005.02.003

Hohm, E., Jennen-Steinmetz, C., Schmidt, M. H., & Laucht, M. (2007). Language development at ten months: Predictive of language outcome and school achievement ten years later? *European Child & Adolescent Psychiatry*, *16*, 149–156. https://doi.org/10.1007/s00787-006-0567-y

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science*, *16*(5), 367–371. https://doi.org/10.1111/j.0956-7976.2005.01542.x

Karlsson, L., Tolvanen, M., Scheinin, N. M., Uusitupa, H.-M., Korja, R., Ekholm, E., Tuulari, J. J., Pajulo, M., Huotilainen, M., Paunio, T., Karlsson, H., & FinnBrain Birth Cohort Study Group. (2018). Cohort profile: The FinnBrain birth cohort study (FinnBrain). *International Journal of Epidemiology*, *47*(1), 15–16j. https://doi.org/10.1093/ije/dyx173

Karrass, J., & Braungart-Rieker, J. M. (2003). Parenting and temperament as interacting agents in early language development. *Parenting: Science and Practice*, *3*, (3), 235-259. https://doi.org/10.1207/S15327922PAR0303_03

Komsi, N., Räikkönen, K., Pesonen, A. K., Heinonen, K., Keskivaara, P., Järvenpää, A. L., & Strandberg, T. E. (2006). Continuity of temperament from infancy to middle childhood. *Infant Behavior and Development*, *29*(4), 494–508. https://doi.org/10.1016/j.infbeh.2006.05.002

Kubicek, L. F., & Emde, R. N. (2012). Emotional expression and language: A longitudinal study of typically developing earlier and later talkers from 15 to 30 months. *Infant Mental Health Journal*, *33*(6), 553–584. https://doi.org/10.1002/imhj.21360

Kuhn, L. J., Willoughby, M. T., Wilbourn, M. P., Vernon-Feagans, L., & Blair, C. B. (2014). Early communicative gestures prospectively predict language development and executive function in early childhood. *Child Development*, *85*, 1898–1914. https://doi.org/10.1111/cdev.12249

Laake, L. M., & Bridgett, D. J. (2014). Happy babies, chatty toddlers: Infant positive affect facilitates early expressive, but not receptive language. *Infant Behavior and Development*, *37*(1), 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006

Laake, L. M., & Bridgett, D. J. (2018). Early language development in context: Interactions between infant temperament and parenting characteristics. *Early Education & Development*, *29*(5), 730–746. https://doi.org/10.1080/10409289.2018.1436366

Leerkes, E. M., & Crockenberg, S. C. (2003). The impact of maternal characteristics and sensitivity on the concordance between maternal reports and laboratory observations of infant negative emotionality. *Infancy*, *4*, 517–539. https://doi.org/10.1207/S15327078IN0404_07

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2002). The importance of the normality assumption in large public health data sets. *Annual Review of Public Health*, *23*(1), 151–169. https://doi.org/10.1146/annurev.publheath.23.100901.140546

Lyytinen, P. (1999). Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä. Jyväskylän yliopiston Lapsitutk- imuskeskus ja Niilo Mäki instituutti. [A method for assessing early communication and language. University of Jyväskylä Child Research Centre and the Niilo Mäki Institute]. Niilo Mäki Säätiö.

McClelland, M. M., Cameron, C. E., Connor, C. M. D., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*, *43*(4), 947–959. https://doi.org/10.1037/0012-1649.43.4.947

Molfese, V. J., Rudasill, K. M., Beswick, J. L., Jacobi-Vessels, J. L., Ferguson, M. C., & White, J. M. (2010). Infant temperament, maternal personality, and parenting stress as contributors to infant developmental outcomes. *Merrill-Palmer Quarterly*, *56*(1), 49–79. https://doi.org/10.1353/mpq.0.0039

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Neal, R., & Schwartz, H. K. (2000). Gaze following, temperament, and language development in 6-month-olds: A replication and extension. *Infant Behavior and Development*, *23*(2), 231–236. https://doi.org/10.1016/S0163-6383(01)00038-8

Moreno, A. J., & Robinson, J. L. (2005). Emotional vitality in infancy as a predictor of cognitive and language abilities in toddlerhood. *Infant and Child Development*, *14*(4), 383–402. https://doi.org/10.1002/icd.406

Newman, R. S., Rowe, M. L., & Bernstein Ratner, N. (2016). Input and uptake at 7 months predicts toddler vocabulary: The role of child-directed speech and infant processing skills in language development. *Journal of Child Language*, *43*(5), 1158–1173. https://doi.org/10.1017/S0305000915000446

Nigg, J. T. (2017). Annual Research Review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *58*(4), 361–383. https://doi.org/10.1111/JCPP.12675

Noel, M., Peterson, C., & Jesso, B. (2008). The relationship of parenting stress and child temperament to language development among economically disadvantaged preschoolers. *Journal of Child Language*, *35*(4), 823–843. https://doi.org/10.1017/S0305000908008805

Nozadi, S. S., Spinrad, T. L., Eisenberg, N., & Eggum-Wilkens, N. D. (2015). Associations of anger and fear to later self-regulation and problem behavior symptoms. *Journal of Applied Developmental Psychology*, *38*, 60–69. https://doi.org/10.1016/j.appdev.2015.04.005

Nozadi, S. S., Spinrad, T. L., Eisenberg, N., Bolnick, R., Eggum-Wilkens, N. D., Smith, C. L., Gaertner, B., Kupfer, A., & Sallquist, J. (2013). Prediction of toddlers' expressive language from maternal sensitivity and toddlers' anger expressions: A developmental perspective. *Infant Behavior and Development*, *36*(4), 650–661. https://doi.org/10.1016/j.infbeh.2013.06.002

Ollas, D., Rautakoski, P., Nolvi, S., Karlsson, H., & Karlsson, L. (2020). Temperament is associated with the use of communicative gestures in infancy. *Infant and Child Development*, *29*(3), 1–15. https://doi.org/10.1002/icd.2166

Peterson, E. R., Waldie, K. E., Mohal, J., Reese, E., Atatoa Carr, P. E., Grant, C. C., & Morton, S. M. B. (2017). Infant behavior questionnaire–revised very short form: A new factor structure's associations with parenting perceptions and child language outcomes. *Journal of Personality Assessment*, *99*(6), 561–573. https://doi.org/10.1080/00223891.2017.1287709

Planalp, E. M., Hulle, C. V., Gagne, J. R., & Hill Goldsmith, H. (2017). The infant version of the laboratory temperament assessment battery (Lab-TAB): Measurement properties and implications for concepts of temperament. *Frontiers in Psychology*, *8*, 1–17. https://doi.org/10.3389/fpsyg.2017.00846

Prior, M., Bavin, E. L., Cini, E., Reilly, S., Bretherton, L., Wake, M., & Eadie, P. (2008). Influences on communicative development at 24 months of age: Child temperament, behaviour problems, and maternal factors. *Infant Behavior and Development*, *31*(2), 270–279. https://doi.org/10.1016/j.infbeh.2007.11.001

Psyridou, M., Eklund, K., Poikkeus, A. M., & Torppa, M. (2018). Reading outcomes of children with delayed early vocabulary: A follow-up from age 2–16. *Research in Developmental Disabilities*, *78*, 114–124. https://doi.org/10.1016/J.RIDD.2018.05.004

Pérez-Edgar, K., & Fox, N. A. (2005). Temperament and anxiety disorders. *Child and Adolescent Psychiatric Clinics of North America*, *14*(4), 681–706. https://doi.org/10.1016/j.chc.2005.05.008

Pérez-Pereira, M., Fernández, P., Resches, M., & Luisa Gómez-Taibo, M. (2016). Does temperament influence language development? Evidence from preterm and full-term children. *Infant Behavior and Development*, *42*, 11–21. https://doi.org/10.1016/j.infbeh.2015.10.003

Reck, C., Van Den Bergh, B., Tietz, A., Müller, M., Ropeter, A., Zipser, B., & Pauen, S. (2018). Maternal avoidance, anxiety cognitions and interactive behaviour predicts infant development at 12 months in the context of anxiety disorders in the postpartum period. *Infant Behavior and Development*, *50*, 116–131. https://doi.org/10.1016/j.infbeh.2017.11.007

Robinson, J. A. L., & Acevedo, M. C. (2001). Infant reactivity and reliance on mother during emotion challenges: Prediction of cognition and language skills in a low-income sample. *Child Development*, *72*(2), 402–415. https://doi.org/10.1111/1467-8624.00286

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology*. Social, emotional, and personality development (Vol. 3, pp. 105–176). Wiley.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon, R. M. Lerner, & N. Eisenberg (Eds.), *Handbook of child psychology*. Social, emotional, and personality development (Vol. 3, pp. 99–166). Wiley.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, *1*, 2–7. https://doi.org/10.1111/j.1750-8606.2007.00002.x

Rothbart, M. K., Sheese, B. E., Rueda, M. R., & Posner, M. I. (2011). Developing mechanisms of self-regulation in early life. *Emotion Review*, *3*(2), 207–213. https://doi.org/10.1177/1754073910387943

Rowe, M. L., & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science*, *12*(1), 182–187. https://doi.org/10.1111/j.1467-7687.2008.00764.x

Salley, B. J., & Dixon, W. E. (2007). Temperamental and joint attentional predictors of language development. *Merrill-Palmer Quarterly*, *53*, 131–154.

Sohr-Preston, S. L., & Scaramella, L. V. (2006). Implications of timing of maternal depressive symptoms for early cognitive and language development. *Clinical Child and Family Psychology Review*, *9*(1), 65–83. https://doi.org/10.1007/s10567-006-0004-2

Stifter, C. A., & Fox, N. A. (1990). Infant reactivity: Physiological correlates of newborn and 5-month temperament. *Developmental Psychology*, *26*(4), 582–588. https://doi.org/10.1037/0012-1649.26.4.582

Stifter, C. A., Willoughby, M. T., & Towe-Goodman, N. (2008). Agree or agree to disagree? Assessing the convergence between parents and observers on infant temperament. *Infant and Child Development*, *17*(4), 407–426. https://doi.org/10.1002/icd.584

Taanila, A., Murray, G. K., Jokelainen, J., Isohanni, M., & Rantakallio, P. (2005). Infant developmental milestones: A 31-year follow-up. *Developmental Medicine and Child Neurology*, *47*(09), 581–586. https://doi.org/10.1017/S0012162205001155

Trentacosta, C. J., & Shaw, D. S. (2009). Emotional self-regulation, peer rejection, and antisocial behavior: Developmental associations from early childhood to early adolescence. *Journal of Applied Developmental Psychology*, *30*(3), 356–365. https://doi.org/10.1016/j.appdev.2008.12.016

Ursache, A., Blair, C., Stifter, C., & Voegtline, K. (2013). Emotional reactivity and regulation in infancy interact to predict executive functioning in early childhood. *Developmental Psychology*, *49*(1), 127–137. https://doi.org/10.1037/a0027728

Valiente, C., Eisenberg, N., Smith, C. L., Reiser, M., Fabes, R. A., Losoya, S., Guthrie, I. K., & Murphy, B. C. (2003). The relations of effortful control and reactive control to children's externalizing problems: A longitudinal assessment. *Journal of Personality*, *71*(6), 1171–1196. https://doi.org/10.1111/1467-6494.7106011

Vouloumanos, A., & Curtin, S. (2014). Foundational tuning: How infants' attention to speech predicts language development. *Cognitive Science*, *38*(8), 1675–1686. https://doi.org/10.1111/cogs.12128

Zerbeto, A. B., Cortelo, F. M., & Filho, É. B. C. (2015). Association between gestational age and birth weight on the language development of Brazilian children: A systematic review. *Jornal de Pediatria*, *91*(4), 326–332. https://doi.org/10.1016/j.jpedp.2015.05.004

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RESEARCH ARTICLE OPEN ACCESS

Maternal Emotional Availability Supports Child Communicative Development Regardless of Child Temperament—Findings From the FinnBrain Birth Cohort Study

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ABSTRACT

The interplay of emotional availability (EA) and child temperament in association with early language development is understudied. We explored associations between maternal EA and infant communicative development and possible moderations by child temperament. Participants were 151 mother-child dyads from the FinnBrain Birth Cohort Study. Path models of associations between 8-month maternal EA and 14-month communicative development and moderation by infant temperament traits were created using SEM. Results show that EA positively predicted a latent variable of communicative development at 14 months. No direct longitudinal effect of EA on 30-month vocabulary was found. Child surgency/extraversion at 6 and 12 months significantly predicted 14-month communicative skills. Temperament did not moderate the association between EA and communicative development. Findings underscore the additive role of maternal caregiving and early surgency/extraversion in predicting early communicative development. The emotional aspects of parenting should be acknowledged as contributors to early communicative development in future studies.

1 | Introduction

Infant communicative development takes place in interaction with others, and therefore the quality of early interactions experienced by the infant is relevant to investigate in the context of communicative development (Tamis-LeMonda, Bornstein, and Baumwell 2001). Both infant characteristics and factors related to the interaction partner are likely to contribute to the

quality of the interaction. Consequently, it is important to study the contributions from both members of the dyad to infant communicative development and how these factors possibly interact. This is notable because early communication and language development predict later language skills, and have implications for other later developmental outcomes such as socio-emotional functioning and academic achievement (Hohm et al. 2007). Furthermore, the concept of emotional availability —referring to caregiving quality in terms of emotional connection in the mother-child dyad—has frequently been overlooked in the context of communicative development in past studies in favor of studying caregiving from a narrower viewpoint.

1.1 | Caregiving Quality and Communicative Development

Several studies report that parent caregiving quality predicts communicative development (Leigh, Nievar, and Nathans 2011; Nozadi et al. 2013; Tamis-LeMonda, Bornstein, and Baumwell 2001). Similar findings have been reported in a Finnish sample, suggesting that across cultures, caregiving quality is an important contributor to early communicative development (Paavola et al. 2006). Nevertheless, the terms used for caregiving quality and what is included in the definitions vary between studies. Most typically, maternal responsiveness or sensitivity are the foci of interest in studies of caregiving quality. Sensitivity generally refers to the parent's awareness of the child's signals and needs (Ainsworth et al. 2014), and responsiveness is often thought of as the behavioral consequence of sensitivity—reacting to meet the needs of the child (Biringen and Easterbrooks 2012). Findings across studies consistently report sensitivity/responsiveness to be positively related to language development regardless of socioeconomic status (SES) or ethnicity of the sample (Pungello et al. 2009). For example, Leigh, Nievar, and Nathans (2011) found that higher maternal sensitivity during the first and second year of life predicted better expressive language skills at two and 3 years of age. They also found that concurrent relations between sensitivity and child language were stronger as the child grew older, with the strongest relationship at the last assessment point at 3 years (Leigh, Nievar, and Nathans 2011). Tamis-LeMonda, Bornstein, and Baumwell (2001) reported positive associations between maternal responsiveness at 9 and 13 months postpartum and the achievement of infant expressive language milestones. Associations between maternal sensitivity and both expressive and receptive language skills in preschool-aged children have also been found (Keown, Woodward, and Field 2001). Additionally, maternal responsiveness demonstrated positive associations with non-verbal communicative behaviors such as symbolic play (Bornstein and Tamis-LeMonda 1997). Although findings have been fairly consistent across studies, there are reports where responsiveness did not significantly associate with gesturing or language outcomes in infancy and toddlerhood (e.g., Bruce et al. 2022).

Another caregiving-related concept studied in relation to communicative development is scaffolding (Dieterich et al. 2006; Landry et al. 1997). Scaffolding generally refers to providing support adapted to the individual child's needs to help them accomplish goals they would not be able to accomplish on their own, while allowing and encouraging independent problem-solving (Wood, Bruner, and Ross 1976). A subcategory is verbal scaffolding, referring to rich verbal input from the parent encouraging independent problem solving by the child (Dieterich et al. 2006). Particularly, verbal scaffolding is regarded as supportive of communicative development (Dieterich et al. 2006; Landry et al. 2002). Scaffolding has some overlap with the responsiveness concept, and some consider it a subcategory of it (Landry, Smith, and Swank 2006; Mermelshtine 2017; Tamis-LeMonda, Kuchirko, and Song 2014).

Further, the concept of structuring, used in our study, has commonalities with scaffolding, but where scaffolding describes general parenting, structuring refers to the parent's interactive, behavioral structuring of their and the child's actions in the immediate situation at hand (Saunders et al. 2015). It is not merely assessing the parent's ability to support child development, but the parent's interactive ability to structure the situation according to the child's signals. Optimal structuring helps the child be active and autonomous, and understand what is expected of them in a situation (Biringen 2000).

Whereas positive aspects of caregiving have been considered in prior studies, the negative aspects of caregiving have been studied less commonly in relation to language development. One aspect of negative caregiving is parental intrusiveness. Parental intrusiveness typically refers to caregiver over-involvement, and the inability to let the child take the lead or react adequately to the child's signals (Laake and Bridgett 2018; Saunders et al. 2015). Some studies have found negative associations between higher levels of parent intrusiveness and child language (Bruce et al. 2022; Keown, Woodward, and Field 2001; Pungello et al. 2009). However, others have found the effect to disappear when simultaneously accounting for positive caregiving (Tamis-LeMonda et al. 2004) or the associations to appear only at specific age points (Cabrera, Shannon, and Tamis-LeMonda 2007).

In this study, we measured caregiving quality during mother-child interaction using the emotional availability (EA) construct (Biringen 2000; Biringen and Easterbrooks 2012; Saunders et al. 2015). Within the EA scales framework, EA is defined as the dyad's ability to form a genuine positive emotional connection and adapt to and regulate negative emotions (Biringen and Easterbrooks 2012). High EA characterizes a healthy, positive, and mutually enjoyable interaction and relationship. The EA framework includes the aspects of *sensitivity*, but also *structuring, non-intrusiveness,* and *non-hostility* (Biringen 2000). These aspects are consistently related to child emotion regulation (Frick et al. 2018) and empathy development (Moreno, Klute, and Robinson 2008), as well as mental health and behavior problems (Easterbrooks, Bureau, and Lyons-Ruth 2012); factors that are also commonly linked to communicative development (Moreno, Klute, and Robinson 2008; Reilly and Downer 2019). Although measures of sensitivity/responsiveness, scaffolding, or structuring, and intrusiveness, corresponding in varying degrees to the equivalent subscales involved in EA, have been explored in relation to communication development, we are not aware of previous studies that have used the concept of EA and the

combination of the subscales into a latent variable depicting overall caregiving quality. Thus, using the EA framework enables exploration of the effects of a broader, multifaceted conceptualization of caregiving including both emotional and behavioral dimensions.

1.2 | Temperament and Communicative Development

Whereas caregiving quality is an important parental factor influencing early communicative development, temperament is one infant-related factor that plays a role in shaping child language. Temperament is commonly defined as individual differences in emotional, motor, and attentional reactivity and self-regulation (Rothbart and Bates 1998). The temperament framework of Rothbart contains three overarching factors: surgency/extraversion, negative emotionality, and self-regulation (Gartstein and Rothbart 2003). Surgency/extraversion is a temperament trait generally involving characteristics such as pleasure related to high-intensity stimuli, high approach, impulsivity, and activity level (Putnam, Ellis, and Rothbart 2001). Negative emotionality, in turn, involves characteristics related to expression of negative emotions such as sadness, frustration, and fear. Self-regulation is defined as the processes that control reactivity. That is, self-regulation involves controlling attention, approach, and inhibition. Early manifestations of self-regulation involve attentional processes that support the emergence of effortful self-regulation of behavior and emotion (i.e., effortful control; Bridgett et al. 2011; Putnam, Ellis, and Rothbart 2001). Self-regulation (Bruce et al. 2022; Dixon and Smith 2000) and surgency/extraversion (Bruce et al. 2022; Dixon and Smith 2000; Laake and Bridgett 2014) have previously been reported to be positively associated with communicative development. In turn, there is more variability in the findings regarding negative emotionality. Some studies have reported negative associations between infant language development and high negative emotionality (Bloom and Capatides 1987; Kubicek and Emde 2012; Salley and Dixon 2007), whereas others have reported opposite relations (Molfese et al. 2010; Moreno and Robinson 2005; Robinson and Acevedo 2001) or no association at all (Ollas-Skogster et al. 2023).

The associations between temperament and communicative skills are also hypothesized to, at least to some extent, be due to the influence of temperament traits on the child's interaction with others (Laake and Bridgett 2014). For instance, it is thought that child temperament may influence the adults' interaction style with the infant (Conture, Kelly, and Walden 2013). It may be that adults interact more with infants who show high surgency/extraversion, resulting in larger amounts of communicative stimulation supporting the learning of communicative skills (Laake and Bridgett 2014). Furthermore, infant self-regulation, including higher attentiveness and duration of orienting, is suggested to support communicative development through the improved ability to focus on interactions with the caregiver and acquire communicative skills by observing and engaging in interaction with others (Gartstein, Crawford, and Robertson 2008). The infant's better ability to focus attention possibly also serves as a motivator for the partner to continue the verbal interaction (Gartstein, Crawford, and Robertson 2008).

The positive associations between negative emotionality and language development also have been explained by displays of negative emotions resulting in the engagement of the caregiver, and consequently more interactive and communicative stimulation (Moreno and Robinson 2005). This possibly shows that negative emotions can also be seen as a prelinguistic infant's regulatory strategy related to the interaction with the adult (Moreno and Robinson 2005). For this to be beneficial for communicative development, adult sensitivity to these signals is required, again underscoring the codependence in the interactional relationship within the dyad. However, more emotionally negative infants have also been reported to make fewer bids to initiate joint attention (Salley and Dixon 2007); that is, they may initiate communication with the caregiver less frequently.

1.3 | Caregiving Quality, Temperament, and Communicative Development

To summarize, there is a growing body of literature reporting associations between temperament as well as caregiving quality and communicative development, and these findings are often explained by factors related to dyadic interaction. Given that parents and children act together to form a relationship (Collins et al. 2000), and the temperament of the infant can influence the qualities of the caregiving (Kochanska et al. 2004), and possibly also maternal language used in interaction with the infant (Vernon-Feagans et al. 2008), surprisingly few studies have focused on the moderating role of temperament in explaining the association between caregiving quality and language development.

To describe the few exceptions, Karrass and Braungart-Rieker (2003), Laake and Bridgett (2018), and Nozadi et al. (2013) found caregiving quality and temperament traits to interact in predicting language skills in toddlerhood (14–18 months of age). In contrast, Gartstein, Crawford, and Robertson (2008) and Bruce et al. (2022) found caregiving factors and temperament to have only independent effects on communicative skills in infancy and toddlerhood (6–24 months). Karrass and Braungart-Rieker (2003) found maternal responsiveness to positively predict total language ability when child fearfulness was low. Maternal responsiveness also predicted stronger language abilities in boys with a low level of smiling and laughter—an aspect of surgency/extraversion. Karrass and Braungart-Rieker (2003) suggest that infants with low emotionality of both negative and positive quality may be advantaged in engaging in communication with the caregiver, and thereby better equipped to utilize the input by highly responsive caregivers (Karrass and Braungart-Rieker 2003). Conversely, Laake and Bridgett (2018) found that high surgency/extraversion at 10 months was predictive of better expressive language at 14 months only in the context of higher maternal support. Infants higher in positive as well as negative emotionality benefited from lower maternal intrusiveness, but unexpectedly, in infants lower in negative emotionality, higher

maternal intrusiveness had positive effects on expressive language. The authors suggested that in a context where the infant's temperament does not favor eliciting interaction, even intrusive maternal initiatives can support communicative development as more intrusive parents may initiate more interaction with infants than parents lower in intrusiveness. Finally, Nozadi et al. (2013) found that maternal sensitivity influenced boys' expressive language development in toddlerhood indirectly through its role in regulating anger expression.

To conclude, existing studies have mostly underscored the role of infant affectivity as a moderator of the association between caregiving quality and communicative development. Furthermore, preverbal gesturing has seldom been involved in the assessment of infant communicative skills in this context, although it is a precursor of verbal language (Iverson and Goldin-Meadow 2005) and offers an opportunity to study the earliest forms of emerging infant communication.

1.4 | The Current Study

The aim of the current study was to investigate how early maternal caregiving quality assessed as EA at 8 months predicted preverbal communicative behaviors (at 14 months) and early verbal language skills (at 14 months and 30 months). An additional aim was to test whether infant temperament moderated the association between maternal EA and communicative skills. This study builds on the limited existing work in this area by using a wider perspective on caregiving quality involving all scales of EA including sensitivity, structuring, non-intrusiveness, and non-hostility. It also involves gesturing as a measure of early preverbal communicative skills and explores associations between overarching latent concepts of both caregiving quality and infant communicative skills. We used structural equation modeling (SEM) to create a path model of a latent EA-variable and temperament traits predicting a latent variable of 14-month communicative skills and observed 30-month expressive vocabulary. The use of latent variables allows for more statistically sound assessments of the phenomena of caregiving and communicative development on a general level. Furthermore, the use of EA offers a new, emotional viewpoint on caregiving rarely utilized in this context before. Finally, we also tested possible moderation effects of temperament traits (surgency/extraversion, negative emotionality, fear, and emerging self-regulation) on the relations between EA and communicative skills.

Based on prior research, we hypothesized that emotional availability at 8 months would positively predict children's communicative skills at 14 months and again at 30 months of age. We expected emotional availability and temperament traits to interact in predicting communicative skills in infancy and toddlerhood. More specifically, surgency/extraversion, negative emotionality, fear, and emerging self-regulation were considered as possible moderators based on prior studies. We expected that higher emotionality of both positive and negative quality paired with high quality caregiving would be positively associated with communicative development. We assumed emotional expressions and bids would be particularly efficient in initiating interaction with an emotionally available caregiver. Similarly, we expected high emerging self-regulatory ability in infants to be positively associated with communicative development accompanied by high-quality caregiving, since this trait could support infant involvement in joint activities further enhanced by high-quality caregiving. As previous findings on interactions between positive and negative emotionality and caregiving quality as predictors of communicative outcomes are mixed and corresponding findings regarding self-regulation and caregiving quality are, to our knowledge, missing, these analyses were considered exploratory.

2 | Method

2.1 | Participants

The study involved 151 families participating in the FinnBrain Birth Cohort Study (Karlsson et al. 2018). Compared to corresponding studies in the field that have found statistically significant associations (Bruce et al. 2022; Gartstein, Crawford, and Robertson 2008; Karrass and Braungart-Rieker 2003; Laake and Bridgett 2018; Nozadi et al. 2013), the current sample size is medium-sized. It is a convenience sample derived from a large cohort study representative of the geographically defined target population (Karlsson et al. 2018) and based on the availability of relevant data. Since the data are part of a large longitudinal cohort with a variety of research questions and were already collected at the time of planning this study, we could not calculate a priori power analyses for this study specifically. Nevertheless, the sample size is considered sufficient for detecting medium-sized and clinically relevant effects. The study follows the guidelines of the Declaration of Helsinki. Parents or guardians of each child provided written informed consent prior to the child participating in any study procedure. The cohort study protocol has received approval from the Ethics Committee of the Hospital District of Southwest Finland. All families who took part in laboratory visits for temperament and EA observations as well as provided at least one of the communicative development questionnaires at either 14 months or 30 months of age were included in the sample. The participating families were for the most part included in the FinnBrain "Focus cohort." The families in the Focus cohort are followed using comprehensive multidisciplinary assessments during the first years of the child's life (Karlsson et al. 2018). Demographic characteristics regarding the families can be seen in Table 1. The demographic features of the current sample correspond quite well to the characteristics of the entire cohort (Karlsson et al. 2018), except for children being primiparous more often in the current sample. Regarding attrition, the subsample that had not filled in the 30-month language development questionnaire did not differ significantly from the rest of the sample regarding any of the demographic characteristics. Five children were born preterm, one in gestational week 34 and the rest in week 36. The final models reported were run without the prematurely born infants for comparison and did not differ from the original versions. Hence, the prematurely born infants were involved in the final analyses. In this sample, monolingualism was defined as being exposed to another

TABLE 1 | Demographic characteristics of the sample.

	Mean (*SD*)	%	Range
Child characteristics			
Gender, girl		51.0	
First-born		63.6	
One sibling		27.2	
≥ 2 siblings		9.3	
Gestational age at delivery	39.8 (1.34)		34.4–42.3
Age at 8-month laboratory visit (months)	8.2 (0.4)		7.0–9.6
Family characteristics			
Family language status			
Monolingual family		64.9	
Bilingual family		5.3	
Data missing regarding bilingualism		29.8	
Maternal educational level			
University degree		39.7	
Polytechnic/applied university degree		38.4	
Vocational training/high school/basic education		19.8	
Data missing regarding maternal education		2.0	
Maternal age at delivery	31.2 (4.0)		21–44
Paternal age at delivery	32.2 (4.6)		21–45

language besides the mother tongue < 20%. Bilingual families completed the CDI in Finnish. In bilingual families, the families most typically spoke Finnish and Swedish, both national languages of Finland. No significant differences between bi- and monolingual infants in communicative skills were found in independent samples *t*-tests, and consequently, all infants were included in further analyses.

2.2 | Procedures

Families were recruited in the maternal welfare clinics at gestational week 12 through personal contact with a research nurse. Background information regarding the families was collected using questionnaires at gestational week 14 and supplemented with information from later data points when needed. Additionally, information regarding child gender and gestational age at birth from the maternity ward was retrieved from the wellbeing services county of Southwest Finland (VARHA) records. When the child was 8 months of age, the families in the focus cohort were invited to a laboratory visit at the FinnBrain research site in Turku, where experimental assessments of temperament, as well as emotional availability in the mother-child dyad, were carried out by trained psychologists or advanced-level psychology master's students. Maternal reports on infant temperament were collected at 6 and 12 months of age, and questionnaires regarding child communicative development were filled out by families when the child was 14 months and 30 months old.

2.3 | Measures

2.3.1 | Communicative Development

Communicative skills were assessed using the Finnish versions of the Mac-Arthur-Bates Communication Development Inventories (CDI), the Words and Gestures-version at 14 months, and the Words and Sentences-version at 30 months (Fenson et al. 1994; Lyytinen 1999). The CDI is a commonly used, reliable, and valid parent report of infant and toddler communicative development. In two cases, the Swedish version (Eriksson and Berglund 1999) was used in monolingual Swedish-speaking Finnish families. Since the sample included two Swedish CDI-versions in addition to the Finnish ones and the total sum scores differ between the versions, we used the percent scores (percent of maximum score) for the language variables to be able to use both versions in the same analyses. We used the sum scores for words understood (receptive vocabulary) and spoken (expressive vocabulary), as well as the use of gestures at 14 months, and the sum score for total vocabulary (expressive) at 30 months. The actions and gestures assessment consists of lists of the first communicative gestures, games and routines, actions with objects, pretending to be a parent, and imitating other adult actions. The communicative gestures section includes options to check whether the gesture is used often, sometimes, or not at all by the infant, whereas the use of the remaining actions and gestures listed is assessed on a yes/no basis. The sum score for the total use of gestures was used (McDonald's $\omega = 0.79$). Vocabulary sum scores are attained from a checklist of words in different semantic categories, where

the parent checks whether the infant understands ($\omega = 0.96$) or understands and produces ($\omega = 0.89$) the word in the Words and Gestures version, whereas no distinct assessment of receptive vocabulary, only production of the words, is included in the Words and Sentences-version ($\omega = 0.99$). The final SEM-models reported were run with and without possible outliers (one observation for the gestures measure and one for expressive vocabulary at 14 months that had z-scores of $\pm$ 3 SD). Models did not change significantly due to excluding outliers. The only observed difference was the significance value of a negative association between surgency/extraversion at 6 months and EA in the final model decreasing below the significance threshold. Hence, outliers were kept in further analyses.

2.3.2 | Emotional Availability

Emotional availability was assessed using the fourth edition of the Emotional Availability Scales (EAS, Biringen 2008). The assessment was based on a 20-min free play session between the infant and mother in a laboratory setting. The dyad was instructed to sit on the floor and play as they normally would at home. A set of age-appropriate toys was available, and the dyad was instructed to use them if they wished. The session was videotaped and coded on six dimensions of emotional availability: four for the adult and two for the child. These dimensions are adult sensitivity, structuring, non-intrusiveness, and non-hostility, and child responsiveness and involvement (Saunders et al. 2015). In this study, we only used the adult scales from which a latent variable of total emotional availability was created. Sensitivity refers to how the mother strives to create a healthy, positive emotional connection with the child using different actions and emotions. Structuring is the adult's ability to scaffold the child by adapting the situation according to the child's abilities, creating opportunities for learning, and providing help when needed without restricting the child's autonomy. Non-intrusiveness is the ability to let the child take the lead in the situation, permitting age-appropriate independence, and not interfering or interrupting unless needed or requested by the child. Non-hostility is the functional regulation of adult negative emotions and the absence of overt or covert displays of hostile emotions or behaviors, such as frustration, boredom, or aggression.

Dimensions are scored on a scale ranging from 1 to 7, where higher scores indicate warm and healthy emotional availability, whereas low scores are indicative of reasons for concern regarding the relationship (Saunders et al. 2015). Reliability was assessed in 10% of the cases. The intraclass correlation coefficients were as follows: sensitivity 0.80, structuring 0.72, non-intrusiveness 0.85, and non-hostility 0.70. In cases of differing assessments between coders, the coders negotiated and obtained consensus ratings for subsequent analyses.

2.3.3 | Temperament

2.3.3.1 | Observed Temperament. Episodes from the Laboratory Temperament Assessment Battery—Prelocomotor version (Lab-TAB, Goldsmith and Rothbart 1999) were used to assess temperament at the infant age of 8 months. The Lab-TAB is a standardized temperament assessment battery in which child reactions to different stimuli are videotaped and used as indicators of temperament dimensions (Planalp et al. 2017). In addition to child reactions, caregiver behavior/interference was coded for every temperament episode (0 = very inefficient parent behavior, does not follow instructions; 1 = parent mildly deviates from instructions; and 2 = parent behaves as instructed). Caregiver behavior was consequently controlled for in analyses involving the respective temperament episode. Coding of the videotapes was performed by trained coders.

The temperament dimension of Fear was evaluated during the Masks episode from Lab-TAB. During the episode, the infant is presented with four different masks in order of increasing probability of eliciting a fear reaction. The episode is coded for four fear responses for each individual mask presentation: escape behaviors (0–3), facial fear (0–3), bodily fear (0–3), and fearful vocalizations (0–5) (intercorrelations ranging from 0.45 to 0.78, McDonald's $\omega = 0.90$). The sum score, composed of the standardized scores for all responses, was used. The episode presented good inter-rater reliability (Cohen's Kappa ranging from 0.73 to 0.83, with inter-rater correlations of $r = 0.95$–0.98).

Task orientation/attentiveness, an aspect of emerging self-regulatory capacity, was observed during the Blocks episode. During the episode, the infant is given a set of blocks to play with during a 3-min session. The caregiver is instructed to be as uninvolved in the play as possible. During the episode, infant intensity of facial interest (0–3), duration of looking (0–2), and manipulation of stimuli (0–3), are coded for. A standardized sum score is calculated from the indicators (intercorrelation = 0.30, $\omega = 0.77$). The manipulation indicator was excluded from the sum score in this case due to low variability within this indicator. The episode had adequate inter-rater reliability (Cohen's $K = 0.72$–0.79, with inter-rater correlations ranging from $r = 0.47$ to 0.99).

Evaluations of negative emotionality and self-regulation were obtained from the Restraint episode, where the infant is given an interesting toy with which to play. Subsequently, the caregiver is instructed to start holding the infant's arms gently by their sides, which results in infant frustration because they can no longer reach the desired toy. This is continued for two episodes of 30 s with a break in between when the child can play with the toy again. We used the negative emotionality-indicators: facial anger (0–3), facial sadness (0–3), and distress vocalizations (0–5) for the sum score (intercorrelation ranging from 0.48 to 0.84, $\omega = 0.89$). Inter-rater reliability was adequate (Cohen's $K = 0.62$–0.79, with inter-rater correlations ranging from $r = 0.64$–99). Although not part of the original Lab-TAB setup, we also used the same Restraint episode for coding self-regulation by gaze aversion (Ollas-Skogster et al. 2023). Gaze aversion is the earliest emerging indicator of self-regulation in infancy (Rothbart et al. 2011). It was coded as the number of seconds spent looking away from the toy during the episode, and the variable was a sum of seconds looking away during all epochs. The reliability was at a good level (inter-rater correlations ranging from $r = 0.78$–0.95).

2.3.3.2 | Reported Temperament. Parent reports of temperament were carried out at the infant ages of 6 and 12 months using the Infant Behavior Questionnaire – Revised (IBQ-R, Gartstein and Rothbart 2003), which is a questionnaire on infant behavior in a variety of everyday situations. Mothers rated on a 7-point scale from "never" to "always" how often they had observed a certain behavior in the child during the past week. From the questionnaires, 14 subscales and three broader factor dimensions were obtained: surgency/extraversion (McDonald's ω = 0.87–0.89 for 6 and 12-month assessments, consisting of the subscales approach, vocal reactivity, high-intensity pleasure, smiling and laughter, activity level, and perceptual sensitivity), negative emotionality (ω = 0.80–0.89, consisting of sadness, distress to limitations, fear, and falling reactivity) and emerging self-regulation (ω = 0.85–0.87, consisting of low intensity pleasure, cuddliness/affiliation, duration of orienting, and soothability) are obtained (Gartstein and Rothbart 2003). In the current study, we used the three broad factors, as well as the subscale of Fear (ω = 0.83–0.84) to match the observed temperament measures used. Furthermore, the theoretical rationale for examining fear separately stems from previous literature suggesting that, for some individuals, the trajectory of fear reactivity might differ from other aspects of negative emotionality (e.g., Gartstein et al. 2010; Rothbart 2011).

2.3.4 | Covariates

To control for other variables that have been observed to relate to communicative development, we chose to include infant gender, maternal education level, number of siblings, and gestational age as covariates in the analyses (Berglund, Eriksson, and Westerlund 2005; Hoff-Ginsberg 1998; Zerbeto, Cortelo, and Filho 2015).

Data regarding gender and gestational age were obtained from the Wellbeing Services County of Southwest Finland (VARHA) records. Mothers self-reported their educational level in a questionnaire package during the first trimester of pregnancy. Educational level was coded as a categorical variable with four categories: high school-level, vocational training, polytechnic degree, or university degree. Mothers also reported how many siblings the infant had. We primarily used sibling data from when the infant was 12 months old, and completed missing data with corresponding data from 3 months postpartum, and used number of siblings as a continuous variable in analyses.

Additionally, maternal psychological distress has been found to relate to both child communicative development and temperament, as well as mother's ratings of child behavior (Durbin and Wilson 2012; Hanington, Ramchandani, and Stein 2010; Reck et al. 2018; Sohr-Preston and Scaramella 2006). To control for these potential effects in our sample, a maternal psychological distress composite score was computed by summing standardized sum scores from the Edinburgh Postnatal Depression Scale (EPDS, Cox, Holden, and Sagovsky 1987), completed at 12 months postpartum, and the anxiety subscale of the Symptom Checklist – 90 (SCL-90, Derogatis, Lipman, and Covi 1973) at 6 months postpartum (correlation between the measures: r = 0.70). In one case where SCL-90 data from 6 months were missing, we used the corresponding data from 3 months postpartum. The psychological distress score was used as a continuous covariate in analyses. To control for maternal language skills, we used the Wechsler Adult Intelligence Scale – Fourth Edition Verbal Comprehension subscale (WAIS-IV VCI, Wechsler 2012).

2.4 | Data Analysis Strategy

Data were analyzed using IBM SPSS versions 28–29 and Mplus 8.7 software with maximum likelihood estimation and robust standard errors (MLR) (Muthén and Muthén 1998–2017). SPSS was used for descriptive data analyses and zero-order correlation analysis. In the study, p-values below 0.05 were considered significant. Correction for multiple comparisons was done using the Benjamini–Hochberg false discovery rate procedure. To examine bivariate associations, Spearman's correlation coefficient was used since not all included variables were normally distributed. Data were missing in 11%–20% of cases for observed self-regulation by gaze aversion, the 12-month reported temperament factors, 14-month communicative gesturing, and 30-month vocabulary. For the remaining variables, data was missing in 0%–10% of the cases. According to Little's MCAR test, data were missing completely at random (chi-square = 534.80, DF = 505, p = 0.17). Missing data were handled using full information maximum likelihood estimation (FIML) in Mplus.

Mplus was used to create and test path models involving emotional availability and temperament traits as predictors of communicative development. The MLR estimation method was used since not all variables were normally distributed. Model fit was assessed using the chi-square test statistic, where a non-significant test was regarded as an indicator of adequate model fit, along with Tucker-Lewis index (TLI, cutoff > 0.95), comparative fit index (CFI, cutoff > 0.95), root mean square error of approximation (RMSEA, cutoff < 0.06), and standardized root mean square residual (SRMR, cutoff < 0.06) (Hu and Bentler 1999). Standardized coefficients (STDYX) were reported. First, a latent variable for emotional availability consisting of all the EA-subscales (sensitivity, structuring, non-intrusiveness, and non-hostility) was created. Similarly, we created a latent variable for 14-month communicative skills consisting of gesturing, expressive, and receptive vocabulary.

A flow chart depicting the model building process is provided in Figure 1. First, a basic model including paths between the emotional availability latent variable and the communication variables at 14 months and 30 months was created to investigate how emotional availability predicts communicative development. Second, interaction terms consisting of the emotional availability latent variable and each temperament trait respectively (observed variables for reported temperament traits at 6 and 12 months and 8-month observational measures separately) were created using the XWITH-command (Maslowsky, Jager, and Hemken 2015). Interaction terms were added to the basic model separately, accompanied by selected covariates, to test for moderation effects in analyses. Continuous covariates

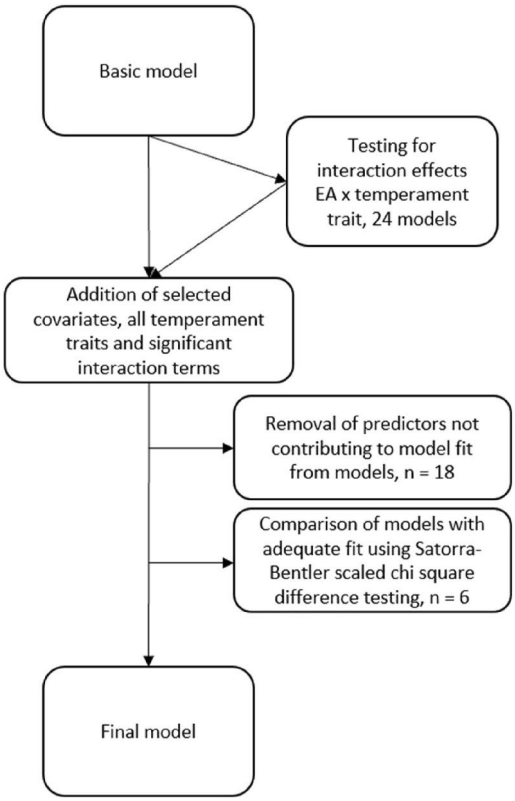

FIGURE 1 | The model building process.

displaying significant zero-order correlations with any of the 14-month communicative skills (i.e., gestational age at birth), as well as child gender and maternal education level, were chosen as covariates in the models. Moderation was tested for 14-month language and 30-month vocabulary in separate models. In cases where the interaction term significantly predicted the 14-month or 30-month language variable in the basic model with the emotional availability latent and the temperament trait included as predictors, model fit was compared between the null model, without the interaction term, and the alternative model, including the interaction term, using a log-likelihood ratio test with scaling correction factors (Satorra and Bentler 2010). The interaction effect was regarded as significant in cases where there was a significant improvement in the model fit in the models including the interaction term compared to the null model (i.e., the basic model with covariates but no interaction term), according to the log-likelihood ratio test (Maslowsky, Jager, and Hemken 2015).

Third, a final model was built, initially including the emotional availability latent variable, all temperament traits (the observed reported temperament variables at 6 and 12 months, and observationally assessed observed variables at 8 months separately), the selected covariates mentioned above, as well as potential significant interaction terms as predictors of 14-month and 30-month language, and then improving the model by stepwise removing predictors not contributing to the model fit. When creating the basic and final models, possible competing models of adequate fit were to be compared using the Satorra–Bentler scaled chi-square for chi-square difference testing (Satorra and Bentler 2010). $N = 151$ for all models reported. The hypothetical final model is pictured in Figure 2.

3 | Results

Descriptive statistics regarding the measures used in the study are displayed in Table 2.

3.1 | Zero-Order Associations

Zero-order correlations between study variables are reported in Table 3. Significant correlations were found between communicative skills and EA scales as well as some of the observed and reported temperament traits. Of the covariates, gestational age was positively correlated with all 14-month communicative skills and was thus included as a covariate in model building.

3.2 | SEM-Results

3.2.1 | Path Model of the Association Between Emotional Availability and Early Communicative Development

First, measurement models were tested for two latent constructs: communicative development and emotional availability. The model fit for communicative development was $\chi^2(2) = 0.58$, $p = 0.748$, RMSEA = 0.00, CFI = 1.00, TLI = 1.00, SRMR = 0.02. The best-fitting measurement model for emotional availability was one where all emotional availability scales (sensitivity, structuring, non-intrusiveness, and non-hostility) were used as a single latent variable ($\chi^2(1) = 0.08$, $p = 0.781$, RMSEA = 0.00, CFI = 1.00, TLI = 1.00, SRMR = 0.00). Sensitivity and structuring were allowed to correlate to improve model fit. We also tried creating different latent variables for positive (sensitivity and structuring) and negative parenting (non-intrusiveness and non-hostility); but the high correlation between these two latent variables would have resulted in high risk of multicollinearity. We found no significant direct prediction of emotional availability on expressive language at 30 months, resulting in leaving out that path from the final model. Rather, the emotional availability latent variable was directly associated with the 14-month communicative skills latent variable, which in turn was significantly associated with 30-month vocabulary ($\chi^2(18) = 13.6$, $p = 0.757$, RMSEA = 0.00, CFI = 1.00, TLI = 1.00, SRMR = 0.03). The indirect effect between emotional availability and 30-month vocabulary through 14-month communication was significant ($b = 0.19$, $p = 0.003$). The basic model is depicted in Figure 3.

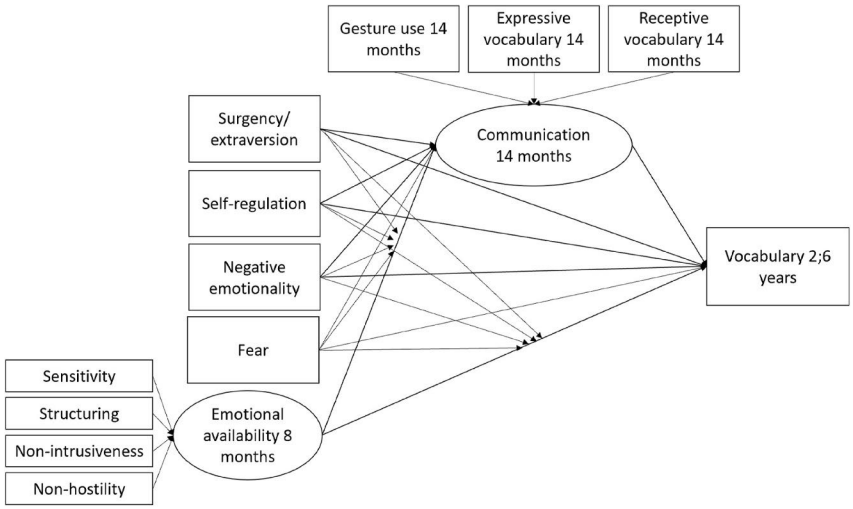

FIGURE 2 | Hypothetical final model of associations between EA, temperament and communicative skills.

TABLE 2 | Descriptive statistics for the measures used in the study.

Measure (theoretical range)	*M* (*SD*)	Range
CDI		
Gesture use 14 months (100%)	54.6 (13.2)	9.1–87.9
Expressive vocabulary 14 months (100%)	2.8 (4.1)	0–35.5
Receptive vocabulary 14 months (100%)	36.7 (19.4)	1.8–91.3
Expressive vocabulary 30 months (100%)	71.1 (24.7)	2.0–100
EAS		
Sensitivity (1–7)	5.3 (1.3)	2–7
Structuring (1–7)	5.0 (1.5)	2–7
Non-intrusiveness (1–7)	5.7 (1.4)	1–7
Non-hostility (1–7)	6.1 (1.0)	3–7
Lab-TAB		
Fear (0–14)	3.7 (2.3)	0–12.1
Attention (0–5)	3.7 (0.6)	0.8–4.7
Negative emotionality (0–11)	4.5 (2.0)	0.5–8.2
Self-regulation by gaze aversion (0–60)	21.7 (10.3)	0–54
IBQ-R 6 months (1–7)		
Surgency/extraversion	4.6 (0.8)	2.5–6.3
Negative emotionality	3.0 (0.8)	1.5–5.0
Emerging self-regulation	5.3 (0.6)	3.4–6.6
Fear	2.6 (1.2)	1.0–6.0
IBQ-R 12 months (1–7)		
Surgency/extraversion	5.1 (0.6)	3.6–6.3
Negative emotionality	3.3 (0.7)	1.6–4.8
Emerging self-regulation	5.0 (0.7)	3.1–6.3
Fear	2.9 (1.2)	1.0–6.3

TABLE 3 | Zero-order correlations between measures in the study.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
1. Receptive vocabulary 14 months																							
2. Expressive vocabulary 14 months	0.39**																						
3. Gesture use 14 months	0.56**	0.32**																					
4. Vocabulary 30 months	0.43**	0.38**	0.45**																				
5. Negative emotionality 8 months	0.06	−0.06	−0.03	0.05																			
6. Fearfulness 8 months	0.12	0.12	0.18*	0.02	−0.00																		
7. Attention 8	−0.05	−0.07	−0.10	−0.08	0.09	−0.07																	
8. Regulation by gaze aversion 8 months	−0.21*	−0.24**	−0.17	−0.08	−0.07	−0.20*	−0.04																
9. Surgency/extraversion 6 months	0.31**	0.19*	0.37**	0.27**	0.02	−0.01	−0.06	−0.03															
10. Negative emotionality 6 months	0.01	−0.03	−0.01	0.04	0.17	0.11	−0.12	−0.04	0.24**														
11. Fear 6 months	0.09	0.14	0.12	0.08	0.04	0.07	−0.15	−0.03	0.18*	0.61**													
12. Emerging self-regulation 6 months	0.12	0.11	0.21*	0.05	−0.18*	−0.14	0.00	−0.14	0.46**	−0.22*	0.01												
13. Surgency/extraversion 12 months	0.27**	0.16	0.46**	0.21*	0.09	−0.03	0.03	0.03	0.61**	−0.09	0.03	0.31**											
14. Negative emotionality 12 months	−0.06	−0.02	0.06	−0.01	0.18*	0.08	−0.24**	0.05	0.11	0.58**	0.34**	−0.13	0.15										
15. Fear 12 months	0.02	0.08	0.04	0.09	0.11	0.08	−0.17	0.20*	0.09	0.25**	0.41**	0.06	0.08	0.55**									
16. Emerging self-regulation 12 months	0.21*	0.16	0.43**	0.17	−0.02	−0.05	0.02	−0.01	0.44**	−0.30**	−0.10	0.66**	0.39**	−0.15	0.13								
17. Maternal sensitivity 8 months	0.18*	0.05	0.11	0.10	−0.01	0.06	−0.03	−0.05	−0.20*	−0.16	−0.05	0.02	0.01	−0.17	−0.12	0.05							
18. Maternal structuring 8 months	0.19*	0.04	0.15	0.04	−0.00	−0.04	−0.02	−0.06	−0.14	−0.21*	0.01	0.11	0.03	−0.08	−0.05	0.11	0.71**						
19. Maternal non-intrusiveness 8 months	0.27**	0.18*	0.14	0.18*	−0.05	0.03	−0.04	−0.05	0.00	0.04	0.13	−0.02	0.13	0.07	0.05	0.10	0.53**	0.38**					
20. Maternal non-hostility 8 months	0.20*	−0.01	0.04	0.01	−0.02	0.06	0.01	−0.08	−0.10	−0.01	0.05	−0.02	−0.01	0.00	0.02	0.10	0.59**	0.39**	0.49**				
21. Number of siblings	−0.11	−0.04	0.05	−0.21**	0.06	0.06	−0.03	−0.10	−0.08	0.00	0.12	0.00	−0.03	0.16**	0.07	−0.01	0.13	0.09	0.16	0.18*			
22. Gestational age	0.20**	0.15*	0.14*	0.11	0.03	0.02	0.08	−0.11	0.10	0.08	0.00	0.04	0.02	−0.00	0.03	0.09	−0.04	−0.05	0.08	0.13	−0.06		
23. Psychological distress	−0.09	−0.02	−0.08	−0.13*	0.05	0.03	−0.02	−0.05	−0.02	0.29**	0.13*	−0.08	−0.00	0.32**	0.06	−0.14*	−0.09	−0.07	−0.01	−0.14	−0.07	0.09	
24. Maternal verbal intelligence	−0.04	0.15	0.07	0.27*	−0.03	0.02	−0.01	−0.09	−0.21	−0.05	0.10	−0.11	−0.13	0.08	0.14	0.03	−0.05	0.01	0.18	−0.08	0.24*	−0.01	−0.18

*$p < 0.05$, **$p < 0.01$.

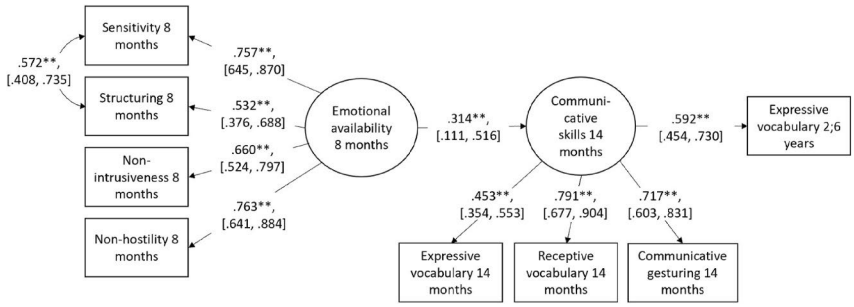

FIGURE 3 | Basic path model describing associations between emotional availability and communicative development. $N = 151$. $\chi^2(18) = 13.6$, $p = 0.757$, RMSEA = 0.00, CFI = 1.00, TLI = 1.00, SRMR = 0.03. Standardized coefficients. 95% CI for estimates are reported in brackets. $^{**}p < 0.01$.

3.2.2 | Moderation Effects of Temperament Traits on the Association Between Emotional Availability and Communicative Development

In the test of moderation by temperament on associations between EA and communicative development, individual models were built for all temperament traits respectively. That is, interaction terms were created for all individual temperament traits at 6, 8, and 12 months and tested in separate models along with the EA latent and the corresponding temperament main effect. There was some evidence of an interaction effect of negative emotionality by emotional availability. More specifically, the interaction term of reported negative emotionality at 6 months and emotional availability was associated with 14-month communicative skills when added to a model consisting of the basic model (Figure 3) along with the main effects in the interaction term and the chosen covariates (fit indices for the null model without the interaction term: $\chi^2(40) = 56.4$, $p = 0.04$, RMSEA = 0.05, CFI = 0.95, TLI = 0.94, SRMR = 0.06, $N = 151$). The Satorra–Bentler chi-square test comparing the null model and the model including the interaction term ($\Delta\ \chi^2(-1) = 6.2$, $p = 0.01$) indicated that the fit of the model including the interaction term was superior to that of the null model. Additionally, the interaction term consisting of reported negative emotionality at 12 months of age and the emotional availability latent significantly predicted 30-month vocabulary in a corresponding model (null model: $\chi^2(40) = 66.9$, $p = 0.005$, RMSEA = 0.07, CFI = 0.92, TLI = 0.90, SRMR = 0.09, $N = 151$). Similarly, the Satorra–Bentler chi square test comparing the null model and model including the interaction term ($\Delta\ \chi^2(-1) = 4.9$, $p = 0.03$) indicated that the fit of the model including the interaction term exceeded that of the null model. The interactions suggested that low negative emotionality at 6 months combined with high emotional availability was related to relatively better communicative skills at 14 months, whereas high negative emotionality at 12 months combined with high emotional availability predicted better vocabulary at 30 months. However, the significant interactions did not survive the correction for multiple comparisons (diagrams shown in Supporting Informations S1 and S2). No additional interaction terms were significant.

3.2.3 | Final Path Model of Relations Between Emotional Availability, Temperament Traits, Covariates and Early Communicative Development

First, all temperament traits and selected covariates were added to the model. Paths to both 14-month communicative skills and 30-month expressive vocabulary were tested for all temperament traits. Non-significant predictors were eliminated from the model one by one until models with acceptable model fit were achieved. The satisfactory models were compared using the Satorra–Bentler chi-square difference test (Satorra and Bentler 2010) to choose the best model. The final model ($\chi^2(39) = 46.3$, $p = 0.1978$, RMSEA = 0.04, CFI = 0.98, TLI = 0.98, SRMR = 0.05) is presented in Figure 4. Communicative skills at 14 months were positively predicted by higher emotional availability and reported surgency/extraversion at both 6 and 12 months of age, as well as by female gender. The only significant path to 30-month expressive vocabulary was from 14-month communicative skills.

4 | Discussion

The aim of the current study was to examine the relations between caregiving quality, infant temperament attributes, and communicative development, and to explore possible moderation effects between temperament and emotional availability in explaining communicative development. We found evidence that maternal EA in infancy is associated with favorable early toddlerhood communicative development, which in turn is positively related to 30-month vocabulary. Furthermore, higher infant surgency/extraversion positively contributed to communicative development, but no convincing evidence was found for temperament being a moderator between caregiving quality and language outcomes. Female infants also tended to have stronger early communicative skills, corresponding to the tendency for advantages of female sex in early language development frequently reported and discussed in the literature (e.g., Lange and Zaretsky 2021; Rinaldi et al. 2023). To our knowledge, this study is among the first to examine the relations between caregiving quality in the comprehensive EA framework and child communicative development, accompanied by child temperament as a moderating factor.

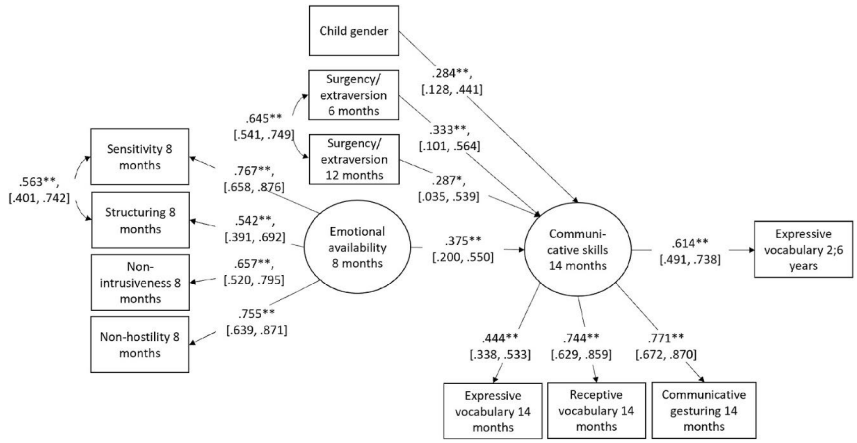

FIGURE 4 | Final path model describing associations between emotional availability, infant temperament, covariates and communicative development. $N = 151$. Standardized coefficients. 95% CI for estimates are reported in brackets. $^{*}p < 0.05$, $^{**}p < 0.01$.

4.1 | Caregiving Quality and Communicative Development

In accordance with our hypothesis, the latent variable of maternal EA comprising different aspects of sensitive caregiving in infancy positively predicted child communicative skills at 14 months of age. In other words, high-quality caregiving in infancy predicted better communicative skills in early toddlerhood. This finding concurs with the current literature (Leigh, Nievar, and Nathans 2011; Nozadi et al. 2013; Tamis-LeMonda, Bornstein, and Baumwell 2001). However, the current study offers unique new contributions to existing knowledge by showing that relations are found also when considering emotional availability and communicative skills as latent variables.

The emotional availability latent variable used involves all EA scales (sensitivity, structuring, non-intrusiveness, and non-hostility), and thereby comprises a more overarching concept of caregiving quality, whereas previous studies have involved aspects of caregiving independently and have mainly studied sensitivity/responsiveness (Leigh, Nievar, and Nathans 2011; Nozadi et al. 2013; Tamis-LeMonda, Bornstein, and Baumwell 2001), and in some cases intrusiveness (Bruce et al. 2022; Cabrera, Shannon, and Tamis-LeMonda 2007; Keown, Woodward, and Field 2001; Pungello et al. 2009; Tamis-LeMonda et al. 2004). It seems theoretically plausible that including structuring and non-hostility in the concept of caregiving quality further enhances the relationship with communicative development due to the nature of these subscales. Structuring is the parent's ability to support the child to learn and be active by adapting the situation according to the child's abilities, allowing autonomy but offering support when needed (Saunders et al. 2015). Possibly, this also leads to using age-appropriate and contextually relevant child-directed language. Furthermore, non-hostility refers to the parent's regulation of their own negative emotions and behaviors, for example boredom, frustration or aggression, towards the child (Saunders et al. 2015), which is likely to also be accompanied by more positive and engaged communication from the parent and encourage communicative initiatives from the child. In summary, in relation to aspects of caregiving previously studied, EA has more emphasis on emotional aspects (Biringen 2000) rather than a communicative focus. For example, EA does not involve a direct measure of responsiveness to or development of infant communicative initiatives. Taken together, high overall EA is indicative of a warm, sound, invested, mutually enjoyable relationship between parent and child (Biringen and Easterbrooks 2012). Consequently, the parent can be highly sensitive with the infant using mostly eye contact, gestures, facial expressions, and tone of voice, without necessarily offering rich verbal stimulation. It is, however, noteworthy that the current design with a latent variable does not allow drawing conclusions regarding which fine-grained aspects of EA are particularly related to communicative development. Hence, it may be either the emotional or interactional aspects or both intertwined that underlie the association with communicative skills. This could be examined further in future studies.

Regarding communication as an outcome, it has most often been assessed as either only expressive (Leigh, Nievar, and Nathans 2011; Tamis-LeMonda, Bornstein, and Baumwell 2001) or both expressive and receptive language skills (Keown, Woodward, and Field 2001; Pungello et al. 2009). In rare cases, preverbal communication such as gesturing (Bruce et al. 2022) or other communicative dimensions such as symbolic play (Bornstein and Tamis-Lemonda 1997) have been considered. In the current study, we aimed to have a more general perspective on early communicative skills by using a latent variable involving gesturing, expressive, and receptive vocabulary, which all loaded onto the same latent factor. Including gesturing in the assessment of this age group is important, as nonverbal communication constitutes a large part of communication at this age and is tightly related to later verbal communication (Iverson and Goldin-Meadow 2005). Consequently, the current findings suggest that relations do not exist only between specific subscales of caregiving quality and dimensions of communication, but also when considering the more general phenomena of emotional availability and communicative skills.

There was no significant direct longitudinal prediction of emotional availability on 30-month vocabulary. However, there was a positive indirect longitudinal association between EA and 30-month vocabulary through communicative skills at 14 months. In a previous longitudinal study with consecutive assessments of both maternal sensitivity and child language from infancy up to 3;0 years, Leigh, Nievar, and Nathans (2011) found both significant longitudinal and concurrent associations between sensitivity and language, as well as significant associations between earlier sensitivity and language on the corresponding dimensions later on in the same statistical model. This led them to conclude that the longitudinal associations between expressive language and maternal sensitivity are relatively stable over time. The strong associations between maternal sensitivity and language in toddlerhood, along with the strong prediction of early sensitivity on later sensitivity, highlight the importance of sensitivity starting from the earliest days (Leigh, Nievar, and Nathans 2011). These findings, together with our study, indicate that early caregiving quality can be of particular importance for stimulating a favorable start for the communicative development. Later in childhood, favorable language development may be more strongly related to the child's previous language skills and more direct verbal language stimulation, resulting in diminishing direct effects of early caregiving quality on later language skills.

4.2 | Caregiving Quality, Temperament, and Communicative Development

In the final model, there were direct positive effects of emotional availability, surgency/extraversion, and female gender on 14-month communicative development. The main effect of surgency/extraversion predicting communication corresponds well with previous research, where temperament traits related to extraversion and positive emotionality are frequently reported to have positive associations with language (Laake and Bridgett 2014) and also gesturing in our previous study (Ollas et al. 2020). Suggested explanations are that the sociability and approach tendencies related to infant surgency/extraversion elicit more communication experiences, and the trait perhaps encourages caregivers to interact with the infant, resulting in more language and communication stimulation (Laake and Bridgett 2014). Contrary to the hypothesis, no significant moderation effects of any temperament trait on associations between caregiving quality and communicative development were found after taking into account multiple comparisons. Thus, our findings do not support the hypothesis that the relation between caregiving quality, here measured as EA, and communicative development is moderated by infant temperament. They rather suggest that infant surgency/extraversion has an independent positive influence on infant communicative development, and that high emotional availability is positive for communicative development even when controlling for infant temperament.

Previous studies on interaction effects have differed in their methodology and are not directly comparable, but seem to suggest that higher positive and/or negative emotionality is beneficial for language development when paired with high responsiveness (Karrass and Braungart-Rieker 2003; Laake and Bridgett 2018; Nozadi et al. 2013), whereas parental intrusiveness paired with high emotionality has negative associations with language, but can have positive effects if paired with low negative emotionality (Laake and Bridgett 2018). The studies differed regarding which aspects of caregiving and language were studied, and some of the associations were found for boys only. Considering this, it is not surprising that no significant effects were found in our study with more general perspectives on both caregiving and communication. Additionally, our study was conducted in a relatively low risk sample with relatively high overall EA. This results in lower power for detecting effects of the more extreme variations within caregiving. Possibly, caregiving quality and temperament would be more closely related in samples with higher risks in terms of caregiving, SES, psychosocial welfare, or child communicative development challenges. For example, it seems plausible caregivers low in EA would be more likely to ignore or communicate in a negative tone with infants high in negative emotionality. Taken together, the exploration of interaction effects between temperament and caregiving quality as predictors of communicative development is still at an early stage, and more studies in the field are needed.

As discussed previously, EA as a concept does not involve specific assessment of maternal communicative responses, but rather has an emotional focus (Biringen 2000). Thereby, high EA is not automatically accompanied by high verbal or communicative stimulation, but may serve as an enforcement of communicative skills through creating an enjoyable relationship and positive experiences of interaction. Instead, perhaps surgency/extraversion in the infant specifically encourages more verbal interaction and lexical variability outside of the context of basic caregiving quality. For example, a study focusing on maternal lexical input, rather than overall caregiving quality, found lexical input to moderate associations between infant orienting and toddlerhood language (Spinelli et al. 2018). Possibly, the verbal dimensions of parent-child interaction could be more interrelated with other temperamental dimensions as well, such as surgency/extraversion in this study. Additionally, surgency/extraversion may be efficient in supporting communicative development and language learning in other contexts, outside of interaction with the primary caregiver. Surgency/extraversion may have a larger influence on eliciting communication with persons besides the primary caregivers. For example, other persons may be more inclined to interact with infants that spontaneously show more joy and interest in interacting, providing them with more diverse communicative experiences. Indeed, Sheinkopf et al. (2017) found that infant positive affect towards the examiner, but not towards the mother, in 4-month-old infants predicted their verbal IQ at 4;6 years of age.

In sum, results of the moderation analysis suggest that emotional availability has an independent effect on communicative development and further highlight the importance of emotional aspects of caregiving in supporting communicative development in infants across variable temperament profiles. However, future studies need to continue attempts to replicate our findings. Extending such work using samples from more diverse backgrounds, higher number of participants with established parenting risks (high socioeconomic or psychosocial

risk), or risks for atypical communication development will be particularly important.

4.3 | Strengths, Limitations and Directions for Future Research

The current study has several notable strengths. It addresses several gaps in the existing literature on associations between caregiving quality, infant temperament, and communicative development. Furthermore, the sample is relatively large and is part of a prospective birth cohort study that has a sample relatively representative of the Finnish population. We also employed both objective and parent reported measures of child temperament in accordance with recommendations for studying temperament (Stifter, Willoughby, and Towe-Goodman 2008) and we utilized SEM to create latent factors allowing the study of more general phenomena of emotional availability and communicative development, and offering a longitudinal perspective into toddlerhood vocabulary. However, there are several limitations. The use of latent variables of EA and communicative skills can be considered strengths of the study design. However, the use of a latent variable does not allow for assessing effects of more fine-grained aspects of EA and communicative skills. Particularly in the case of EA, future studies should assess how the different EA scales individually relate to communicative development, as this is currently not known. Moreover, although our sample size is similar to other studies in the field, there may be a risk for false negatives regarding smaller effects. Longitudinal studies involving assessments of EA later in development and more comprehensive assessments of communicative development similar to the study by Leigh, Nievar, and Nathans (2011) are needed. Also, direct assessments of maternal language input would be important to include in future studies to distinguish between the influence of maternal emotional availability and linguistic input in predicting child communicative development. Additionally, the relatively low risk level for both EA and child communicative development in the sample indicates that caution is needed in generalizing the findings reported in this study to higher risk populations. Considering the assessment of child EA in addition to maternal EA would have been valuable and will be considered in future studies. In the current study, only maternal caregiving quality was studied. This can be considered a limitation since fathers and other frequent communication partners in the child's life have been found to have associations with child language outcomes as well (Cabrera, Shannon, and Tamis-LeMonda 2007; Rost and McMurray 2009; Seidl, Onishi, and Cristia 2014). Additionally, assessments of both home languages were not available for the bilingual children, resulting in a potentially unrepresentative assessment of their communicative ability. However, the number of bilingual children was relatively low, 8 out of the total sample of 151. Furthermore, communicative development was only assessed by parent report. While this is a common and valid method in studies on toddler language skills (Feldman et al. 2000; Stolt et al. 2009), future studies should complement parental report with direct observation of child communicative behaviors. Finally, we did not involve an observational assessment of child surgency/extraversion, and future studies should consider doing so.

5 | Conclusions

The current study provides further support for caregiving quality playing an important role in scaffolding communicative development in infancy and early toddlerhood, and adds to the knowledge by observing this association in a context of studying caregiving as a general measure of emotional availability and communicative development, combining several important infant milestones: gesturing, expressive, and receptive vocabulary. Additionally, maternal emotional availability and infant surgency/extraversion had independent associations with communicative outcomes. No compelling evidence of infant temperament moderating the association between emotional availability and communicative development was identified in the current study. Consequently, the results highlight the importance of supporting emotional availability starting from early infancy in all caregiver-child dyads to foster young children's communicative development.

Author Contributions

Denise Ollas-Skogster: conceptualization, data curation, formal analysis, funding acquisition, methodology, writing–original draft. **Riikka Korja:** investigation, writing–review & editing. **Akie Yada:** data curation, formal analysis. **Elina Mainela-Arnold:** conceptualization, writing–review & editing. **Hasse Karlsson:** funding acquisition, project administration, resources. **David J. Bridgett:** conceptualization, writing–review & editing. **Pirkko Rautakoski:** conceptualization, funding acquisition, supervision, writing–review & editing. **Linnea Karlsson:** conceptualization, funding acquisition, supervision, writing–review & editing. **Saara Nolvi:** conceptualization, formal analysis, funding acquisition, methodology, supervision, writing–original draft.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Access to the FinnBrain cohort data can be acquired by contacting PI Prof Linnea Karlsson (linnea.karlsson@utu.fi) to establish research collaboration. Sharing data outside research collaboration is precluded by Finnish national legislation on personal data protection and the ethics regulations of the FinnBrain cohort.

References

Ainsworth, M. D. S., M. C. Blehar, E. Waters, and S. N. Wall. 2014. *Patterns of Attachment: A Psychological Study of the Strange Situation*. New York: Psychology Press.

Berglund, E., M. Eriksson, and M. Westerlund. 2005. "Communicative Skills in Relation to Gender, Birth Order, Childcare and Socioeconomic Status in 18-Month-Old Children." *Scandinavian Journal of Psychology* 46, no. 6: 485–491. https://doi.org/10.1111/j.1467-9450.2005.00480.x.

Biringen, Z. 2000. "Emotional Availability: Conceptualization and Research Findings." *American Journal of Orthopsychiatry* 70, no. 1: 104–114. https://doi.org/10.1037/h0087711.

Biringen, Z. 2008. Emotional Availability (EA) Scales Manual, 4th Edition. Part 1: Infancy/Early Childhood Version (Child Age: 0–5 Years) [Unpublished manuscript].

Biringen, Z., and M. A. Easterbrooks. 2012. "Emotional Availability: Concept, Research, and Window on Developmental Psychopathology." *Development and Psychopathology* 24, no. 1: 1–8. https://doi.org/10.1017/S0954579411000617.

Bloom, L., and J. B. Capatides. 1987. "Expression of Affect and the Emergence of Language." *Child Development* 58, no. 6: 1513. https://doi.org/10.2307/1130691.

Bornstein, M. H., and C. S. Tamis-Lemonda. 1997. "Maternal Responsiveness and Infant Mental Abilities: Specific Predictive Relations." *Infant Behavior and Development* 20, no. 3: 283–296. https://doi.org/10.1016/S0163-6383(97)90001-1.

Bridgett, D. J., M. A. Gartstein, S. P. Putnam, et al. 2011. "Emerging Effortful Control in Toddlerhood: The Role of Infant Orienting/Regulation, Maternal Effortful Control, and Maternal Time Spent in Caregiving Activities." *Infant Behavior and Development* 34, no. 1: 189–199. https://doi.org/10.1016/j.infbeh.2010.12.008.

Bruce, M., T. C. McFayden, T. H. Ollendick, and M. A. Bell. 2022. "Expressive Language in Infancy and Toddlerhood: The Roles of Child Temperament and Maternal Parenting Behaviors." *Developmental Psychobiology* 64, no. 6: e22287. https://doi.org/10.1002/dev.22287.

Cabrera, N. J., J. D. Shannon, and C. Tamis-LeMonda. 2007. "Fathers' Influence on Their Children's Cognitive and Emotional Development: From Toddlers to Pre-K." *Applied Developmental Science* 11, no. 4: 208–213. https://doi.org/10.1080/10888690701762100.

Collins, W. A., E. E. Maccoby, L. Steinberg, E. M. Hetherington, and M. H. Bornstein. 2000. "Contemporary Research on Parenting: The Case for Nature and Nurture." *American Psychologist* 55, no. 2: 218–232. https://doi.org/10.1037/0003-066X.55.2.218.

Conture, E. G., E. M. Kelly, and T. A. Walden. 2013. "Temperament, Speech and Language: An Overview." *Journal of Communication Disorders* 46, no. 2: 125–142. https://doi.org/10.1016/j.jcomdis.2012.11.002.

Cox, J. L., J. M. Holden, and R. Sagovsky. 1987. "Detection of Postnatal Depression." *British Journal of Psychiatry* 150, no. 6: 782–786. https://doi.org/10.1192/bjp.150.6.782.

Derogatis, L. R., R. S. Lipman, and L. Covi. 1973. "SCL-90: An Outpatient Psychiatric Rating Scale - Preliminary Report." *Psychopharmacology Bulletin* 9, no. 1: 13–28.

Dieterich, S. E., M. A. Assel, P. Swank, K. E. Smith, and S. H. Landry. 2006. "The Impact of Early Maternal Verbal Scaffolding and Child Language Abilities on Later Decoding and Reading Comprehension Skills." *Journal of School Psychology* 43, no. 6: 481–494. https://doi.org/10.1016/j.jsp.2005.10.003.

Dixon, W. E., and P. H. Smith. 2000. "Links Between Early Temperament and Language Acquisition." *Merrill-Palmer Quarterly* 46, no. 3: 417–440.

Durbin, C. E., and S. Wilson. 2012. "Convergent Validity of and Bias in Maternal Reports of Child Emotion." *Psychological Assessment* 24, no. 3: 647–660. https://doi.org/10.1037/a0026607.

Easterbrooks, M. A., J.-F. Bureau, and K. Lyons-Ruth. 2012. "Developmental Correlates and Predictors of Emotional Availability in Mother–Child Interaction: A Longitudinal Study From Infancy to Middle Childhood." *Development and Psychopathology* 24, no. 1: 65–78. https://doi.org/10.1017/S0954579411000666.

Eriksson, M., and E. Berglund. 1999. "Swedish Early Communicative Development Inventories: Words and Gestures." *First Language* 19, no. 55: 55–90. https://doi.org/10.1177/014272379901905503.

Feldman, H. M., C. A. Dollaghan, H. M. Feldman, et al. 2000. "Measurement Properties of the MacArthur Communicative Development Inventories at Ages One and Two Years." *Child Development* 71, no. 2: 310–322. https://doi.org/10.1111/1467-8624.00146.

Fenson, L., P. S. Dale, J. S. Reznick, et al. 1994. "Variability in Early Communicative Development." *Monographs of the Society for Research in Child Development* 59, no. 5: i–185. https://doi.org/10.2307/1166093.

Frick, M. A., T. Forslund, M. Fransson, M. Johansson, G. Bohlin, and K. C. Brocki. 2018. "The Role of Sustained Attention, Maternal Sensitivity, and Infant Temperament in the Development of Early Self-Regulation." *British Journal of Psychology* 109, no. 2: 277–298. https://doi.org/10.1111/bjop.12266.

Gartstein, M. A., D. J. Bridgett, M. K. Rothbart, et al. 2010. "A Latent Growth Examination of Fear Development in Infancy: Contributions of Maternal Depression and the Risk for Toddler Anxiety." *Developmental Psychology* 46, no. 3: 651–668. https://doi.org/10.1037/a0018898.

Gartstein, M. A., J. Crawford, and C. D. Robertson. 2008. "Early Markers of Language and Attention: Mutual Contributions and the Impact of Parent-Infant Interactions." *Child Psychiatry and Human Development* 39, no. 1: 9–26. https://doi.org/10.1007/s10578-007-0067-4.

Gartstein, M. A., and M. K. Rothbart. 2003. "Studying Infant Temperament via the Revised Infant Behavior Questionnaire." *Infant Behavior and Development* 26, no. 1: 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8.

Goldsmith, H. H., and M. K. Rothbart. 1999. *The Laboratory Temperament Assessment Battery (LAB-TAB, Prelocomotor Version, Edition 3.1)*. Madison, Wisconsin: University of Wisconsin Press.

Hanington, L., P. Ramchandani, and A. Stein. 2010. "Parental Depression and Child Temperament: Assessing Child to Parent Effects in a Longitudinal Population Study." *Infant Behavior and Development* 33, no. 1: 88–95. https://doi.org/10.1016/j.infbeh.2009.11.004.

Hoff-Ginsberg, E. 1998. "The Relation of Birth Order and Socioeconomic Status to Children's Language Experience and Language Development." *Applied PsychoLinguistics* 19, no. 4: 603–629. https://doi.org/10.1017/S0142716400010389.

Hohm, E., C. Jennen-Steinmetz, M. H. Schmidt, and M. Laucht. 2007. "Language Development at Ten Months: Predictive of Language Outcome and School Achievement Ten Years Later?" *European Child & Adolescent Psychiatry* 16, no. 3: 149–156. https://doi.org/10.1007/s00787-006-0567-y.

Hu, L., and P. M. Bentler. 1999. "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives." *Structural Equation Modeling: A Multidisciplinary Journal* 6, no. 1: 1–55. https://doi.org/10.1080/10705519909540118.

Iverson, J. M., and S. Goldin-Meadow. 2005. "Gesture Paves the Way for Language Development." *Psychological Science* 16, no. 5: 367–371. https://doi.org/10.1111/j.0956-7976.2005.01542.x.

Karlsson, L., M. Tolvanen, N. M. Scheinin, et al. 2018. "Cohort Profile: The FinnBrain Birth Cohort Study (FinnBrain)." *International Journal of Epidemiology* 47, no. 1: 15–16j. https://doi.org/10.1093/ije/dyx173.

Karrass, J., and J. M. Braungart-Rieker. 2003. "Parenting and Temperament as Interacting Agents in Early Language Development." *Parenting: Science and Practice* 3, no. 3: 235–259. https://doi.org/10.1207/S15327922PAR0303_03.

Keown, L. J., L. J. Woodward, and J. Field. 2001. "Language Development of Pre-School Children Born to Teenage Mothers." *Infant and Child Development* 10, no. 3: 129–145. https://doi.org/10.1002/icd.282.

Kochanska, G., A. E. Friesenborg, L. A. Lange, and M. M. Martel. 2004. "Parents' Personality and Infants' Temperament as Contributors to Their Emerging Relationship." *Journal of Personality and Social Psychology* 86, no. 5: 744–759. https://doi.org/10.1037/0022-3514.86.5.744.

Kubicek, L. F., and R. N. Emde. 2012. "Emotional Expression and Language: A Longitudinal Study of Typically Developing Earlier and

Later Talkers From 15 to 30 Months." *Infant Mental Health Journal* 33, no. 6: 553–584. https://doi.org/10.1002/imhj.21360.

Laake, L. M., and D. J. Bridgett. 2014. "Happy Babies, Chatty Toddlers: Infant Positive Affect Facilitates Early Expressive, but not Receptive Language." *Infant Behavior and Development* 37, no. 1: 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006.

Laake, L. M., and D. J. Bridgett. 2018. "Early Language Development in Context: Interactions Between Infant Temperament and Parenting Characteristics." *Early Education & Development* 29, no. 5: 730–746. https://doi.org/10.1080/10409289.2018.1436366.

Landry, S. H., C. L. Miller-Loncar, K. E. Smith, and P. R. Swank. 2002. "The Role of Early Parenting in Children's Development of Executive Processes." *Developmental Neuropsychology* 21, no. 1: 15–41. https://doi.org/10.1207/S15326942DN2101_2.

Landry, S. H., K. E. Smith, C. L. Miller-Loncar, and P. R. Swank. 1997. "Predicting Cognitive-Language and Social Growth Curves From Early Maternal Behaviors in Children at Varying Degrees of Biological Risk." *Developmental Psychology* 33, no. 6: 1040–1053. https://doi.org/10.1037/0012-1649.33.6.1040.

Landry, S. H., K. E. Smith, and P. R. Swank. 2006. "Responsive Parenting: Establishing Early Foundations for Social, Communication, and Independent Problem-Solving Skills." *Developmental Psychology* 42, no. 4: 627–642. https://doi.org/10.1037/0012-1649.42.4.627.

Lange, B. P., and E. Zaretsky. 2021. "Sex Differences in Language Competence of 4-Year-Old Children: Female Advantages Are Mediated by Phonological Short-Term Memory." *Applied PsychoLinguistics* 42, no. 6: 1503–1522. https://doi.org/10.1017/S0142716421000333.

Leigh, P., M. A. Nievar, and L. Nathans. 2011. "Maternal Sensitivity and Language in Early Childhood: A Test of the Transactional Model." *Perceptual and Motor Skills* 113, no. 1: 281–299. https://doi.org/10.2466/10.17.21.28.PMS.113.4.281-299.

Lyytinen, P. 1999. *Varhaisen kommunikaation ja kielen kehityksen arviointimenetelmä [A Method for Assessing Early Communication and Language]*. Child Research Center of the University of Jyväskylä and the Niilo Mäki institute.

Maslowsky, J., J. Jager, and D. Hemken. 2015. Estimating and Interpreting Latent Variable Interactions: A Tutorial for Applying the Latent Moderated Structural Equations Method. https://journals.sagepub.com/doi/full/10.1177/0165025414552301?casa_token=7lKq60c1fegAAAAA%3AkXlXDzFjJi-lCGOQrESUKxLvWhZKRWDH8SRUznxEgFu950iKEXepZtClRKQ8UUkbFmGR28Q1Ydrt.

Mermelshtine, R. 2017. "Parent–Child Learning Interactions: A Review of the Literature on Scaffolding." *British Journal of Educational Psychology* 87, no. 2: 241–254. https://doi.org/10.1111/bjep.12147.

Molfese, V. J., K. M. Rudasill, J. L. Beswick, J. L. Jacobi-Vessels, M. C. Ferguson, and J. M. White. 2010. "Infant Temperament, Maternal Personality, and Parenting Stress as Contributors to Infant Developmental Outcomes." *Merrill-Palmer Quarterly* 56, no. 1: 49–79. https://doi.org/10.1353/mpq.0.0039.

Moreno, A. J., M. M. Klute, and J. L. Robinson. 2008. "Relational and Individual Resources as Predictors of Empathy in Early Childhood." *Social Development* 17, no. 3: 613–637. https://doi.org/10.1111/j.1467-9507.2007.00441.x.

Moreno, A. J., and J. L. Robinson. 2005. "Emotional Vitality in Infancy as a Predictor of Cognitive and Language Abilities in Toddlerhood." *Infant and Child Development* 14, no. 6: 383–402. https://doi.org/10.1002/icd.406.

Muthén, L. K., and B. O. Muthén. 1998–2017. *Mplus User's Guide*. Eighth Edition. Los Angeles, CA: Muthén & Muthén.

Nozadi, S. S., T. L. Spinrad, N. Eisenberg, et al. 2013. "Prediction of Toddlers' Expressive Language From Maternal Sensitivity and Toddlers' Anger Expressions: A Developmental Perspective." *Infant Behavior and Development* 36, no. 4: 650–661. https://doi.org/10.1016/j.infbeh.2013.06.002.

Ollas, D., P. Rautakoski, S. Nolvi, H. Karlsson, and L. Karlsson. 2020. "Temperament Is Associated With the Use of Communicative Gestures in Infancy." *Infant and Child Development* 29, no. 3: e2166. https://doi.org/10.1002/icd.2166.

Ollas-Skogster, D., P. Rautakoski, D. Bridgett, et al. 2023. "Associations Between Observed and Reported Infant Negative Affectivity, Fear and Self-Regulation, and Early Communicative Development—Evidence From the FinnBrain Birth Cohort Study." *Infancy* 28, no. 2: 410–434. https://doi.org/10.1111/infa.12508.

Paavola, L., K. Kemppinen, K. Kumpulainen, I. Moilanen, and H. Ebeling. 2006. "Maternal Sensitivity, Infant Co-Operation and Early Linguistic Development: Some Predictive Relations." *European Journal of Developmental Psychology* 3, no. 1: 13–30. https://doi.org/10.1080/17405620500317789.

Planalp, E. M., C. V. Hulle, J. R. Gagne, and H. Hill Goldsmith. 2017. "The Infant Version of the Laboratory Temperament Assessment Battery (Lab-TAB): Measurement Properties and Implications for Concepts of Temperament." *Frontiers in Psychology* 8, no. MAY. https://doi.org/10.3389/fpsyg.2017.00846.

Pungello, E. P., I. U. Iruka, A. M. Dotterer, R. Mills-Koonce, and J. S. Reznick. 2009. "The Effects of Socioeconomic Status, Race, and Parenting on Language Development in Early Childhood." *Developmental Psychology* 45, no. 2: 544–557. https://doi.org/10.1037/a0013917.

Putnam, S., L. Ellis, and M. Rothbart. 2001. "The Structure of Temperament From Infancy Through Adolescence." 165–182.

Reck, C., B. Van Den Bergh, A. Tietz, et al. 2018. "Maternal Avoidance, Anxiety Cognitions and Interactive Behaviour Predicts Infant Development at 12 Months in the Context of Anxiety Disorders in the Postpartum Period." *Infant Behavior and Development* 50: 116–131. https://doi.org/10.1016/j.infbeh.2017.11.007.

Reilly, S. E., and J. T. Downer. 2019. "Roles of Executive Functioning and Language in Developing Low-Income Preschoolers' Behavior and Emotion Regulation." *Early Childhood Research Quarterly* 49: 229–240. https://doi.org/10.1016/j.ecresq.2019.07.006.

Rinaldi, P., P. Pasqualetti, V. Volterra, and M. C. Caselli. 2023. "Gender Differences in Early Stages of Language Development. Some Evidence and Possible Explanations." *Journal of Neuroscience Research* 101, no. 5: 643–653. https://doi.org/10.1002/jnr.24914.

Robinson, J. A. L., and M. C. Acevedo. 2001. "Infant Reactivity and Reliance on Mother During Emotion Challenges: Prediction of Cognition and Language Skills in a Low-Income Sample." *Child Development* 72, no. 2: 402–415. https://doi.org/10.1111/1467-8624.00286.

Rost, G. C., and B. McMurray. 2009. "Speaker Variability Augments Phonological Processing in Early Word Learning." *Developmental Science* 12, no. 2: 339–349. https://doi.org/10.1111/j.1467-7687.2008.00786.x.

Rothbart, M. K. 2011. *Becoming Who We Are: Temperament and Personality in Development*. New York: Guilford Press.

Rothbart, M. K., and J. E. Bates. 1998. "Temperament." In *Handbook of Child Psychology. Social, Emotional, and Personality Development*, edited by W. Damon and N. Eisenberg, 105–176. New York: Wiley.

Rothbart, M. K., B. E. Sheese, M. R. Rueda, and M. I. Posner. 2011. "Developing Mechanisms of Self-Regulation in Early Life." *Emotion Review* 3, no. 2: 207–213. https://doi.org/10.1177/1754073910387943.

Salley, B. J., and W. E. Dixon. 2007. "Temperamental and Joint Attentional Predictors of Language Development." *Merrill-Palmer Quarterly* 53: 131–154.

Satorra, A., and P. M. Bentler. 2010. "Ensuring Positiveness of the Scaled Difference Chi-Square Test Statistic." *Psychometrika* 75, no. 2: 243–248. https://doi.org/10.1007/s11336-009-9135-y.

Saunders, H., A. Kraus, L. Barone, and Z. Biringen. 2015. "Emotional Availability: Theory, Research, and Intervention." *Frontiers in Psychology* 6. https://doi.org/10.3389/fpsyg.2015.01069.

Seidl, A., K. H. Onishi, and A. Cristia. 2014. "Talker Variation Aids Young Infants' Phonotactic Learning." *Language Learning and Development* 10, no. 4: 297–307. https://doi.org/10.1080/15475441.2013.858575.

Sheinkopf, S. J., E. J. Tenenbaum, D. S. Messinger, et al. 2017. "Maternal and Infant Affect at 4 Months Predicts Performance and Verbal IQ at 4 and 7 Years in a Diverse Population." *Developmental Science* 20, no. 5: e12479. https://doi.org/10.1111/desc.12479.

Sohr-Preston, S. L., and L. V. Scaramella. 2006. "Implications of Timing of Maternal Depressive Symptoms for Early Cognitive and Language Development." *Clinical Child and Family Psychology Review* 9, no. 1: 65–83. https://doi.org/10.1007/s10567-006-0004-2.

Spinelli, M., M. Fasolo, P. E. Shah, G. Genovese, and T. Aureli. 2018. "The Influence of Early Temperament on Language Development: The Moderating Role of Maternal Input." *Frontiers in Psychology* 9. https://doi.org/10.3389/fpsyg.2018.01527.

Stifter, C. A., M. T. Willoughby, and N. Towe-Goodman. 2008. "Agree or Agree to Disagree? Assessing the Convergence Between Parents and Observers on Infant Temperament." *Infant and Child Development* 17, no. 4: 407–426. https://doi.org/10.1002/icd.584.

Stolt, S., L. Haataja, H. Lapinleimu, and L. Lehtonen. 2009. "Associations Between Lexicon and Grammar at the End of the Second Year in Finnish Children." *Journal of Child Language* 36, no. 4: 779–806. https://doi.org/10.1017/S0305000908009161.

Tamis-LeMonda, C. S., M. H. Bornstein, and L. Baumwell. 2001. "Maternal Responsiveness and Children's Achievement of Language Milestones." *Child Development* 72, no. 3: 748–767. https://doi.org/10.1111/1467-8624.00313.

Tamis-LeMonda, C. S., Y. Kuchirko, and L. Song. 2014. "Why Is Infant Language Learning Facilitated by Parental Responsiveness?" *Current Directions in Psychological Science* 23, no. 2: 121–126. https://doi.org/10.1177/0963721414522813.

Tamis-LeMonda, C. S., J. D. Shannon, N. J. Cabrera, and M. E. Lamb. 2004. "Fathers and Mothers at Play With Their 2- and 3-Year-Olds: Contributions to Language and Cognitive Development." *Child Development* 75, no. 6: 1806–1820. https://doi.org/10.1111/j.1467-8624.2004.00818.x.

Vernon-Feagans, L., N. Pancsofar, M. Willoughby, E. Odom, A. Quade, and M. Cox. 2008. "Predictors of Maternal Language to Infants During a Picture Book Task in the Home: Family SES, Child Characteristics and the Parenting Environment." *Journal of Applied Developmental Psychology* 29, no. 3: 213–226. https://doi.org/10.1016/j.appdev.2008.02.007.

Wechsler, D. 2012. *WAIS IV esitys- ja pisteytyskäsikirja [WAIS IV Manual]*. Helsinki: Hogrefe Psykologien Kustannus Oy [Psychological Corporation].

Wood, D., J. S. Bruner, and G. Ross. 1976. "The Role of Tutoring in Problem Solving." *Journal of Child Psychology and Psychiatry* 17, no. 2: 89–100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x.

Zerbeto, A. B., F. M. Cortelo, and É. B. C. Filho. 2015. "Association Between Gestational Age and Birth Weight on the Language Development of Brazilian Children: A Systematic Review." *Jornal de Pediatria* 91, no. 4: 326–332. https://doi.org/10.1016/j.jped.2014.11.003.

Supporting Information

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

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IV

Original draft

Infant temperament predicts early communicative skills in the FinnBrain Birth Cohort Study

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Data availability statement: Access to the FinnBrain cohort data can be acquired by contacting the FinnBrain executive board and PI Prof Linnea Karlsson (linnea.karlsson@utu.fi) to establish research collaboration. Sharing data outside research collaboration is precluded by Finnish national legislation on personal data protection and the ethics regulations of the FinnBrain cohort

Highlights:

- High infant positive emotionality is associated with stronger communicative skills
- High infant self-regulation is associated with stronger communicative skills
- Infant temperament is more strongly linked to preverbal than to verbal communication
- Infant temperament has implications for early language development.

Abstract

Studies have established that dimensions of temperament and language development are associated in childhood. Insofar, however, longitudinal studies from infancy into toddlerhood accounting for all temperament dimensions and covering preverbal communication in addition to emerging verbal skills are scarce. Existing findings are inconclusive.

The current study is an extension of our previous study (*N* = 91) on a large cohort sample (*N* = 1200 and 1039 depending on analysis). Temperament (positive emotionality, negative emotionality and emerging self-regulation) was assessed at 6 and 12 months of age and gesturing and receptive vocabulary at 14 months. As an extension to the previous study, expressive vocabulary and sentence complexity in toddlerhood, at 30 months, were also assessed. All assessments utilized parent reports.

The temperament traits of positive emotionality and self-regulation positively predicted all communicative skills except sentence complexity. Positive emotionality accounted for 10-11% of the variance in gesturing, 4-5% in receptive vocabulary and 1-3% in expressive vocabulary. Self-regulation accounted for 4-6% of the variance in gesturing, 2-3% in receptive vocabulary and 0-1% in expressive vocabulary.

Results aligned with the findings of our prior study but also highlighted weak longitudinal positive associations between positive emotionality and self-regulation and gesturing and vocabulary. However, associations were notably stronger with gesturing compared to verbal skills, suggesting temperament and preverbal communication are intertwined on a higher level compared to verbal skills. Longitudinal weakening of associations suggests the role of infant temperament is replaced by other factors influencing language development moving into toddlerhood.

Key words: infant, toddler, temperament, positive emotionality, self-regulation, vocabulary, gesturing

1. Introduction

The importance of adequate communication and language skills in several contexts over the life span, such as academic achievement, and behavioral functioning is undebated (Morgan et al., 2015). Consequently, mapping of the factors influencing language and communication development is an important research field. A large proportion of communication and language skills and their precursors are acquired during infancy and toddlerhood. Individual children's communication skills develop at different rates. Growth rates of vocabulary at the earliest ages predict later language skills (Rowe et al., 2012). Early gesturing also has significant predictive value for later communicative skills (Iverson & Goldin-Meadow, 2005; Kuhn et al., 2014). This indicates that individual differences in communicative skills in the very earliest years of development highlights the focus of research seeking protective and risk factors for this development. Given that temperament is one of the innate factors defining infant's daily interactions, it naturally possesses a role as a factor needing to be explored in the context of early communicative development. Nevertheless, our knowledge in this field is surprisingly limited.

Temperament is composed of the infant's individual emotional, motor, and attentional reactivity and self-regulation (Rothbart & Bates, 1998). Thereby it contributes to how the infant interacts with both the physical environment and the people present in the infant's life. For instance, temperament is linked to social learning (Rothbart & Bates, 2006). Social interaction is, in turn, the basis of communicative development (Kuhl, 2007). However, the body of literature including measures of infant temperament and communicative skills arching longitudinally into toddlerhood are still relatively scarce, and the samples of such studies are typically modest. Particularly, the knowledge of associations between early temperament and preverbal gesturing is limited, although some evidence of such relations is starting to emerge (Bruce et al., 2022; Ollas et al., 2020; Ollas-Skogster et al., 2023). Gesturing is an important early communication modality and precursor of language development (Iverson & Goldin-Meadow, 2005; Kuhn et al., 2014). The timing of gesturing emerging coincides with temperamental differences becoming more observable and stable. This further motivates studying relations between temperament and gesturing, as it allows

observing at what time associations between communicative development and temperament start to emerge.

1.1. Temperament and early communicative development

Temperament is considered to be biologically based, but is modified throughout life due to experience, maturation, and environmental factors (Goldsmith et al., 1987; Rothbart & Bates, 2006). Hence, temperament is relatively stable within an individual, but nonetheless undergoes change, particularly during the earliest years when different skills emerge and develop or are expressed in different ways due to maturation (Caspi & Roberts, 2001; Rothbart & Bates, 2006). Consequently, it is essential to assess associations over different time points since associations may differ depending on point of assessment, especially during the most rapid development of temperament in early life.

Within Rothbart's psychobiological framework, which is applied in the current study, three distinct temperamental dimensions are specified in infancy: positive emotionality, emerging self-regulation, and negative emotionality (Gartstein & Rothbart, 2003). Positive emotionality involves the subscales approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level and perceptual sensitivity. Negative emotionality is composed of sadness, distress to limitations, fear and falling reactivity. In turn, low intensity pleasure, soothability, cuddliness and duration of orienting form the factor emerging self-regulation (Gartstein & Rothbart, 2003). Some previous work has studied the aforementioned dimensions in relation to infant/toddler language. Typically, positive emotionality is hypothesized to influence communicative development by encouraging social interactions and consequently increasing the amount of communicative experiences and language stimulation (Dixon & Smith, 2000). Empirical results regarding positive emotionality in support of this hypothesis are relatively conclusive: studies report positive relations between the aspects of positive emotionality/extraversion and expressive language (Dixon & Smith, 2000; Kubicek & Emde, 2012; Laake & Bridgett, 2014), including early syntax (Davison et al., 2019), receptive language (Dixon & Smith, 2000; Morales et al., 2000) and early communicative skills (Peterson et al., 2017), also including gesturing (Bruce et al., 2022; Ollas et al., 2020). Some studies have found no significant

associations (e.g. Spinelli et al., 2018). Furthermore, in regard to early syntax, the few previous findings have differed somewhat. Davison et al. (2019) report positive associations between the aspects of positive emotionality at 8 months, but not 12 months, and average phrase length at 24 months. Bruce et al. (2022), on the other hand, found no association between 10- and 24-month positive emotionality and syntactic measures at 24 months.

Self-regulation is also hypothesized to have positive associations with communicative development. The suggested mechanism is that self-regulation promotes the communicative development by supporting focusing on interaction and joint attention, leading to the child making better use of the language and communication stimuli in the environment (Dixon & Smith, 2000). The mechanisms behind higher self-regulation supporting communicative development may be related both to the attentiveness and self-regulatory ability that are often involved in measures of self-regulation. Attentiveness is suggested to allow better focus on interaction and language stimuli promoting development (Gartstein et al., 2008). Early self-regulatory ability by allocating attention, on the other hand, is thought to create more instances of interaction (Gartstein et al., 2008). Additionally, a more regulated emotional state may leave cognitive resources free for communication (Bloom & Capatides, 1987). Similar to positive emotionality, self-regulation is typically reported as being positively related to expressive (Dixon & Smith, 2000) and receptive (Dixon & Smith, 2000; Morales et al., 2000) language, including early syntax (Bruce et al., 2022; Spinelli et al., 2018), early communicative skills (Gartstein et al., 2008; Peterson et al., 2017) and gesturing (Ollas-Skogster et al., 2023) in infancy and toddlerhood. The first dimensions of self-regulation are known to appear during the latter half of the first year (Rothbart & Bates, 2006). However, it is also known that self-regulation develops over a long period of time, with rapid growth in self-regulatory abilities taking place after infancy (Rothbart et al., 2004), leading to less inter-individual stability in self-regulation during the first years of life (Putnam et al., 2008). Consequently, results of previous studies have differed depending on the child or infant age and the communicative outcome reported (e.g. Bruce et al., 2022; Spinelli et al., 2018). Some studies also report null associations between early self-regulation and communicative skills (Karrass & Braungart-Rieker, 2003). In line with these challenges, in our previous work, we only found associations

between self-regulation assessed at 12 months of age and gesturing at 14 months of age, not with the earlier measure of self-regulation at 6 months. Neither did any of these self-regulation measures in infancy predict vocabulary at 14 nor 30 months (Ollas-Skogster et al., 2023). Similarly, Bruce et al. (2022) found that self-regulation only was associated with expressive skills (vocabulary and early syntax) concurrently at 24 months, not longitudinally when self-regulation was assessed at 10 months. In contrast, they found no association between self-regulation and gesturing at 10 months (Bruce et al., 2022). Most previous studies have had moderate sample sizes. Further, associations with early communicative skills such as gesturing are scarcely studied. Taken together, there is a gap in the knowledge of how relations between emerging self-regulation during infancy and verbal and nonverbal communication develop, calling for more research utilizing larger samples and several age points to better understand developmental underpinnings of self-regulation and communication development specifically.

In contrast to positive emotionality and self-regulation, different hypotheses regarding mechanisms behind possible associations between negative emotionality and communicative development are suggested. Those arguing that negative emotionality is negatively related to communicative development state that a more aroused emotional state, positive or negative, taxes the attentional resources available for communication (Bloom & Capatides, 1987). Others suggest that emotionality of both positive and negative quality is effective in initiating and maintaining interaction and thus promotes language learning, and thereby expect negative emotionality to have positive associations with communicative development (Moreno & Robinson, 2005).

Like the suggested mechanisms, the empirical findings regarding negative emotionality also differ between studies. Results range from positive (Moreno & Robinson, 2005; Spinelli et al., 2018) and negative (Kubicek & Emde, 2012) associations with expressive language, as well as reports of no significant relations with any communicative outcome (Ollas-Skogster et al., 2023). Associations of different directionality have also been found within the same study, since Bruce et al. (2022) found that 10-month negative emotionality was positively associated with concurrent gesturing, but negatively predicted 24-

month sentence complexity. They concluded that negative emotionality may, on the one hand, lead to more initiation of interaction and hence support gesturing, but on the other hand, as negative emotionality may relate negatively to amount and quality of lexical input during interaction (Vernon-Feagans et al., 2008), it can ultimately have a negative influence on toddler sentence complexity (Bruce et al., 2022).

In sum, the existing reports on associations between early negative emotionality and communicative development have mainly been based on moderate sample sizes and results are inconsistent. Thus, previous studies fail to provide conclusive knowledge on how these developmental dimensions are interrelated in infancy and toddlerhood. We hypothesize that the inconsistency in results is due to changes in the relationship between dimensions of temperament and language development over the course of development. Thus, more studies using several age points across infancy are needed to gain further understanding of when associations appear and possibly change over time.

Another gap in the existing research is related to the use of vocabulary as the measure of early language development, while less attention has been paid to gesturing and early syntax. Communicative gesturing is one of the earliest expressive modalities in infants, preceding and predicting emergence of the first words and sentence structures (Iverson & Goldin-Meadow, 2005; Kuhn et al., 2014), and thus variance in this modality should be of great interest when studying associations between temperament and early communicative development. Nevertheless, we are only aware of four previous studies investigating relations between early temperament and preverbal gesturing separate from other modalities of communicative development, those by Bruce et al. (2022) and Salvadori et al. (2024), and our own studies on the FinnBrain pilot and focus cohort samples (Ollas et al., 2020; Ollas-Skogster et al., 2023). The latter indicate that gestures may in fact be more strongly related to temperament than verbal language. Results however differ remarkably between the studies. Bruce et al. (2022) found positive associations between both positive and negative emotionality and gesturing, but no relation with self-regulation at 10 months, whereas we found gesturing at 12 months to be positively associated with positive emotionality at 6 and 12 months and aspects of self-regulation at 12 months, but not negative emotionality (Ollas et al., 2020; Ollas-

Skogster et al., 2023). Salvadori et al. (2024) found positive emotionality to negatively predict and negative emotionality to positively predict use of pointing gestures with fathers only. Further, Salvadori et al. (2024) found positive emotionality to enhance relations between early socioemotional communication with parents and use of pointing gestures, whereas negative emotionality dampened the association between socioemotional communication with strangers and development of pointing.

In addition to gesturing being underrepresented in studies, the same seems to be true for syntactic skills in toddlerhood. However, some of the studies involving syntax measures in toddlerhood indeed suggest this dimension of language may be more related to temperament than vocabulary (Bruce et al., 2022). This indicates this dimension of communicative development is not to be neglected in the study of associations between temperament and early communicative development.

In sum, the existing research on temperament and communicative development is yet to provide an exhaustive and conclusive longitudinal overview of how temperament traits in infancy relate to the different dimensions of infant and toddler communicative development, particularly preverbal communication such as gestures, and syntactic skills. Sample sizes in previous studies tend to be moderate, leading to uncertainty of power to detect smaller effects.

1.2. The current study

The aim of the current study was to extend our previous study on associations between temperament and communicative development in infancy in the FinnBrain pilot sample (Ollas et al., 2020) using 1) the finalized, larger cohort sample that was not available at the time of the previous study and 2) a wider spectrum of communicative gestures and 3) by adding measures of vocabulary and syntax in toddlerhood as communicative outcomes. Specifically, the current study aims to extend the limited knowledge of associations between infant temperament and preverbal gesturing, which remains a less studied aspect of communicative development. Altogether, we investigate the associations between the infant temperament factors positive emotionality, negative emotionality and emerging self-regulation at 6 and 12 months and

verbal and preverbal communicative skills (gesturing and receptive vocabulary at 14 months, expressive vocabulary and syntax at 30 months) in infancy and toddlerhood.

Based on the existing literature and our previous study (Ollas et al., 2020), we hypothesized that infant positive emotionality and self-regulation would be positively associated with all communicative skills across infancy and toddlerhood. We did not set any hypothesis for associations between negative emotionality and communicative development as such associations were not present in our previous study. We expected relations to be stronger with communicative gesturing than with receptive vocabulary in infancy in correspondence with our previous study.

2. Method

2.1. Participants

The participants of the study were families taking part in the FinnBrain Birth Cohort Study in Finland (Karlsson et al., 2018). The cohort study is planned in accordance with the guidelines of the Declaration of Helsinki. Written informed consent from caregivers of the children was provided prior to participation in the study. The cohort study protocol has been approved by the Ethics Committee of the Hospital District of Southwest Finland. The sample in the current study is a convenience sample from the whole cohort based on availability of relevant data. The sample included a slightly higher percentage of firstborn children and highly educated mothers compared to the whole cohort sample (N = 3837) as reported in Karlsson et al. (2018) but it was similar regarding other demographic characteristics. The sample size (N = 1200 at 14 months and N = 1039 at 30 months, overlap between the samples: n = 789) is large compared to most prior studies in the field. Prematurely born infants were excluded from the sample (infants born at <37 gestational weeks: n = 55 at 14 months and n = 50 at 30 months). The participants were monolingual Finnish-speaking children. Families reporting over 20% exposure to a language other than Finnish were excluded. Cases were chosen for analyses depending on availability of communication development data. Demographic characteristics of the sample are presented in Table 1.

Table 1

Demographic Characteristics of the Samples

	14 months (*n* = 1200)			30 months (*n* = 1039)		
	Mean (*SD*)	%	range	Mean (*SD*)	%	range
Child characteristics						
Sex assigned at birth, girl		47.2			47.7	
First-born		52.3			53.6	
One sibling		30.7			28.6	
≥ 2 siblings		12.1			12.7	
Data missing on siblings		4.9			5.1	
Twin		.8			.8	
Gestational age at delivery	40.0 (1.22)		37.0 – 42.6	40.0 (1.22)		37.0-42.4
Family characteristics						
Maternal educational level						
University degree		39.8			37.8	
Polytechnic/applied university degree		25.8			28.2	
Vocational training/high school/basic education		30.3			29.7	
Data missing regarding maternal education		4.1			4.2	
Maternal age at delivery	30.8 (4.5)		18 – 45	30.9 (4.3)		18 – 45
Paternal age at delivery	32.4 (5.4)		18 – 54	32.4 (5.3)		18 – 54
Child age at questionnaire completion (days)						
Temperament 6mo	195.3 (9.9)		172-290	194.8 (8.51)		172-260
Temperament 12mo	379.4 (9.6)		342-449	379.0 (9.3)		342-430
Communicative skills 14mo	434.8 (22.0)		365-661	433.8 (24.6)		365-806
Communicative skills 30mo	897.0 (11.1)		879-973	897.7 (13.6)		879-1122

2.2. Procedures

Families were recruited during the first trimester at maternal welfare clinics by personal contact with a research nurse. Information about the families was collected during gestational week 14. Data of child biological sex assigned and gestational age at birth was retrieved from the wellbeing services county of Southwest Finland (VARHA) records from the maternity ward. The mothers completed reports on infant temperament when the child was 6 and 12 months of age. The questionnaires regarding communicative development were completed by the mother when the child was 14 months and 30 months of age.

2.3. Measures

2.3.1. Communicative development

Communicative development was assessed utilizing the Mac-Arthur-Bates Communication Development Inventories (CDI) (Fenson, 1994; Lyytinen, 1999), which is a parent report for assessing infant and toddler language and communication. The Words and gestures-version (CDI-WG) was used at 14 months and the Words and sentences-version (CDI-WS) at 30 months. The CDI-WG for infants contains one section for Actions and gestures, with five subcategories: first communicative gestures, games and routines, actions with objects, pretending to be a parent and imitating other adult actions. For first communicative gestures the reporter checks whether the gesture in question is used often, sometimes or not at all by the infant, and for the remaining subcategories reports whether the gesture/action is used or not. In our previous study (Ollas et al., 2020), only the subcategory ”first communicative gestures” was used, but in the current study the concept of gesturing also involved the symbolic play behaviors (McDonald's ω for Actions and gestures = .83). From the CDI-WG at 14 months we also used the receptive vocabulary measure containing a comprehensive list of common words where the reporter checks whether the infant is perceived to understand the word in question or not (ω = .97). From the CDI-WS for toddlers we used the checklist of words for assessing expressive vocabulary (ω = .99), as well as the number of morphemes in the three longest reported phrases used by the toddler for calculation of maximal utterance length (M3L).

2.3.2. Infant temperament

For the current study, we used the Infant Behavior Questionnaire – Revised Short Form (IBQ-R, Gartstein & Rothbart, 2003; Putnam et al., 2014) at 6 and 12 months of age for temperament assessment. The IBQ-R short form is a 91-item parent report that contains 14 subscales forming three factor dimensions: approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level and perceptual sensitivity form the factor positive emotionality (McDonald's ω for 6- and 12-month measures for both subsets of data = .85-.88), sadness, distress to limitations, fear and falling reactivity form the factor negative emotionality (ω = .82-.85) and low intensity pleasure, soothability, cuddliness and duration of orienting form the factor self-regulation (ω = .82-.83). The parent is instructed to assess the infant's behavior in a variety of everyday

situations over the past week. The assessment is done by rating how often the infant has displayed a certain behavior by choosing an alternative from a 7-point scale.

2.3.3. Covariates

Factors previously found to be associated with child language and communicative development – child biological sex assigned at birth, gestational age, SES and maternal psychological distress (Fenson et al., 1994; Hoff, 2006; Reck et al., 2018; Snijders et al., 2020; Sohr-Preston & Scaramella, 2006) – were chosen as covariates in the study. Maternal education level has been shown to be the best SES-predictor of maternal language use with the infant (Vernon-Feagans et al., 2008), and was hence chosen in the current study as a covariate representing SES. Mothers provided information regarding educational level during the first trimester of pregnancy, and the data was coded categorically as follows: 1 = higher secondary education (high school-level or vocational training), 2 = polytechnic degree or 3 = university degree. Maternal psychological distress was chosen considering it is of particular interest in the FinnBrain cohort study design (Karlsson et al., 2018) and as it is known to affect the reporting of temperament traits and child language (Durbin & Wilson, 2012). A maternal psychological distress composite score was calculated by standardizing and summing scores of mother-reported postnatal depressive symptoms (the Edinburg Postnatal Depression Scale (EPDS) (Cox et al., 1987) at 12 months postpartum) and anxiety symptoms (the anxiety subscale from the Symptom Checklist – 90, (SCL-90, Derogatis, Lipman, & Covi, 1973) that was only available at 6 months postpartum). This score was used as a continuous covariate in analyses.

2.4. Data analysis strategy

Analyses were carried out using R Statistical software (v4.3.2, R Core Team, 2023). All temperament variables, the 14-month gesturing and 30-month mean length of utterance variables were considered normally distributed by visual inspection. After square root transformation, the distribution of the 14-month receptive vocabulary variable was considered close enough to normal. Expressive vocabulary at 30 months of age was skewed due to an expected ceiling effect of the measure (Fenson et al., 1994) and deviated from the normal distribution even after transformation. Due to this non-normality, Spearman's

rank correlation coefficient was used for zero-order correlations. Correlations were calculated using Hmisc-package (Harrell, 2024) and visualized using the corrplot-package (Wei & Simko, 2021). Additionally, regression models were built differently for the 30-month vocabulary outcome, as described later in the following paragraphs.

In the 14-month dataset, information was missing regarding temperament (6.3-10.9% missing), maternal postpartum psychological distress (1.2%), maternal education level (4.1 %) and gesture use (3.5%). According to Little's MCAR test, the data was not missing completely at random (MCAR, chi-square = 178.1, *DF* = 148, p = .046). Since the non-randomness was assumed to be due to SES-related factors, the data was considered missing at random (MAR) (Enders, 2011; Rubin, 1976). In the 30-month dataset, data was missing regarding temperament (6.9-11.9%), maternal postpartum psychological distress (1.3%), maternal education level (4.2%) and M3L (16.6%). This data was not MCAR either, according to Little's MCAR test (chi-square = 246.9, *DF* = 144, p < .001), but was also considered MAR. As recommended in cases with moderate amounts of data missing and data not meeting the assumption of MCAR (Jakobsen et al., 2017), missing data was handled by multiple imputations. The number of imputations was set to 10 and multiple imputations by chained equations (MICE) was used to handle missing data in regression models (van Buuren & Groothuis-Oudshoorn, 2011). Two separate datasets were imputed, one with complete data on 14-month vocabulary prior to imputation (*N* = 1200), and one with complete unimputed 30-month vocabulary data (*N* = 1039). Results were essentially the same using the original and imputed datasets.

Gesturing, receptive vocabulary and M3L variables were considered suitable for use as dependent variables in regular linear regression models due to the large sample size (Lumley et al., 2002). Models were built using the lme4-package (Bates et al., 2015) and the ggeffects-package (Lüdecke, 2018) was used for data visualization. However, in the case of 30-month expressive vocabulary deviating more strongly from the normal distribution, we modeled temperament traits as a function of expressive vocabulary and covariates instead of vocabulary as a function of temperament and covariates. This

approach was chosen as an analytically equivalent option to analyze the conceptual association between infant temperament and toddlerhood expressive vocabulary, although technically modeled in the other direction in order to have a dependent variable with a distribution suited for the analysis. Continuous covariates correlating at a level of > .20 with any of the response variables were chosen as covariates in regression models. Continuous predictors were *z*-transformed prior to use in models. Models were built by including chosen covariates in the first model (for the sake of brevity models including only covariates are reported in the Supplements 1-3) and then adding the three temperament variables one by one in the consecutive steps. Separate models for different temperament traits were conducted to avoid multicollinearity. The reported change in adjusted R^2 refers to the change in adjusted R^2 when adding a temperament trait to the model involving only covariates. Finally, the sex by temperament interaction effects were tested for in all models and reported in cases any significant interaction effects were found. The Benjamini-Hochberg-procedure with alpha level < .05 was used to correct *p*-values for multiple comparisons per sets of comparisons for each hypothesis (i.e., for negative emotionality and all communicative outcomes; for positive emotionality and all communicative outcomes, and for emerging self-regulation and all communicative outcomes separately, eight comparisons per hypothesis, and according to the same scheme for the separate sex by negative emotionality/positive emotionality/self-regulation interaction effects and all communicative outcomes separately, eight comparisons per hypothesis).

3. Results

Descriptive statistics regarding the measures in the 14- and 30-month subsamples are displayed in Table 2.

Table2

Descriptive Statistics for the Measures used in the Two Separate Study Samples Including Communicative Outcomes at 14 Months and at 30 Months. $N_{14mo} = 1200$ *and* $N_{30mo} = 1039$.

Measure (theoretical range)	*M* (*SD*) original data	*M* (*SD*) imputed data	Range
14-month dataset			
CDI			
Gesture use 14 months (0-65)	36.0 (8.8)	35.9 (8.9)	6 – 63
Receptive vocabulary 14 months (0-380)	121.7 (72.6)		0 – 336
IBQ-R 6 months (1-7)			
Positive emotionality	4.7 (.7)	4.7 (.7)	2.5 – 6.6
Negative emotionality	3.0 (.8)	3.0 (.8)	1.2 – 6.5
Emerging self-regulation	5.3 (.6)	5.3 (.6)	3.0 – 7.0
IBQ-R 12 months (1-7)			
Positive emotionality	5.1 (.6)	5.1 (.6)	3.2 – 6.5
Negative emotionality	3.3 (.7)	3.3 (.7)	1.5 – 5.5
Emerging self-regulation	5.0 (.6)	5.0 (.6)	2.4 – 6.7
30-month dataset			
CDI			
Expressive vocabulary 30 months (0-594)	409.4 (158.0)		0-594
M3L 30 months	8.3 (3.4)	8.3 (3.5)	1-30
IBQ-R 6 months (1-7)			
Positive emotionality	4.7 (.7)	4.7 (.7)	2.4-6.6
Negative emotionality	3.0 (.7)	3.0 (.8)	1.2-6.0
Emerging self-regulation	5.3 (.6)	5.3 (.6)	3.3-7.0
IBQ-R 12 months (1-7)			
Positive emotionality	5.1 (.6)	5.1 (.6)	3.2-6.5
Negative emotionality	3.3 (.7)	3.3 (.7)	1.5-5.5
Emerging self-regulation	5.0 (.6)	5.0 (.6)	3.1-6.6

Note: overlap between the 14- and 30-month datasets = 789

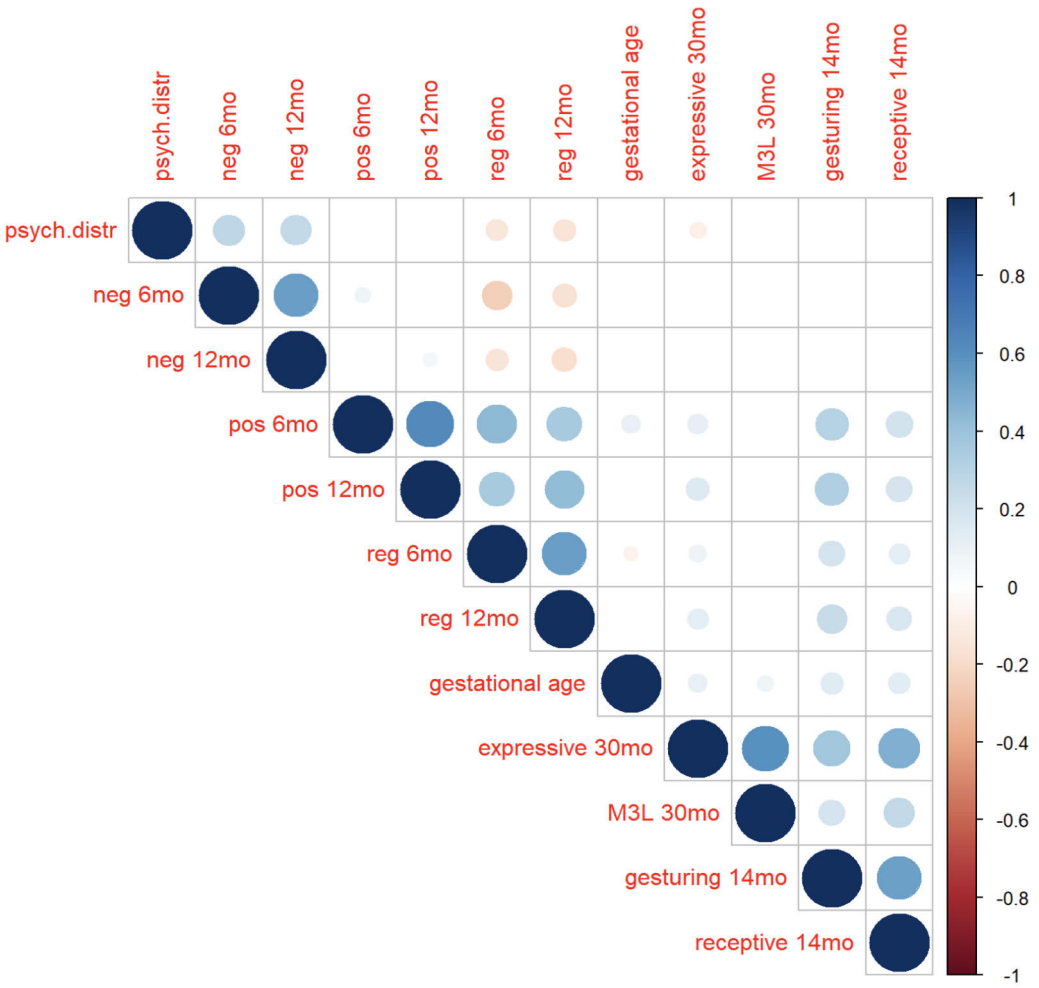
3.1. Zero-order correlations

Zero-order correlations between continuous variables are presented in Figure 1. Positive emotionality and emerging self-regulation had positive bivariate correlations with all later communicative skills except 30-month M3L. The strongest correlations were with gesturing. Negative emotionality had no significant correlation with any communicative skill. Concerning covariates, maternal postpartum psychological distress correlated with negative emotionality at a level > .20 (used as dependent variable in regression models involving 30-month expressive vocabulary) and was hence used as a covariate in regression models.

Gestational age correlated at a level of <.20 with all dependent variables and was hence not used in regression models.

Figure 1

Zero-order Correlations Between Temperament Traits, Continuous Covariates and Communicative Skills



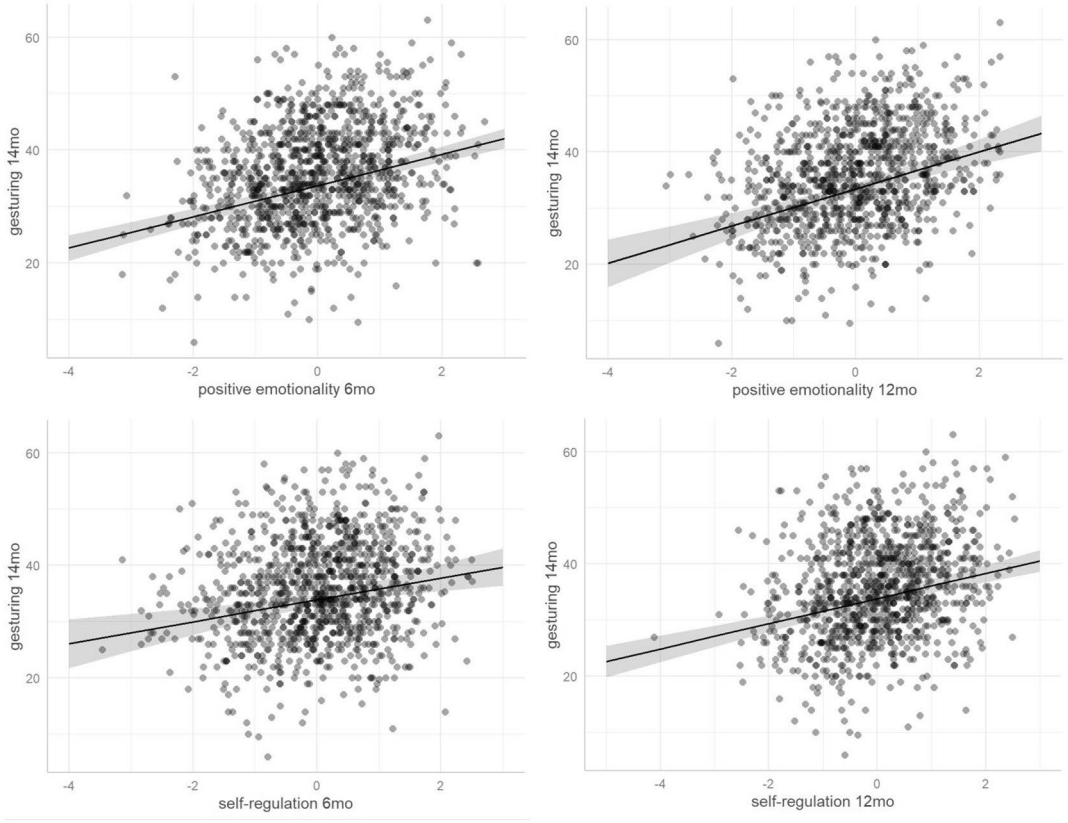
Note. Psych.distr = maternal postpartum psychological distress, neg = negative emotionality, pos = positive emotionality, reg = self-regulation, expressive = expressive vocabulary, M3L = mean length of 3 longest utterances in morphemes, receptive = receptive vocabulary. Only significant correlations ($p < .05$) are represented by a circle.

3.2. Temperament and communicative development at 14 months

When controlling for child sex, maternal psychological distress and education, positive emotionality and self-regulation assessed at both 6 and 12 months were positively associated with gesturing at 14 months of age of age (estimate for positive emotionality at 6 months = 2.89[95% CI 2.40-3.39], p <.001, and at 12 months = 3.09[2.56-3.61], p <.001, estimate for self-regulation at 6 months = 1.90[1.38-2.42], p <.001, and at 12 months = 2.40[1.87-2.94], p <.001). Associations are depicted in Figure 2. Full regression model summaries are reported in the supplements (supplements 4 and 5). Positive emotionality explained 10-11% and self-regulation 4-6% of the variance in gesturing (i.e. Δ adj. R^2 when adding the temperament trait to the model involving only covariates). Negative emotionality had no significant associations with gesturing (supplement 6).

Figure 2

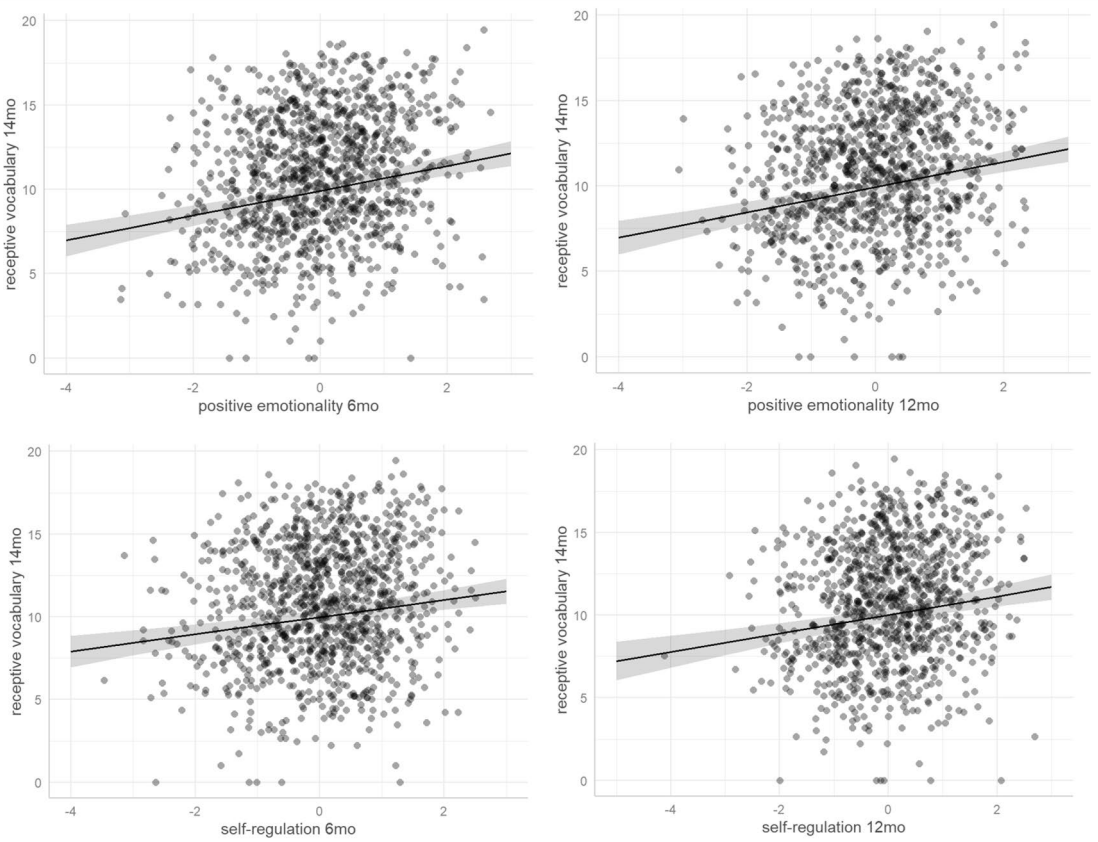
Associations Between Positive Emotionality and Self-regulation at 6 and 12 Months and Gesturing at 14 Months



Similarly, after controlling for covariates, infant positive emotionality and self-regulation at both 6 and 12 months of age were positively associated with receptive vocabulary at 14 months (estimate for positive emotionality at 6 months = 0.79[0.58-0.99], p <.001, and at 12 months = 0.76[0.54-0.97], p <.001, estimate for self-regulation at 6 months = 0.54[0.32-0.76], p <.001, and at 12 months = 0.61[0.39-0.82], p <.001, see supplements 7 and 8). Associations are illustrated in Figure 3. Positive emotionality explained 4-5%, and self-regulation 2-3% of the variation in receptive vocabulary. Negative emotionality had no significant associations with receptive vocabulary (supplement 9).

Figure 3

Associations Between Positive Emotionality and Self-regulation at 6 and 12 Months and Receptive Vocabulary at 14 Months



3.3. Temperament and language skills at 30 months

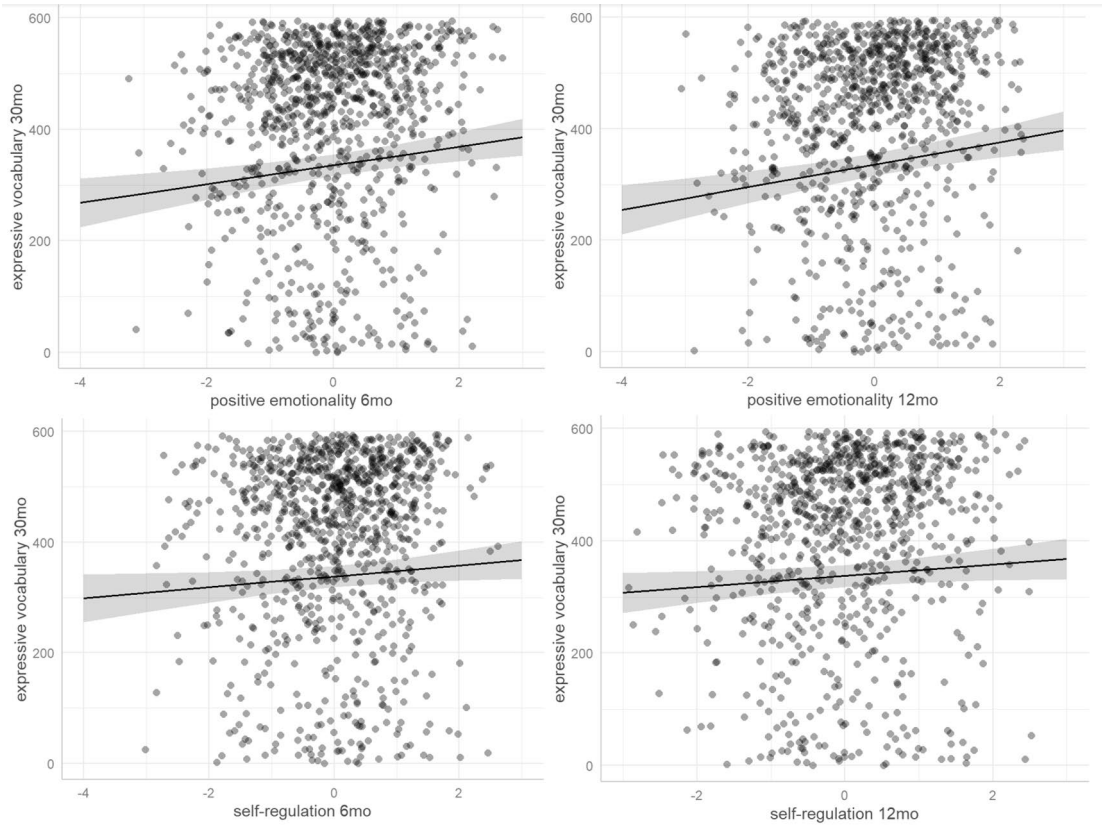
Although conceptually investigating temperament as a predictor of expressive vocabulary at 30 months, due to expressive vocabulary not being normally distributed we modeled temperament as a function of expressive vocabulary. After accounting for covariates, positive associations between positive emotionality at 6 and 12 months as well as self-regulation at 6 and 12 months and expressive vocabulary at 30 months of age were observed (estimate for vocabulary as a predictor of positive emotionality at 6 months = 0.08[0.04-0.13], p <.001, and at 12 months = 0.10[0.06-0.14], p <.001, estimate for vocabulary as a predictor of self-regulation at 6 months = 0.05[0.01-0.09], p <.001, and at 12 months = 0.06[0.02-0.10], p <.001,

supplements 10 and 11). Associations are illustrated in Figure 4. Associations between positive emotionality and expressive vocabulary explained 1-3% of the variance in the model. Corresponding values for self-regulation were 0-1% with 30-month expressive vocabulary. There were no significant associations between negative emotionality and expressive vocabulary (supplement 12).

In contrast to all other communicative development outcomes, M3L at 30 months of age was not significantly associated with any of the infant temperament traits (supplements 13-15).

Figure 4

Associations Between Positive Emotionality and Self-regulation at 6 and 12 Months and Expressive Vocabulary at 30 Months



Note: Due to the ceiling effect in the distribution of expressive vocabulary, regression models were built with temperament traits as a function of expressive vocabulary, but for better interpretability, associations are pictured here as theoretically interpreted with expressive vocabulary as dependent variable.

3.4. Temperament by sex interaction effects on communicative development

Of the tested temperament trait by child sex interaction effects tested in all models, two were significant.

Namely, there was a significant interaction between 6-month negative emotionality and child official sex at birth in predicting child receptive vocabulary at 14 months (estimate = -0.55[-0.97—0.14], p = .009, corrected p = .039, ΔR^2 = .00). Girls with higher reported negative emotionality had smaller receptive vocabularies, whereas for boys, no such association was observed (Figure 5). Additionally, there was a significant interaction between 30-month expressive vocabulary and sex in association with 6-month negative emotionality (estimate = -0.16 [-0.26—0.07], p < .001, corrected p = .005, ΔR^2 = .01), suggesting higher negative emotionality in girls was associated with weaker expressive vocabulary, whereas the opposite was true for boys (Figure 6).

Figure 5

Associations Between 6-month Negative Emotionality and 14-month Receptive Vocabulary for Girls and Boys Separately

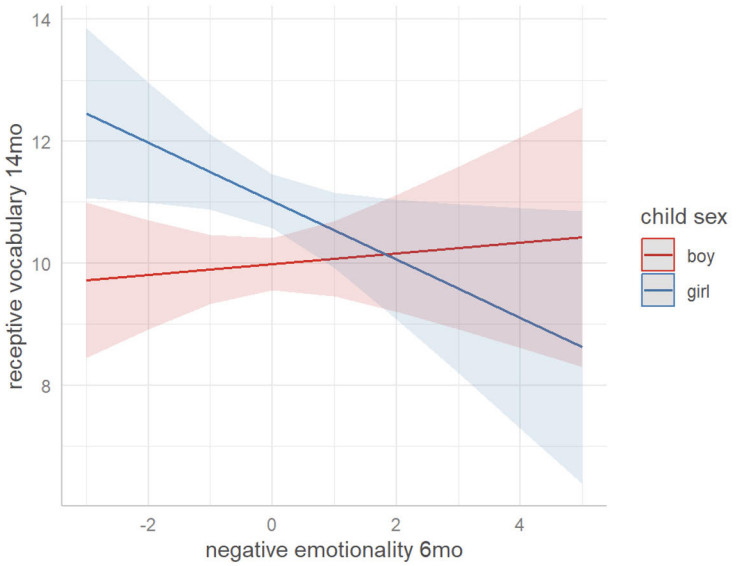
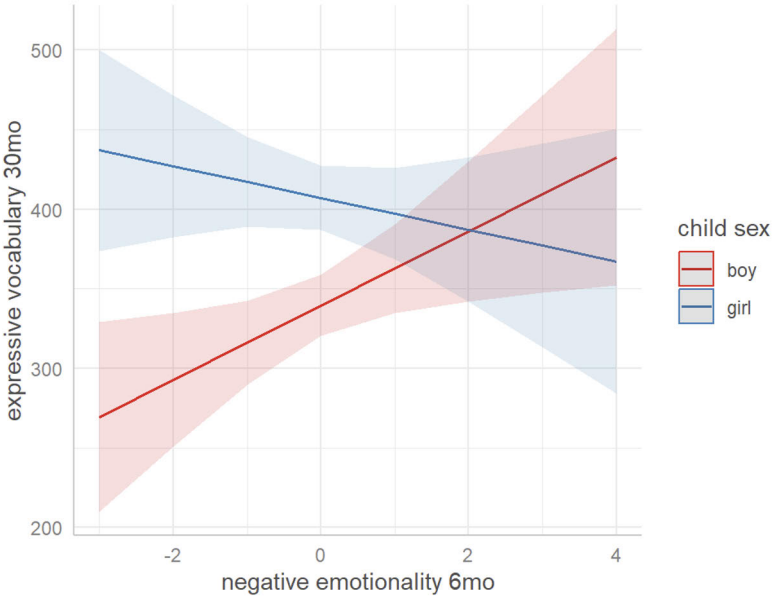


Figure 6

Associations Between 6-month Negative Emotionality and 30-month Expressive Vocabulary for Girls and Boys Separately



4. Discussion

In this study, we examined the associations between infant temperament traits of positive and negative emotionality and regulation at 6 and 12 months, and infant and toddler communicative development outcomes at 14 and 30 months. The findings extended those of our previous study (Ollas et al., 2020) in a substantially larger sample, using the whole cohort sample available. In line with our hypotheses and the previous study, positive associations were found between infant positive emotionality and self-regulation assessed at both age points in infancy and all aspects of communicative skills, except syntax measured as maximum sentence length at 30 months. Thus, infants higher in positive emotionality and with better self-regulation as reported by caregivers tend to use more communicative gestures and understand and produce more words in infancy and toddlerhood. The associations were, qualitatively assessed, the strongest with infant gesturing, whereas the effect sizes were more modest with outcomes assessed later in toddlerhood. Similarly, partially in line with our hypothesis and based on the mixed findings from previous studies, we

found no significant associations between negative emotionality and any of the communicative dimensions. The sample size of the current study is, to our knowledge, the largest in the field reporting associations between early temperament and communicative development. Thus, our findings considerably strengthen the evidence for the variation in the temperament traits of positive emotionality and emerging self-regulation being relevant for early communicative development.

4.1. Temperament and gesturing versus verbal language outcomes

In line with our hypothesis, we found positive associations between the hypothesized temperament traits and early gesturing, a dimension of communicative development that is less studied across the literature. As we also expected, the amount of variance explained by individual temperament traits was, qualitatively assessed, notably larger (5-12%) for gesturing as compared to verbal language skills (1-5% and no association with M3L). Although we did not test the difference in effect sizes statistically, the finding is in line with earlier research and thus could reflect an actual difference in the role of temperament as contributor to communicative development. The explanation could lie in some shared modality between temperament and gesturing, since motor activity is involved in both the concept of temperament (Rothbart & Bates, 1998) and gesturing. Additionally, the expression of temperament traits is likely to happen partially using gesturing. For example, positive emotionality may be accompanied by more use of gestures to request being picked up, have someone joining in play, shared play, social gestures and so forth. In the case of self-regulation, higher gesturing may occur as a consequence of more focused play in infants higher on this temperamental dimension, since part of the gesturing assessed by the CDI is play behavior. Infants higher in emerging self-regulation ability are likely to play with the same items for longer periods of time, both making play behaviors more observable for adults and encouraging joint play supporting development of this type of gesturing.

However, following this logic, associations between negative emotionality and gesturing would also be expected, but were not found in our previous studies (Ollas et al., 2020; Ollas-Skogster et al., 2023), or in the present one. Negative emotionality is also likely to be expressed using gestures, for example

to request comforting in a distressed state or refuse undesired actions or objects. However, these situations may require a more restricted repertoire of gestures and the emotional state not be as fruitful for developing more advanced gesturing. Further, the negative emotional tone in an interactive situation may cause parents to attend to the emotional state rather than potential gesturing used by the child, leading to them not encouraging the gesturing per se. Comparing these results to other studies is challenging since we are not aware of other studies using the same assessment points. Bruce et al. (2022) assessed only gesturing at 10 months and language skills at 24 months, and thus their findings do not allow comparing variance explained in concurrent gesturing and verbal skills. Neither do the results allow direct comparison of R^2-values, since Bruce et al. (2022) had added all temperament traits into the same model (which we wanted to avoid due to multicollinearity effects) and consequently received a common R^2-value for all traits and covariates. Interestingly, in contrast to our findings they also found associations between negative emotionality and gesturing, but not self-regulation (Bruce et al., 2022). They had also defined gesturing more restrictively and used only the subcategory First communicative gestures from the CDI-WG, not the gestures involved in symbolic play behaviors included in subsequent subcategories of the Actions and gestures-section. Hence, our findings combined could support the hypothesis that negative emotionality may be more related to a narrower repertoire of gestures communicating a need, as seen in Bruce et al. (2022), whereas self-regulation may be more related to gesturing involving a wider variety of play behaviors, as seen in our study. Another possibility is simply that gesturing is the dominant mode of (expressive) communication preceding verbal skills (Iverson & Goldin-Meadow, 2005) in infancy, and therefore associations with temperament are the most evident with this modality when assessing gesturing and emerging verbal skills concurrently.

To conclude, associations were observed between temperament and both nonverbal gesturing and a variety of verbal measures ranging into toddlerhood in our study, but may be stronger for gesturing than other measures. Contrary to our hypothesis, no associations were found between temperament traits and early syntax assessed as M3L. Together, our results suggest that temperament and communication are intertwined also on a more fundamental level and are not merely explained by shared

expressions of gesturing and temperament in infancy. Furthermore, as early gesturing is predictive of later verbal language development (Kuhn et al., 2014; Rowe et al., 2022; Rowe & Goldin-Meadow, 2009), these associations imply intra-individual factors associated with gesturing provide an early insight into factors related to language development later on. Longitudinal follow-up of temperament in toddlerhood is needed to further understand the development of these associations across early childhood.

4.2. Positive emotionality and communicative development

The robust finding of positive emotionality being positively associated with communicative development across all modalities further support the relatively conclusive previous findings (Bruce et al., 2022; Dixon & Smith, 2000; Kubicek & Emde, 2012; Laake & Bridgett, 2014; Morales et al., 2000) and highlights positive emotionality as the temperament trait most clearly related to early nonverbal and verbal communicative skills starting from the first half of the first year of life. In other words, infants with a tendency for positive emotionality and extraversion seem to have an advantage in developing gesturing, vocabulary and sentence complexity. This has often been explained as being a result of positive emotionality enhancing and encouraging interaction with caregivers (Bruce et al., 2022) and consequently increasing the amount of language (Laake & Bridgett, 2014) and nonverbal communicative stimulation. However, in our recent study based on data from the same cohort, we found only independent effects of emotional caregiving quality and positive emotionality on communicative development and no moderation effects between the two (Ollas-Skogster et al., 2025). This suggests the relation between positive emotionality and communicative skills can not only be explained by how it influences interaction with the caregiver, at least not when interaction is assessed from an emotional viewpoint. We did not, however, assess caregiver communication. Hence, it is possible that caregiver communication is more intertwined with infant temperament than basic, emotional caregiving. Götz et al. (2024) indeed found an association between positive emotionality and number of conversational turns with the caregiver in early infancy, but unexpectedly caregivers had more conversational turns with infants lower in positive emotionality. Nevertheless, results suggest that

temperament can be associated with caregiver communication, although we do not yet fully understand these associations and more research is needed on the mechanisms between the two.

Where previous studies have often reported relations with positive emotionality to differ between communicative modalities, our results seem to suggest associations are present with all modalities but are the strongest with gesturing and weaker with toddlerhood vocabulary. For example, Laake and Bridgett (2014) reported associations between infant positive emotionality and toddler expressive vocabulary only, not receptive skills, whereas we found associations with both expressive gesturing and receptive vocabulary in infancy and expressive vocabulary in toddlerhood. Thus, our results suggest no difference between these domains. Furthermore, Bruce et al. (2022) found concurrent positive emotionality to predict only expressive vocabulary, not syntactic skills, at 24 months. Similarly, in our study infant positive emotionality did not reach significance as a predictor of M3L. However, the R^2 change (.01-.03) in the model explained by the association between positive emotionality and expressive vocabulary was very modest. Thus, our results do not motivate claiming a clear difference in the strength of the longitudinal association between infant positive emotionality and toddlerhood expressive vocabulary and syntactic skills. Of course, adding concurrent toddlerhood temperament assessment will add to our understanding of these associations in future studies.

Another interpretation of the result may be that the temperament trait of positive emotionality is associated with a high *use* of communicative skills rather than an advantage in the level of the skills themselves. This may be true especially in this context where communication skills are reported by the parent and assessed informally in everyday situations – possibly the infants higher in positive emotionality are keener to display their acquired communicative skills compared to peers lower in this dimension. For example, an emotionally positive child may utter a newly acquired word 10 times in the same amount of time a child lower in this dimension utters it once, and hence parents of a child higher in positive emotionality are more likely to become aware of their child having acquired the word in question. In a sample of older children, DeThorne et al. (2011) indeed found that positive emotionality was related to

language measures based on whole speech samples, but not based on standardized measures unaffected by talkativeness. On the other hand, as extraversion may be associated with talkativeness and a desire to interact, it is also likely to cause a snowball effect as it simultaneously leads to more exposure to communicative stimuli. Indeed, parents are found to talk more to children who have started to talk themselves (Dailey & Bergelson, 2023). Further studies on the mechanisms behind the relation between positive emotionality and communicative development as well as the relations between parental interaction quality and infant temperament are needed.

To conclude, as results rather robustly suggest positive emotionality is positively related to early communicative development, it may be important to keep in mind that infants lower in positive emotionality may be at risk for having a disadvantage in communicative development and care to provide them with a sufficient amount of high-quality interaction and verbal and communicative stimuli in mutually enjoyable contexts and activities.

4.3. Self-regulation and communicative development

Emerging self-regulation was significantly associated with all measured communicative skills except M3L, indicating infants higher in self-regulation tended to use more gesturing and have somewhat larger receptive and expressive vocabularies. It explained a larger proportion of the variance in gesturing (4-6%) as compared to verbal skills (0-3%) where the amount of variance explained was rather small. Contrastingly, the only study we are aware of with corresponding measures by Bruce et al. (2022) found no significant associations between self-regulation and more strictly defined communicative gesturing at 10 months, only concurrent associations with self-regulatory ability and expressive language at 24 months.

The variance explained was smaller in models with toddlerhood expressive vocabulary, which is reasonable considering self-regulation undergoes radical change at the earliest ages as new abilities come online and skills develop (Putnam et al., 2008; Rothbart et al., 2004; Rothbart et al., 2007). Hence, the relatively weak link between the earliest expressions of emerging self-regulation in infancy and toddlerhood vocabulary is comprehensible as the temperament dimension changes substantially due to maturation

during the time passing between assessments. In light of the typical developmental changes in self-regulation between the ages of 6 and 30 months, it is rather remarkable that a significant, however weak, association can be found between the earliest emerging self-regulatory capacity and vocabulary two years later. Indeed, the associations tended to be stronger for the most proximal assessments of 12-month self-regulation and 14-month communicative skills as compared to the 6-month assessment. Our results align with several previous studies reporting positive relations between early self-regulation and communicative development (Dixon & Smith, 2000; Gartstein et al., 2008; Morales et al., 2000; Ollas et al., 2020; Peterson et al., 2017). The association between early self-regulation and preverbal gesturing is noteworthy. The finding implies self-regulation may especially relate to nonverbal communication, possibly by self-regulation aiding child visual attention to nonverbal communicative stimuli. Whereas words can be overheard and learned while paying attention to something else, nonverbal gesturing requires visual attention. In fact, Vouloumanos and Curtin (2014) found verbal language skills to be related only to attention to verbal stimuli, not overall attentiveness. Possibly a similar mechanism of differing subdimensions of attention/orienting could explain the stronger associations between overall self-regulation and gesturing in comparison to verbal skills in our study. This hypothesis should be tested in future studies assessing attentiveness to verbal stimuli as well.

Considering the development of self-regulation is thought to be supported by coregulation with the parent (Bernier et al., 2010; Lobo & Lunkenheimer, 2020) and self-regulation in the current study is reported by the parent, it is likely the parent's role in the measure is significant. Consequently, measures of higher co/self-regulation probably entail higher amounts of both verbal and nonverbal interaction as well. Better ability to stay oriented towards interactional stimuli naturally would also benefit development of gesturing and verbal language (Dixon & Smith, 2000). Additionally, the child being engaged in interaction likely encourages adults to interact more and makes interacting enjoyable for both parties.

In sum, our results indicate that associations between self-regulation and communicative skills can be seen starting from 6 months of age. Infant self-regulation is most clearly associated with

gesturing but only marginally with toddlerhood expressive vocabulary, indicating a need for follow-up of this developing temperament dimension in toddlerhood to uncover development of associations.

4.4. Negative emotionality and communicative development

Negative emotionality is the temperament trait with the most inconclusive associations with communicative development in the literature. The results of the current study, as well as our other studies within the same cohort (Ollas et al., 2020; Ollas-Skogster et al., 2023, 2025), lend little support for infant negative emotionality being associated with early communicative development. Previous studies that have found associations between negative emotionality and communicative development have explained positive associations with negative emotions often initiating interaction with an adult (Bruce et al., 2022; Moreno & Robinson, 2005), and negative associations with high negative emotionality leading to less attentive resources assigned to interaction (Bloom & Capatides, 1987). If both arguments hold place, the conclusion could be that the benefits and disadvantages of negative emotionality cancel each other out, especially over time, which may explain associations being missing in our study. Although observable already in toddlerhood, vocabulary and self-regulation become increasingly intertwined as verbal skills become more advanced (Vallotton & Ayoub, 2011). Hence, assuming higher negative emotionality would support communicative development by entailing a desire to express and regulate negative emotions, the shift to successfully communicating such emotions verbally could perhaps be expected only later in childhood. Consequently, such associations may only be observable at a later age and require concurrent measures of negative emotionality in toddlerhood. Furthermore, since the proposed association between negative emotionality and communicative skills is explained by regulation of negative emotionality (by initiating interaction for emotional support (Bruce et al., 2022; Moreno & Robinson, 2005), or inversely being unable to interact due to attentional resources being allocated to self-regulation (Bloom & Capatides, 1987)), there is conceptual overlap with the self-regulation temperament dimension. Self-regulation did, in turn, have significant associations with most communicative dimensions in our study. Hence, it is possible that the theoretical associations between negative emotionality and communicative development are, in fact,

observed in the self-regulation trait instead. A future study of associations between longitudinal temperament and communicative development profiles based on the same sample as in the present study is planned to examine these associations in a comprehensive manner.

Another possibility is that the effects of infant negative emotionality are dependent on sample characteristics. Our sample was relatively low risk in terms of SES and psychosocial wellbeing. This could result in the parents' communication with their infant being less likely to be influenced by infant negative emotionality, whereas infant negative emotionality may entail a higher risk of leading to harsh parenting or decreased communication in more high-risk samples. In a previous study based on a subsample of the current study sample, we found no interaction effects between emotional caregiving quality and infant temperament on communicative development, suggesting the associations between caregiving and communicative development are not moderated by temperament traits in this sample (Ollas-Skogster et al., 2025). Studies have shown relations between negative emotionality and parenting factors to differ depending on family SES (Paulussen-Hoogeboom et al., 2007). More specifically, higher infant negative emotionality is associated with more supportive parenting in high-SES context whereas the opposite is observed in families with low SES (Paulussen-Hoogeboom et al., 2007). Similar SES-related differences could be present when it comes to parental communication. It is also possible associations are conversation partner dependent, since Salvadori et al. (2024) found negative emotionality with fathers only to positively predict the development of gesturing, and our study included mother reports only. Future studies should thus include both parents and diverse family models to further examine the role of negative emotionality among factors related to communicative development.

However, although preliminary, it is noteworthy that we found some tentative evidence for child official sex (determined at birth) moderating the association between early infancy negative emotionality and communicative development. Namely, high 6-month negative emotionality was associated with lower receptive vocabulary at 14 months and expressive vocabulary at 30 months in girls only, whereas boys with high negative emotionality at 6 months seemed to have larger expressive vocabularies at 30

months. By contrast, Nozadi et al. (2013) found that higher negative emotionality at 30 months in boys only was associated with lower concurrent expressive vocabulary, but that higher negative emotionality in early toddlerhood was positively associated with expressive vocabulary for both sexes. They hypothesize that early expressions of negative emotionality at an age where communicative and self-regulation skills are rudimentary may be beneficial for communicative development as they are effective in initiating interaction and coregulation. However, high negative emotionality later in toddlerhood when verbal skills and self-regulation are expected to be at a higher level may be more maladaptive (Nozadi et al., 2013). In our sample, this hypothesis seemed to be supported for boys only, whereas very early negative emotionality in girls seemed to have negative associations with later language skills. Possibly social factors explain the sex differences (Huttenlocher et al., 1991) if negative emotional expressions elicit different responses from caregivers depending on child sex. The interaction effects found in the present study were, however, very modest. Although of little clinical relevance due to the small effect sizes, these findings suggest sex differences in relations between negative emotionality and communicative development need further theoretical investigation.

4.5. Strengths, limitations and directions for future research

Strengths of the current study are its sample size warranting good statistical power, being part of a prospective longitudinal cohort study, the design with repeated measures of both temperament and communicative development, the involvement of all infant temperament dimensions as well as use of a range of communicative development outcomes, including both gesturing and verbal communicative development. Obtaining similar results as in our previous study with the cohort pilot sample further supports robustness of the findings.

However, the study also has limitations that need to be taken into consideration. Assessment of temperament and communicative skills were not conducted at the exact same time points in our study, and temperament was assessed in infancy only. Concurrent temperament and language skill assessment in toddlerhood would be important to gain further understanding of how relations between temperament and

communicative skills possibly change over childhood. Considering associations were the strongest between temperament traits and nonverbal communication, future studies should examine such relations at later ages and continue to compare with verbal communication. We are planning future studies with longitudinal language and temperament trajectory data to further illustrate the long-term associations between the two.

Assessment of temperament and communicative development relying on parent reports allowed the large sample size and is considered a reliable and valid method (e.g. Feldman, 2007; Fenson et al., 1994; Komsi et al., 2006), but may nevertheless be considered a limitation due to lack of objectivity. Also, involvement of only mother and not father reports can be considered a limitation since fathers are also frequent interaction partners likely to play a role for infant communicative development (Cabrera et al., 2007). Longitudinal task- and observation-based data of both temperament and communicative development is needed to make more far-reaching conclusions less dependent on possible reporter bias. Studies have indicated associations between temperament and language may depend on parental language input (Spinelli et al., 2018). Thus, controlling this would be important in future studies.

4.6. Conclusion

The results confirm the findings of our previous, smaller study and highlight positive emotionality and self-regulations as the key temperament traits to positively predict communicative skills across several assessed communicative modalities in infancy and toddlerhood. Gesturing was particularly evidently associated with these temperament traits. Clinically, the results suggesting infant temperament is related to communicative development up until toddlerhood imply a need to take temperament into account in early care, or counselling focused on caregiving, to provide all infants with a sufficient amount of communicative experience for developing gesturing and verbal language skills. More specifically, infants lower in positive emotionality and early self-regulation ability may benefit from more explicit (parental) communicative stimulation and scaffolding to acquire strong early communicative skills.

References

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/doi:10.18637/jss.v067.i01

Bernier, A., Carlson, S. M., & Whipple, N. (2010). From External Regulation to Self-Regulation: Early Parenting Precursors of Young Children's Executive Functioning. *Child Development*, *81*(1), 326–339. https://doi.org/10.1111/j.1467-8624.2009.01397.x

Bloom, L., & Capatides, J. B. (1987). Expression of affect and the emergence of language. *Child Development*, *58*(6), 1513–1522. https://doi.org/10.2307/1130691

Bruce, M., McFayden, T. C., Ollendick, T. H., & Bell, M. A. (2022). Expressive language in infancy and toddlerhood: The roles of child temperament and maternal parenting behaviors. *Developmental Psychobiology*, *64*(6), e22287. https://doi.org/10.1002/dev.22287

Cabrera, N. J., Shannon, J. D., & Tamis-LeMonda, C. (2007). Fathers' Influence on Their Children's Cognitive and Emotional Development: From Toddlers to Pre-K. *Applied Developmental Science*, *11*(4), 208–213. https://doi.org/10.1080/10888690701762100

Caspi, A., & Roberts, B. W. (2001). Personality Development Across the Life Course:The Argument for Change and Continuity. *Psychological Inquiry*, *12*(2), 49–66. https://doi.org/10.1207/S15327965PLI1202_01

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of Postnatal Depression. *British Journal of Psychiatry*, *150*(6), 782–786. https://doi.org/10.1192/bjp.150.6.782

Dailey, S., & Bergelson, E. (2023). Talking to talkers: Infants' talk status, but not their gender, is related to language input. *Child Development*, *94*(2), 478–496. https://doi.org/10.1111/cdev.13872

Davison, L., Warwick, H., Campbell, K., & Gartstein, M. A. (2019). Infant temperament affects toddler language development. *Journal of Education and E-Learning Research*, *6*(3), 122–128. https://doi.org/10.20448/journal.509.2019.63.122.128

DeThorne, L. S., Deater-Deckard, K., Mahurin-Smith, J., Coletto, M.-K., & Petrill, S. A. (2011). Volubility as a mediator in the associations between conversational language measures and child temperament.

International Journal of Language & Communication Disorders, *46*(6), 700–713. https://doi.org/10.1111/j.1460-6984.2011.00034.x

Dixon, W., & Smith, P. (2000). Links between temperament and language acquisition. *Merrill-Palmer Quarterly*, *46*, 417–440.

Durbin, C. E., & Wilson, S. (2012). Convergent validity of and bias in maternal reports of child emotion. *Psychological Assessment*, *24*(3), 647–660. https://doi.org/10.1037/a0026607

Enders, C. K. (2011). Analyzing longitudinal data with missing values. *Rehabilitation Psychology*, *56*(4), 267–288. https://doi.org/10.1037/a0025579

Feldman, R. (2007). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, *16*(6), 340–345. https://doi.org/10.1111/j.1467-8721.2007.00532.x

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i–185. https://doi.org/10.2307/1166093

Gartstein, M. A., Crawford, J., & Robertson, C. D. (2008). Early markers of language and attention: Mutual contributions and the impact of parent–infant interactions. *Child Psychiatry and Human Development*, *39*(1), 9–26. https://doi.org/10.1007/s10578-007-0067-4

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*, *26*(1), 64–86. https://doi.org/10.1016/S0163-6383(02)00169-8

Götz, A., Altuntas, E., Kalashnikova, M., Best, C., & Burnham, D. (2024). Shaping linguistic input in parent-infant interactions: The influence of the Infant's temperament. *Infancy*, *n/a*(n/a). https://doi.org/10.1111/infa.12629

Harrell, F. (2024). *Hmisc: Harrell miscellaneous* (Version 5.2-0) [Computer software]. https://CRAN.R-project.org/package=Hmisc

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology*, *27*(2), 236–248.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science*, *16*(5), 367–371. https://doi.org/10.1111/j.0956-7976.2005.01542.x

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 162. https://doi.org/10.1186/s12874-017-0442-1

Karlsson, L., Tolvanen, M., Scheinin, N. M., Uusitupa, H.-M., Korja, R., Ekholm, E., Tuulari, J. J., Pajulo, M., Huotilainen, M., Paunio, T., Karlsson, H., & FinnBrain Birth Cohort Study Group. (2018). Cohort profile: The FinnBrain Birth Cohort Study (FinnBrain). *International Journal of Epidemiology*, *47*(1), 15–16j. https://doi.org/10.1093/ije/dyx173

Karrass, J., & Braungart-Rieker, J. M. (2003). Parenting and temperament as interacting agents in early language development. *Parenting*, *3*(3), 235–259. https://doi.org/10.1207/S15327922PAR0303_03

Komsi, N., Räikkönen, K., Pesonen, A.-K., Heinonen, K., Keskivaara, P., Järvenpää, A.-L., & Strandberg, T. E. (2006). Continuity of temperament from infancy to middle childhood. *Infant Behavior and Development*, *29*(4), 494–508. https://doi.org/10.1016/j.infbeh.2006.05.002

Kubicek, L. F., & Emde, R. N. (2012). Emotional expression and language: A longitudinal study of typically developing earlier and later talkers from 15 to 30 months. *Infant Mental Health Journal*, *33*(6), 553–584. https://doi.org/10.1002/imhj.21364

Kuhl, P. K. (2007). Is speech learning 'gated' by the social brain? *Developmental Science*, *10*(1), 110–120. https://doi.org/10.1111/j.1467-7687.2007.00572.x

Kuhn, L. J., Willoughby, M. T., Wilbourn, M. P., Vernon-Feagans, L., Blair, C. B., & Investigators, T. F. L. P. K. (2014). Early communicative gestures prospectively predict language development and executive

function in early childhood. *Child Development*, *85*(5), 1898–1914. https://doi.org/10.1111/cdev.12249

Laake, L. M., & Bridgett, D. J. (2014). Happy babies, chatty toddlers: Infant positive affect facilitates early expressive, but not receptive language. *Infant Behavior and Development*, *37*(1), 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006

Lobo, F. M., & Lunkenheimer, E. (2020). Understanding the parent-child coregulation patterns shaping child self-regulation. *Developmental Psychology*, *56*(6), 1121–1134. https://doi.org/10.1037/dev0000926

Lüdecke, D. (2018). ggeffects: Tidy data frames of marginal effects from regression models. *Journal of Open Source Software*, *3*(26), 776. https://doi.org/10.21105/joss.00772

Lumley, T., Diehr, P., Emerson, S., & Chen, L. (2002). The importance of the normality assumption in large public health data sets. *Annual Review of Public Health*, *23*(1), 151–169. https://doi.org/10.1146/annurev.publhealth.23.100901.140546

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Neal, R., & Schwartz, H. K. (2000). Gaze following, temperament, and language development in 6-month-olds: A replication and extension. *Infant Behavior and Development*, *23*(2), 231–236. https://doi.org/10.1016/S0163-6383(01)00038-8

Moreno, A. J., & Robinson, J. L. (2005). Emotional vitality in infancy as a predictor of cognitive and language abilities in toddlerhood. *Infant and Child Development*, *14*(4), 383–402. https://doi.org/10.1002/icd.406

Morgan, P. L., Farkas, G., Hillemeier, M. M., Hammer, C. S., & Maczuga, S. (2015). 24-month-old children with larger oral vocabularies display greater academic and behavioral functioning at kindergarten entry. *Child Development*, *86*(5), 1351–1370. https://doi.org/10.1111/cdev.12398

Nozadi, S. S., Spinrad, T. L., Eisenberg, N., Bolnick, R., Eggum-Wilkens, N. D., Smith, C. L., Gaertner, B., Kupfer, A., & Sallquist, J. (2013). Prediction of toddlers' expressive language from maternal sensitivity and toddlers' anger expressions: A developmental perspective. *Infant Behavior and Development*, *36*(4), 650–661. https://doi.org/10.1016/j.infbeh.2013.06.002

Ollas, D., Rautakoski, P., Nolvi, S., Karlsson, H., & Karlsson, L. (2020). Temperament is associated with the use of communicative gestures in infancy. *Infant and Child Development*, *29*(3), e2166. https://doi.org/10.1002/icd.2166

Ollas-Skogster, D., Korja, R., Yada, A., Mainela-Arnold, E., Karlsson, H., Bridgett, D. J., Rautakoski, P., Karlsson, L., & Nolvi, S. (2025). Maternal emotional availability supports child communicative development regardless of child temperament—Findings from the FinnBrain Birth Cohort Study. *Infancy*, *30*(1), e12649. https://doi.org/10.1111/infa.12649

Ollas-Skogster, D., Rautakoski, P., Bridgett, D., Kataja, E.-L., Karlsson, H., Karlsson, L., & Nolvi, S. (2023). Associations between observed and reported infant negative affectivity, fear and self-regulation, and early communicative development—Evidence from the FinnBrain Birth Cohort Study. *Infancy*, *28*(2), 410–434. https://doi.org/10.1111/infa.12508

Paulussen-Hoogeboom, M. C., Stams, G. J. J. M., Hermanns, J. M. A., & Peetsma, T. T. D. (2007). Child negative emotionality and parenting from infancy to preschool: A meta-analytic review. *Developmental Psychology*, *43*(2), 438–453. https://doi.org/10.1037/0012-1649.43.2.438

Peterson, E. R., Waldie, K. E., Mohal, J., Reese, E., Atatoa Carr, P. E., Grant, C. C., & Morton, S. M. B. (2017). Infant Behavior Questionnaire–Revised Very Short Form: A new factor structure's associations with parenting perceptions and child language outcomes. *Journal of Personality Assessment*, *99*(6), 561–573. https://doi.org/10.1080/00223891.2017.1287709

Putnam, S. P., Helbig, A. L., Gartstein, M. A., Rothbart, M. K., & Leerkes, E. (2014). Development and assessment of short and very short forms of the infant behavior questionnaire-revised. *Journal of Personality Assessment*, *96*(4), 445–458. https://doi.org/10.1080/00223891.2013.841171

Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development*, *17*(4), 387–405. https://doi.org/10.1002/icd.582

R Core Team. (2023). *R: A language and environment for statistical computing* (Version 4.3.2) [Computer software]. R Foundation for Statistical Computing. <https://www.R-project.org/>

Reck, C., Van Den Bergh, B., Tietz, A., Müller, M., Ropeter, A., Zipser, B., & Pauen, S. (2018). Maternal avoidance, anxiety cognitions and interactive behaviour predicts infant development at 12 months in the context of anxiety disorders in the postpartum period. *Infant Behavior and Development*, *50*, 116–131. https://doi.org/10.1016/j.infbeh.2017.11.007

Rothbart, M., Ellis, L. K., & Posner, M. (2004). Temperament and self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 357–370).

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology, vol. 3: Social, emotional, and personality development* (pp. 105–176). Wiley.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology* (Vol. 6). John Wiley & Sons, Inc.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, *1*(1), 2–7. https://doi.org/10.1111/j.1750-8606.2007.00002.x

Rowe, M. L., & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science*, *12*(1), 182–187. https://doi.org/10.1111/j.1467-7687.2008.00764.x

Rowe, M. L., Raudenbush, S. W., & Goldin-Meadow, S. (2012). The pace of vocabulary growth helps predict later vocabulary skill. *Child Development*, *83*(2), 508–525. https://doi.org/10.1111/j.1467-8624.2011.01710.x

Rowe, M. L., Wei, R., & Salo, V. C. (2022). Early gesture predicts later language development. In A. Morgenstern & S. Goldin-Meadow (Eds.), *Gesture in Language* (pp. 93–112). American Psychological Association. https://www.jstor.org/stable/j.ctv249sgdf.7

Rubin, D. B. (1976). Inference and missing data. *Biometrika*, *63*(3), 581–592. https://doi.org/10.2307/2335739

Salvadori, E. A., Colonnesi, C., Oort, F. J., & Messinger, D. S. (2024). Predicting pointing from early socioemotional communication with mothers, fathers, and strangers through the lens of temperamental reactivity. *Developmental Psychology*. https://doi.org/10.1037/dev0001671.supp

Snijders, V. E., Bogicevic, L., Verhoeven, M., & van Baar, A. L. (2020). Toddlers' language development: The gradual effect of gestational age, attention capacities, and maternal sensitivity. *International Journal of Environmental Research and Public Health*, *17*(21), Article 21. https://doi.org/10.3390/ijerph17217926

Sohr-Preston, S. L., & Scaramella, L. V. (2006). Implications of timing of maternal depressive symptoms for early cognitive and language development. *Clinical Child and Family Psychology Review*, *9*(1), 65–83. https://doi.org/10.1007/s10567-006-0004-2

Spinelli, M., Fasolo, M., Shah, P. E., Genovese, G., & Aureli, T. (2018). The influence of early temperament on language development: The moderating role of maternal input. *Frontiers in Psychology*, *9*. https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01527

Vallotton, C., & Ayoub, C. (2011). Use your words: The role of language in the development of toddlers' self-regulation. *Early Childhood Research Quarterly*, *26*(2), 169–181. https://doi.org/10.1016/j.ecresq.2010.09.002

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*(3), 1–67. https://doi.org/10.18637/jss.v045.i03

Vernon-Feagans, L., Pancsofar, N., Willoughby, M., Odom, E., Quade, A., & Cox, M. (2008). Predictors of maternal language to infants during a picture book task in the home: Family SES, child characteristics and the parenting environment. *Journal of Applied Developmental Psychology*, *29*(3), 213–226. https://doi.org/10.1016/j.appdev.2008.02.007

Vouloumanos, A., & Curtin, S. (2014). Foundational tuning: How infants' attention to speech predicts language development. *Cognitive Science*, *38*(8), 1675–1686. https://doi.org/10.1111/cogs.12128

Wei, T., & Simko, V. (2021). *R package "corrplot": Visualization of a correlation matrix* (Version 0.92) [Computer software]. https://github.com/taiyun/corrplot

Supplements

Supplement 1

Summary of Linear Regression Models of Associations Between Covariates and Communicative Dimensions

	Gesturing 14mo					Receptive vocabulary 14mo					M3L 30mo				
Predictors	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2
					.03					.02					.02
Intercept	34.2	33.20-35.29	64.38	<.001		10.20	9.79-10.61	48.45	<.001		7.31	6.85-7.76	32.21	<.001	
Child sex (ref. = boy)	2.99	1.98-4.01	5.79	<.001		1.00	0.59-1.41	4.82	<.001		0.64	0.18-1.11	2.75	.007	
Maternal postpartum psychological distress	-0.11	-062-0.40	-0.43	.668		-0.12	-0.33-0.08	-1.16	.245		-0.08	-0.30-0.14	-0.71	.478	
Maternal education - mid	.37	-0.98-1.73	0.54	.589		0.56	0.02-1.11	2.02	.042		0.57	-0.05-1.19	1.85	.069	
Maternal education - high	.30	-0.91-1.52	0.49	.623		0.38	-0.11-0.86	1.51	.131		0.98	0.42-1.54	3.48	<.001	

Supplement 2

Summary of Linear Regression Models of Associations Between Covariates and Temperament Traits at 6 Months

	Positive emotionality 6mo					Negative emotionality 6mo					Self-regulation 6mo				
Predictors	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2
					.02					.08					.02
Intercept	4.85	4.76-4.94	105.72	<.001		2.94	2.84-3.03	61.29	<.001		5.28	5.20-5.36	126.49	<.001	
Child sex (ref. = boy)	-0.07	-0.16-0.01	-1.66	.097		0.08	-0.01-0.17	1.69	.091		0.01	-0.08-0.09	0.14	.883	
Maternal postpartum psychological distress	-0.03	-0.07-0.02	-1.14	.255		0.22	0.17-0.26	8.89	>.001		-0.08	-0.12—0.04	-3.65	<.001	
Maternal education - mid	-0.03	-0.14-0.09	-0.47	.636		0.02	-0.10-0.15	0.34	.736		0.05	-0.05-0.16	0.95	.345	
Maternal education - high	-0.21	-0.32—0.10	-3.69	<.001		0.09	-0.02-0.21	1.64	.102		-0.09	-0.19-0.00	-1.87	.062	

Supplement 3

Summary of Linear Regression Models of Associations Between Covariates and Temperament Traits at 12 Months

	positive emotionality 12mo					negative emotionality 12mo					self-regulation 12mo				
Predictors	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2	Est.	CI 95%	*t*-value	*p*	Adj. R^2
					.00					.10					.01
Intercept	5.16	5.08-5.24	127.37	<.001		3.16	3.07-3.25	70.71	<.001		5.00	4.91-5.08	111.47	<.001	
Child sex (ref. = boy)	-0.07	-0.14-0.01	-1.75	.081		0.16	0.07-0.25	3.55	<.001		0.05	-0.03-0.13	1.26	.210	
Maternal postpartum psychological distress	-0.02	-0.06-0.02	-0.98	.329		0.23	0.19-0.28	10.06	<.001		-0.08	-0.12—0.04	-3.69	<.001	
Maternal education - mid	-0.02	-0.12-0.08	-0.42	.677		-0.00	-0.12-0.12	-0.04	.969		0.03	-0.08-0.14	0.59	.556	
Maternal education - high	-0.09	-0.19-0.01	-1.76	.081		0.08	-0.03-0.19	1.43	.152		-0.05	-0.15-0.06	-0.92	.357	

Supplement 4

Summary of the Linear Regression Models of Associations Between Positive Emotionality at 6 and 12 Months and Gesturing at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.10						.11
Intercept	33.82	32.79-34.85	64.59	<.001			33.6	32.55-34.68	62.04	<.001		
Child sex (ref. = boy)	3.08	2.09-4.06	6.14	<.001			3.12	2.10-4.15	5.97	<.001		
Maternal postpartum psychological distress	-0.23	-0.72-0.26	-0.92	.355			0.07	-0.45-0.59	0.25	.799		
Maternal education - mid	.40	-0.90-1.70	0.60	.546			0.92	-0.43-2.28	1.34	.182		
Maternal education - high	.28	-0.91-1.48	0.47	.069			0.98	-0.26-2.22	1.55	.122		
Positive emotionality 6mo	2.89	2.40-3.39	11.44	<.001	.001							
Positive emotionality 12mo							3.09	2.56-3.61	11.54	<.001	.001	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates. *N* = 1200.

Supplement 5

Summary of the Linear Regression Models of Associations Between Emerging Self-regulation at 6 and 12 Months and Gesturing at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.04						.06
Intercept	34.09	33.03-35.14	63.23	<.001			34.02	32.94-35.11	61.65	<.001		
Child sex (ref. = boy)	2.93	1.92-3.95	5.66	<.001			2.60	1.54-3.65	4.85	<.001		
Maternal postpartum psychological distress	-0.02	-0.53-0.49	-0.07	.943			0.30	-0.24-0.83	1.09	.278		
Maternal education - mid	0.21	-1.14-1.55	0.30	.761			0.49	-0.90-1.88	0.69	.491		
Maternal education - high	0.64	-0.59-1.87	1.02	.307			0.59	-0.68-1.85	0.91	.361		
Self-regulation 6mo	1.90	1.38-2.42	7.19	<.001	.001							
Self-regulation 12mo							2.40	1.87-2.94	8.76	<.001	.001	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates. *N* = 1200.

Supplement 6

Summary of the Linear Regression Models of Associations Between Negative Emotionality at 6 and 12 Months and Gesturing at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.00						.00
Intercept	34.02	32.94-35.11	61.53	<.001			34.15	33.02-35.27	59.59	<.001		
Child sex (ref. = boy)	3.09	2.05-4.14	5.83	<.001			2.85	1.76-3.95	5.11	<.001		
Maternal postpartum psychological distress	-0.19	-0.73-0.34	-0.71	.477			-0.06	-0.63-0.51	-0.21	.831		
Maternal education - mid	0.40	-0.97-1.78	0.58	.565			0.49	-0.94-1.93	0.67	.501		
Maternal education - high	0.58	-0.68-1.84	0.91	.364			0.19	-1.13-1.51	0.29	.773		
Negative emotionality 6mo	-0.17	-0.71-0.37	-0.62	.536								
Negative emotionality 12mo							.15	-0.42-0.71	0.50	.616		

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates

Supplement 7

Summary of the Linear Regression Models of Associations Between Positive Emotionality at 6 and 12 Months and Receptive Vocabulary at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.05						.04
Intercept	10.02	9.60-10.44	46.85	<.001			10.05	9.62-10.49	45.80	<.001		
Child sex (ref. = boy)	1.05	0.64-1.47	5.04	<.001			1.06	0.63-1.47	4.88	<.001		
Maternal postpartum psychological distress	-0.14	-0.35-0.06	-1.35	.175			-0.09	-0.31-0.12	-0.85	.394		
Maternal education – mid	0.63	0.08-1.17	2.25	.024			0.72	0.15-1.28	2.49	.013		
Maternal education – high	0.71	0.21-1.20	2.81	.005			0.59	0.08-1.09	2.25	.024		
Positive emotionality 6mo	0.79	0.58-0.99	7.46	<.001	.001							
Positive emotionality 12mo							0.76	0.54-0.97	6.87	<.001	.001	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1200

Supplement 8

Summary of the Linear Regression Models of Associations Between Emerging Self-regulation at 6 and 12 Months and Receptive Vocabulary at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.02						.03
Intercept	10.11	9.69-10.53	46.80	<.001			10.15	9.72-10.58	46.07	<.001		
Child sex (ref. = boy)	1.01	0.59-1.43	4.76	<.001			0.93	0.50-1.35	4.25	<.001		
Maternal postpartum psychological distress	-0.09	-0.29-0.12	-0.80	.422			-0.04	-0.25-0.18	-0.32	.751		
Maternal education - mid	0.55	-0.00-1.10	1.96	.051			0.63	0.06-1.19	2.17	.031		
Maternal education - high	0.57	0.07-1.06	2.23	.026			0.50	-0.01-1.01	1.91	.056		
Self-regulation 6mo	0.54	0.32-0.76	4.97	<.001	.001							
Self-regulation 12mo							0.61	0.39-0.82	5.50	<.001	.001	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1200

Supplement 9

Summary of the Linear Regression Models of Associations Between Negative Emotionality at 6 and 12 Months and Receptive Vocabulary at 14 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.00						.00
Intercept	10.07	9.66-10.52	46.05	<.001			10.17	9.73-10.61	45.48	<.001		
Child sex (ref. = boy)	1.06	0.64-1.48	4.92	<.001			1.01	0.57-1.44	4.54	<.001		
Maternal postpartum psychological distress	-0.11	-0.33-0.10	-1.02	.307			-0.10	-0.33-0.13	-0.87	.386		
Maternal education - mid	0.61	0.05-1.17	2.14	.032			-0.60	0.02-1.17	2.03	.042		
Maternal education - high	0.57	0.07-1.07	2.22	.027			-0.40	-0.11-0.92	1.53	.125		
Negative emotionality 6mo	-0.12	-0.34-0.009	-1.11	.265								
Negative emotionality 12mo							-0.05	-0.27-0.18	-0.39	.695		

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1200

Supplement 10

Summary of the Linear Regression Models with Positive Emotionality at 6 and 12 Months Modeled as a Function of 30-month Expressive Vocabulary

	Positive emotionality 6mo						Positive emotionality 12mo					
Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.01						.03
Intercept	4.89	4.80-4.99	104.41	<.001			5.21	5.13-5.29	127.92	<.001		
Child sex (ref. = boy)	-0.11	-0.20—0.02	-2.37	.018			-0.11	-0.19—0.03	-2.70	.007		
Maternal postpartum psychological distress	-0.02	-0.07-0.03	-0.88	.378			-0.01	-0.05-0.03	-0.67	.528		
Maternal education - mid	-0.06	-0.17-0.06	-0.99	.324			-0.06	-0.16-0.04	-1.11	.266		
Maternal education - high	-0.24	-0.35--0.13	-4.26	<.001			-0.13	-0.23—0.03	-2.54	.012		
Expressive vocabulary 30mo	0.08	0.04-0.13	3.54	<.001	.001		0.10	0.06-0.14	4.71	<.001	.001	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

Supplement 11

Summary of the Linear Regression Models with Emerging Self-regulation at 6 and 12 Months Modeled as a Function of 30-month Expressive Vocabulary

	Self-regulation 6 months					Self-regulation 12 months				
Predictors	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2
					.00					.01
Intercept	5.30	5.22-5.39	123.02	<.001		5.02	4.93-5.11	110.11	<.001	
Child sex (ref. = boy)	-0.01	-0.10-0.07	-0.31	.753		0.03	-0.05-0.11	0.64	.525	
Maternal postpartum psychological distress	-0.07	-0.12—0.03	-3.49	<.001		-0.07	-0.11—0.03	-3.47	<.001	
Maternal education - mid	0.03	-0.07-0.14	0.61	.059		0.01	-0.10-0.12	0.19	.848	
Maternal education - high	-0.11	-0.21--.01	-2.21	.027		-0.07	-0.18-0.03	-1.35	.177	
Expressive vocabulary 30mo	0.05	0.01-0.09	2.23	.026		0.06	0.02-0.10	2.74	.007	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

Supplement 12

Summary of linear regression models with negative emotionality at 6 and 12 months modeled as a function of 30-month expressive vocabulary

	Negative emotionality 6mo					Negative emotionality 12mo				
Predictors	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2
					.00					.00
Intercept	2.93	2.83-3.03	59.43	<.001		3.15	3.06-3.24	67.97	<.001	
Child sex (ref. = boy)	0.09	-0.01-0.18	1.77	.078		0.17	0.07-0.26	3.62	<.001	
Maternal postpartum psychological distress	0.21	0.16-0.26	8.82	<.001		0.22	0.18-0.27	9.98	<.001	
Maternal education – mid	0.03	-0.10-0.15	0.41	.681		0.01	-0.11-0.13	0.10	.916	
Maternal education – high	0.10	-0.01-0.21	1.71	.088		0.09	-0.02-0.20	1.57	.118	
Expressive vocabulary 30mo	-0.01	-0.06-0.03	-0.57	.567		-0.02	-0.07-0.02	-0.98	.327	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

Supplement 13

Summary of the Linear Regression Models of Associations Between Positive Emotionality at 6 and 12 Months and M3L at 30 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.01						.02
Intercept	7.31	6.83-7.79	30.48	<.001			7.09	6.61-7.57	29.15	<.001		
Child sex (ref. = boy)	0.65	0.19-1.11	2.81	.006			0.84	0.36-1.32	3.44	<.001		
Maternal postpartum psychological distress	-0.09	-0.32-0.14	-0.78	.437			-0.16	-0.41-0.09	-1.26	.209		
Maternal education - mid	0.55	-0.08-1.19	1.73	.087			0.83	0.22-1.45	2.67	.008		
Maternal education - high	1.02	0.42-1.62	3.39	.001			1.19	0.63-1.76	4.17	<.001		
Positive emotionality 6mo	0.16	-0.05-0.38	1.50	.133								
Positive emotionality 12mo							0.21	-0.03-0.45	1.73	.085		

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

Supplement 14

Summary of the Linear Regression Models of Associations Between Self-regulation at 6 and 12 Months and M3L at 30 Months

Predictors	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	corr. *p*	Δ adj. R^2
						.02						.02
Intercept	7.15	6.68-7.63	29.85	<.001			7.12	6.64-7.59	29.50	<.001		
Child sex (ref. = boy)	0.82	0.35-1.31	3.39	<.001			0.80	0.32-1.28	3.26	.001		
Maternal postpartum psychological distress	-0.14	-0.39-0.11	-1.13	.262			-0.14	-0.40-0.11	-1.12	.265		
Maternal education - mid	0.77	0.19-1.36	2-60	.009			0.81	0.19-1.43	2.58	.011		
Maternal education - high	1.30	0.75-1.85	4.66	<.001			1.18	0.62-1.74	4.14	<.001		
Self-regulation 6mo	0.07	-0.17-0.31	0.56	.575								
Self-regulation 12mo							0.18	-0.04-0.41	1.58	.116		

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

Supplement 15

Summary of the Linear Regression Models of Associations Between Negative Emotionality at 6 and 12 Months and M3L at 30 Months

Predictors	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2	Est.	CI 95%	*t*-value	*p*	Δ adj. R^2
					.02					.02
Intercept	7.14	6.68-7.62	29.89	<.001		7.08	6.61-7.56	29.41	<.001	
Child sex (ref. = boy)	0.85	0.37-1.33	3.52	<.001		0.84	0.36-1.32	3.44	<.001	
Maternal postpartum psychological distress	-0.09	-0.35-0.17	-0.70	.484		-0.11	-0.37-0.14	-0.87	.384	
Maternal education - mid	0.75	0.16-1.33	2.51	.012		0.83	0.21-1.45	2.64	.009	
Maternal education - high	1.31	0.76-1.85	4.72	<.001		1.17	0.61-1.73	4.12	<.001	
Negative emotionality 6mo	-0.15	-0.41-0.10	-1.20	.233						
Negative emotionality 12mo						-0.16	-0.41-0.10	-1.19	.234	

Note. Est = estimates, corr. *p* = Benjamini Hochberg corrected *p*-value, Δ adj. R^2 refers to the change in adj. R^2 when adding a temperament trait to the model involving only covariates, *N* = 1039

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