UNIVERSITY OF PAVIA – IUSS SCHOOL FOR ADVANCED STUDIES PAVIA

Department of Brain and Behavioral Sciences (DBBS)
MSc in Psychology, Neuroscience and Human Sciences

Precursors of Socio-Cognitive Development in Infants with Visual Impairment and in Sighted Controls from 9 to 12 Months

Supervisor:

Prof. Livio Provenzi

Elena Capelli

Thesis written by

Aysel Bilgesu Sancar

501018

Academic year 2023/2024

TABLE OF CONTENTS

Abstract

Infants' precursors of social cognition, including social attention and social awareness behaviors, are meant to emerge through face-to-face interactions early during their development. Their initial tendency to approach social stimuli and later gain awareness of others' internal processes create a foundation for social, communicative, and cognitive abilities. By 9 months, behavioral indicators of this development are quite evident. Infants with visual impairment (VI) might follow atypical developmental paths and show an increased risk of developmental delay due to their limited access to visual cues. The present study investigates the difference in the display of specific infant socio-cognitive behaviors (i.e., gaze orientation, communication, pointing, emotional responses) in sighted infants (SIs) and in counterparts with VI between 9- and 12-months age, during a face-to- face interaction with mother. Fifty-three mother-infant dyads participated: 39 SIs assessed at 9 months (mean age = 9.61 months) and reassessed at 12 months (N=24, mean age= 12.75 months); 14 infants with VI between 9 and 12 months of age (corrected age= 10.18 months) were included for comparison. Mother-infant dyads participated in a 6-minute online video- recorded interaction with 9 structured phases: initial face-to-face play, 4 exposure episodes to auditory stimuli (human and non-human sounds), and 4 reprise episodes. Results showed that SIs from 9 to 12 months showed similar attention to sounds and interacted with mothers using gaze and communication. Pointing, however, increased significantly at 12 months. Emotional responses were more affected by the type of interaction than age, with negativity rising during non-interactive episodes. Furthermore, for infants with VI, the study revealed similar interest in social interaction with their mother as SIs, but not toward the auditory source. Infants with VI exhibited less gaze orientation, communication during the non-human exposure episode, and overall pointing. However, communication with auditory source during the human exposure episode remained similar, suggesting an intent to engage socially. Additionally, while infants with VI displayed blunted emotional responses compared to Sis, their decrease in positive emotionality during still-face suggest they remained sensitive to changes in interaction. This study contributes to our understanding of the early socio- cognitive development in infants with VI and further highlights the importance of investing in early interventions engaging parents that to support their communicate and social development.

Keywords: social cognition, infant, visual impairment, mother-infant

Prologue

The first year of life is a remarkable period for human development. Through their experiences, infants acquire social and cognitive skills, laying the foundation for future learning and interaction. But what happens when a crucial sense like vision is impaired? This thesis, titled "Precursors of Socio-Cognitive Development in Infants with Visual Impairment and in Sighted Controls from 9 to 12 Months" discusses the socio-cognitive development of infants towards the end of their first year of life and the developmental differences of infants with visual impairment.

While my research interests have always encompassed the reflections of the interaction between humans and environment on individuals, my initial focus within this master's program did not necessarily lie in the specific field of early childhood development. However, the developmental psychobiology course taught by Prof. Provenzi in my first semester significantly influenced the evolution of my research interest and my perspective. It was really inspiring for me to consider the environment and human beings as a whole system and to treat this interaction as an existential predisposition from the first years of life, rather than a direct linear approach to human adaptation to or manipulation of the environment. This experience not only expanded my academic horizons but also enriched my personal understanding of human development. Besides the satisfaction of studying on this topic, collaborating with Prof. Provenzi and his research team has been one of the most enjoyable parts of this journey. The warm, dynamic and sharing atmosphere of our team fueled my enthusiasm for research and deepened my commitment to this field.

This thesis is structured into four chapters. The first two chapters provide the theoretical foundation for the study. Chapter one explores the trajectory of socio-cognitive development during the first year of life, detailing the behavioral precursors that indicate infants' socio-cognitive development and examining the mother-infant interaction through the lens of dynamic systems theory. Chapter two delves into the development of visually impaired infants, analyzing how visual impairment affects their socio-cognitive and language development.

Chapter three presents the rationale behind the current study, emphasizing the significance of investigating socio-cognitive behaviors in infants with visual impairment. This section also outlines the study's procedures and includes the results obtained. Finally, chapter four interprets the data, discussing the empirical and clinical implications of the findings and suggesting potential directions for future research.

Acknowledgement

I would like to express my sincere gratitude to my supervisor Prof. Livio Provenzi, my co-supervisor the Doctoral Candidate Elena Capelli for their support, guidance and patience throughout this Master's thesis, and the rest of our research team for the assistance.

I would also like to thank the members of my family and friends who supported me in my scientific journey. My father, my mother and my brother for being consistently present to offer encouragement, and Lorenzo, Deniz, Elio and Tuba for their valuable support over the last two years.

Chapter I

Socio-Cognitive Development in the First Year of Life

1.1. A look at development from the dynamic systems perspective

> The seasons change in ordered measure, clouds assemble and disperse, trees grow to a certain shape and size, snowflakes form and melt, minute plants and animals pass through elaborate life cycles that are invisible to us, and social groups come together and disband. Science has revealed many of nature's secrets, but the process by which these complex systems form patterns – an organized relationship among the parts- remain largely a mystery (Thelen & Smith, 2006, p. 271).

A system contains distinct components that collaborate towards a shared objective. In addition to fields such as physics and mathematics, this concept also attracts the attention of researchers in the field of developmental psychology. Human development serves as an illustrative example of such a complex system. The growth and progression of a human being involve a multitude of diverse components, ranging from molecules to cells, and further on to organs and systems like sensation and cognition.

In tracing the evolution of the concept of "system", we find its roots reaching back to ancient times. However, it was not until the first half of the 20th century that it began to be seen not just as a term, but as a comprehensive concept with distinct features. Ludwig von Bertalanffy has explained this concept in the biological field with his General Systems Theory. While reductionism has long dominated various disciplines since the 1930s, Bertalanffy's theory has challenged this paradigm by spotlighting the interrelationships among a system's constituent elements (von Bertalanffy, 1968). Within this framework, underlying principles applicable across diverse entities emerged. Terms within theory have found their places also in the psychology field. For instance, the principle of self-organization refers to resonance in 'homeostasis,' where internal stressors propel organisms towards behavioral and physiological adjustments, seeking equilibrium. Another principle, openness underscores the active engagement of organisms within open systems, driving them to seek stimulation during imbalance, thereby fostering change.

Subsequently, Dynamic Systems Theory (DST), an outgrowth of General System Theory, has expanded its reach beyond the physical sciences, gaining prominence in psychology and human sciences. Over time, DST has found diverse applications in various domains, including neuroscience (Kelso, 1997), human development (Thelen & Smith, 2006), and interpersonal relationships (Granic & Hollestain, 2003). For example, Thelen (1995), employed the term in the field of human development to understand the progression from initially unpredictable limb movements in newborns to the eventual acquisition of functional skills like grasping objects and walking. Moreover, DST reveals its relevance not only at the individual level but also in understanding group dynamics, as demonstrated by Moussaïd et al. (2010), who revealed the significant influence of social interactions alongside environmental constraints on crowd behavior.

Although there are similarities between the structural approach of Piaget (1954), which constitutes a large part of the basis of developmental psychology studies, and DST in terms of recognizing the natural tendency of the universe towards disorder (entropy), equilibration and the importance of self-organization in the construction of cognitive order, their views on the key driver of development differ. Piaget's structuralism posits predetermined mental structures as internal blueprints guiding distinct developmental stages (Boyd & Bee, 2010), whereas DST advocates a non-linear, emergent perspective (Lewis, Norgate, Collis & Reynolds, 2000). In DST, cognitive structures arise from the continuous interplay between our internal state and the external environment, similar to a complex ecosystem constantly adapting and evolving. This dynamic view necessitates abandoning the idea of pre-programmed structures and instead embraces emergent patterns that come from the ongoing interactions between ourselves and the world around us (Thelen et. al, 1991; Thelen & Smith, 2006). Instead of the notion of structures, Thelen, Ulrich and Wolff (1991) have suggested infants' behaviors are driven by flexible sets of influences called "behavioral attractors". These attractors can fluctuate in performance, leading to different actions depending on the situation. This means we can predict infants' behavior in specific situations, but it's crucial not to assume a rigid, pre-programmed response. Instead, their actions adapt to the circumstances they encounter (Hsu & Fogel, 2003).

Development is depicted as a self-organizing process, wherein various mental components spontaneously align to form intricate and orderly structures (Thelen & Smith, 2006). Within this dynamic framework, these components possess the capacity to undergo modifications, both individually and in their interactions with other elements, thereby shaping the overall behavior of the system. In essence, "change" emerges as a result of multifaceted, interactive processes spanning multiple levels (Thelen & Smith, 2006). It is important to consider this interaction comprehensively. Not only internal interactions but also external factors are, of course, involved. For example, the initiation of crawling is not a pre-programmed motor pattern just activated by the brain. Instead, it necessitates a multifaceted organization of muscle control, sensory integration, cognitive processing and intrinsic motivation. As infants actively engage with their environment, the novel challenges encountered during these explorations act as a catalyst for the advancement of their motor repertoire (Corbetta & Snapp-Childs, 2009).

In addition, the reliance on DST on the nonlinearity of such systems implies that even minor changes can lead to chaotic behavior and unexpected outcomes (Thelen & Smith, 2006). However, these systems possess an inherent capacity for self-organization, enabling them to restore balance after chaos and evolve into more complex and orderly structures (Guastello, Koopmans & Pincus, 2009). Relatedly, DST proposes continuity across behavioral performance across development, as common factors influence behavioral performance at any given time and prior experiences shape the developmental landscape in which future behaviors will emerge (Babik, Galloway & Lobo, 2022). For example, infants first begin picking things up with their whole hand, while they get older, they start to use the pincer grasp while they gain more precise motor control (Thoermer et al., 2013).

In conclusion, with the emergence of the Dynamic Systems Theory, the developmental field of psychology has gained a different perspective on the development of the infant. By emphasizing the continuous interplay between internal states and external environments, this theory highlights the crucial role of experience in shaping an infant's capabilities. This perspective moves away from the idea of predetermined stages and instead embraces the dynamic nature of development, where infants actively construct their understanding of the world through ongoing interactions. The ability to learn and adapt to new challenges becomes paramount, with the environment acting as a catalyst for the emergence of complex skills. Therefore, DST underscores the importance of creating rich and stimulating environments for infants, as these experiences provide the foundation for ongoing growth and development.

1.2. Socio-Cognitive Skills Through the First Year of Life

Many adult mammals and primates live in social groups where they can recognize each other and build different kinds of relationships (Tomasello & Call, 1997). Humans stand out among social animals due to their unmatched sophistication in navigating social cues. This complexity demands constant development and refinement of a vast skill set throughout life. The most appropriate strategy is found to adapt to the environment and maintain balance (Guastello et al., 2009). We sense from the beginning and while getting older we learn to identify, process, interpret, and react to the ever-shifting landscape of social cues, which can be subtle, numerous, conflicting, and even contradictory (Beaudoin & Beauchamp, 2020). Dynamic Systems Theory supports this view by emphasizing how social interactions are constantly evolving and how individuals adapt through self-organization and interaction with their environment. This perspective underscores the importance of flexible and adaptable responses to the complex and dynamic nature of social life.

The complex process of acquiring and responding to information forms the basis of social cognition, the study of how people think and feel about other people and themselves. In every interaction with our environment, a constant evaluation unfolds within us. We receive information through our senses, filter it through our past experiences and the current context, and based on this analysis, we make decisions, plan actions, and ultimately take steps into the world.

Infants demonstrate early signs of social awareness from birth, but the foundations of social cognition are built through face-to-face interactions that develop over time. By 6 months, infants can engage with their social partners by manipulating interactions and recognizing and responding to others' emotions while also expressing their own (Boyd & Bee, 2010). By 9 months, this knowledge expands to understanding not only the emotions of others in their relationships with themselves but also the intentions in their interactions with the outside world (Rochat, 1999). Around this age, infants show the capacity to engage in triadic interactions, involving the ability to share attention on the same object or event with another person. They start to engage in gaze following, tune in to the adult's attention and behavior toward external entities. Moreover, they realize that they can manipulate adults' attention and behavior through gestures (Rochat, 1999). This growing social cognition fuels their interaction with both people and the environment. They begin to utilize cultural tools and language, allowing them to fully participate in traditions, rituals, and games (Tomasello, 1995). In essence, their social understanding expands from basic emotions to encompass intentions and cultural practices.

Carpenter and colleagues (1998) have shown that the period between 9 and 12 months is important in the development of infants’ initial skills in social cognition and communication.

In addition, this period was followed by infants' acquisition of both language comprehension and production skills. Most infants demonstrated proficiency in all skills assessed at 12 months of age, except productive language which conveys meaning, thoughts etc. (Carpenter et al., 1998). Furthermore, individual differences in socio-communicative skills start to be evident between 9 and 12 months (Hatch et al., 2021; Miller et al., 2017).

Nevertheless, there are still innate clues to this development of socio-cognitive behavior prior to the association with a partner. Our faces, gazes, and expressions serve as powerful social stimuli, and infants are drawn to them from birth. Infants' sensitivity to gazes, which can be observed even in the early stages. For instance, newborn infants prefer face-like patterns to non-face-like patterns with eye and head movements (Easterbrook, Kisilevsky, Hains & Muir, 1999). In literature, this early sensitivity refers to social attention which plays a key role in the social, cognitive and motor development of infants. Research suggests that infants' inherent sensitivity to social cues fosters an attuned responsiveness to the world around them, creating a stable environment conducive to learning (Shultz, Klin & Jones, 2018). Their heightened attention to faces, in particular, facilitates dyadic interactions with caregivers, laying the groundwork for the emergence of reciprocal social exchanges (Senju & Johnson, 2009). Furthermore, object-directed behaviors such as reaching, manipulating, and exploring, also contribute positively to infants' socio-cognitive development (Hunnius & Bekkering, 2014). The link between early social attention and later social information processing has been well-established, with studies demonstrating its influence on subsequent social-communicative and cognitive abilities (Klin, Shultz & Jones, 2015; Dawson, Bernier & Ring, 2012). Behaviors such as orienting, pointing ve communicating with a third object which shows social attention, are considered as halfway between socio-emotional skills such as approach to other people and socio-cognitive abilities such as recognizing others as separated and sharing a specific interest for an object in the environment (Legerstee & Barillas, 2003). In addition, some authors have argued that directing infants' own attention to something is a more complex behavior than following and directing the attention of others, i.e. joint attention. (Bates et al., 1979).

This section examines the emergence and transformation of these verbal and non-verbal skills and behaviors in the first year of life, with a particular focus on how they illuminate infants' socio-cognitive development.

1.2.1 Gaze orientation

Gaze orientation has been extensively studied in various contexts in infant social cognition research. It is interpreted as a significant social cue and has been frequently observed in studies with newborn infants. Remarkably, even newborns between 2 and 5 days old have shown sensitivity to differences in gaze orientation, distinguishing between direct and averted gaze and using gaze direction as a spatial cue, suggesting a primitive form of gaze tracking (Farroni et al., 2004). By the age of 2 months, infants are more alert, have better control of head and gaze direction and are able to sustain visual attention for longer periods of time. (Kärtner, Keller & Yovsi, 2010; van Wulfften Palthe & Hopkins, 1993; Lavelli & Fogel, 2002). By 3-8 months, infants demonstrate improved visual processing efficiency. This coincides with the development of brain regions critical for visual processing and the growing influence of endogenous attention (Colombo, 2001). Infants who manage their gaze effectively incorporate gaze into their social interactions; direct eye contact indicates readiness to interact, whereas gaze avoidance signals disinterest. Moreover, these functions of gaze form the basis of early co-regulation between infants and caregivers, promoting turn-taking and responsiveness to interpersonal cues that are crucial for healthy social development (Reddy, Hay, Murray, & Trevarthen, 1997). Many neurodevelopmental and psychiatric disorders affecting social functioning have pointed to atypical gaze behaviors in early childhood (Watson et al., 2008; Yirmiya et al., 2006). Understanding and responding to gaze forms the basis of meaningful face-to-face interactions between infants and their caregivers and is crucial for establishing strong emotional bonds and developing social skills (Feldman, 2007).

From the birth of the infant, looking at each other's face or mutual gaze has served crucial communicative and affective functions in caregiver-infant interaction (Csibra & Gergely, 2009; Heyes, 2015). Infants at 5 months have selectively attended to a native-language speaker, who is looking directly at them while speaking (Marno et al., 2016). Around 8-9 months, infants demonstrate the ability to direct their attention towards an object and acquire the attention of another individual without employing gaze alternation. However, by 10-11 months, a shift occurs, and they begin to utilize gaze orientation strategically, looking back and forth between the object of interest and the person they wish to engage (Beuker, Rommelse, Donders & Buitelaar, 2013). Meanwhile, individual differences in this period were thought to be related to later language development (Carpenter et al., 1998; Morales et al., 2000). Furthermore, the effect of some maternal behaviors and speech such as touch also have been found related to gaze orientation behavior of the infant (Grumi et al., 2024). More nurturing use of speech has shown positive effects on infants' gaze orientation to mother in typically developed infants during the Face-to-face still-face (FFSF) paradigm.

1.2.2. Communication

In the first weeks following birth, infants produce sounds known as hums and murmurs, which are not necessarily associated with specific emotions like laughing or crying but rather with being alert or relaxed (Oller et al., 2013). These speech-like sounds of human infants have been considered as precursors to speech because they show a gradual progression in acquiring the distinct sound characteristics of spoken language (Koopmans-Van Beinum & Van Der Stelt, 1986). These sounds, referred to as protophones, are mostly assumed to be endogenously generated because even when infants are alone, the rate of production remains high (Oller et al., 2021). The production of these protophones later emerges as canonical babbling. In the latter part of the first year of infancy, typically developed infants produce babbling sounds resembling speech, which are often mistaken for meaningful communication. The syllables prevalent in babbling also commonly appear in early spoken language (Oller, Eilers, Bull & Carney, 1985). Although infants produce vocalizations right from birth, the onset of first words and the ability to direct adults' attention through vocalizations and facial expressions is generally expected at around 12 months of age (Oller, 2000). Beuker et al. (2013) have shown that the age range of 8 to 15 months is critical for the development of early communication skills and the onset of many verbal and non-verbal communication behaviors. Most distal gestures appeared between 8 and 11 months, while proximal gestures such as give and show appeared around 12 months. Infants advance from merely sharing attention to following and eventually directing others' attention and actions. Most infants are capable of using gestures during interaction at 10 months of age, then it takes several months before they can effectively coordinate these gestures with gaze shifts, thereby enhancing their communicative abilities. However, Carpenter et al. (1998) reported that some early communication skills such as proximal showing gestures such as shows do not fully emerge at 15 months. In addition, while spoken language becomes more important as infants develop, it doesn't replace non-verbal communication entirely. Between 9 and 13 months, infants actually add new ways to communicate both verbal and non-verbal to their existing toolbox, rather than just switching to speaking completely (Bates et al., 1979).

One of the most important contributors to infants acquiring language skills is considered to be environmental factors. While older studies suggested that infants begin to imitate sounds from birth and focused on parental input as the primary mechanism for acquiring language components (Kymissis & Poulson, 1990), recent studies emphasize the importance of the environment, especially parental speech (Perszyk & Waxman, 2019). Activities such as parents telling stories and reading books to their infants before the age of 3 have a significant impact on their cognitive and language acquisition development (Bornstein & Haynes, 1998). Increased communication with parents of infants between the ages of 2 months and 36 months has been associated with vocabulary development and higher IQ scores at later ages (Hart & Risley, 1995). Moreover, Caskey and colleagues (2011) have examined the sound environment and language exposure effects on vocalization in premature infants cared for in the NICU. Results have indicated that infants produce more vocalizations with increased language exposure, highlighting the significant impact of parental talk on vocalization in preterm infants.

1.2.3. Pointing

In the first year of life, infants begin to communicate using various methods, including gestures. Gestures used to draw attention to an event or object can be defined as deictic gestures, such as open-handed reaching or ritualized gestures to indicate refusal. Effective use of this movement is seen in infants aged around 9 to 11 months (Crais, Douglas & Campbell, 2004). Open-handed reaching behavior, which is typically seen around 8 or 9 months, is followed by showing and giving, which is observed between 9 and 13 months (Masur, 1983). By 10 to 13 months, they are interacting with the object that attracts their attention using pointing behavior (Beuker et al., 2013). At 12 months they can use pointing to direct adult attention towards objects they find interesting (Liszkowski et al., 2004). Sensitivity to the communicative properties of the 'give-me' gesture, characterized by an open palm directed towards the observer with the face looking upwards, develops around 12 months of age. Similarly, the development of pointing, another gesture involving interaction with distant objects or events, also occurs during this period (Elsner et al., 2014).

A pivotal stage in the development of preverbal socio-cognitive abilities involves pointing, which is described as the act of extending the arm and the index finger toward a target, while keeping the other fingers curled (Bates, Camaioni & Volterra, 1975; Colonnesi, Stams, Koster & Noom, 2010). Pointing is widely regarded as the primary deictic gesture for communication, playing a crucial role in the development of social cognition and language (Colonnesi et al., 2010; Liszkowski, Carpenter & Tomasello, 2007). In infants, the act of pointing manifests with distinct motivational underpinnings: imperative, declarative and interrogative.

Imperative pointing denotes the infant's expression of a desire for a specific action or object. Infants engaging in imperative pointing demonstrate an emerging awareness of utilizing others to satisfy their needs and desires (Liszkowski et al., 2004). Declarative pointing, on the other hand, is primarily utilized for sharing and informing about objects and events. The aim is not to achieve a specific goal but to perceive the interactive partner as a mental agent and direct their attention towards communication or providing information about a third entity (Camaioni,1997; Liszkowski et al., 2004; Behne et al., 2012). Research has indicated that declarative pointing is associated with language ability both concurrently and longitudinally (Southgate, van Maanen & Csibra, 2007; Salo et al., 2019).

Interrogative pointing is thought to be an important tool for cultural learning, allowing infants to seek and absorb different types of information, such as showing how an object works, describing an object, understanding its significance, or explaining an event (Southgate et al., 2007). In this case, an infant exhibits pointing behavior with the aim of acquiring information about an object or mechanism they are curious about (Baldwin & Moses, 1996; Southgate et al., 2007).

Pointing is considered one of the key precursors to subsequent socio-cognitive development and language abilities (Baron-Cohen, Allen & Gillberg, 1992; Cochet, Jover, Rizzo & Vauclair, 2017; Colonnesi et al., 2010; Lüke et al., 2017; Rohlfing et al., 2022). Delays in pointing behavior onset may signal atypical socio-cognitive development, such as autism spectrum disorder or delayed language development (Ibanez, Grantz & Messenger, 2013; Sansavini et al., 2019; Rohlfing et al., 2022). Typically, infants exhibit pointing behavior between 7 and 15 months of age, and although the average onset is thought to be around 12 months of age (Camaioni, Perucchini, Bellagamba & Colonnesi, 2004; Perucchini, Bello, Presaghi & Aureli, 2021), some studies suggest that the use of index finger pointing using the typical hand posture may not be fully observed until approximately 18 months of age (McGillion, Pine, Herbert & Matthews, 2017). Recent research has shown that in typically developing infants, imperative pointing begins to emerge as early as 12 months, while the use of declarative and informative motivations for this behavior starts around 14 months (Rohlfing et al., 2022). Moreover, infants showing delayed language development exhibited index-finger pointing behavior approximately 2 months later than typically developing infants (Rohlfing et al., 2022).

Environmental factors significantly influence the occurrence of this behavior. Parents who engage in more pointing gestures tend to have infants who also demonstrate increased pointing behavior during interactions. Rowe and Leech (2019) conducted a study where they educated parents of 10-month-old infants about the significance of pointing in language development and how frequent pointing can positively impact their infants' development. Infants whose parents received this training exhibited more frequent pointing behavior toward a wider variety of objects during play compared to infants whose parents did not receive the training (Rowe & Leech, 2019). Parents' pointing behavior also influences their infants' adoption of this behavior. Salo and colleagues (2019) showed that mothers' use of declarative pointing correlated with their infants' concurrent language development, whereas their use of imperative pointing did not. Furthermore, there was an interaction between parental and infant declarative pointing, indicating that the positive correlation between mothers' declarative pointing and infants' concurrent receptive language skills was observed only among infants who also exhibited declarative pointing behavior (Salo et al., 2019). In addition, recent findings by Nazzari and colleagues (2023) indicate that maternal stress during pregnancy, particularly during the pandemic, can impact infants' socio-cognitive development by the age of 12 months. Infants whose mothers experienced elevated prenatal stress levels related to the pandemic showed less index finger pointing behavior, suggesting the impact of maternal stress exposure on infants' socio-cognitive behaviors.

1.2.4. Emotionality

Hobson (1993) proposes that the foundation for a child's understanding of other minds lies in their innate ability to respond to the emotions of others. This suggests that empathy and emotional regulation play a crucial role in the early development of socio-cognition. For instance, infants who exhibit a heightened still-face response, characterized by increased negative emotionality and decreased positive emotionality, at 6 months demonstrated a greater propensity to engage in gaze following and pointing gestures by stranger adults during play sessions at 12 months (Yazbek & D'Entremont, 2006). Moreover, early abnormalities in socio-emotional experience may contribute to social, cognitive and communicative delays and abnormalities (Minter, Hobson & Bishop, 1998; Zwaigenbauma et al., 2005).

Recent studies delving into the biological underpinnings of how early psychosocial factors shape neuronal development propose that human development results from a dynamic interplay between biology and social experiences, rather than adhering to a predetermined sequence of developmental stages (Cross, Fani, Powers & Bradley, 2017; Newman, Sivaratnam & Komiti, 2015). This perspective underscores a dynamic systems approach, highlighting the interaction between internal and external influences in fostering adaptation. Since the child is unable to independently regulate emotions, they rely on parental assistance for regulation, which in turn facilitates the eventual development of independent emotional regulation, known as self-regulation (Kappas, 2011). It has been shown that caregiving plays a unique role in the development of self-regulation, which is a fundamental component of executive functioning

(Nelson, Bos, Gunnar & Sonuga-Barke, 2011). In this sense, the social-emotional development necessary for emotion regulation is intertwined with socio-cognitive development and relates to the growth of the basic aspects necessary for the child to participate effectively as a partner in social relationships.

Positive emotionality typically emerges in the initial months of infancy, gradually becoming more common and intense as infancy progresses into the toddler years (Dinehart et al., 2005; Sallquist et al., 2010). Active and meaningful smiling begins to appear around 3 weeks of age, with social smiling behavior exhibited around the second month. Laughter is observed around the 4th month (Srofe & Walters, 1976). Numerous studies have examined the dynamic expression of infants' positive emotions in joint attention contexts (Jones & Hong, 2005; Striano & Bertin 2005, Carpenter & Liebal 2012). Towards the end of the initial year of life, infants start integrating their smiling gestures into intentional communication with their mothers (Jones & Hong, 2005). Carpenter and Liebal (2012) conceptualized the significance of mutual eye contact accompanied by positive emotions between infants and their caregivers as a form of recognizing the shared awareness during their interactions. They suggest that infants and their caregivers acknowledge the collaborative nature of these moments of joint attention through mutual gazes and smiles.

Like positive emotionality, negative emotionality has been associated with infants' socio-cognitive development. Negative emotionality is defined as an individual's inclination to respond negatively, exhibiting feelings of anger, anxiety, fear, and sadness (Rothbart & Bates, 1998). Behaviors addressed under the umbrella of negative emotionality in infant studies have varied in their research objectives. Behavioral codings such as anger, inhibition, difficulty, irritability and fear, among others, are commonly used in studies to indicate negative emotionality (Paulussen-Hoogeboom, Stams, Hermanns & Peetsma, 2007). Studies have demonstrated the predictive effect of the interactive influence of infant negative emotionality and cognition on later developmental differences in attention, executive functions, and language skills (Joseph et al., 2022; Cioffi et al., 2021). While employing executive function and language skills can help infants manage their negative emotions strategically, heightened negative emotionality ultimately limits infants' ability to utilize advanced regulatory strategies effectively (Cole, Bendezú, Ram, & Chowa, 2017). Cioffi and colleagues (2021) showed that negative emotionality at 9 months old was associated with decreased executive function and language skills by the time the children reached 7 years old. These studies underscore the existence of an affective-cognitive pathway in infants' development and highlight the importance of emotionality research in socio-cognitive studies.

Previously, emotionality was defined as characteristic traits that infants bring from birth, known as temperament (Rothbart & Bates, 1998). However, recent approaches indicate that emotionality in infancy is not solely biological. The importance of the quality and quantity of interaction with parents in emotional development has been demonstrated in many studies (Propper & Moore, 2006; Paulussen-Hoogeboom et al., 2007; Bridgett, Laake, Gartstein & Dorn 2013). Propper and Moore (2006) have shown that although certain genetic variations may lead to different infant emotionalities, such as depression, impulse control, or behavioral problems, this connection becomes stronger when combined with factors like insensitive parenting, abuse, neglect, or challenging family environments. Moreover, it has been observed that the problem-solving and planning abilities of mothers have an impact on infants' negative emotions (Valiente, Lemery-Chalfant & Reiser, 2007). Infants of mothers who excel in this regard have shown more initial smiling and laughter (Bridgett et al., 2013).

This section examines behaviors indicative of social attention, such as gaze orientation, communication, pointing, and emotionality, to illuminate the socio-developmental trajectory of infants nearing the end of their first year. While research has shown that these behaviors are influenced by both the infant's developmental stage and environmental factors, caregivers hold a particularly crucial role within an infant's environment during this critical first year (Rocha, Santos Silva, Santos & Dusing, 2020). Consequently, infant studies have predominantly focused on caregiver-infant interactions and related procedures when observing social skills and development. One such procedure involves observing face-to-face interaction between these dyads under specific conditions relevant to the skills being assessed. This topic will be addressed in more detail in the next section.

1.3. Face-to-Face Caregiver-Infant Interaction

The interaction between infants and caregivers, initiated even before birth, strengthens over time through gestures, smiles, mutual gaze, and vocalizations (Colonnesi, Zijlstra, van der Zande & Bögels, 2012). As research accumulates, our understanding of infant-caregiver interactions has evolved, recognizing infants as active contributors rather than passive recipients (Murray & Traverthen, 1986). Provenzi et al. (2018) further argue that the dynamic systems approach (Sravish et al., 2013; Beebe et al., 2016) offers a more nuanced understanding of the infant's role in these interactions. Correspondingly, observational studies exploring the significance of early infant-caregiver interaction have gained prominence (Rocha et al., 2020).

1.3.1. Face-to-Face Still-Face Paradigm

Notably, the Face-to-Face Still-Face Paradigm (FFSF) remains one of the most widely used procedures for observing caregiver-infant interactions within the literature (Provenzi et al., 2018). FFSF was introduced to investigate the idea that infants actively participate in social interactions (Tronick et al., 1978). This paradigm allows for the observation and analysis of the implicit dynamics during the interaction between a mother and her child. Initially, researchers use this paradigm to understand how infants develop emotional regulation skills, how mothers and infants adjust their behavior towards each other, and how these early interactions lay the foundation for personality development.

During the development of the "face-to-face" procedures to investigate mother-child interaction in a controlled environment, various methodologies were designed using audio-visual technologies and applied to infants of different age groups (Provenzi et al., 2018). Its flexibility allows researchers to assess not only infants' early sensory experiences but also their social understanding, emotional regulation, attention control, and other social, emotional, and cognitive skills (Adamson & Frick, 2003). Studies have successfully used the FFSF to explore various developmental areas, including emotional regulation (Hsu & Jeng, 2008), behavioral stress response (Montirosso et al., 2015), physiological reactivity (Provenzi et al., 2017), and socio-cognitive development (Montirosso et al., 2014; 2015).

In the classical experimental setup, mother and infant were typically seated facing each other in the absence of any external individuals or objects, with the instruction for the mother not to physically hold the child. The primary aim of this methodological approach was to assess the child's ability to adjust their communicative behaviors in response to the mother, as well as to analyze the mother's communicative responses to the child (Als, 1982). The traditional FFSF paradigm exposes young infants to three consecutive interactive scenarios: Firstly, a regular face-to-face interaction between caregiver and infant, where caregivers engage with their infants in a typical manner. This is followed by a *still-face episode*, during which caregivers are instructed to maintain a neutral, unresponsive expression, refraining from smiling, touching, or communicating with their infants. Finally, a *reunion episode* occurs, where caregivers and infants resume their typical face-to-face interaction. Each segment typically lasts 2–3 minutes, with a modal length of 2 minutes. The paradigm has been utilized with infants aged 2–12 months (Adamson & Frick, 2003). Infants commonly exhibit what researchers term *the still-face effect* in response to the still-face scenario. Consistently observed across multiple studies, this effect is characterized by infants showing a notable rise in avoiding eye contact, a reduction in displaying positive emotions, increase in negative affect, visual scanning, pick-me-up gestures, as well as psychophysiological stress indicators, such as heart, respiratory sinus arrhythmia (Adamson & Frick, 2003; Weinberg, Tronick, Cohn & Olson, 1999; Abney, da Silva & Bertenthal, 2021; Jones-Mason, Alkon, Coccia, & Bush, 2018). While the still-face phase dominates research, *the reunion phase* offers valuable insights into emotional regulation between mothers and infants (Weinberg & Tronick, 1996). Initially, it has been thought that reunions typically show an increase in positive emotions. Infants display joy through facial expressions, increased eye contact with their mothers, and positive vocalizations/gestures (Weinberg & Tronick, 1996).

However, some infants have exhibited signs of negative emotions, such as gestures indicating a desire to be picked up, moving away from the caregiver, and displaying autonomic stress signals. They have been more prone to fussiness and crying during the reunion episode compared to the still-face episode. These findings showed that the infant's negative emotional states were not quickly alleviated by the return of maternal interaction, suggesting that negative emotions persisted from the immobile face period to the reunification period (Weinberg, Olson, Beeghly & Tronick, 2006; Tronick et al., 1978). Additionally, some infants show a *carry-over effect* with reduced smiles in reunion compared to the play episode (Weinberg & Tronick, 1996).

The most common version of the FFSF procedure comprises three equally timed phases conducted in a controlled environment: an initial play episode featuring natural interaction between mother and infant, followed by a still-face episode where the mother exhibits unresponsiveness and maintains a neutral expression, concluding with a reunion episode to observe the infant's response to re-engagement. Variations of this classic procedure exist, with some studies incorporating a double still-face episode to intensify the infant's stress level within the paradigm (Haley & Stansbury, 2003). Regardless of the specific version employed, the FFSF setup typically involves positioning the mother and infant facing each other in a quiet room for a set period. Cameras strategically capture frontal views of their faces and hands throughout the interaction, providing researchers with valuable data for analyzing the subtle cues and behaviors exchanged during these critical moments.

The traditional structure of the FFSF paradigm typically involves recording interactions between infants and their mothers in a laboratory setting. However, in response to the challenges posed by the COVID-19 pandemic, researchers have developed strategies for remote data collection, particularly in the field of developmental psychology. This methodology, particularly facilitating the collection of behavioral data, has demonstrated its effectiveness in remote data collection concerning mother-infant interactions and infant developmental monitoring, as evidenced by previous studies (Shin, Smith & Howell, 2021). Nazzari and colleagues (2023) employed remote data collection techniques with the FFSF procedure and demonstrated the socio-cognitive development of 12-month-old infants of mothers exposed to prenatal stress.

In conclusion, the FFSF paradigm emerges as a powerful tool with a solid foundation for observing the socio-cognitive and socio-emotional development of both typical and at-risk infants (Mesman,van Ijzendoorn & Bakermans-Kranenburg, 2009; Provenzi et al., 2017). Its strong scientific basis and flexibility make it a potential source of inspiration for other caregiver-infant procedures.

1.3.2. Observing Infants' Socio-Cognitive Behaviors During Face-to-Face Caregiver-Infant Interaction with Auditory Stimulation

The previous section highlighted social attention behavior as a crucial indicator of emerging socio-cognitive abilities in infancy. This cognitive function is shaped by the interplay between sensory-motor integration processes and environmental stimuli (Dionne-Dostie et al., 2015). Infants actively engage with their surroundings, bombarded by visual, auditory, and tactile experiences. Through sensory-motor integration, these stimuli influence the direction, duration, and intensity of an infant's attention. Caregivers, as primary figures in an infant's first year, provide a rich mix of these environmental stimulations. This fosters expectations about the environment and promotes the development of early attention skills (Baker et al., 2010; Provenzi et al., 2017). Consequently, observing how infants interact with caregivers by tracking their attention sheds light on the development of social skills.

Traditionally, research on infant attention and social interaction within a socio-cognitive and socio-emotional framework has primarily relied on visual stimuli, such as the FFSF (Bastianello et al., 2022; Shultz, Klin & Jones, 2018; Provenzi et al., 2018). However, recent studies have sparked curiosity about the potential impact of non-visual stimuli on infant socio-cognitive attention (White-Traut et al., 2022; Perucchini et al., 2021; Botero, 2016). One such stimulus is auditory stimuli, especially human sounds (Dawson et al., 2004). Between 8- and 10-months infants can recognize the speech sounds of their own language and by 9 months they demonstrate an understanding of simple words such as mommy and daddy (Benedict, 1979). As early as 12 months, infants begin to actively share interesting sounds with their caregivers during social interactions, highlighting the important role of auditory stimuli in communication and attention development (Stern, 1985; Fernald et al., 1989). Research suggests that auditory social information supports infants' inherent ability to engage in interactive exchanges with caregivers (Adamson et al., 2019). For instance, mothers' vocalizations are not only captivating to infants but also influence their behavior, emotions, and physiological state (Williamson & McGrath, 2019; Abrams et al., 2016). Furthermore, a lack of attention to human sounds in early infancy can be indicative of atypical development, such as autism spectrum disorder (Dawson et al., 2004). These findings demonstrate that auditory experiences not only shape infant development but also serve as a valuable tool for researchers to observe and understand this process.

Beyond the general influence of auditory stimuli, research has also explored the significance of sound type. It has been argued that infants discriminate between speech and non-speech sounds (Moore & Linthicum, 2007). Adamson et al. (2019) investigated how infants respond to different sounds during face-to-face interactions with parents, focusing on attention and sharing behaviors. The study included various sounds such as speech about the infant, instrumental music, animal calls, and mechanical noises. Notably, even at 12 months old, infants attempted to share these sounds with their caregivers, especially speech and mechanical noises. However, unlike previous research, the study did not find a significant difference between speech and mechanical sounds. By 30 months, almost all infants displayed this sharing behavior. The research also uncovered a significant trend in pointing behavior, which increased markedly between 12 and 18 months before declining. The researchers suggest that this decline could be attributed to language development, with improved vocal skills leading infants to rely more on vocalizations than pointing for communication (Adamson et al., 2019). Moreover, a recent study by Nazzari et al. (2023) found no difference in orientation towards human and non-human auditory stimuli in 12-month-olds. While 80% of infants exhibited communication behavior directed at the sound, only 48% displayed index finger pointing during the interactive task. Examining the type of sound in a clinical sample also yielded interesting results. Infants with ASD have shown less alertness and orientation to speech about their sound compared to typically developing infants and non-ASD developmental disorders, although their response to other sound types did not differ such as mechanical noises, animal calls and instrumental music. Additionally, infants with ASD were less likely to share sounds with their parents (Adamson et al., 2020).

In conclusion, there are various methods to observe infants' socio-cognitive behaviors during caregiver-infant interactions. FFSF is a popular procedure that allows researchers to explore infants' attention behaviors such as orienting, pointing, communicating as well as emotionality, all of which contribute to socio-cognitive development. While visual attention has traditionally been the primary focus in this research area, recent procedures have shown new ways to explore infant attention using auditory stimuli. However, there is still little longitudinal data assessing socio-cognitive responses to sound in typical development. In addition, this opens doors to investigating how infants, both typically developing and those with clinical conditions, utilize their senses and social skills during interactions with caregivers (Adamson et al., 2019; 2020).

Given the significant role of sensory inputs from the environment and their integration in infant development, a crucial question emerges: what happens when one of these sensory channels is missing? The next section will delve into this topic and explore the implications for infants with sensory impairments.

Chapter II

A Glimpse to Infants with Visual Impairment

2.1. Vision in Infancy

Vision plays a crucial role in numerous adaptive functions, including the formation of the bond with the caregiver, facilitating motor development, supporting cognitive processes such as attention and memory, fostering communication and language acquisition skills, and promoting spatial awareness (Fazzi et al., 2005). It allows us to perceive the world around us by interpreting the interaction of light with various objects. The eye, intricately designed for the detection, localization, and analysis of light, comprises several distinct components, each serving a specific function.

At the core of the visual process lies the pupil, controlling the entry of light into the eye, surrounded by the iris and supported by the cornea and sclera. The eyeball, housed in the bony socket of the eye's orbit, is moved by extraocular muscles attached to the sclera, while the conjunctiva conceals these muscles. Beyond the eye, the optic nerve connects to the base of the brain, with optic vesicle development beginning in the 4th week of gestation and critical components like the retina and ganglion cells differentiating between the 15th and 30th weeks. However, neural connections between the visual cortex and subcortical structures develop after birth (Bear et al., 2006).

At birth, infants exhibit a visual acuity ranging from 20/200 to 20/400, which rapidly improves due to critical brain developments such as myelination, dendritic growth, and synaptic pruning (Keech, 2002). By around 2 months, infants begin to track moving objects, though initially inefficiently, with significant improvements noted between 6 to 10 weeks (Aslin, 1987; Boyd

& Bee, 2010). Between 2 and 3 months, cortical development facilitates a shift in infant attention from locating objects to identifying them, enabling infants to scan entire figures and focus on internal features, thereby enhancing their ability to recognize objects and discern detailed patterns (Boyd & Bee, 2010). By 3 months, infants start using kinetic information to judge depth and exhibit a dedicated face-processing area in the brain, showing preferences for attractive faces and their mother's face (Bornstein et al., 1992; Frichtel & Lécuyer, 2006; Bushnell, 2001). By 4 months, they begin utilizing binocular cues for depth perception, where each eye receives slightly different images to aid in distance judgment (Bornstein et al., 1992; Frichtel & Lécuyer, 2006). Between 5 to 7 months, infants start using pictorial or monocular cues, such as interposition and relative size, to understand spatial relationships, with depth perception abilities evident by 6 months (Bornstein et al., 1992; Frichtel & Lécuyer, 2006; Gibson & Walk, 1960). Throughout the first year, infants continue refining their visual acuity, achieving approximately 20/20 vision by two years of age (Keech, 2002). Additionally, early audiovisual integration is evidenced by newborns' recognition of their mother's voice, which directs their attention to her face (Sai, 2005). These interconnected developments highlight the rapid and profound advancements in infants' visual and cognitive processing during their first year.

2.1.1. Visual Impairment in Infancy

The International Classification of Diseases (ICD-10) provides a framework for categorizing levels of visual impairment based on best-corrected presenting distance visual acuity. The categories range from mild or none to blindness, with corresponding acuity thresholds. Mild or none visual impairment is defined by best-corrected presenting distance visual acuity worse than 6/18 but equal to or better than 3/10, while blindness encompasses acuities worse than 3/60. The severity of impairment progresses from mild to moderate, severe, and ultimately blindness, with specific acuity thresholds delineating each category (WHO, 2010).

Diagnosing and intervening in visual impairment and blindness in infancy presents significant challenges due to various factors. These challenges stem from several factors, including infants' inability to verbally express symptoms and potentially incomplete medical histories provided by caregivers. The initial year of life is pivotal for visual system maturation and the formation of binocular vision (Day, 1997). If visual impairments are not addressed during this critical window, they can lead to conditions like amblyopia and permanent visual deficits. This underscores the critical importance of early identification and prompt intervention (Rahi, Gilbert, Foster & Minassian, 1999). Early visual loss can also profoundly impact infants' motor development, social interactions, emotional well-being, and psychological growth (Dale & Salt, 2007).

Congenital visual impairment (CVI) can arise from abnormal development or damage to components of the visual system during gestation or early infancy. These impairments may manifest either before birth (prenatal) or after birth (postnatal) (Gilbert, Foster, Négrel & Thylefors, 1993). Such impairments can originate from cerebral sources affecting the posterior visual pathways or peripheral sources affecting the globe, retina, or optic pathway. Cerebral source (posterior visual pathways and visual nervous system) causes may include complications of prematurity, hypoxic-ischaemic encephalopathy, cytomegalovirus infection, or oculomotor disorders, while peripheral (globe, retina or anterior optic pathway disorders may manifest as symptoms of central nervous system syndromes or as isolated conditions (Sonksen & Dale, 2002).

Prenatal causes encompass congenital anomalies such as anophthalmos, microphthalmos, and coloboma, congenital cataract, retinal dystrophies like Leber's congenital amaurosis, infantile glaucoma, and congenital cloudy cornea (Gogate, Gilbert, & Zin, 2011). The occurrence of congenital cataract stands at 3-5 cases per 1,000 births. While various factors such as genetic abnormalities, syndromes, metabolic disorders, and congenital rubella syndrome are known to contribute to this condition, the cause remains unidentified in most cases (Rahi & Dezateux, 2001). Notably, congenital cataract is becoming a more significant cause of childhood blindness in developing nations, while other causes are decreasing (Mwende et al., 2005). Retinal dystrophies such as Leber's congenital amaurosis, another cause of CVI, exhibit various inheritance patterns and are more frequent in communities with high consanguinity rates. Leber's congenital amaurosis, which appears in infancy, is a condition where the retina may look normal or have signs like peripheral chorioretinal atrophy and graininess, along with nystagmus (Cetin, Yaman & Berk, 2004; Gogate et al., 2011).

Perinatal conditions, occurring between the 28th week of gestation and the first month of life, can also contribute to CVI. These include cortical impairment due to birth asphyxia, ophthalmia neonatorum, and retinopathy of prematurity (ROP). In many developed nations, optic nerve damage and cerebral visual impairment are leading causes of visual impairment, often stemming from preterm birth. Conditions like birth asphyxia, which can lead to cerebral palsy, may also impact the optic nerve and result in cortical visual impairment (Rudanko, Fellman & Laatikainen, 2003; Gogate et al., 2011). ROP is a congenital disorder of the peripheral visual system. It is a condition characterized by ischemia-induced retinal proliferation, primarily affecting premature infants with low birth weight. The severity of ROP ranges from self-resolving cases to bilateral retinal detachment and complete blindness. ROP stands as a prominent cause of visual impairment and blindness in infants.

Lastly, in infancy, conditions acquired after birth, known as postnatal conditions, are uncommon. For instance, causes of blindness such as vitamin A deficiency, measles, trauma, and trachoma are rare in infants. This rarity can be attributed largely to the protective antibodies passed from mothers to their infants and the timely administration of immunizations (Gogate et al., 2011).

Traditional visual acuity measurements classify individuals, both children and adults, as either 'blind' or 'partially sighted' for educational purposes. Visual acuity assessment can be categorized into three primary methods based on the stimulus employed: detection acuity, resolution acuity, and recognition acuity. Detection acuity measures the smallest detectable stimulus, while resolution acuity assesses the ability to distinguish separate elements within a stimulus (e.g., stripes or a grid). Finally, recognition acuity evaluates the capacity to identify symbols, letters, or numbers, often using optotype charts (van Hof-van Duin, 1989).

Various methods exist for assessing visual acuity in newborns and infants, including electrophysiological approaches and behavioral techniques such as preferential looking (Dobson & Teller, 1978). Preferential looking involves observing how newborns and infants react to different visual stimuli. Behavioral responses like gazing, turning the head towards the stimulus, and eye movements serve as indicators of the child's response. The goal is to determine the child's visual perception threshold by observing their reactions to the presented stimuli (Fantz, 1958).

One example of preferential looking is the Teller Acuity Cards, often preferred over alternative tests and methods like optokinetic nystagmus and visual evoked potentials (Teller et al., 1986). Research suggests it can effectively assess infants from 1 month to at least 36 months of age (Mayer et al., 1995). During testing, the tester observes the infant's reactions, such as looking at or reaching for the cards, to establish the infant's visual acuity threshold. The cards are presented at progressively finer spatial frequencies until the child can no longer distinguish the patterns, allowing the tester to assess the child's visual acuity. This method is popular because it does not require verbal responses from the infant and can be adapted to suit the developmental capabilities of young children (Teller et al., 1986).

2.2. Development in Infants with Visual Impairment

As infants grow, they progressively acquire new skills through interaction with their environment, often reaching developmental milestones within crucial periods. Development encompasses social-emotional, linguistic, motor, and cognitive domains, which are interdependent. Cognitive development involves making sense of experiences, with motor development crucially supporting cognition and language (Boyd & Bee, 2010; Iverson, 2010). Infants integrate sensory and motor information, developing cognitive strategies based on experiences (Boyd & Bee, 2010).

Infants with VI often follow atypical developmental paths and show an increased risk of developmental delay throughout the infancy and preschool years (Hatton, Schwietz, Boyer & Rychwalski, 2007; Dale et al., 2019). Previous studies showed the developmental differences between SIs and infants with VI in terms of social communication (Dale, Tadić & Sonksen, 2014), motor development (Fotiadou et al., 2014), joint attention (Tadic, Pring & Dale, 2009) and verbal skills (Brambring, 2007). For instance, in early interactions between infants and caregivers, actions like infant cooing and caregiver smiling, may initially result from automatic responses and operant conditioning. Over time, these experiences contribute to the formation of cognitive schemas underlying concepts such as objects. However, in infants with VI, the shaping of cognitive schemas will be different because access to vision-based sources of social information such as these facial expressions is limited. VI in infancy can impact the diversity of their experiences, their mobility, and their ability to navigate and interact with their environment (Maćesić-Petrović, Vučinić, & Eškirović, 2010). Dale and Salt (2007), investigated developmental setbacks occurring between 16 and 27 months of age in infants with blindness or VI. They found that around 25–33% of infants with blindness experienced setbacks during this period, particularly those with profound VI, neurological issues, or facing social adversity (Vervloed, van den Broek & van Eijden, 2019).

However, discerning the nature of observed developmental challenges in infants with blindness presents difficulties. Are these challenges indicative of skill loss, stalled progress, true delays, or simply an adaptive, albeit atypical, developmental pathway due to blindness? Further complicating this issue is the inherent variability in individual maturation and developmental trajectories, along with methodological challenges like measurement inaccuracies and potential misdiagnosis of autism spectrum disorder (Vervloed et al., 2019). This underscores the importance of studying development in infants with VI with careful consideration and sensitivity.

2.2.1. Socio-Cognitive Development

Social-cognitive development is intricately linked to environmental exploration, facilitated by sensory input. Infants with VI demonstrate differences in sensory utilization compared to SIs in the motor, linguistic, and cognitive aspects. Studies on the nature of this difference have been emphasized in the literature.

Preisler (1991) suggested that blindness alone may not necessarily limit an infant's joint attention, but delays in sharing experiences with others regarding objects may occur due to the need for visual references. For example, while SIs exhibit joint attention behaviors like shared focus on toys or interests between 11 and 14 months, infants with VI, particularly during play, appear to experience difficulties (Trevarthen & Hubley, 1978; Recchia, 1997). This has been attributed to the challenges faced by parents in using language and establishing shared meanings, given the absence of visual cues for joint attention in blind infants (Bigelow, 2003). While these infants remain alert and attentive, their behavior may be misinterpreted as disinterest by caregivers, potentially hindering the development of intersubjectivity, a crucial process in social-cognitive development (Rogers & Puchalski, 1984; Conti-Ramsden & P´erez-Pereira, 1999). The absence of requesting and conventional gestures like looking, pointing, and reaching in infants with blindness aged 11-32 months could also contribute to this hindrance (Rowland, 1984; Preisler, 1991).

As infants acquire primary intersubjectivity, they become able to perceive the caregiver as an interactive partner, while the caregiver also starts to view the infant as a "real" subject in communication (Emde et al., 1976). Because of their lack of vision, infants with blindness might have difficulties in understanding and identifying themselves using cues of their social partners' emotional reactions (Pérez-Pereira & Conti-Ramsden, 2001). This might limit socio-emotional experiences which cause social, cognitive and linguistic abnormalities in infants with blindness (Hobson, Lee & Brown, 1999). For instance, SIs exhibited a wide range of facial and vocal expressions, whereas infants with VI appear to have a more restricted repertoire of facial expressions during the interactions (Lavelli & Fogel, 2005; Fraiberg, 1975; Tröster & Brambring, 1993). At 12 months old, infants with VI exhibited limited emotional expressions, including anger and pleasure, only in response to intense tactile stimuli. However, during interactive play, they reacted with positive emotionality similar to (SIs) (Brambring et al., 1987). Additionally, the frequency of smile was less in infants with VI than SIs, and eliciting a smile from them is more challenging (Rogers & Puchalski, 1986). Pérez-Pereira and Conti-Ramsden (2005) argued that since the inability of infants with blindness to perceive their mothers' gestures and facial expressions they produce less expression as a reaction to them. Therefore, they might have difficulties experiencing regularity and turn-taking during the interaction with their caregivers.

Furthermore, as discussed in the language development section, in terms of verbal interactions, infants with VI face certain limitations compared to their sighted counterparts. Studies noted a lower frequency of positive vocalizations, reduced responsiveness, and fewer instances of initiating communication in dialogues between children with VI and their caregivers (Rogers & Puchalski, 1984; Skellenger et al., 1997). Although children with blindness may use vocalizations while exploring toys, it has been observed difficulties in sharing these experiences with caregivers (Presiler, 1991). However, research suggests that by the second year, the frequency of vocalizations falls within normal limits (Rowland, 1984).

Furthermore, as another nonverbal communicative behavior, pointing is generally used by infants with blindness to interact with a nearby object, while SIs use it in relation to both distant and nearby objects by 12 to 28 months. This difference extends to the pointing gesture itself, with infants with blindness employing their entire palm rather than a single extended finger, likely due to their inability to observe and imitate adult gestures (Iverson, Tencer, Lany & Goldin-Meadow, 2000).

Despite the anticipated and well-studied variations in social-cognitive development among infants with VI, monitoring this development remains a topic of ongoing research debate. Several factors contribute to this debate. Dale and colleagues (2014) identified the lack of a standardized tool specifically designed to observe early socio-communicative behaviors in preschoolers with VI. They argued that most existing tools rely on behaviors such as gaze, joint visual attention, and gesture, making them inappropriate for children with VI. For instance, it has been suggested that primary intersubjectivity, which begins to emerge towards the end of the first year in SIs (Trevarthen, 1979), is organized through non-visual sensory channels in children with VI (Bigelow, 2003).

2.2.2. Verbal Communication

Language plays a critical role in child development, with deficits in this area linked to social difficulties and behavioral problems (Menting, van Lier & Koot, 2010). Research on individuals with blindness and VI is crucial due to their unique developmental trajectories, observed at both the behavioral and neural levels. Typically, language processing relies on a specific network of brain regions, mainly the frontotemporal cortical areas, mostly located on the left side. However, in individuals with congenital blindness, this network expands to include parts of the brain typically associated with vision (Wernicke, 1874). Lane and colleagues (2017) have shown that in individuals with blindness, the language areas in the brain are reduced on the left side, demonstrating that VI alters the neurobiology of language. This may be due to a delay in language acquisition that disrupts the typical timing of left lateralization (Lane et al., 2017). Furthermore, infants with blindness experience a slight delay in producing their first words and their first two-word sentences (Landau & Gleitman, 1985). These delays are attributed to limited access to non-linguistic contexts that facilitate language learning. The left lateralization of language may have a critical period similar to the critical period for language acquisition (Johnson & Newport, 1989). Additionally, children with blindness tend to have a more limited vocabulary and experience difficulties using language in different contexts compared to sighted children (Dunlea, 1989).

Shared attention between infant, caregiver, and object/event is a crucial step in typical language development. Infants' alternating gaze towards the object and caregiver signifies their intent to share interest. This highlights the importance of visual perception for language development through shared attention (Moore & Dunham, 1995). Visual experiences in early childhood that drive joint attention play a crucial role in general language development, providing a foundation for language learning to take place. Although there is significant variation in visual characteristics, children with both peripheral and central VI may demonstrate language and communication disorders (Tadić et al., 2010). Fazzi and colleagues (2019) propose that this may indicate the impact of the VI itself on early experiences of interaction with the environment, or it may indicate an associated neurodevelopmental condition that occurs independently of the VI, or, more commonly, it may be a consequence of both conditions. Impairment of central origin and language difficulties may result from both the severity of VI and widespread brain damage that affects the brain network organization. However, infants with VI from peripheral causes show more potential for compensating for early deficits in developing interpersonal understanding (Recchia, 1997). Moreover, although children with peripheral blindness often exhibit well-developed structural language skills, such as phonology, morphology and syntax, which facilitate fluent speech (APA, 2013), their semantic and pragmatic abilities, which are crucial for effective social communication, tend to be weaker (Tadić et al., 2010).

Typically developing infants acquire their first 50 words between 12-18 months. Infants with blindness, however, rapidly expand their vocabulary between 18 and 20 months, focusing on words related to their own experiences, emphasizing the importance of touch and movement in their language learning. They also tend to focus their initial vocabulary on names of people, animals, toys, and body parts pointed out by adults, emphasizing the importance of residual vision and kinesthetic involvement in their learning process (McConachie et al., 1994). In addition, typically developing infants benefit from seeing objects, facilitating this process, while children with blindness rely on auditory or tactile methods for assembling categories. So, they have difficulties with the ability to generalize words, hindering their formation of categories (Dunlea & Andersen, 1992).

2.2.3. Parent-Infant Interaction in Visual Impairment

In earlier chapters, it emphasized that early parenting shapes children's ability to regulate stress and emotions, forming their expectations about the world and fostering positive growth in emotional, cognitive, and social development. The parents’ attentiveness to their infant’s communication attempts is crucial for their development of socio-cognitive skills and emotional regulation (Borstein & Manian, 2013; Provenzi el al., 2017).

While vision is crucial for much of the social development of an infant, infants with VI compensate with their other senses like touch, hearing, smell, and taste (Dare & O’Donovan, 1997). These infants face challenges in developing socio-cognitive skills due to their limited reliance on vision-dependent behaviors such as eye contact and facial expression recognition

(Dale et al., 2014). To compensate for this, they might communicate in ways that differ from SIs. For example, they could rely on a distinctive set of signals, including tactile strategies. However, parents may sometimes be unaware of these distinctive signals, leading them to misinterpret them as meaningless (Chen & Downing, 2006).

Infants with VI, due to their reliance on different senses, may develop social interaction patterns distinct from those of SIs. These infants have shown diminished reactivity to maternal stimuli and lower levels of initiation in social interactions (Grumi et al., 2021). For example, during the initial two years of life, infants with VI due to retinopathy of prematurity, retrolental fibroplasia, or optic nerve hypoplasia, typically did not respond with smiles or vocalizations to their mothers' verbal or tactile interactions, nor they react consistently to stimuli from caregivers (Nagayoshi et al., 2017; Rogers & Puchalski, 1984; Rowland, 1984). One critical indicator to the development of socio-cognitive skills in infants is joint engagement which gradually emerges between 9 and 15 months. This construct refers to coordinated attentional shifts between a social partner and an external object or event that captures the interest of both the infant and the caregiver (Bakeman & Adamson, 1984). Studies suggested that even infants with VI can show joint engagement around the age of 12 months (Urqueta Alfaro, Morash, Lei & Orel-Bixler, 2018), visual acuity is an important effector of joint engagement (Urqueta Alfaro, Bakeman, Suma & Robins, 2021). However, it's important to note that this doesn't necessarily translate to a lack of social motivation. Research by Pérez-Pereira and Conti-Ramsden (2001) suggests that infants with VI aged between 28 and 36 months can initiate speech at similar rates to sighted children in everyday interactions. Furthermore, they build social understanding and interpret interactions primarily through non-visual cues (Bigelow, 2003; Bakeman, Adamson, Konner & Barr, 1990). Non-visual cues can further complicate social interactions for these infants, as they require clearer information about others' mental and emotional states (Damen, Janssen, Ruijssenaars & Schuengel, 2015). In addition, Urqueta

Alfaro and colleagues (2022) have reasoned that infants with VI do not exhibit typical gaze and facial expression patterns, prompting parents to focus more on non-facial behaviors, such as infants' body movements, that reflect their preferred communication style. Interestingly, despite using fewer nonverbal gestures and less direct facial orientation, mothers of blind or VI infants still initiate and maintain conversations more frequently compared to mothers of SIs (Conti-Ramsden & Pérez-Pereira, 1999; Pérez-Pereira & Conti-Ramsden, 2001).

In conclusion, questioning the appropriateness of current observation methods to the nature of these infants requires a re-evaluation of the conclusions drawn from past studies on social-cognitive development in infants with VI. In addition to this, the social behaviors developed by these infants should be examined in a more detailed and comprehensive manner.

Chapter III

The Current Study

3.1. Rationale and Study Aim

The first year of life is a critical period for socio-cognitive development in infants, marked by significant milestones in attention, communication and emotional regulation. Understanding the developmental trajectory of these skills is crucial, particularly for infants with VI, who may face unique challenges. While visual input significantly influences social interactions by enabling eye contact, facial recognition, and interpretation of non-verbal cues, there is comparatively little understanding regarding behavioral responses to auditory stimuli. Infants with VI might experience disruptions in these areas, potentially affecting their socio-cognitive development. However, there is also evidence which reveals infants with VI use their other sensory modalities to compensate for difficulties in their interactions. Previous research has highlighted the importance of gaze behavior, pointing and emotional responses in early development, yet there is limited understanding of how these behaviors manifest and evolve in infants with VI compared to their sighted peers. This study aims to fill this gap by investigating the developmental changes and differences in socio-cognitive behaviors precursors and emotional responses between SIs and infants with VI from 9 to 12 months of age.

The primary aims of this study is twofold:

> **Aim 1- Developmental changes:** To investigate the development of socio-cognitive behaviors (e.g. gaze orientation, pointing, communication and emotional responses) in response to auditory stimuli during face-to-face mother interaction with SIs between 9 and 12 months of age.

Aim 2- Comparative analysis: To compare socio-cognitive behaviors (i.e., gaze orientation, communication, pointing, emotional responses) in response to auditory stimuli during face-to-face mother interaction between infants with VI and age-matched SIs.

3.2. Method

The study is a part of the Understanding Low Vision Infants Socio-cognitive Skills Emergence (ULISSE) research project. The overall aim of the study was to investigate the developmental trajectory of specific socio-cognitive behaviors of infants, such as gaze orientation, communication, pointing and emotionality and to find out how these behaviors are affected by VI. The clinical group was compared to a control group composed by sighted age-matched infants. Mothers and infants took part in a recorded face-to-face interaction from their home when the infants were 9 months old and 12 months old. The innovative methodology of the ULISSE project was inspired by the Face-to-Face Still procedure; thus, it is strengthened by a validated procedure. The study both tracks the early developmental socio-cognitive behavioral change in infants and shows the impact of a clinical condition such as VI on the developmental trajectory.

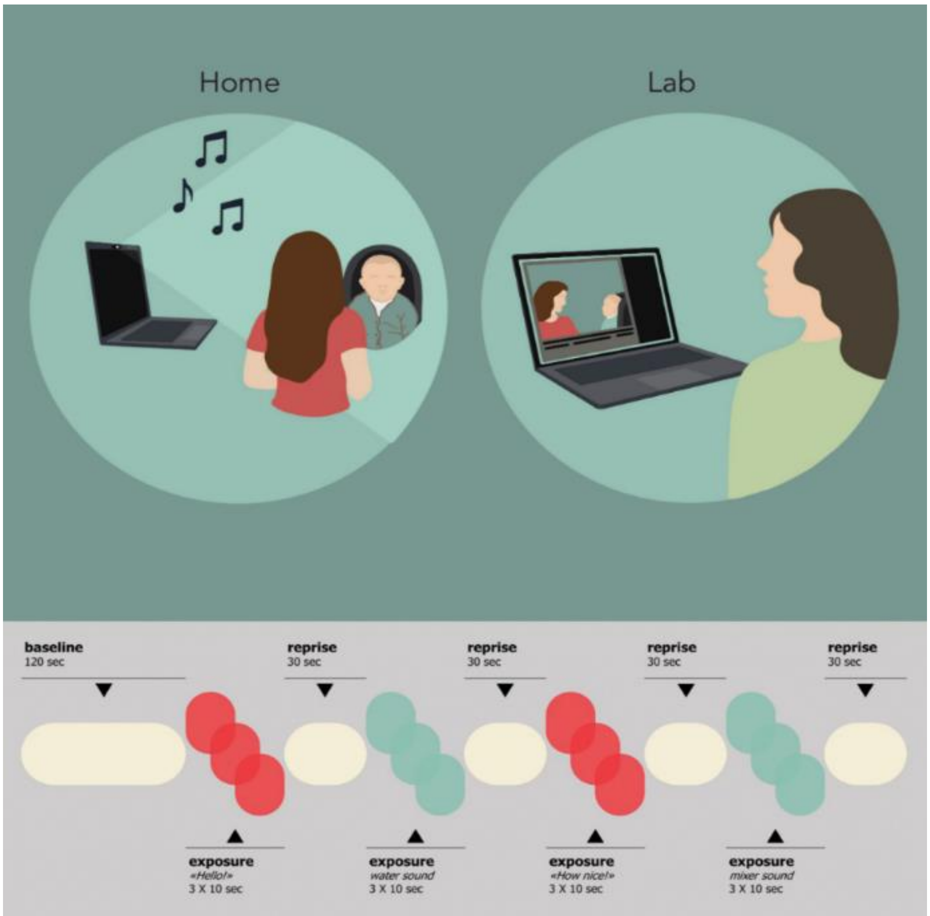
3.2.1. Participants

Fifty-three mother-infant dyads participated: 39 SIs assessed at 9 months (N=39, mean age = 9.61 months) and reassessed at 12 months (N=24, mean age= 12.75 months); 14 infants with VI between 9 and 12 months of age (corrected age= 10.18 months) were included for comparison. The recruitment of infants with the VI group was carried out at the Developmental Psychobiology Unit of the IRCCS Mondino Foundation, in collaboration with the Center for Child Neuro-ophthalmology of the same scientific institute, and the recruitment of the sighted group (SI) was carried out in collaboration with the University of Milano-Bicocca. SI group were included if (1) they had no history of visual impairments or other sensory or neurological conditions and (2) they were born at term from healthy pregnancies. Infants in the VI group were included if (1) they had received a clinical diagnosis of visual impairment, based on the standardized evaluation of grating acuity using Teller Acuity Cards (2) they did not meet the diagnostic criteria for blindness (i.e., light perception or total blindness). For infants born preterm (N = 6) we considered corrected age. VI group could be of both peripheral or cerebral origin. Peripheral visual impairment (PVI) is due to the involvement of the pre-geniculostriate primary visual pathways (i.e. eye and optic nerve, as in inherited retinal dystrophy or congenital cataract or abnormalities of ocular motility such as nystagmus), while cerebral visual impairment (CVI) is due to the involvement of retro-geniculostriate visual pathways. All infants but 2 (diagnosed with isolated congenital cataract) underwent brain MRI, that showed abnormalities in 6 (lesions consistent with distress during delivery or periventricular leukomalacia due to prematurity in 4 infants with CVI and cerebral palsy; polimicrogiria in 1 infant with CVI; slight focal alteration in 1 infant with macular dystrophy). About the clinical picture: 6 of the included infants presented significant motor delay (42.86%) and 2 infants had epilepsy as a comorbidity (14.28%). As for ethology: 6 infants presented a VI characterized by central visual deficits (e.g., cerebral palsy, central nervous system lesions or malformations); 8 presented a visual loss linked to peripheral deficits (e.g., congenital cataract; retinopathy or nystagmus). Overall, 5 (35.71%). Infants with VI were diagnosed with severe VI (based on age corrected cycles/degree measured via Teller acuity cards) and 9 with moderate (64.28%). The consent and the willingness of the mother and infant to participate were signed by the parents before the procedure.

3.2.2. Procedure

Mother-infant dyads were recorded using the Zoom video conferencing platform while interacting face-to-face in a home environment. The remote observational procedure was structured according to recommendations from previous studies (Shin et al., 2021). The online session was scheduled based on the parents' availability, and video recording commenced only when the infant was in a calm and attentive state. Before the interaction began, mothers were given instructions to position the smartphone or tablet in a way that provided a complete side view of both participants in the interaction. The infant was placed in front of the mother at a distance of around 40 centimeters, allowing visual contact and maternal touch. Throughout the entire interaction, both the mother and the experimenter turned off their screens, and the experimenter also muted her microphone when sharing PC-generated audio.

The interactive task had a duration of 6 minutes, as indicated in Figure 3.1. Initially, the mother and infant engaged in direct face-to-face interaction without the use of toys or pacifiers for two minutes. Subsequently, one of four previously recorded auditory stimuli was played three times with a 10-second gap between repetitions, constituting the “exposure episode”. Among these stimuli, two were human sounds - specifically, “Ciao” (Italian for “Hello”) and “Che bello!” (Italian for “How nice!”), while the other two were non-human, consisting of water and mixer sounds. All infants were exposed to the complete set of four auditory stimuli, but the order of exposure was counterbalanced among participants to prevent any bias caused by the sequence. During each exposure episode, the mother maintained a calm and neutral facial expression. After each 30-second exposure episode, the mother and infant returned to their face-to-face interaction in the “reprise episode”.



Picture from Anastasiia Samoukina

Figure 3.1 | Setting and task overview

3.2.3. Measures

3.2.3.1. Interactive measures

The remote observational procedure was structured according to recommendations from previous studies (Shin et al., 2021). Recordings of mother-infant interactions were recorded online using the Zoom video conferencing platform using their smartphones or tablets. Meanwhile, the experimenter remotely observed mother-infant face-to-face interactions, which were video recorded at the participants' homes via the platform. Recordings were used for offline coding purposes. Micro-analytically 2-sec coding occurred via ELAN Linguistic

Annotator Software (version 5.9; Max-Planck-Institute for Psycholinguistics, Nijmegen, The Netherlands; https://archive.mdpi.nl/tla/elan).

3.2.3.2. Behavioral Measures

For the present study, infants' specific socio-cognitive behaviors – i.e., gaze orienting, communication, pointing and emotionality – were micro-analytically coded. The coding scheme was developed specifically for the project in the lab and has been previously utilized in other studies (Nazzari et al., 2023). Gaze orienting was coded as any occurrence of an infant's face and/or gaze clearly directed toward the source of the auditory stimuli or their mother. Communication was coded as any behavior of the infant clearly directed as communicating toward the source of the auditory stimuli or their mother, including waving bye with hand, vocal production while looking at the source etc. Pointing was coded as any clear gesture made with the index finger toward the source of the auditory stimuli or their mother. Emotionality was included in two subtypes as positive and negative emotionality. Positive emotionality was coded by any clear gesture or behavior of the infant including smiling. Negative emotionality was coded as any behavior of the infant which shows inhibited (e.g., avoiding gaze and entering a "freezing" state) or exhibited stress (e.g., crying, moaning and behavioral protests). Two main trained coders rated the videos independently.

For all coded variables percentages of time were computed, to account for possible small variations in episode durations. For pointing behaviors (as these were observed in a limited number of participants and the variable was not normally distributed) the participants were identified as pointers if they showed at least 1 pointing behavior in the selected episode.

Table 3.1 | Infants' socio-cognitive behavior coding system.

Variable	Description	Levels
Source orientation	The child directs attention towards the source	0 = no; 1 = yes
Orientation to the mother	The child directs attention towards the mother's face	0 = no; 1 = yes
Pointing to the source	The child points towards the source	0 = no; 1 = yes
Pointing to the mother	Child points towards mother	0 = no; 1 = yes
Active communications towards the source	The child vocalizes, gesticulates or reaches towards the source (with a positive emotional state)	0= no; 1 = yes
Active communications towards the mother	The child vocalizes, gesticulates or reaches towards the mother (with a positive emotional state)	0 = no; 1 = yes
Stress	The child shows stress with facial expressions, crying or moaning, behavioral protests or may avoid looking or enter a state of "freezing"	0 = no; 1 = yes
Smile	The child may smile or laugh while oriented towards the source or mother	0 = no; 1 = yes

3.2.4. Statistical Analysis

All the statistical analyses were carried out using Jamovi 2.2.5 (version 2.2, The Jamovi Project, 2021; https://www.jamovi.org) and setting the level of significance at $p < 0.05$.

3.2.4.1. Aim 1

For SIs' measure of gaze orienting to source, gaze orienting to mother, communication to source, communication to mother, positive emotionality and negative emotionality, 2 sessions (9-month-old infants vs. 12-month-old infants) x 5 episodes (baseline vs. human exposure vs. human reprise vs. non-human exposure vs. non-human reprise) repeated measures ANOVA was carried out to investigate: session main, episode main and interaction effect. When a significant main or interaction effect emerged paired t-test post-hoc comparisons were performed to better understand the results. A chi-square test of independence performed to examine the relation between time sessions (9-month-old infants vs. 12-month-old infants) and pointing (pointers vs. non-pointers).

3.2.4.2. Aim 2

For infants' measure of gaze orienting to source, gaze orienting to mother, communication to source, communication to mother, positive emotionality and negative emotionality, 2 groups (VI vs. SI) x 5 episodes (baseline vs. human exposure vs. human reprise vs. non-human exposure vs. non-human reprise) repeated measures ANOVA was carried out to investigate: group main effect, episode main effect, interaction effect. When a significant main or interaction effect emerged paired t-test post-hoc comparisons were performed to better understand the results. A chi-square test of independence was performed to examine the relation between groups (VI vs. SI) and pointing (pointers vs. non-pointers).

3.3. Results

3.3.1. Aim 1- Socio-Cognitive Developmental Trajectory between 9 - 12 months

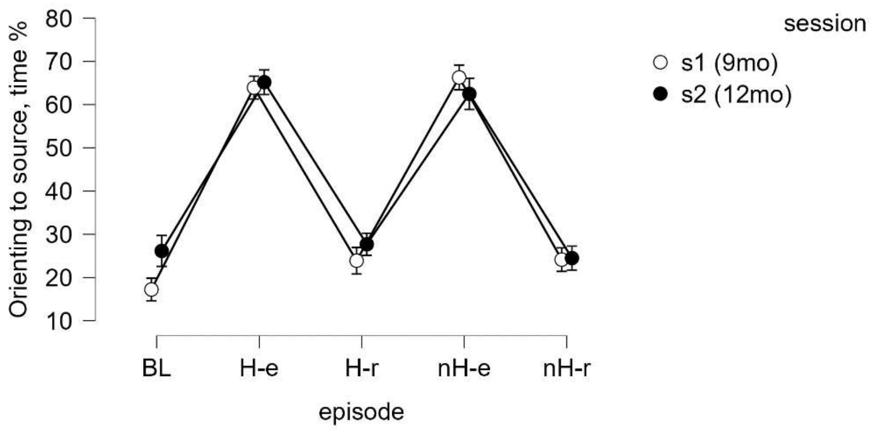
For the first purpose, SIs were observed between 9 and 12 months. Each socio-cognitive skill was analyzed for the effect of age, episode of the task and their interaction.

3.3.1.1. Gaze Orientation

3.3.1.1.1. Gaze Orientation to Source

Infants' gaze orientation to source by Session and Episode is reported in Figure 3.2. The analysis of variance yielded a significant main effect of Episode, F (4,92) = 97.903, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (92) = -13.479, p < .001, baseline vs. non-human exposure episode, t (92) = -13.424, p < .001. The main effect of Session was not statistically significant, F (1, 23) = 0.616, p =.441. The interaction effect was not significant between Session*Episode, F (4, 92) = 2.228, p = 0.072.

Figure 3.2 | Infants' orientation to source by Session and Episode

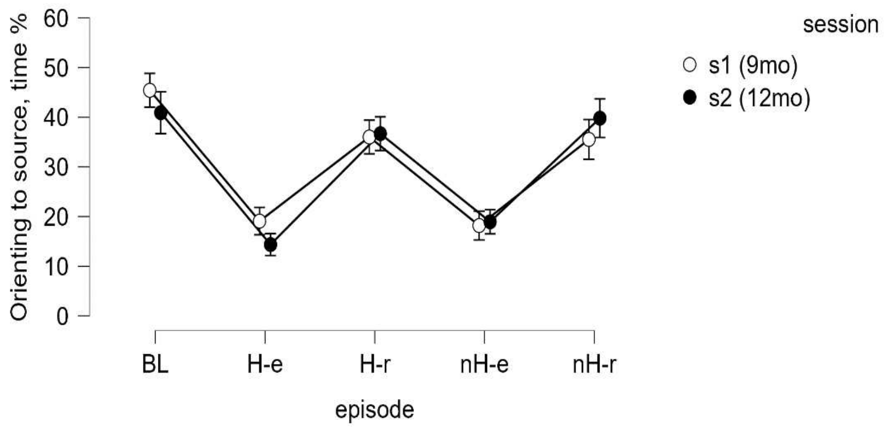


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

3.3.1.1.2. Gaze Orientation to Mother

Infant's gaze orientation to mother by Session and Episode is reported in Figure 3.3. The analysis of variance yielded a main effect for the Episode, F (4,92) = 24.496, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (92) = 7.698, p < .001, baseline vs. non-human exposure episode, t (92) = 7.159, p < .001. The main effect of Session was not statistically significant, F (1, 23) = 0.048, p =.828. The interaction effect was not significant between Session*Episode, F (4, 92) = 1.140, p = .343.

Figure 3.3 | Infants' orientation to mother by Session and Episode.



Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

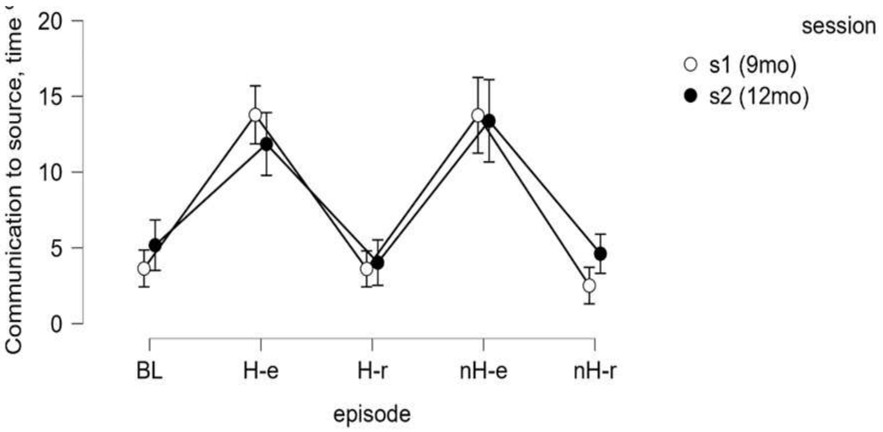
3.3.1.2. Communication

3.3.1.2.1. Communication to Source

Infant's communication to source by Session and Episode is reported in Figure 3.4. The analysis of variance yielded a main effect for the Episode, F (4,92) = 14.519, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (92) = -4.454, p < .001, baseline vs. non-human exposure episode, t (92) = -4.850, p < .001. The main effect of

Session was not statistically significant, *F* (1,23) = 0.042, *p* =.839. The interaction effect was not significant between Session*Episode, *F* (4, 92) = 0.658, *p* = .623.

Figure 3.4 | Infants' communication to source by Session and Episode.

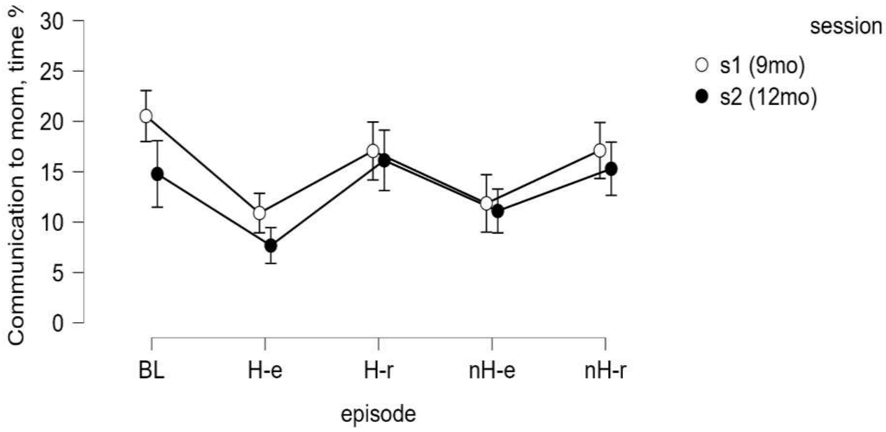


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

3.3.1.2.2. Communication to Mother

Infant's communication to mother by Session and Episode is reported in Figure 3.5. The analysis of variance yielded a main effect for the Episode, *F* (4,92) = 5.445, *p*<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, *t* (92) = 3.786, *p* =.003, baseline vs. non-human exposure episode, *t* (92) = -4.850, *p* = .041. The main effect of Session was not statistically significant, *F* (1, 23) = 0.695, *p* =.413. The interaction effect was not significant between Session*Episode, *F* (4, 92) = 0.421, *p* = .793.

Figure 3.5 | Infants' communication to mother by Session and Episode.



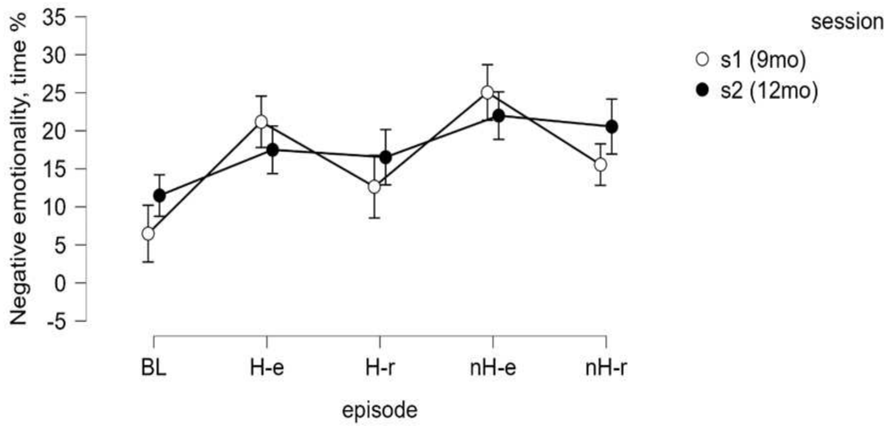
Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

3.3.1.3. Emotionality

3.3.1.3.1. Negative Emotionality

Infant's negative emotionality by Session and Episode is reported in Figure 3.6. The analysis of variance yielded a main effect for the Episode, F (4,92) = 6.548, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (92) = -3.434, p =.008, baseline vs. non-human exposure episode, t (92) = -4.819, p < .001, baseline vs. non-human reprise, t (92) = -3.015, p =.02. The main effect of Session was not statistically significant, F (1, 23) = 0.154, p =.699. The interaction effect was not significant between Session*Episode, F (4, 92) = 1.106, p = .358.

Figure 3.6 | Infants' negative emotionality by Session and Episode.

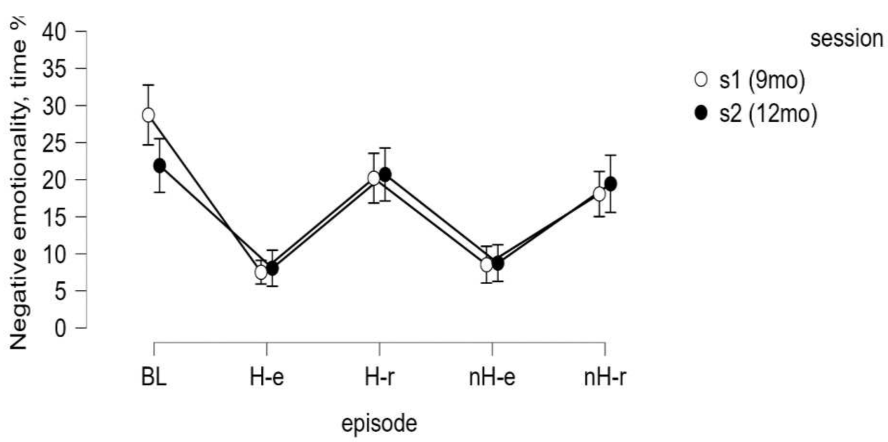


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

3.3.1.3.2. Positive Emotionality

Infant's positive emotionality by Session and Episode is reported in Figure 3.7. The analysis of variance yielded a main effect for the Episode, F (4,32) = 14.078, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (92) = 6.059, p < .001, baseline vs. non-human exposure episode, t (92) = 5.765, p < .001. The main effect of Session was not statistically significant, F (1, 23) = 0.068, p =.797. The interaction effect was not significant between Session*Episode, F (4, 23) = 0.786, p = .537.

Figure 3.7 | Infants' positive emotionality by Session and Episode.



Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; s1, session 1 in 9 months; s2, session 2 in 12 months

3.3.1.4. Pointing

3.3.1.4.1. Pointing during exposure episodes

The chi-squared test of independence was conducted between sessions and pointing behavior during exposure episodes. There was a statistically significant difference in percentage of pointers between sessions, χ^2 (1, N= 48) = 5.169, p = 0.023. As Table 3.2 illustrates that 12-month-old infants were more likely to show pointing behavior than 9-month-old infants, during exposure episodes.

Table 3.2 | Number of infants who show pointing behavior during exposure episodes

Contingency Tables

		Pointing during exposure		
session		**NO**	**YES**	**Total**
9 months	Count	21	3	24
	% within row	87.5 %	12.5%	100 %
12 months	Count	14	10	24
	% within row	58.3 %	41.6 %	100 %

Contingency Tables				
		Pointing during exposure		
session		NO	YES	Total
Total	Count	35	13	48
	% within row	72.9 %	27.0 %	100 %

3.3.1.4.2. Pointing during reprise

The chi-squared test for association was conducted between sessions and pointing behavior during reprise episodes. There was a statistically significant difference in percentage of pointers between sessions, χ^2 (1, *N*= 48) = 10.084, p = 0.001. As Table 3.3 illustrates that 12-month-old infants were more likely to show pointing behavior than 9-month-old infants, during the reprise episodes.

Table 3.3 | Number of infants who show pointing behavior during exposure episode

Contingency Tables				
		Pointing during reprise		
session		NO	YES	Total
9 months	Count	22	2	24
	% within row	91.6 %	8.3 %	100 %
12 months	Count	12	12	24
	% within row	50 %	50 %	100 %
Total	Count	34	14	48
	% within row	70.8 %	29.1 %	100 %

3.3.2. Aim 2 – Differences between Infants with Visual Impairment and Sighted Infants

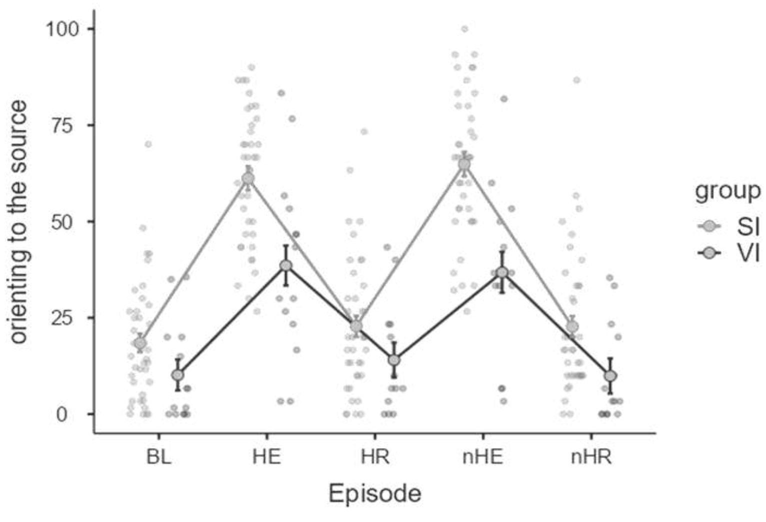
For the second aim, VI and SI groups aged from 9 to 12 months were compared. Each socio-cognitive skill was analyzed for the group (VI vs SI) and episode of the task.

3.3.2.1. Gaze Orientation

3.3.2.1.1. Gaze Orientation to Source

Infants' gaze orientation to source by Episode and Group is reported in Figure 3.8. The analysis of variance yielded an interaction effect for Episode*Group, F (3.07,156.39) = 4.85, p=.003. Post-hoc analyses highlighted significant differences for SI vs. VI during human exposure episode, t (51) = 3.7533, p<.001 and during non-human exposure, t (51) = 4.5444, p<.001. There was a statistically significant main effect of Episode, F (3.07,156.39) = 86.88, p<.001. The main effect of the Group was statistically significant, F (1, 51) = 14.8, p<.001.

Figure 3.8 | Gaze orientation to source by Episode and Group.

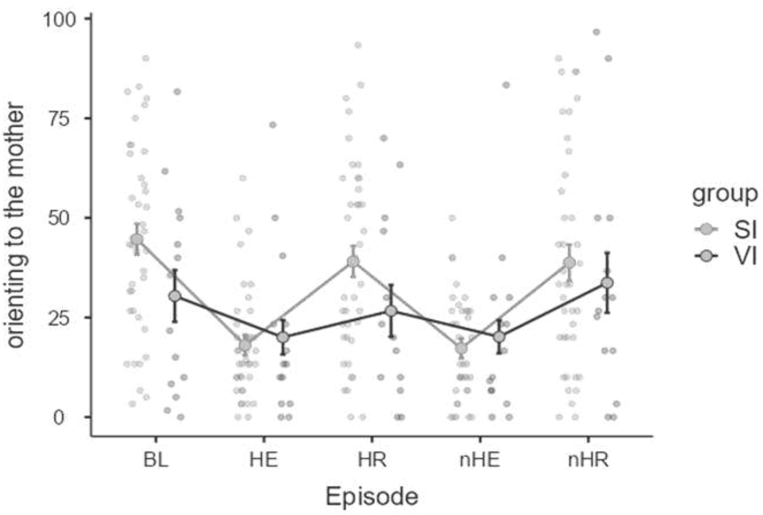


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.1.2. Gaze Orientation to Mother

Infants' gaze orientation to mother by Episode and Group is reported in Figure 3.9. The analysis of variance yielded a significant interaction effect for Episode*Group, F (2.90,174.68) = 2.97, p=.035. SI showed a significant reduction in gaze orientation between baseline and human exposure episode, t (51) = 7.7411, p<.001 and non-human exposure, t (51) = 7.5033, p<. 001. Conversely, VI did not show significant differences between baseline and human exposure, t (51) = 1.8076, p=.07 and non-human exposure episodes, t (51) = 1.6777, p=100. There was a statistically significant main effect of Episode, F (2.90,174.68) = 16.33, p<.001. However, the main effect of Group was no statistically significant, F (1, 51) = 0.925, p=.0.341

Figure 3.9 | Gaze orientation to mother by Episode and Group.



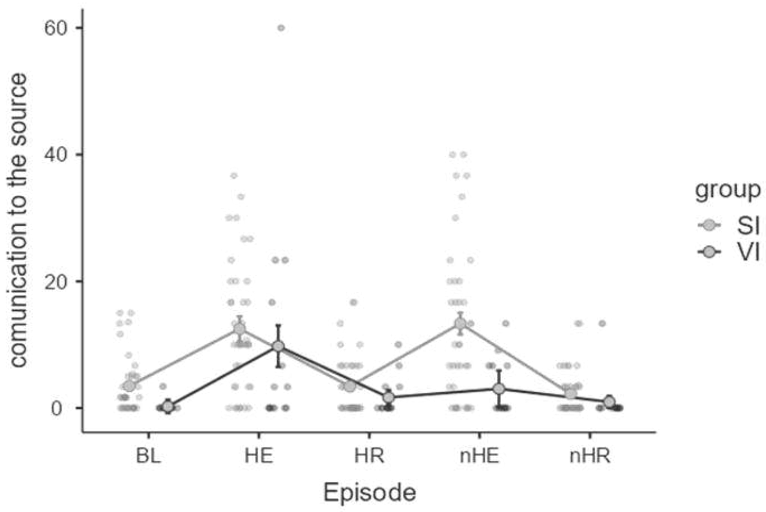
Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.2. Communication

3.3.2.2.1. Communication to Source

Infants' communication to source by Episode and Group is reported in Figure 3.10. The analysis of variance yielded an interaction effect that tended to significance for Episode*Group, F (2.41, 122.91) = 2.82, *p*=.054. Post-hoc analyses highlighted significant differences for SI vs. VI during non-human exposure, *t* (51) = 3.0663, *p*=.003. In this episode, SI communicated to the source more frequently than VI. There was a statistically significant main effect of Episode, F (2.41, 122.91) = 15.60, p<.001. The main effect of the Group was statistically significant, F (1, 51) = 6.68, p=.013.

Figure 3.10 | Communication to source by Episode and Group.

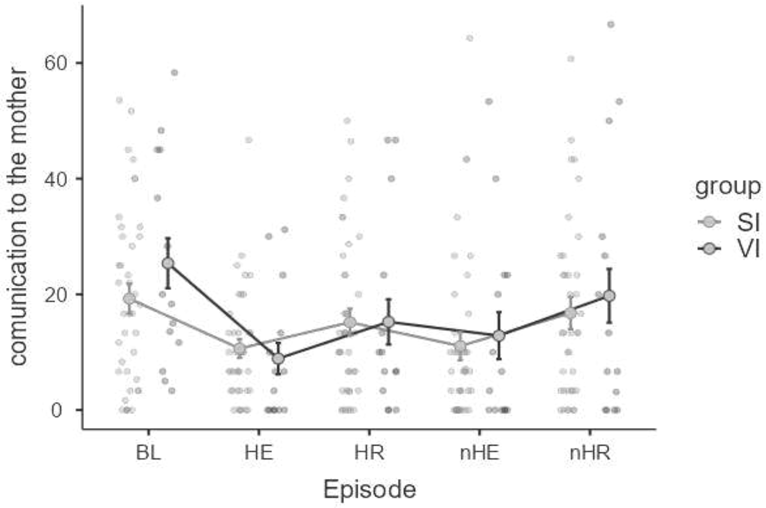


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.2.2. Communication to Mother

Infants' communication to mother by Episode and Group is reported in Figure 3.11. The analysis of variance yielded a main effect for the Episode, *F* (4, 204) = 9.332, *p*<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, *t* (51) = 6.25, *p*<.001, baseline vs. human reprise episode, *t* (51) = 2.94, *p*=.005, baseline vs. non-human exposure episode, *t* (51) =3.93, *p*<.001. The main effect of the Group was not statistically significant, *F* (1,51) = 0.261, *p*=.612. The interaction effect was not significant between Episode* Group, *F* (4, 204) = 0.834, *p* = .505.

Figure 3.11 | Communication to mother by Episode and Group.



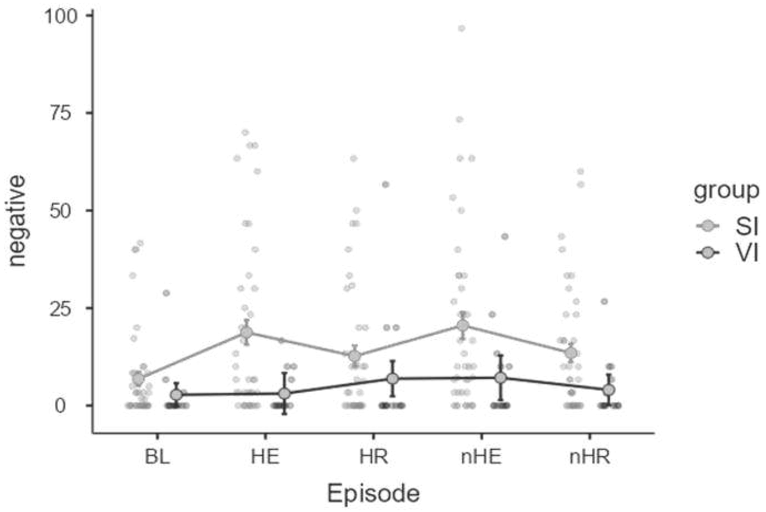
Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.3. Emotionality

3.3.2.3.1. Negative Emotionality

Infants' negative emotionality by Episode and Group is reported in Figure 3.12. The analysis of variance yielded a main effect for the Episode, F (3.32, 169.31) = 2.61, p=.048. Post-hoc analyses highlighted significant differences for baseline vs. non-human exposure episodes for both groups, *t* (51) = -2.487, *p*=.016. The main effect of the Group was statistically significant, F (1, 51) = 6.22, p=.016. SI showed negative emotionality more frequently than VI. The interaction effect was not significant between Episode* Group, *F* (3.32, 169.31) = 1.45, *p* =.228.

Figure 3.12 | Negative emotionality by Episode and Group.

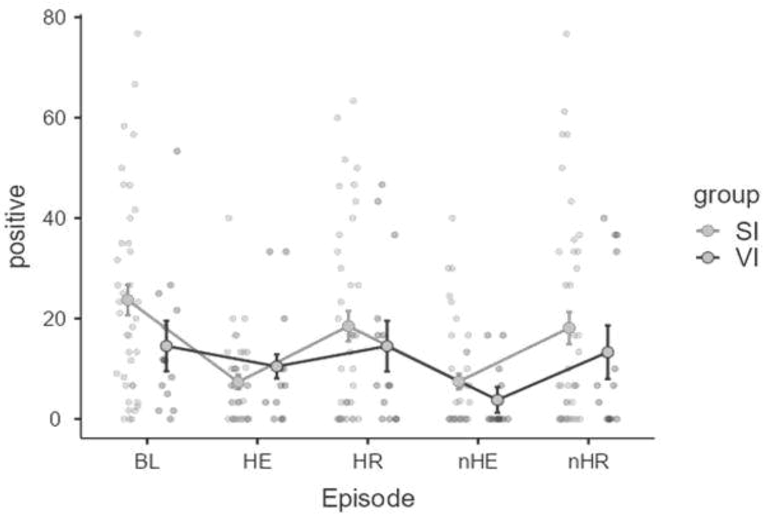


Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.3.2. Positive Emotionality

Infants' positive emotionality by Episode and Group is reported in Figure 3.13. The analysis of variance yielded a main effect for the Episode, F (3.18, 162.34) = 8.42, p<.001. Post-hoc analyses highlighted significant differences for baseline vs. human exposure episode, t (51) = 3.53, p<.001 and baseline vs. non-human exposure episode, t (51) = 4.761, p<.001. The main effect of the Group was not statistically significant, F (1,51) = 1.08, p=.303. The interaction effect was not significant between Episode* Group, F (3.18, 162.34) = 1.28, p = .284.

Figure 3.13 | Positive emotionality by Episode and Group.



Note. BL, base-line; H-e, human exposure; H-r, human reprise; nH-e, non-human exposure; nH-r, non-human reprise; SI, sighted group; VI, visually impaired group

3.3.2.4. Pointing

The chi-squared test of independence was conducted between groups and pointing behavior/being a pointer during the task. There was a difference in percentage of pointers between groups that tended to statistical significance, χ^2 (1, N=53) = 3.11, p = 0.078. As Table 3.4 illustrates, SI were more likely to show pointing behavior than VI, during the task.

Table 3.4 | Number of infants who show pointing behavior during the task

Contingency Tables

		Pointing during exposure		
Pointer DIC		**SI**	**VI**	**Total**
Pointers	Count	27	13	40
	% within row	69.2 %	92.9 %	75.5 %
Non-pointers	Count	12	1	13
	% within row	30.8 %	7.1 %	24.5 %
Total	Count	39	14	53
	% within row	100.0 %	100.0 %	100.0 %

Chapter IV

4.1. Discussion

4.1.1. Developmental changes in social cognition between 9 and 12 months

The first aim of the study was to investigate the presence of statistically significant age-related differences in infant attention behavior, a key indicator of social cognition at 9 and 12 months of age. Studies have shown that this age range marks a critical period of the emergence of variations in both socio-communicative abilities and social cognition (Hatch et al., 2021; Miller et al., 2017; Carpenter et al., 1998). Infant social attention behavior such as gaze orientation, pointing, communication attempts and emotional expression, collectively provide valuable insights into ongoing socio-cognitive development (Camaioni et al., 2004; Legerstee & Barillas, 2003). We can also gain insight into infants' social attention behaviors by observing their responses to auditory stimuli during interactions with their caregivers (Nazzari et al., 2023).

The initial study of this research explored gaze orientation in infants aged 9 to 12 months. This aimed to elucidate the role of gaze in their social cognition and explore potential developmental variations during this critical period. Findings revealed that infants at both ages displayed an orienting response, directing their gaze towards the source of sound regardless of whether it was human speech or a non-human sound. This aligns with existing literature suggesting that infants can understand speech in their language between 9 and 12 months and have an innate interest in social sounds (Benedict, 1979; Moore & Linthicum, 2007). Unexpectedly, there were no significant differences in gaze orientation between human and non-human sounds at either age, despite the anticipation that social stimuli would attract infants more (Dawson et al., 2004). This finding aligns with Adamson, Bakeman, Suma and Robins (2019) have also shown that infants from 12 to 30 months do not differ between speech about them and mechanical or animal sounds in terms of attention. The authors suggested infants may have thought that these environmental sounds come from potentially tangible objects and since their parents labeled these sounds more than speech about them and scaffolded joint engagement more with these sounds. Similarly, Nazzari et al. (2023) found no difference in orientation towards human and non-human auditory stimuli such as mixer and water sounds in 12-month-olds. Therefore, results in this study might indicate that the initial focus in early social interactions might not depend on whether the sound is human or non-human, suggesting both types can serve as triggers for initiating interaction. These observations collectively suggest that the source type of auditory information might not be a crucial factor for initial attention allocation during early social interactions such as joint engagement in this age. However, further investigation is warranted to definitively establish this proposition.

Furthermore, gaze orientation during interaction with mothers was evident in both ages during baseline and reprise episodes. This supports the notion that gaze plays a crucial role in early social communication and is already gained at 9 months of age (Heyes, 2015; Marno et al., 2016). Additionally, the study suggests that this ability to shift attention between social sources (mother and computer) is stable between 9 and 12 months, as evidenced by the significant difference between baseline and exposure episodes. In both ages, infants consistently oriented towards their mothers during baseline and reprise episodes, but shifted their gaze to the novel social stimulus (computer) during exposure. This aligns with existing research on the development of visual processing and the ability to direct attention based on individual interests (Kärtner, Keller & Yovsi,2010; Lavelli & Fogel, 2002; Colombo, 2001). These findings highlight a potential link between age and strategic attention management in response to social cues.

The study also investigated the influence of age on the communication behavior of infants. While previous literature suggests an increase in overall communication between 9 and 12 months (Carpenter et al., 1998; Bates et al., 1979; Crais, Douglas & Campbell, 2004), the findings revealed a more nuanced interaction between social communication and developmental stages. There were no significant differences in verbal communication behaviors between 9 and 12 months. This finding could suggest that by 9 months, infants may already establish a baseline level of verbal communication competency. However, it is important to consider that the assessed communication behaviors encompassed both verbal and non-verbal cues, and the study's focus was not on linguistic abilities per se. Rather, it aimed to evaluate infants' socio-cognitive skills during mother interaction. Given that 9-month-olds are expected to be capable of triadic interactions (Rochat, 1999), these results may be unsurprising. Nonetheless, by focusing on specific non-verbal behavior such as pointing, the study revealed a critical developmental trajectory. The literature suggests that pointing behavior typically emerges around 12 months and becomes more pronounced by 18 months (Camaioni et al., 2004; Perucchini et al., 2021; McGillion et al., 2017). Consistent with this, we expected an increase in pointing behavior between 9 and 12 months in the study. Although pointing behavior was observed in a limited number of cases, it was tracked throughout the procedure for infants at both 9 and 12 months. This low frequency aligns with existing research, indicating that pointing behavior, while emerging around 12 months, may not be consistently observed until later developmental stages. Notably, in the study, approximately 10% of 9-month-olds exhibited pointing, whereas this rate increased to 45.5% at 12 months, indicating an appropriate developmental progression in line with the literature. These findings underscore the development of pointing behavior, reinforcing that this socio-cognitive skill becomes more prevalent and pronounced as infants approach their first birthday. The increase in pointing behavior from 9 to 12 months reflects a significant milestone in non-verbal communication, supporting infants' ability to engage with their environment and direct adult attention towards objects of interest.

Lastly, based on the results, several inferences can be drawn about the socio-cognitive development trajectory regarding emotional responses of typically developing infants between 9 and 12 months. The type of episode significantly affected both negative and positive emotionality in infants. Specifically, compared to the baseline episode, negative emotionality increased during both the human and non-human exposure episodes, while positive emotionality decreased. These infant reactions align with the classic still-face effect observed in the FFSF paradigm, characterized by reduced positive affect displays and increased negative affect (Adamson & Frick, 2003; Legerstee & Markova, 2007).

Interestingly, no significant differences were found in either negative or positive emotionality between 9-month and 12-month-olds. This might suggest that infants' overall emotional responses may be relatively stable across different sessions. This indicates that the observed variations in emotionality are primarily due to the type of episode rather than the age. Similar findings have been reported in the literature, observing no significant behavioral differences in distress levels between 7 and 10-month-old infants during the still-face paradigm (Striano & Rochat, 1999).

In conclusion, the first study investigated social-cognitive development in infants between 9 and 12 months of age in response to auditory stimuli. While in both ages, infants exhibited a similar tendency to approach to source and interacted with their mothers using their gaze and communicative behaviors, this may be attributable to the establishment of baseline communication and interaction skills by 9 months (Rochat, 1999). However, pointing behavior showed a more strategic allocation of attention, increasing significantly between 9 and 12 months. Lastly, the study found that the type of episode, not age, affected emotional responses. Infants displayed heightened negative emotions during exposure episodes compared to those involving interaction with their mothers. This might suggest that there is even auditory stimulation as a distractor, an interruption of the interaction in which the mother gives stress to infants and it has a strong effect on the infants' emotionality. Overall, the study contributes to a nuanced understanding of development, highlighting the selective nature of skill advancement, where specific behaviors like pointing become more pronounced, while emotional responses remain dynamic and influenced by social cues.

4.1.2. Differences in social cognition between infant with visual impairment and sighted infants

The second aim of the study was to evaluate the potential statistically significant differences in the social attention behavior of infants, specifically focusing on the social cognition of infants with VI compared to SIs within the 9–12-month age range. Early childhood is a critical period for brain development, and pathological conditions during infancy can be associated with adverse affective, social, and cognitive outcomes, often attributed to disruptions in the quality of early dyadic interactions (Montirosso, Fedeli & Murray, 2012). Sensory processing disruptions, particularly VI, can limit an infant's range of experiences and potentially impact their cognitive and social development (Iverson, 2010; Boyd & Bee, 2010). Infants with VI face specific challenges in dyadic interactions with their caregivers. These challenges include difficulties with eye contact, facial expression recognition, communicative gestures, gaze monitoring, and visual imitation which are important for their socio-cognitive and socio-emotional development (Dale et al., 2014).

The study investigated the influence of VI on gaze behavior as a socio-cognitive precursor. The observed disparities in gaze orientation towards the source and the mother between infants with VI and SIs suggest a fundamental alteration in how VI shapes infants' engagement with their environment and social partners. Notably, during the exposure episodes, the SI group shifted their gaze towards the source of the sound, while their gaze toward their mothers decreased. In contrast, no such significant alteration in gaze behavior was observed in the VI group, they showed a similar amount of gaze orientation to their mothers during their interaction and the exposures. Previous research indicated that SIs aged 9-15 months exhibit evidence of joint attention by coordinating gaze shifts between the object and their social partner (Carpenter et al., 1998). Furthermore, Bigelow (2003) posits a potential delay in the development of joint attention skills in infants with VI compared to their sighted counterparts. Consequently, the observed findings in this study might be attributable to this disparity in joint attention development between SI and VI groups. That means SIs may use gaze orientation more efficiently than infants with VI within the context of social interaction.

The study also investigated the influence of VI on the communication behavior of infants with VI. The difference in communication to source was observed only during the non-human exposure episode while there was no difference in human exposure episode between the both groups. This finding could be interpreted as suggesting that sensory processing difficulties do not significantly impact the infants' initial interest in approaching a social partner. As suggested in a new review by Grumi et al., 2021, this finding might indicate that the observed social approach deficit in infants with VI is not due to a lack of social intentionality to engage in joint attention. Instead, infants with VI may develop social representations of interactions by relying more on non-visual channels (Bakeman et al., 1990).

While existing literature has documented limitations in non-verbal expressive behaviors of infants with VI such as facial expressions and gestures during interaction (Rowland, 1984; Rogers & Puchalksi, 1984), and reports of them ignoring maternal communicative signals for longer periods compared to SIs (Rogers & Puchalski, 1984), the current results showed a different picture. Contrary to the expectation that infants with VI would rely more on communication with their mothers during the procedure, there was no statistically significant difference between SI and VI groups in their communication directed towards their mothers. Some similar results have been found in the literature. Conti-Ramsden and Perez-Pereira (1999) have shown that infants with blindness tend to use non-verbal turns in dialogue. Moreover, they were equally capable in communication, initiating and maintaining conversations as SIs. Additionally, infants with VI and SIs have shown comparable performance during symbolic play and language abilities (Lewis et al., 2000).

However, pointing revealed a potential developmental difference between the VI and SI groups. The pointing behavior shown by the SI group during the procedure, a critical gesture for joint attention and communication, was less commonly seen in the VI group. This could be due to the reliance on visual cues to initiate pointing, which are less accessible to infants with VI (Admiraal, Keijsers & Gielen, 2003). Existing literature supports this notion, as research by Rowland (1984) and Preisler (1991) has documented difficulties in infants with blindness using proto-imperative, proto-declarative gestures, and conventional communicative gestures. Furthermore, infants with VI have demonstrated different than usual extending an index-finger pointing gesture using their entire palm (Iverson et al., 2000). Therefore, this disparity in pointing behavior may lead to ambiguity in interpreting the intentionality behind pointing attempts of infants with VI, potentially confounding the motor execution of the behavior itself. Given the observed similarity in communication behaviors between the two groups, further research specifically investigating pointing development of VI infants is warranted.

Lastly, based on the results, several inferences can be made concerning the socio-cognitive behaviors regarding the emotional responses of infants with VI. The SI group exhibited greater negative emotionality throughout the entire procedure compared to the VI group. While the SI group showed classic still-face effect patterns during the exposure episodes, the VI group's negative emotionality showed a more linear trend. This finding is consistent with previous research (Pérez-Pereira & Conti-Ramsden, 2005), which indicates that VI can hinder infants' ability to perceive caregivers' facial expressions. This limitation may affect their emotionality in unexpected situations or during interactions that depend on emotional signals. However, no statistically significant differences were observed in positive emotionality between the groups, with both showing similar responses during all interaction with mothers. Tröster and Brambring (1993) showed infants with blindness responded positively to interactive games with their mothers that incorporated tactile stimulation as SIs. Additionally, positive reactions of infants with VI to their mothers' voices offered evidence of their ability to discriminate between their mothers and unfamiliar individuals, suggesting that auditory cues play a significant role in this process. These emotionality findings might highlight the potential importance of mothers' participation in both groups' emotional engagement during the interaction. Vocal attendance of mothers has been found as a crucial factor in the connection between dyads (Fraiberg, 1975; 1977). Moreover, one of the important components of this vocal attendance has been found as tactile attendance by the mother. As it has been shown by Grumi et al., (2021), especially infants' emotional regulation and adaptive socio-cognitive abilities in a clinical group are affected by social touch by the mother (Provenzi et al., 2020). Additionally, while the negative emotions of infants with VI might not have been directly influenced by their mothers' facial expressions or play interruptions, the observed decrease in positive emotions during these episodes suggests they remained sensitive to changes in the interaction flow. This sensitivity aligns with research by Pérez-Pereira and Conti-Ramsden (2005) who reported that the mean length of turns taken by blind infants is comparable to SIs. This suggests that blind infants are equally likely to initiate conversation, demonstrating their ability to engage and respond to social cues through non-visual channels.

In short, although behaviors demonstrating social attention and social cognition, such as gaze orientation and pointing, were observed less frequently in infants with VI compared to SIs, the VI group showed similar performance to the SI group in terms of attempts at communication with social stimuli such as their mothers and human voices. This suggests that infants with VI have communicative intent and enthusiasm, but they may not express it as overtly due to two interconnected reasons. Firstly, infants with VI often experience delays in motor skill competence, affecting their ability to independently support their head, and develop fine motor and locomotor skills (Wagner, Haiback & Lieberman, 2013; Prechtl et al., 2001; Tröster and Brambring, 1993). Secondly, successful social interaction requires that displayed behaviors are correctly interpreted by social partners. Infants with VI may engage less with objects, leading to fewer opportunities for mothers to interpret their behaviors as having an external focus (Bigelow, 2003). Additionally, mothers might struggle to identify when children with VI are attending to an object due to atypical behaviors, such as turning their heads away while listening (Preisler, 1991).

In addition, emotionality results provide further evidence of the engagement and enthusiasm of infants with VI in interactions. While their negative reactions during the still-face procedure—indicative of emotional involvement—differ, the decrease in positive affect during the exposure episode shows they are still affected by interaction changes. These findings highlight that perhaps it is not just the limited behaviors of infants with VI that need to be investigated, but also the challenges that parents and researchers face in observing and interpreting these behaviors.

This study underscores significant differences in the socio-cognitive behaviors of infants with VI and SIs, particularly in gaze orientation, communication, and emotional responses. SIs demonstrated more effective use of gaze orientation and pointing, crucial for social interaction and joint attention. Although infants with VI face challenges in non-verbal communication and gestures, their initial interest in social partners remains intact. These findings highlight the need for early interventions that support alternative sensory modalities and enhance the socio-cognitive development of infants with VI. Future research should continue to explore these developmental trajectories and the long-term effects of early interventions on the socio-cognitive and emotional well-being of infants with VI.

Examining the early indicators of socio-cognitive development in infants aged 9 to 12 months, this study provides a specific focus on how these indicators manifest in visually impaired infants. The findings from this study have several important implications. The differences in gaze orientation and pointing behaviors between infants with VI and SIs underline the need for early intervention programs that target these specific skills, incorporating alternative sensory modalities to enhance social attention and joint attention skills. Parental guidance and support are crucial, with training programs emphasizing vocal and tactile interactions to compensate for the lack of visual cues. Educators and therapists can develop tailored strategies to encourage non-verbal communication and recognize subtle cues from infants with VI. The study's insights contribute to a broader understanding of socio-cognitive development, suggesting the need for further research on long-term developmental trajectories and the efficacy of specific interventions. However, the study's limitations should be acknowledged. The relatively small and homogeneous sample size may limit the generalizability of the findings. Observational measures, which can be subject to bias, were used to assess social attention behaviors, communication, and emotional responses; future research should incorporate more objective measures.

4.2. Conclusion

In conclusion, this study explored the socio-cognitive development of infants between 9 and 12 months, highlighting key differences between SIs and infants with VI. Firstly, the study revealed that while infants at both age points showed similar tendencies to approach sources in case of auditory stimulation and interact with their mothers using gaze and communicative behaviors during their interaction, significant developmental progress was observed in pointing behavior, which increased markedly between 9 and 12 months. Additionally, it was found that the type of episode, rather than age, significantly affected attentional and emotional responses. This underscores a nuanced picture of development between these months where certain skills, like pointing, become more pronounced, while attentional and emotional responses are influenced by social auditory cues.

Furthermore, the study compared infants with VI to their SIs to examine differences in these skills between these groups. It revealed that while infants with VI exhibited less frequent behaviors demonstrating social attention and cognition, such as gaze orientation and pointing, they showed similar levels of communicative attempts with social stimuli like their mothers and human sounds. The emotionality results further highlighted that infants with VI are affected by interaction changes, indicating their engagement and enthusiasm in social interactions. This suggests that infants with VI possess communicative intent and enthusiasm but may express it less overtly due to delays in motor skill competence and the challenge of their behaviors being correctly interpreted by social partners. Furthermore, caregivers might struggle to identify when infants with VI are attending to an object due to atypical behaviors, such as turning their heads away while listening.

These findings highlight the significant differences in socio-cognitive behaviors between infants with VI and SIs, emphasizing the crucial role of gaze orientation and pointing in social interaction and joint attention for SIs, while also recognizing the communicative potential and initial social interest of infants with VI. Dynamic systems theory underscores the importance of viewing these developmental changes as part of a broader, interconnected system where individual and environmental factors continuously interact. This perspective helps in understanding how infants with VI adapt to their sensory environment and develop alternative strategies for social engagement.

Overall, this study underscores the significant differences in socio-cognitive behaviors between infants with VI and SIs, emphasizing the crucial role of gaze orientation and pointing in social interaction and joint attention for SIs, while also recognizing the communicative potential and initial social interest of infants with VI. These findings highlight the necessity for early interventions that support alternative sensory modalities and enhance the socio-cognitive development of infants with VI. Future research should continue to explore these developmental trajectories and the long-term effects of early interventions on the socio-cognitive and emotional well-being of infants with VI, ensuring they receive the necessary support to thrive in social interactions.

REFERENCES

Adamson, L. B., & Frick, J. E. (2003). The Still Face: A History of a Shared Experimental Paradigm. *Infancy*, 4(4), 451–473. https://doi.org/10.1207/S15327078IN0404_01

Adamson, L. B., Bakeman, R., Suma, K., & Robins, D. L. (2019). Sharing sounds: The development of auditory joint engagement during early parent-child interaction. *Developmental psychology*, *55*(12), 2491–2504. https://doi.org/10.1037/dev0000822

Adamson, L. B., Bakeman, R., Suma, K., & Robins, D. L. (2021). Autism Adversely Affects Auditory Joint Engagement During Parent-toddler Interactions. *Autism research: Official journal of the International Society for Autism Research*, *14*(2), 301–314. https://doi.org/10.1002/aur.2355

Admiraal, M. A., Keijsers, N. L., & Gielen, C. C. (2003). Interaction between gaze and pointing toward remembered visual targets. *Journal of neurophysiology*, *90*(4), 2136–2148. https://doi.org/10.1152/jn.00429.2003

Als, H. (1982). *The unfolding of behavioral organization in the face of a biological violation*. In E. Z. Tronick (Ed.), *Social interchange in infancy: Affect, cognition and communication* (pp. 125-160). Baltimore: University Park Press.

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)* American Psychiatric Pub; Washington, DC, USA.

Aslin, R. N. (1987). Motor aspects of visual development in infancy. In P. Salapatek & L. Cohen (Eds.), *Handbook of infant perception: Vol. 1. From sensation to perception* (pp. 43–113). Orlando, FL: Academic Press.

Babik, I., Galloway, J. C., & Lobo, M. A. (2022). Early exploration of one's own body, exploration of objects, and motor, language, and cognitive development relate dynamically across the first two years of life. *Developmental Psychology, 58*(2), 222-235.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interactions. *Child Development,* 55(4), 1278–1289.

Bakeman, R., Adamson, L. B., Konner, M., & Barr, R. G. (1990). Kung infancy: The social context of object exploration. *Child Development,* 61(3), 794–809.

Baker, J. K., Messinger, D. S., Lyons, K. K., & Grantz, C. J. (2010). A pilot study of maternal sensitivity in the context of emergent autism. *Journal of autism and developmental disorders*, *40*(8), 988–999. https://doi.org/10.1007/s10803-010-0948-4

Baldwin, D. A., & Moses, L. J. (1996). The ontogeny of social information gathering. *Child Development,* 67(5), 1915–1939. https://doi.org/10.2307/1131601

Baron-Cohen, S., Allen, J., & Gillberg, C. (1992). Can autism be detected at 18 months? The needle, the haystack, and the CHAT. *The British journal of psychiatry: the journal of mental science*, *161*, 839–843. https://doi.org/10.1192/bjp.161.6.839

Bastianello, T., Keren-Portnoy, T., Majorano, M., & Vihman, M. (2022). Infant looking preferences towards dynamic faces: A systematic review. *Infant behavior & development*, *67*, 101709. https://doi.org/10.1016/j.infbeh.2022.101709

Bates, E., Camaioni, L., & Volterra, V. (1975). The acquisition of performatives prior to speech. *Merrill-Palmer Quarterly of Behavior and Development,* *21*(3), 205–226. http://www.jstor.org/stable/23084619

Bates, E., Benigni, L., Bretherton, I., Camaioni, L., Volterra, V., Carlson, V., Carpen, K., & Rosser, M. (1979). *The emergence of symbols: cognition and communication in infancy*. Academic Press. June 10, 2024,

Beaudoin, C., & Beauchamp, M. H. (2020). Social cognition. *Handbook of clinical neurology*, 173, 255–264. https://doi.org/10.1016/B978-0-444-64150-2.00022-8

Beebe, B., Messinger, D., Bahrick, L. E., Margolis, A., Buck, K. A., & Chen, H. (2016). A systems view of mother–infant face-to-face communication. *Dev. Psychol*., 52, 556–571. doi: 10.1037/a0040085

Behne, T., Liszkowski, U., Carpenter, M., & Tomasello, M. (2012). Twelve-month-olds' comprehension and production of pointing. *British Journal of Developmental Psychology, 30*(3), 359–375. https://doi.org/10.1111/j.2044-835X.2011.02043.x

Benedict, H. (1979). Early lexical development: Comprehension and production. *Journal of Child Language, 6*(2), 183–200. https://doi.org/10.1017/S0305000900002245

Bertalanffy, L. von (1969). General system theory: Foundations, development, applications. New York: G. Braziller.

Beuker, K. T., Rommelse, N. N., Donders, R., & Buitelaar, J. K. (2013). Development of early communication skills in the first two years of life. *Infant behavior & development*, *36*(1), 71–83. https://doi.org/10.1016/j.infbeh.2012.11.001

Bigelow, A.E. (2003). The development of joint attention in blind infants. *Development and Psychopathology,* 15, 259–275. doi:10.1017/S095457940300014

Bornstein, M. H., Tamis-LeMonda, C. S., Tal, J., Ludemann, P., Toda, S., Rahn, C. W., Pecheux, M., Azuma, H., & Vardi, D. (1992).Maternal responsiveness to infants in three societies: The United States, France, and Japan. *Child Development,* 63, 808–821.

Bornstein, M. H., & Haynes, O. M. (1998). Vocabulary competence in early childhood: Measurement, latent construct, and predictive validity. *Child Development, 69*(3), 654–671.

Bornstein, M. H., & Manian, N. (2013). Maternal responsiveness and sensitivity reconsidered: some is more. *Development and psychopathology*, *25*(4 Pt 1), 957–971. https://doi.org/10.1017/S0954579413000308

Botero, M. (2016). Tactless scientists: Ignoring touch in the study of joint attention. *Philosophical Psychology*, 29, 1200–1214. doi:10.1080/09515089.2016.1225293

Boyd, D. R., & Bee, H. L. (2010). *The developing child / Denise Boyd, Helen Bee.* (13th edition.). Pearson.

Brambring M., Dobslaw G., Klee K., Obermann S., & Tröster H. (1987). *Der Bielefelder Elternfragebogen für blinde unde sehende Klein—und Vorschulkinder [The Bielefeld Parents' Questionnaire for Blind and Sighted Infants and Preschoolers] (unpublished research report).* Bielefeld, Germany: University of Bielefeld, Special Research Unit on Prevention and Intervention in Childhood and Adolescence.

Brambring, M. (2007). Divergent development of verbal skills in children who are blind or sighted. *Journal of Visual Impairment and Blindness,* 101(12), 749–762. https://doi.org/10.1177/0145482X0710101205

Bridgett, D. J., Laake, L. M., Gartstein, M. A., & Dorn, D. (2013). Development of infant positive emotionality: The contribution of maternal characteristics and effects on subsequent parenting. *Infant and Child Development, 22*(4), 362–382. https://doi.org/10.1002/icd.1795

Bushnell, I. (2001). Mother's face recognition in newborn infants: Learning and memory. Infant and *Child Development,* 10, 67–74.

Camaioni, L. (1997). The emergence of intentional communication in ontogeny, phylogeny, and pathology. *European Psychologist,* 2(3), 216–225.

Camaioni, L., Perucchini, P., Bellagamba, F., & Colonnesi, C. (2004). The role of declarative pointing in developing a theory of mind. *Infancy,* 5(3), 291–308.

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social Cognition, Joint Attention, and Communicative Competence from 9 to 15 Months of Age. *Monographs of the Society for Research in Child Development*, *63*(4), i–174. https://doi.org/10.2307/1166214

Carpenter, M., & Liebal, K. (2012). Joint attention, communication, and knowing together in infancy. In A. Seemann (Ed.), *Joint Attention: New Developments In Psychology, Philosophy of Mind, and Social Neuroscience* (pp. 159–181). Cambridge, MA: MIT Press.

Caskey, M., Stephens, B., Tucker, R., & Vohr, B. (2011). Importance of parent talk on the development of preterm infant vocalizations. *Pediatrics*, *128*(5), 910–916. https://doi.org/10.1542/peds.2011-0609

Cetin, E., Yaman, A., & Berk, A. T. (2004). Etiology of childhood blindness in Izmir, Turkey. *European Journal of Ophthalmology,* *14*(6), 531–537. https://doi.org/10.1177/112067210401400612

Chen, D., & Downing, J. E. (2006). *Tactile Strategies for Children Who Have Visual Impairments and Multiple Disabilities: Promoting Communication and Learning Skills*. New York, NY: American Foundation for the Blind.

Cioffi, C. C., Griffin, A. M., Natsuaki, M. N., Shaw, D. S., Reiss, D., Ganiban, J. M., Neiderhiser, J. M., & Leve, L. D. (2021). The role of negative emotionality in the development of child executive function and language abilities from toddlerhood to first grade: An adoption study. *Developmental psychology,* 57(3), 347–360. https://doi.org/10.1037/dev0000972

Cochet, H., Jover, M., Rizzo, C., & Vauclair, J. (2017). Relationships between declarative pointing and theory of mind abilities in 3- to 4-year-olds. *European Journal of Developmental Psychology,* 14(3), 324–336. https://doi.org/10.1080/17405629.2016.1205975

Cole, P. M., Bendezú, J. J., Ram, N., & Chowa, S.M. (2017). Dynamical systems modeling of early childhood self-regulation. *Emotion, 17*(4), 684–699.

Colombo J. (2001). The development of visual attention in infancy. *Annual review of psychology*, *52*, 337–367. https://doi.org/10.1146/annurev.psych.52.1.337

Colonnesi, C., Stams, G. J. J. M., Koster, I., & Noom, M. J. (2010). The relation between pointing and language development: A meta-analysis. *Developmental Review*, 30(4), 352 366. https://doi.org/10.1016/J.DR.2010.10.001

Colonnesi, C., Zijlstra, B. J., van der Zande, A., & Bögels, S. M. (2012). Coordination of gaze, facial expressions and vocalizations of early infant communication with mother and father. *Infant behavior & development*, *35*(3), 523–532. https://doi.org/10.1016/j.infbeh.2012.02.004

Conti-Ramsden, G., & P´erez-Pereira, M. (1999). Conversational interactions between mothers and their infants who are congenitally blind, have low vision, or are sighted. *Journal of Visual Impairment & Blindness*, 93, 691–703. https://doi.org/10.1177/0145482x9909301102.

Corbetta, D., & Snapp-Childs, W. (2009). Seeing and touching: The role of sensory-motor experience on the development of infant reaching. *Infant Behavior & Development*, *32*, 44–58.

Crais, E., Douglas, D. D., & Campbell, C. C. (2004). The intersection of the development of gestures and intentionality. *Journal of Speech, Language, and Hearing Research*, *47*(3), 678.

Cross, D., Fani, N., Powers, A., & Bradley, B. (2017). Neurobiological Development in the Context of Childhood Trauma. *Clinical psychology : a publication of the Division of Clinical Psychology of the American Psychological Association*, *24*(2), 111–124. https://doi.org/10.1111/cpsp.12198

Csibra, G., & Gergely, G. (2009). Natural pedagogy. Trends in Cognitive Sciences, 13, 148–153. doi:10.1016/j. tics.2009.01.005

Dale, N., & Salt, A. (2007). Early support developmental journal for children with visual impairment: The case for a new developmental framework for early intervention. *Child: Care, Health and Development, 33*, 684–690. https://doi.org/10.1111/j.1365-2214.2007.00774.x

Dale, N. J., Tadić, V., & Sonksen, P. (2014). Social communicative variation in 1-3-year-olds with severe visual impairment. *Child: Care, Health and Development*, 40(2), 158–164. https://doi.org/10.1111/ cch.12065

Dale, N. J., Sakkalou, E., O'Reilly, M. A., Springall, C., Sakki, H., Glew, S., Pissaridou, E., De Haan, M., & Salt, A. T. (2019). Home-based early intervention in infants and young children with visual impairment using the Developmental Journal: longitudinal cohort study.

Developmental medicine and child neurology, *61*(6), 697–709. https://doi.org/10.1111/dmcn.14081

Dare, A., & O'Donovan, M. (1997). *Good Practice in Caring for Young Children with Special Needs*. Stanley Thornes.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental psychology*, *40*(2), 271–283. https://doi.org/10.1037/0012-1649.40.2.271

Dawson, G., Bernier, R., & Ring, R. H. (2012). Social attention: a possible early indicator of efficacy in autism clinical trials. *Journal of neurodevelopmental disorders*, *4*(1), 11. https://doi.org/10.1186/1866-1955-4-11

Day, S. (1997). Normal and abnormal visual development. *Pediatric ophthalmology* 1(2), 13–28.

Dinehart, L., Messinger, D. S., Acosta, S. I., Cassel, T., Ambadar, Z., & Cohn, J. (2005). Adult perceptions of positive and negative infant emotional expressions. *Infancy,* 8, 279–303. doi:10.1207/s15327078in0803_5

Dionne-Dostie, E., Paquette, N., Lassonde, M., & Gallagher, A. (2015). Multisensory integration and child neurodevelopment. *Brain sciences*, *5*(1), 32–57. https://doi.org/10.3390/brainsci5010032

Dobson, V., & Teller, D. Y. (1978). Visual acuity in human infants: A review and comparison of behavioral and electrophysiological studies. *Vision Research, 18*, 1469-1483.

Dunlea, A. (1989). *Vision and the Emergence of Meaning*. New York: Cambridge University Press.

Dunlea, A., & Andersen, E. S. (1992). The emergence process: Conceptual and linguistic influences on morphological development. *First Language,* 12(34), 95-115.

Easterbrook, M.A., Kisilevsky, B.S., Hains, S.M.J. & Muir, D.W. (1999). Faceness or complexity: evidence from newborn studies. *Infant Behavior and Development,* 22, 17–35

Elsner, C., Bakker, M., Rohlfing, K., and Gredebäck, G. (2014). Infants' online perception of give-and-take interactions. *J. Exp. Child Psychol.* 126, 280–294. doi: 10.1016/j.jecp.2014.05.007

Emde, R. N., Gaensbauer, T. J., & Harmon, R. J. (1976). Emotional expression in infancy: A biobehavioral study. Psychological Issues, 10(1), 1-200.

Fantz, R. L. (1958). Pattern vision in young infants. *Psychological Record, 8*, 43-47.

Farroni, T., Massaccesi, S., Pividori, D., & Johnson, M. H. (2004). Gaze Following in Newborns. *Infancy,* 5(1), 39–60. https://doi.org/10.1207/s15327078in0501_2

Feldman, R. (2007). Parent–infant synchrony and the construction of shared timing; physio-logical precursors, developmental outcomes, and risk conditions. *Journal of Child Psychologyand Psychiatry,*48, 329–354.

Fotiadou, E., Christodoulou, P., Soulis, S.-G., Tsimaras, V. K., & Mousouli, M. (2014). Motor development and self—esteem of children and adolescents with visual impairment. *Journal of Education and Practice,* 5(37), 97–106.

Fraiberg, S. (1975). The development of human attachments in infants blind from birth. Merrill-Palmer Quartery, 21, 315-334.

Fraiberg, S. (1977). *Insights from the Blind: Comparative Studies of*

Blind and Sighted Infants. New

York: Plenum Press.

Frichtel, M., & Lécuyer, R. (2006). The use of perspective as a depth cue with a 2D display in 4- and 5-month-old infants. *Infant Behavior and Development*, 30, 409–421.

Gibson, E. J., & Walk, R. D. (1960). The "Visual Cliff." *Scientific American,* 202, 80–92.

Gilbert, C., Foster, A., Négrel, A. D., & Thylefors, B. (1993). Childhood blindness: a new form for recording causes of visual loss in children. *Bulletin of the World Health Organization*, *71*(5), 485–489.

Gogate, P., Gilbert, C., & Zin, A. (2011). Severe visual impairment and blindness in infants: causes and opportunities for control. *Middle East African journal of ophthalmology*, *18*(2), 109–114. https://doi.org/10.4103/0974-9233.80698

Granic, I. & Hollestain, T. (2003). *Dynamic systems methods for models of developmental psychopathology*. Cambridge University press.

Grumi, S., Capelli, E., Morelli, F., Vercellino, L., Mascherpa, E., Ghiberti, C., Carraro, L., Signorini, S., & Provenzi, L. (2024). Gaze Orienting in the Social World: An Exploration of the Role Played by Caregiving Vocal and Tactile Behaviors in Infants with Visual Impairment and in Sighted Controls. *Brain sciences*, *14*(5), 474.

Grumi, S., Cappagli, G., Aprile, G., Mascherpa, E., Gori, M., Provenzi, L., & Signorini, S. (2021). Togetherness, beyond the eyes: A systematic review on the interaction between visually impaired children and their parents. *Infant behavior & development*, *64*, 101590. https://doi.org/10.1016/j.infbeh.2021.101590

Guastello, S. J., Koopmans, M., & Pincus, D. (2009*). Chaos and complexity in psychology*. Cambridge, Cambridge University.

Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and reunion. Child Development, 74, 1534–1546.

Hart, B., & Risley, T. R. (1995). *Meaningful Differences in the Everyday Experience of Young American Children*. Baltimore, MD: P. H. Brookes.

Hatch, B., Iosif, AM., Chuang, A. *et al.* (2021) Longitudinal Differences in Response to Name Among Infants Developing ASD and Risk for ADHD. *J Autism Dev Disord* **51**, 827–836. https://doi.org/10.1007/s10803-020-04369-8

Hatton, D. D., Schwietz, E., Boyer, B., & Rychwalski, P. (2007). Babies count: The national registry for children with visual impairments, birth to 3 years. *Journal of American Association for Pediatric Ophthalmology and Strabismus*, 11(4), 351–355.

Heyes, C. (2015). Born pupils? Natural pedagogy and cultural pedagogy. *Perspectives on Psychological Science,* 1, 280–295

Hobson, R. P. (1993). The emotional origins of social understanding. *Philos. Psychol.* 6, 227–249. doi: 10.1080/09515089308573090

Hobson, P. Lee, A. & Brown, R. (1999). Autism and congenital blindness. *Journal of Autism and Developmental Disorders,* 29, 45-56.

Hsu, H.C. & Fogel, A. (2003). Stability and Transitions in Mother-Infant Face-to-Face Communication During the First 6 Months: A Microhistorical Approach. *Developmental Psychology*, 39(6), 1061–1082. https://doi.org/10.1037/0012- 1649.39.6.1061

Hsu, H. C., & Jeng, S. F. (2008). Two-month-olds' attention and affective response to maternal still face: a comparison between term and preterm infants in Taiwan. *Infant Behav. Dev.* 31, 194–206. doi: 10.1016/j.infbeh.2007.10.008

Hunnius S, & Bekkering H (2014). What are you doing? How active and observational experience shape infants' action understanding. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1644), 20130490–20130490. 10.1098/rstb.2013.0490

Ibañez, L. V., Grantz, C. J., & Messinger, D. S. (2013). The Development of Referential Communication and Autism Symptomatology in High-Risk Infants. *Infancy : the official journal of the International Society on Infant Studies*, 18(5), 10.1111/j.1532-7078.2012.00142.x.

Iverson, J. M., Tencer, H. L., Lany, J., & Goldin-Meadow, S. (2000). The relation between gesture and speech in congenitally blind and sighted language-learners. Journal of Nonverbal Behavior, 24(2), 105-130.

Iverson, J. M. (2010). Developing language in a developing body: the relationship between motor development and language development. *Journal*

of Child Language, 37(2),

229–261. https://doi.org/10.1017/s0305000909990432

Johnson, J. S., & Newport, E. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology,* 21, 60–99

Jones, S. S., & Hong, H. (2005). How some infant smiles get made. *Infant Behavior & Development, 28*(2), 194–205.

Jones-Mason, K., Alkon, A., Coccia, M., & Bush, N. R. (2018). Autonomic nervous system functioning assessed during the Still-Face Paradigm: A meta-analysis and systematic review of methods, approach and findings. *Developmental review : DR*, 50(Pt B), 113–139. https://doi.org/10.1016/j.dr.2018.06.002

Joseph, H. M., Lorenzo, N. E., Wang, F. L., Wilson, M. A., & Molina, B. S. G. (2022). The interaction between infant negative emotionality and cognition predicts ADHD-related behaviors in toddlerhood. *Infant behavior & development,* 68, 101742. https://doi.org/10.1016/j.infbeh.2022.101742

Kappas, A. (2011). Emotion and Regulation are One! *Emotion Review, 3*(1), 17-25. https://doi.org/10.1177/1754073910380971

Kärtner, J., Keller, H., & Yovsi, R. D. (2010). Mother–infant interaction during the first 3 months: The emergence of culture-specific contingency patterns. *Child Development:* 81., (2), 540–554

Keech, R. (2002). Ophthalmology. In A. Rudolph, R. Kamei, & K. Overby (Eds.), *Rudolph's fundamentals of pediatrics* (3rd ed., pp. 847–862). New York: McGraw-Hill.

Kelso, J.A.S., Zanone, P.G. (1997). Coordination dynamics of learning and transfer: Collective and component levels. *Journal of Experimental Psychology: Human Perception and Performance*, Vol 23(5).

Klin, A., Shultz, S., & Jones, W. (2015). Social visual engagement in infants and toddlers with autism: early developmental transitions and a model of pathogenesis. *Neuroscience and biobehavioral reviews*, *50*, 189–203. https://doi.org/10.1016/j.neubiorev.2014.10.006

Koopmans-Van Beinum, F. J., & Van Der Stelt, J. M. (1986). Early stages in the development of speech movements. In B. Lindblom & R. Zetterstrom (Eds.), *Precursors of Early Speech* (pp. 37–50). New York, NY: Stockton Press.

Kymissis, E., & Poulson, C. L. (1990). The history of imitation in learning theory: the language acquisition process. *Journal of the experimental analysis of behavior*, *54*(2), 113–127. https://doi.org/10.1901/jeab.1990.54-113

Landau, B., & Gleitman, L. R. (1985). *Language and experience: Evidence from the blind child*. Cambridge, MA: Harvard University Press.

Lane, C., Kanjlia, S., Richardson, H., Fulton, A., Omaki, A., & Bedny, M. (2017). Reduced Left Lateralization of Language in Congenitally Blind Individuals. *Journal of Cognitive Neuroscience, 29*(1), 65–78

Lavelli, M., & Fogel, A. (2002). Developmental changes in mother–infant face-to-face communication: Birth to 3 months. *Developmental Psychology:* 38., (2), 288–305.

Lavelli, M., & Fogel, A. (2005). Developmental changes in the relationship between the infant's attention and emotion during early face-to-face communication: The 2-month transition. *Developmental Psychology,* 41(1), 265-280.

Legerstee, M. & Barillas, Y. (2003). Sharing attention and pointing to objects at 12 months: is the intentional stance implied? *Cogn Dev.*18(1), 91–110.

Legerstee, M., & Markova, G. (2007). Intentions make a difference: Infant responses to still-face and modified still-face conditions. *Infant Behavior and Development, 30*(2), 232–250.

Lewis, V., Norgate, S., Collis, G., & Reynolds, R. (2000). The consequences of visual impairment for children's symbolic and functional play. *British Journal of Developmental Psychology,* 18, 449–464. doi:10.1348/026151000165797.

Liszkowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. *Developmental science*, *7*(3), 297–307. https://doi.org/10.1111/j.1467-7687.2004.00349.x

Liszkowski, U., Carpenter, M., & Tomasello, M. (2007). Pointing out new news, old news, and absent referents at 12 months of age. *In Developmental Science,*10,(2). https://doi.org/10.1111/j.1467-7687.2006.00552.x

Lüke, C., Ritterfeld, U., Grimminger, A., Liszkowski, U., & Rohlfing, K. J. (2017). Development of pointing gestures in children with typical and delayed language acquisition. *Journalof Speech, Language, and Hearing Research*, 60, 3185-3197. DOI: 10.1044/2017_JSLHR-L-16-0129

Maćesić-Petrović, D., Vučinić, V., & Eškirović, B. (2010). Cognitive development of children with visual impairment and special educational treatment. *Procedia - Social and Behavioral Sciences, 5*, 157-162. https://doi.org/10.1016/j.sbspro.2010.07.065.

Marno, H., Guellai, B., Vidal, Y., Franzoi, J., Nespor, M., & Mehler, J. (2016). Infants' selectively pay attention to the information they receive from a native speaker of their language. Frontiers in Psychology, 7. doi:10.3389/fp syg.2016.01150

Masur, E. F. (1983). Gestural development, dual-directional signaling, and the transition to words. *Journal of Psycholinguistic Research*, 12, 93-109.

Mayer, D. L., Beiser, A. S., Warner, A. F., Pratt, E. M., Raye, K. N., & Lang, J. M. (1995). Monocular acuity norms for the Teller Acuity Cards between ages one month and four years. *Investigative ophthalmology & visual science*, *36*(3), 671–685.

McConachie, H. R., & Moore, V. (1994). Early expressive language of severely visually impaired children. *Developmental Medicine & Child Neurology,* 36(3), 230-240.

McGillion, M., Pine, J. M., Herbert, J. S., & Matthews, D. (2017). A randomised controlled trial to test the effect of promoting caregiver contingent talk on language development in infants from diverse socioeconomic status backgrounds. *Journal of child psychology and psychiatry, and allied disciplines*, 58(10), 1122–1131. https://doi.org/10.1111/jcpp.12725

Menting, B., van Lier, P. A. C., & Koot, H. M. (2010). Language skills, peer rejection, and the development of externalizing behavior from kindergarten to fourth grade. *Journal of Child Psychology and Psychiatry, 51*(8), 998-1008. https://doi.org/10.1111/j.1469-7610.2010.02279.x

Mesman, J., van Ijzendoorn, M.H., &Bakermans-Kranenburg,M.J. (2009). The many faces of the still-face paradigm: A review and meta-analysis. *Developmental Review,* 29, 120– 162.

Miller, M., Iosif, A.-M., Hill, M., Young, G. S., Schwichtenberg, A. J., & Ozonof, S. (2017). Response to name in infants developing autism spectrum disorder: A prospective study. *The Journal of Pediatrics,* 183, 141–146.e1. https://doi.org/10.1016/j.jpeds .2016.12.071.

Minter, M., Hobson, R. P. & Bishop, M. (1998). Congenital visual impairment and theory of mind. *British Journal of Developmental Psychology,* 16, 183-196.

Montirosso, R., Fedeli, C., Murray, L. et al. (2012). "The role of negative maternal affective states and infant temperament in early interactions between infants with cleft lip and their mothers," *Journal of Pediatric Psychology,* 37(2), 241–250.

Montirosso, R., Provenzi, L., Tronick, E., Morandi, F., Reni, G., and Borgatti, R. (2014). Vagal tone as a biomarker of long-term memory for a stressful social event at 4 months. *Dev. Psychobiol*. 56, 1564–1574. doi: 10.1002/dev.21251

Montirosso, R., Provenzi, L., Tavian, D., Morandi, F., Bonanomi, A., Missaglia, S., et al. (2015). Social stress regulation in 4-month-old infants: contribution of maternal social engagement and infants' 5-HTTLPR genotype. *Early Hum. Dev*. 91, 173–179. doi: 10.1016/j.earlhumdev.2015.01.010

Moore, C., & Dunham, P. J. (Eds.). (1995). *Joint attention: Its origins and role in development.* Lawrence Erlbaum Associates, Inc.

Moore, J. K., & Linthicum, F. H., Jr (2007). The human auditory system: a timeline of development. *International journal of audiology*, *46*(9), 460–478. https://doi.org/10.1080/14992020701383019

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to joint attention across the 6- through 24-month age period and early language acquisition. *Journal of Applied Developmental Psychology, 21*(3), 283-298. https://doi.org/10.1016/S0193-3973(99)00040-4

Moussaïd, M., Perozo, N., Garnier, S., Helbing, D., & Theraulaz, G. (2010). The walking behaviour of pedestrian social groups and its impact on crowd dynamics. *PloS one, 5*(4), e10047. https://doi.org/10.1371/journal.pone.0010047

Murray, L., & Trevarthen, C. (1986). The infant's role in mother–infant communications. *J. Child Lang*. 13, 15–29. doi: 10.1017/S0305000900000271

Mwende, J., Bronsard, A., Mosha, M., Bowman, R., Geneau, R., & Courtright, P. (2005). Delay in presentation to hospital for surgery for congenital and developmental cataract in Tanzania. *British Journal of Ophthalmology, 89*, 1478–1482. https://doi.org/10.1136/bjo.2005.071597

Nagayoshi, M., Hirose, T., Toju, K., Suzuki, S., Okamitsu, M., Teramoto, T., et al. (2017). Related visual impairment to mother-infant interaction and development in infants with bilateral retinoblastoma. European journal of oncology nursing: the official journal of European Oncology Nursing Society, 28, 28–34. https://doi.org/ 10.1016/j.ejon.2017.02.002

Nazzari, S., Grumi, S., Biasucci, G., Decembrino, L., Fazzi, E., Giacchero, R., Magnani, M. L., Nacinovich, R., Scelsa, B., Spinillo, A., Capelli, E., Roberti, E., Provenzi, L., & MOM-COPE Study Group (2023). Maternal pandemic-related stress during pregnancy associates with infants' socio-cognitive development at 12 months: A longitudinal multi-centric study. *PloS one*, *18*(4), e0284578. https://doi.org/10.1371/journal.pone.0284578

Nelson, C. A. III, Bos, K., Gunnar, M. R., & Sonuga-Barke, E. J. (2011). The neurobiological toll of early human deprivation. *Monographs of the Society for Research in Child Development,* 76, 127–146. https://doi.org/10.1111/j.1540-5834.2011.00630.x

Newman, L., Sivaratnam, C., & Komiti, A. (2015). Attachment and early brain development–neuroprotective interventions in infant–caregiver therapy. *Translational Developmental Psychiatry,* 3, 28647. https://doi.org/10.3402/tdp.v3.28647

Oller, D. K., Eilers, R. E., Bull, D. H., & Carney, A. E. (1985). Prespeech vocalizations of a deaf infant: a comparison with normal metaphonological development. *Journal of Speech and Hearing Research, 28*, 47–63. https://doi.org/10.1044/jshr.2801.47

Oller, D.K. (2000). *The Emergence of the Speech Capacity (1st ed.)*. Psychology Press. https://doi.org/10.4324/9781410602565

Oller, D. K., Buder, E. H., Ramsdell, H. L., Warlaumont, A. S., Chorna, L., & Bakeman, R. (2013). Functional flexibility of infant vocalization and the emergence of language. *Proc. Natl. Acad. Sci.* U.S.A. 110, 6318–6323. doi: 10.1073/pnas.1300337110

Oller, D. K., Ramsay, G., Bene, E., Long, H. L., & Griebel, U. (2021). Protophones, the precursors to speech, dominate the human infant vocal landscape. *Philosophical Transactions of the Royal Society B, 376*, 20200255. https://doi.org/10.1098/rstb.2020.0255

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

Pérez-Pereira, M., & Conti-Ramsden, G. (2001). The use of directives in verbal interactions between blind children and their mothers. Journal of Visually Impairment & Blindness, 95(3), 133–149. https://doi.org/10.1177/0145482x0109500302

Pérez-Pereira, M., & Conti-Ramsden, G. (2005). Do blind children show autistic features? In L. Pring (Ed.), *Autism and blindness: Current findings and reflections* (pp. 99-127). Whurr Publishers.

Perszyk, D. R., & Waxman, S. R. (2019). Infants' advances in speech perception shape their earliest links between language and cognition. *Scientific Reports, 9*, 3293. doi:10.1038/s41598-019-39511-9

Perucchini, P., Bello, A., Presaghi, F., & Aureli, T. (2021). Developmental trajectories in infant pointing: The effects of vocalisation and communicative intention. *First Language,* 41(3), 314–335. https://doi.org/10.1177/0142723720980196

Piaget, J. (1954). *The Construction of Reality in the Child.* New York: Basic Books. http://dx.doi.org/10.1037/11168-000

Prechtl, H., Cioni, G., Einspieler, C., Bos, A., & Ferrari, F. (2001). Role of vision on early motor development: Lessons from the blind. Developmental Medicine and Child Neurology, 43(3), 198–201.

Preisler, G. M. (1991). Early patterns of interaction between blind infants and their sighted mothers. *Child: Care, Health and Development, 17*(2), 65–90.

Propper, C., & Moore, G. A. (2006). The influence of parenting on infant emotionality: A multi-level psychobiological perspective. *Developmental Review,* 26(4), 427–460. https://doi.org/10.1016/j.dr.2006.06.003

Provenzi, L., Fumagalli, M., Bernasconi, F., Sirgiovanni, I., Morandi, F., Borgatti, R., et al. (2017). Very preterm and full-term infants' response to socio-emotional stress: the role of postnatal maternal bonding. *Infancy* 22, 695–712. doi: 10.1111/infa.12175

Provenzi, L., Scotto di Minico, G., Giusti, L., Guida, E., & Müller, M. (2018). Disentangling the Dyadic Dance: Theoretical, Methodological and Outcomes Systematic Review of Mother-Infant Dyadic Processes. *Frontiers in psychology,* 9, 348. https://doi.org/10.3389/fpsyg.2018.00348

Provenzi, L., Rosa, E., Visintin, E., Mascheroni, E., Guida, E., Cavallini, A., & Montirosso, R. (2020). Understanding the role and function of maternal touch in children with neurodevelopmental disabilities. *Infant*

Behavior and Development, *58*,

101420.

Rahi, J. S., Gilbert, C. E., Foster, A., & Minassian, D. (1999). Measuring the burden of childhood blindness. *British Journal of Ophthalmology, 83*, 387–388. https://doi.org/10.1136/bjo.83.4.387

Rahi, J. S., & Dezateux, C. (2001). British Congenital Cataract Interest Group. Measuring and interpreting the incidence of congenital ocular anomalies: Lessons from a national study of congenital cataract in the UK. *Investigative Ophthalmology & Visual Science, 42*, 1444–1448.

Recchia, S. L. (1997). Establishing Intersubjective Experience: Developmental Challenges for Young Children with Congenital Blindness and Autism and Their Caregivers. *Blind. Psychol. Dev. Young Child.*, 116–129.

Reddy, V., Hay, D., Murray, L., & Trevarthen, C. (1997). Communication in infancy: Mutual regulation of affect and attention. In G. Bremner, A. Slater, & G. Butterworth (Eds.), Infant development: Recent advances (pp. 247–273). Hove, East Sussex, England: Psychology Press.

Rocha, N. A. C. F., dos Santos Silva, F. P., dos Santos, M. M., & Dusing, S. C. (2020). Impact of mother–infant interaction on development during the first year of life: A systematic review. *Journal of Child Health Care*, 24(3), 365-385. https://doi.org/10.1177/1367493519864742

Rochat, P. (Ed.). (1999). *Early social cognition: Understanding others in the first months of life*. Lawrence Erlbaum Associates Publishers.

Rogers, S. J., & Puchalski, C. B. (1984). Social characteristics of visually impaired infants' play. *Topics in Early Childhood Special Education, 3*(4), 52–56.

Rogers, S. J., & Puchalski, C. B. (1986). Social smiles of visually-impaired infants. *Journal of Visual Impairment & Blindness, 80*(7), 863–865.

Rohlfing, K. J., Lüke, C., Liszkowski, U., Ritterfeld, U., & Grimminger, A. (2022). Developmental Paths of Pointing for Various Motives in Infants with and without Language Delay. *International journal of environmental research and public health,* 19(9), 4982. https://doi.org/10.3390/ijerph19094982

Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology* (Vol. 3, pp. 106–176). New York: Wiley

Rowe, M. L., & Leech, K. A. (2019). A parent intervention with a growth mindset approach improves children's early gesture and vocabulary development. *Developmental science,* 22(4), e12792. https://doi.org/10.1111/desc.12792

Rowland, C. (1984). Preverbal communication of blind infants and their mothers. Journal of Visually Impairment & Blindness, 78, 297–302. https://doi.org/10.1177/0145482x8407800701.

Rudanko, S. L., Fellman, V., & Laatikainen, L. (2003). Visual impairment in children born prematurely from 1972 through 1989. *Ophthalmology, 110*, 1639–1645. https://doi.org/10.1016/S0161-6420(03)00588-4

Sai, F. (2005). The role of the mother's voice in developing mother's face preference: Evidence for intermodal perception at birth. *Infant & Child Development, 14*, 29–50.

Sallquist, J., Eisenberg, N., Spinrad, T. L., Gaertner, B. M., Eggum, N. D., & Zhou, N. (2010). Mothers'and children's positive emotion: Relations and trajectories across four years.*Social Development*,19, 799–821. doi:10.1111/j.1467-9507.2009.00565.x

Salo, V. C., Reeb-Sutherland, B., Frenkel, T. I., Bowman, L. C., & Rowe, M. L. (2019). Does intention matter? Relations between parent pointing, infant pointing, and developing language ability. *Journal of cognition and development : official journal of the Cognitive Development Society*, *20*(5), 635–655. https://doi.org/10.1080/15248372.2019.1648266

Sansavini, A., Guarini, A., Zuccarini, M., Lee, J. Z., Faldella, G., & Iverson, J. M. (2019). Low Rates of Pointing in 18-Month-Olds at Risk for Autism Spectrum Disorder and Extremely Preterm Infants: A Common Index of Language Delay?. *Frontiers in psychology,* 10, 2131. https://doi.org/10.3389/fpsyg.2019.02131

Senju, A., & Johnson, M. H. (2009). The eye contact effect: mechanisms and development. *Trends in cognitive sciences*, *13*(3), 127-134.

Shin, E., Smith, C. L., & Howell, B. R. (2021). Advances in Behavioral Remote Data Collection in the Home Setting: Assessing the Mother-Infant Relationship and Infant's Adaptive Behavior via Virtual Visits. *Frontiers in psychology,* 12, 703822. https://doi.org/10.3389/fpsyg.2021.703822

Shultz S, Klin A, & Jones W (2018). Neonatal Transitions in Social Behavior and Their Implications for Autism. *Trends in Cognitive Sciences,* 22(5), 452–469.

Skellenger, A. C., Rosenblum, L. P., & Jager, B. K. (1997). Behaviors of preschoolers with visual impairments in indoor play settings. *Journal of Visual Impairment & Blindness, 91*(6), 519–530.

Sonksen, P. M., & Dale, N. (2002). Visual impairment in infancy: impact on neurodevelopmental and neurobiological processes. *Developmental Medicine & Child Neurology*, *44*(11), 782–791. doi:10.1017/S0012162201002936

Southgate, V., van Maanen, C., & Csibra, G. (2007). Infant pointing: Communication to cooperate or communication to learn? *Child Development*, 78(3), 735–740. https://doi.org/10.1111/j.1467- 8624.2007.01028.x

Sravish, A. V., Tronick, E., Hollenstein, T., and Beeghly, M. (2013). Dyadic flexibility during the Face-to-Face Still-Face paradigm: a dynamic systems analysis of its temporal organization. *Infant Behav. Dev.* 36, 432–437. doi: 10.1016/j.infbeh.2013.03.013

Srofe, L. A., & Waters, E. (1976). The ontogenesis of smiling and laughter: A perspective on the organization of development in infancy. *Psychological Review, 83*(3), 173–189. https://doi.org/10.1037/0033-295X.83.3.173

Striano, T., & Bertin, E. (2005). Social-cognitive skills between 5 and 10 months of age. *The British journal of developmental psychology*, *23*(4), 559–568.

Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic social competence in infancy. *British Journal of Developmental Psychology*, *17*(4), 551-562.

Tadić, V., Pring, L., & Dale, N. (2009). Attentional processes in young children with congenital visual impairment. *British Journal of Developmental Psychology*, 27(2), 311–330. https://doi.org/10.1348/026151008X310210

Tadić, V., Pring, L., & Dale, N. (2010). Are Language and Social Communication Intact in Children with Congenital Visual Impairment at School Age? *Journal of Child Psychology and Psychiatry, 51*(7), 696–705. https://doi.org/10.1111/j.1469-7610.2010.02247.x

Teller, D. Y., McDonald, M. A., Preston, K., Sebris, S. L., & Dobson, V. (1986). Assessment of visual acuity in infants and children: The acuity cards procedure. *Developmental Medicine and Child Neurology, 28*, 779-789.

Thelen, E., Ulrich, B. D., & Wolff, P. H. (1991). Hidden Skills: A Dynamic Systems Analysis of Treadmill Stepping during the First Year. *Monographs of the Society for Research in Child Development,* 56(1), i–103. https://doi.org/10.2307/1166099

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist*, 50, 79–95

Thelen, E. & Smith, L. B. (2006). *Dynamic Systems Theories.* In R. M. Lerner & W. Damon (Eds.), Handbook of child psychology: Theoretical models of human development (pp. 258– 312). John Wiley & Sons Inc.

Thoermer, C., Woodward, A., Sodian, B., Perst, H., & Kristen, S. (2013). To get the grasp: Seven-month-olds encode and selectively reproduce goal-directed grasping. *Journal Of Experimental Child Psychology*, *116*, 499–509.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 103–130). Hillsdale, NJ: Erlbaum

Tomasello, M., & Call, J. (1997). *Primate cognition.* Oxford University Press.

Trevarthen, C. & Hubley, P. (1978*) Secondary intersubjectivity. In: Confidence, Confiding and Acts of Meaning in the First Year: Action, Gesture, and Symbol* (ed. A. Lock), pp. 183–229. Academic Press, London, UK.

Trevarthen, C. (1979). Communication and cooperation in early infancy: A description of primary intersubjectivity. In M. Bullowa (Ed.), *Before speech: The beginning of human communication* (pp. 321-347). Cambridge: Cambridge University Press.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *J. Am. Acad. Child Psychiatry* 17, 1–13. doi: 10.1016/S0002-7138(09)62273-1

Tröster, H., & Brambring, M. (1993). Early motor development in blind infants. *Journal of Applied Developmental Psychology, 14*(1), 83-106. https://doi.org/10.1016/0193-3973(93)90025-Q

Urqueta Alfaro, A., Morash, V. S., Lei, D., & Orel-Bixler, D. (2018). Joint engagement in infants and its relationship to their visual impairment measurements. *Infant behavior & development*, *50*, 311–323. https://doi.org/10.1016/j.infbeh.2017.05.010

Valiente, C., Lemery-Chalfant, K., & Reiser, M. (2007). Pathways to problem behaviors: Chaotic homes, parent and child effortful control, and parenting. *Social Development, 16*(2), 249–267. https://doi.org/10.1111/j.1467-9507.2007.00383.x

van Hof-van Duin, J. (1989). The development and study of visual acuity. *Developmental Medicine and Child Neurology, 31*, 547-552.

van Wulfften Palthe, T., & Hopkins, B. (1993). A longitudinal study of neural maturation and early mother–infant interaction: A research note. *Journal of Child Psychology and Psychiatry:* 34., (6), 1031–1041.

Vervloed, M. P. J., van den Broek, E. C. G., & van Eijden, A. J. P. M. (2019). Critical Review of Setback in Development in Young Children with Congenital Blindness or Visual Impairment. International Journal of Disability*, Development and Education*, 67(3), 336–355. https://doi.org/10.1080/1034912X.2019.1588231

Wagner, W. O., Haibach, P. S., & Lieberman, L. J. (2013). Gross motor skill performance in children with and without visual impairments – Research to practice. *Research in Developmental Disabilities,* 34, 3246–3252

Watson, C., Hoeft, F., Garrett, A. S., Hall, S. S., & Reiss, A. L. (2008). Aberrant brain activation during gaze processing in boys with fragile X syndrome.Archives of General Psychiatry,65, 1315–1323.

Weinberg, M.K., Tronick, E. (1996). Infant affective reactions to the resumption of maternal interaction after the Still-Face. *Child Development* 67(2), 905-914.

Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology, 35*, 175–188.

Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of child psychology and psychiatry, and allied disciplines,* 47(7), 670–683. https://doi.org/10.1111/j.1469-7610.2005.01545.x

Wernicke, C. (1874). *Der aphasische Symptomencomplex: Eine psychologische Studie auf anatomischer Basis*. Breslau: Cohn and Weigert.

White-Traut, R., Gillette, P., Simpson, P., Zhang, L., Nazarloo, H. P., & Carter, C. S. (2022). Early Postpartum Maternal and Newborn Responses to Auditory, Tactile, Visual, Vestibular, and Olfactory Stimuli. *Journal of obstetric, gynecologic, and neonatal nursing : JOGNN*, *51*(4), 402–417. https://doi.org/10.1016/j.jogn.2022.03.003

World Health Organization. (2022). ICD-11: International classification of diseases (11th revision). https://icd.who.int/

Yazbek, A., & D'Entremont, B. (2006). A longitudinal investigation of the still-face effect at 6 months and joint attention at 12 months. *British Journal of Developmental Psychology*, *24*(3), 589-601.

Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement,communication, and cognition.*Journal of Child Psychology and Psychiatry*,47, 511–523

Zwaigenbauma, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International journal of developmental neuroscience : the official journal of the International Society for Developmental Neuroscience*, *23*(2-3), 143–152. https://doi.org/10.1016/j.ijdevneu.2004.05.001