UNIVERSITY OF PAVIA – IUSS SCHOOL FOR ADVANCED STUDIES PAVIA

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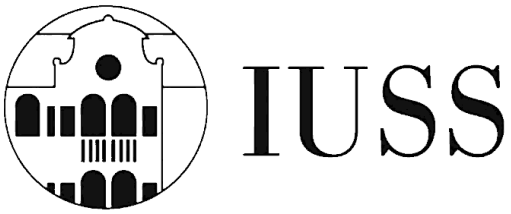
MSc in Psychology, Neuroscience and Human Sciences



How maternal caregiving behavior may shape temperament in infant at neurodevelopmental risk: Findings from a Video-Feedback Intervention study.

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Academic year 2023/2024

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To my grandfather,

To all the moments we spent together,

That I will always guard in my heart.

Abstract

Introduction. Parenting plays a crucial role in a child's development, especially for children at-risk of neurodevelopmental disabilities. One key aspect influenced by maternal caregiving behaviors is the child's temperament, although the existing literature on this topic remains limited. Parents of children at-risk of neurodevelopmental disabilities often face challenges in interacting with their infants and are at a higher risk of developing affective disorders. A promising early intervention to improve caregiving behaviors and mental health, as well as support the child's development, is the Telemedicine-delivered Video-Feedback Intervention (TVFI).

Aims. The SPHERE project aims to identify maternal caregiving behaviors that may predict infant temperament in children at-risk of neurodevelopmental disabilities. We also sought to assess the feasibility of using TVFI as an early intervention tool, given the limited research on this approach. Finally, we investigated the effectiveness of TVFI in enhancing caregiving behaviors, mental health, and child temperament.

Methods. Thirty mother-infant dyads with neurodevelopmental disabilities or with at-risk conditions were enrolled in the SPHERE project. Mothers were asked to record a free-play interaction with their child and to fill online questionnaires before and after the TVFI. The recorded interactions were analyzed to code maternal behaviors.

Findings. The findings revealed a relationship between certain maternal caregiving behaviors, maternal health, and specific traits of infant temperament. Additionally, TVFI was well-accepted by parents and proved effective in promoting positive maternal caregiving behaviors, improving mental health, enhancing dyadic interactions, and fostering healthier child development.

Key words: Maternal Caregiving Behaviors, Neurodevelopmental Disabilities, Tele Video-Feedback Intervention.

Introduction

During the Bachelor I had attended a course about Developmental Psychobiology, so when I was planning the courses, I wanted to attend in my first year of this Master, I did not want to take again a similar class, just to have the possibility to discover new topics that could be interesting for me. Then, during the presentation of the program of the Master all the professors introduced themselves and talk a little about the class they would teach. I remember that I got a good and positive impression from Professor Provenzi and how he presented his course of Developmental Psychobiology, so I decide to change plan and attend it.

As a child, when someone asked me what you want to do in the future, I always answered that I wanted to work with kids, so after attending my first lecture in the Developmental Psychobiology course, I knew that I wanted to join the DPB lab. Indeed, the lab focuses on the psychobiological connection between caregiver and infant, the continuous construction of meaning that occur in their interaction, and what variables may change how these processes work and coordinate in at-risk situations. This new theoretical prospective underpinning all the DPB's project deeply fascinated me, made me interested in understanding the intricate processes of exchange between mother and infant, particularly in the context of developmental disabilities and their impact on child and parents- an area I had not considered until two years ago.

When I first joined the lab, I felt both excited and nervous. It was my first experience working in a team with people with already a lot of experiences, and it was also the first time I was directly involved with families and children in a professional context. I could not help but worry about making mistakes and not meeting the expectations set for me. Now, after a year working in the DPB lab, I can see the significant personal and professional growth I have experienced. Personally, I have become more secure of my abilities and that I have everything that is required to reach my goals. Professionally, being part of this team has though me how a team should work. I have learned to communicate positively and connect with people of different ages, professions, and nationalities, I was able to acquire practical skills, such as setting up experiments, interacting and communicating with children and their families, administering questionnaires, and understood how much we can deduct from just five minutes of mother-infant free-play interaction. The lab environment is incredible positive, and all

the people working in it are always available and always try their best to give us opportunity to gain experience.

During my time in the lab, I worked on two different projects, but I chose to write my thesis on the SPHERE project because it addresses a topic that really match my interest, which grew bigger through this year, as previously mentioned. For instance, the project combines research with clinical work, involving parents and children with neurodevelopmental disabilities. Working in this filed and, on this topic, totally aligns with what I hope to continue doing in the future.

To conclude, I am grateful to have the opportunity to work with the DPB lab for my master thesis project, and to have the possibility to conduct my internship with them, where I know, I will continue to gain valuable skills and knowledge.
My experience here has significantly shaped my academic career, making it an unforgettable journey. It has solidified my passion on the developmental stages of life and parental support, which I hope will continue to be central to my future endeavors.

CHAPTER 1

Developmental Disabilities and their impacts on parenting

1.1) Co-regulation in dyadic interactions

One distinguishes feature of humans is that infants' brain keeps developing after birth, making it susceptible to the environment and experiences that it encounters in the preliminary stages of life (Provenzi et. al., 2018; Trevathan, 2015). Infants and their developmental trajectories are especially dependent on caregiving behaviors exhibited during their interactions (O'Connor, 2003; Swain et. al., 2007). During these exchanges, caregivers respond to the baby's fundamental needs and aim to promote regulatory, emotional, cognitive, and social abilities (Conradt & Ablow, 2010; Kivijärvi et. al., 2001; Malmberg et al., 2016; Provenzi et. al., 2015).

The mechanisms that children acquire during interactions with caregivers are crucial for achieving optimal physical and psychological health (Provenzi et. al., 2018). They also foster a synchronous and co-regulated state between the two partners, which is essential for later cognitive and social-emotional competences (Feldman & Eidelman, 2009).

Given the importance and complexity of parent-infant interactions for developmental trajectories, scientific research has shown great interest in discovering and disentangling the processes that occur during these interactions (Provenzi et. al., 2018). One of the seminal works on caregiver-infant relationships is John Bowlby's research on attachment (Provenzi et. al., 2018). He suggested that the caregiver-infant connection is an evolutionary and innate process that leads to behaviors increasing proximity to the attached figure when feeling threatened or distressed, thereby guaranteeing protection, reassurance, and comfort (Cassidy et. al., 2016). Caregivers undergo a reorganization of both physiology and behaviors, enabling them to become more sensitive to infant cues and ensuring the implementation of processes required for infants' growth and adaptation (Feldman, 2012).

The way caregivers respond to their children influences infants' security and attachment styles, which in turn shape the mental representations of the self, the caregiver, and the environment used throughout life (Cassidy et. al., 2016). Based on

this theory, Mary Ainsworth developed the Strange Situation paradigm to investigate distinctive styles of attachment (i.e., secure, anxious-ambivalent, avoidant, and disorganized/disoriented). This paradigm studies the child's sense of security regarding the availability of the attachment figure (Cassidy et. al., 2016). Ainsworth also introduced the concept of maternal sensitivity, defined as the capacity to read, and correctly interpret infant signals, responding appropriately (Ainsworth et. al., 1978). High maternal sensitivity is crucial for coherent responses to infant behaviors, leading to more positive interactions and better developmental trajectories.

Although these approaches are the first that consider the infant as an active participant of the interaction, there are some limitations (Mesman, 2010). Attachment theory focused on a unidirectional influence that goes from the mother to the child, guided only by behaviors required to survive in stressful situation, without taking in consideration neither emotional connection that develops between the dyadic partners nor the role that both child and caregiver have on the direction of their interaction (Mesman, 2010; Saunders et. al., 2015).
For instance, later studies, beginning with Daniel Stern's work, stated to view the caregiver-infant interactions as a bidirectional process where infants, able to execute, read, and interpret social cues, internalize meanings from interactions and use them to build and understand the self, future relationships, and the environment (Provenzi et. al., 2018; Stern, 1971).

This shift in understanding led to the concept of parent-infant interaction as a proto-conversation characterized by mutuality (Bateson, 1979; Provenzi et. al., 2018). Ed Tronick's Mutual-Regulation Model further elucidates this idea (Provenzi et. al., 2018). This model posits that both caregiver and infant regulate each other's emotions and behaviors through dynamic and reciprocal interaction guided by a feedback process (Gianino & Tronick, 1988). This is crucial for the child's healthy emotional and social development (Gianino & Tronick, 1988; Provenzi et. al., 2018). The interaction involves synchronous phases, where behaviors match, and asynchronous phases, where mismatches occur (Gianino & Tronick, 1988; Provenzi et. al., 2018). Mismatches are natural and not necessarily negative; what matters is the ability to repair ruptures, returning to a matching state (Gianino & Tronick, 1988; Provenzi et al., 2018). A sensitive interactive partner is important to be able to repair the ruptures by displaying

the optimal signals, enabling the dyadic interaction to reach the synchronous phase again (Gianino & Tronick, 1988).

This ability to adjust ruptures indicates interaction quality and is associated with adequate and protective caregiving (DiCorcia & Tronick, 2011; Gianino and Tronick, 1988; Provenzi et. al., 2018). Tronick suggested that all the exchanges occurring inside the interaction results from self and interactive processes, characterized by being both concurrent and reciprocal, affecting also the other (Beebe et. al., 2016).

To study moment-by-moment interactions and the active involvement of the infant in those, Tronick and colleagues developed the Still-Face Paradigm (Tronick et. al., 1978). The paradigm is composed by three different episodes: the recording of a typical face-to-face interaction with the caregiver that is used as baseline, the still-face episode, during which the caregiver maintains a neutral expression and does not interact with the child for two minutes, inducing stress in the child, and the reunion episode, in which the caregiver can start again to interact with the child (Mesman, 2009). What happens during the still-face is a longer and more intense asynchronous phase that the child is not able to repairs with the typical behaviors used to win back the partner (Gianino & Tronick, 1988). The inability of repairing the mismatch leads the infant to inhibit the interactive regulatory mechanisms to deal with the stressful situation and elicit self-regulatory coping strategies and self-soothing behaviors (Brazelton et. al., 1975; Gianino & Tronick, 1988; Papoušek & Papoušek, 1977; Tronick et. al., 1978;).

Tronick explained the still-face effect on infant behaviors by stating that unresponsiveness of the caregiver violates the principles of the face-to-face communication that the infant is expecting, sending to the child contradictory information, and resulting in a withdraw from the situation and the avoidance of the partner (Tronick et. al. 1978).

After Tronick, others researcher kept studying the characteristics of the interaction. Beebe and colleagues described a person's behaviors as created in a joint coordination process that happens with the partner, highlighting the importance of interaction for their elicitation (Jaffe et. al., 2001).

Provenzi and colleagues (2018) meta-analysis enhances understanding of the mechanisms guiding co-regulated parent-infant interactions. The key concepts are mutuality and reciprocity, indicating that both partners contribute to and influence the

interaction. Contingency is the basic process for social communication, allowing partners to adjust behaviors and emotions based on the other's expressions (Beebe et. al., 2016; Provenzi et al., 2018). Indeed, children are significantly susceptible to the partners' responsiveness towards their behaviors (Bornstein & Baumwell, 2001; Hains & Muir, 1996; Murray & Trevarthen, 1986). Studies on interactive contingency during face-to-face communication discovered that already at 3-4 months, the dyads can contingently coordinate their behaviors, such as gaze, facial expression, vocal rhythms, orientation, and touch patterns (Beebe et. al., 2010; Bigelow, 1998; Cohn & Tronick, 1988; Feldman, 2007a; Jaffe et al., 2001; Lester et. al., 1985; Malatesta et. al., 1989; Stern, 1971; Tronick, 1989). Following that, contingent regulation is considered as a form of homeostatic regulation, since caregiver-infant interactions are mediated by a homeostatic control that enables a maintenance of equilibrium between behavioral excitation and inhibition, facilitating the general dyadic regulation (Feldman, 1997, 2007b; Lester et al., 1985).

Effective contingency enhances coordination of behaviors, intentions, and affects, fostering attunement and mirroring processes (Provenzi et al., 2018). Contingency developed between the dyadic partners is required to elicit parent-infant bio-behavioral synchrony, critical especially in the post-partum period, since it help and support neurobehavioral maturation, ability to manage stress, and the future relational abilities (Meaney, 2010).

As discussed, coordination in interaction involves synchronous moments interrupted by mismatches, requiring negotiation and on-the-spot changes to return to a matching state (Provenzi et al., 2018). The ability to co-regulate during these ruptures is vital for interaction quality and influences the child's later developmental abilities (Provenzi et al., 2018). From birth, caregiver-infant interaction can be viewed as a dyadic dance involving cyclical processes essential for achieving co-regulated interactions (Provenzi et al., 2018).

1.2) Parenting as protective factor

Parenting it is an arduous task, which require time and practice since there is no single way to be a good parent, and not everyone implements the same parenting behaviors (Seay et. al., 2014). Positive parenting could be defined as an ongoing relationship that

arises and develops between parents and children, characterized by specific concepts: caring, teaching, leading, communicating, and providing the necessary needs (Seay et. al., 2014). But why is important to adopt positive parenting behaviors?

Parenting plays a crucial role in providing factors that significantly influence a child's development, since its quality affects child's future maturation, adaptation and learning abilities (Provenzi et. al., 2018; Wall et. al., 2023).

A supportive and nurturing parenting style it is important for the development of parent-infant bonding, which is fundamental for healthy emotional and social growth (Lindgren, 2001; Medina et. al., 2021; Wall, et. al., 2023).

In the previous paragraph, we discussed how both parent and infant play an active role in co-regulating their interactions through reciprocity and mutuality (Provenzi et. al., 2018). Based on the behaviors and processes implement during the interaction, they are more likely to engage in adaptive or maladaptive dyadic processes, shaping developmental trajectories of the child (Provenzi et. al., 2018). Given this, a positive caregiving pattern can be found in optimal dyadic interaction, characterized by synchronization, sensitivity, and responsiveness to infant's cues, serving as protective factors for healthy development (DiCorcia and Tronick, 2011; Provenzi et. al., 2018).

Feldam (2012) emphasizes that maternal parenting behaviors essential for the synchronization and co-regulation with an infant's state begin to emerge both before and after birth due to psychobiological changes (Feldamn, 2012). For instance, higher levels of oxytocin, a hormone involved in childbirth and social bonding, have been identified as predictors of effective parenting behaviors (Feldamn et. al., 2007). Research indicates that the co-activation of social brain regions, such as Superior Temporal Sulcus, Inferior Frontal Gyrus, Insula, Pre-Supplementary Areas, Parietal Cortices, Medial Prefrontal Cortex, along with the left Nucleus Accumbens- rather than with right Amygdala, is associated with more responsive and synchronized maternal behaviors (Atzil et. al., 2011). Furthermore, these cortical activations are influenced by the mother's blood levels of oxytocin (Atzil et. al., 2011).

Maternal behaviors shaped by these changes include gazing at the infant, using motherese vocalization, expressing positive affect, and providing affectionate touch, all of which predict the child's future prosocial behaviors, attachment security, and self-regulation (Fledman, 2007; 2012). Particularly during the first months of life, even if, as mentioned, the interaction is typically bidirectional, parents tend to coordinate their

states with the infant more than the infant does (Beebe et. al., 2016). Consistent engagement in synchronized interactions, such as eye contact, vocalization, and physical touch during these early months, lays the foundation for healthy emotional and social development (Feldamn, 2012).
To sum up, optimal parenting practices, marked sensitivity and responsiveness, are fundamental for healthy child development, particularly in mitigating the impact of adverse conditions.

Going back to Ainsworth's theories, we can identify the maternal sensitivity as a behavioral construct in her attachment theory (Cooke et. al., 2022). Parenting sensitivity can be defined as the caregiver's ability to read and respond to infant's signals and needs punctually and properly (Ainsworth et. al., 1974). The sensitivity expressed by the parent exerts a protective role for development and could be associated with all the outcomes that Ainsworth described for secure attachment pattern (i.e., appropriate response to distress, self-regulation, and healthy socio-emotional development), and helps foster of resilience in at-risk situations (Cooke et. al., 2022; Deans, 2020).
Studies evidenced that a sensitive and responsive parent is important for future socio-emotional, executive functions, language, academic achievements, and social functioning development (Ainsworth et al., 1978; De Wolff & Van Ijzendoorn, 1997; Madigan et al., 2019; Raby et al., 2015; Rodrigues et al., 2021; Valcan et al., 2018).
Parental sensitivity must be seen as a continuum, ranging from parents characterized by hypersensitivity to those who show hyposensitivity (Cooke et. al., 2022). For instance, a parent who responds promptly and appropriately to infant's signals fosters a sense of security and trust (Cooke et. al., 2022). A hypersensitive and overly responsive parent may interfere with infant's ability to explore and develop autonomy, inducing a sense of helplessness and avoidance (McLeod et. al., 2007; Pinquart, 2017). On the other hand, hyposensitive and unresponsive parenting can hinder the development of self-esteem and coping strategies, increasing the risk of developing negative schemas and emotional difficulties (Cooke et. al., 2022).
Evidence suggests that children who experience insensitive parenting may develop anxiety, depression, or behavioral issues due to the lack of appropriate emotional support and regulation (Cooke et. al., 2022).

The quality of parenting is also characterized by emotional components, as bonding and emotional availability, which are equally important for child development and well-being (Biringen & Easterbrooks, 2012; Saunders et. al., 2015). The maternal bond includes all the feelings that the caregiver perceives toward the child, which help elicit all the behaviors necessary for the care of the infant (Ainsworth & Bell, 1972). Literature highlighted an association between a stronger bond and positive parenting behaviors and engagement while interacting with the infant, enhancing the growing of parental sensitivity to infant's signals and the optimal development of the child (Behrendt et. al., 2019; Medina et. al., 2021).

The second construct is the emotional availability (EA) that is defined as the capacity of parent and infant to share an emotional connection, which, in turn, shapes the quality of the interactions (Biringen & Easterbrooks, 2012). It is characterized by four components for the caregiver, such as sensitivity (i.e., emotions to maintain positive connection with the child), structuring (i.e., parental guidance), non-intrusiveness (i.e., following child's intention), and non-hostility (i.e., regulation of negative emotions to not express them in front of the child), and two for the infants, that are responsivity (i.e., easily engagement with the interactive partner) and involvement (i.e., easily involve the partner in the interaction) (Saunders et. al., 2015).

The experience of EA in the interaction with the caregiver has been directly associated with infant outcomes, such as emotion regulation, stress regulation, language development, social abilities, and behavioral problems (Biringen et. al., 2005; Howes & Hong, 2008; Kertes et. al., 2009; Little & Carter, 2005; Moreno et. al., 2008).

In conclusion, both parental bond and emotional availability arise usually during the perinatal period and play an important role as protective factors for the developmental trajectories of cognitive, physical, socio-emotional, and relational capacities, shaping the parenting qualities by increasing the parental sensitivity to infant's signals (Cannella, 2005; Guney & Ucar, 2019; Tichelman et al., 2019; Waal et. al., 2023).

Several factors can influence the quality of caregiving behaviors and, consequently, the process of co-regulation between parents and infants (Feldman, 2012). One significant moderator is the child's characteristics, which have been shown to affect parenting quality (Lewis & Feiring, 1989; Saunders et. al., 2015). For instance, at-risk conditions such as preterm birth or Developmental Disabilities can make it more

challenging for parents to understand and adapt to their child's needs, thereby reducing their responsiveness and sensitivity (Azad et. al., 2013; Bornstein et. al., 2021; Dykens, 2015; Guralnick et. al., 2008; Fullone et. al., 2023). These challenges, combined with the daily demands of caring for a child with special needs, can increase parental stress and heighten the risk of developing affective disorders (Scherer et. al., 2019; Olsson et. al., 2001). Additionally, studies have indicated that a child's temperament, responsiveness, and level of involvement, even in the absence of specific diagnoses or at-risk conditions, can also impact the quality of interactions with caregivers (Lewis & Feiring, 1989; Saunders et. al., 2015).

Another crucial factor influencing parenting quality is socioeconomic status (Cooke et. al., 2022). For example, lower socioeconomic status is often associated with higher levels of parental stress and fewer available resources to create an engaging environment for the child, which can negatively affect parenting practices (Mesman, et. al., 2012).

It is also important to consider cultural differences in parenting styles (Feldamn, 2012). Research highlights significant variations in parenting practices between industrialized and developing countries (Feldman, 2012) In industrialized countries, parents typically encourage exploration, use more verbal communication (e.g., motherese), and raise their children in a family-centered environment (Feldamn, 2012; Whiting & Edwards, 1988). In contrast, parents in non-industrialized countries tend to maintain closer physical proximity to their children, create fewer stimulating environments, and integrate their infants more into the community, where dyadic interactions are less emphasized (Feldamn, 2012; Whiting & Edwards, 1988).

In summary, parenting quality is a fundamental protective factor in child development (Cannella, 2005; Cooke et. al., 2022; Deans, 2020; DiCorcia and Tronick, 2011; Guney & Ucar, 2019; Provenzi et. al., 2018a; Tichelman et al., 2019; Waal et. al., 2023). It influences a wide range of developmental outcomes, from emotional regulation and social functioning to academic achievement and stress resilience (Ainsworth et al., 1978; Cannella, 2005; De Wolff & van Ijzendoorn, 1997; DiCorcia and Tronick, 2011; Feldamn, 2012; Guney & Ucar, 2019; Johnson 2023; Madigan et al., 2019; Provenzi et. al., 2018a; Raby et al., 2015; Rodrigues et al., 2021; Tichelman et al., 2019; Valcan et al., 2018; Waal et. al., 2023).

1.3) Developmental Disabilities

An estimated fifty-three million children around the world are diagnosed with Developmental Disabilities, with a higher incidence in low-and middle- income countries (Olusanya et. al, 2018).
Even in Italy, there has been an increase in the prevalence of children diagnosed with a Developmental Disabilities, especially of Autism Spectrum Disorder, Specific Learning Disorders, and Attention-Deficit/Hyperactivity Disorders (ISS, 2022; SINPIA, 2024).

The term Developmental Disabilities (DDs) was introduce in 1970, and come into common use in 1978, to describe "*severe, chronic disability that occurs before an individual is 22 that is likely to continue indefinitely, and results in substantial functional limitations in three or more of the following areas of major life activity: self-care, receptive and expressive language, learning, mobility, self-direction, capacity for independent living, economic self-sufficiency*" (Developmental Disabilities Assistance and Bill of Rights Act, 1978). DDs include conditions that compromise the Central Nervous System (CNS) as well as congenital and acquired disorders not directly caused by CNS impairment (Ismail et. al., 2019).

The definition of Neurodevelopmental Disabilities (NDDs) was later introduced to refer specifically to chronic CNS disorders that begin during the developmental period and affect motor, cognitive, communication, and behavioral domains (Mullin et. al., 2013). According to DSM-5, NDDs include Autism Spectrum Disorders, Attention-Deficit/Hyperactivity Disorder, Intellectual Disability, Specific Learning Disorders, Communication Disorders, Motor Disorders, and Genetic conditions affecting brain development (DSM-5, 2013). These conditions develop early in life, are pervasive, and, although they may improve, they do not disappear entirely, as they are lifelong disorders that affect various areas of daily life (DSM-5, 2013).

Currently, Developmental Disabilities is an umbrella word used to group disorders that cause deficits in physical, language, learning, and behavioral skills that arise during the early developmental period of infancy and childhood (Centers for Disease Control and Prevention, 2024; Scherer et. al., 2019). This category includes all the disorders listed under NDDs in DSM-5, along with other chronic condition not caused by brain

abnormalities, but still associated with physical and mental impairments (Centers for Disease Control and Prevention, 2024). Conditions classified as DDs include Intellectual Disability, ASD, Cerebral Palsy, ADHD; Specific Learning Disorders, Communication Disorders, Motor Disorders, Sensory Disorders, Fetal Alcohol Spectrum Disorders, and genetic conditions (Centers for Disease Control and Prevention, 2024).

The etiology of DDs is multifactorial (Ismail et. al., 2019¸Lichtenstein et. al., 2010; Thapar et. al., 2017). There are three major phases during which distinct factors can influence a child's developmental trajectory (Centers for Disease Control and Prevention, 2024). During the prenatal period, genetic factors, environmental exposures (i.e., toxins), neurobiological factors (i.e., atypical maturation patterns), and maternal health issues (i.e., infections, malnutrition, immunological deficits) can negatively impact future development (Centers for Disease Control and Prevention, 2024; Ismail et. al., 2019). In the perinatal phase, birth complications, premature birth, asphyxia, and low birth wight increase the risk of developing a DDs (Centers for Disease Control and Prevention, 2024; Ismail et. al., 2019). In the postnatal period, events like hypoxic-ischemic insult, trauma, infections, and iatrogenic disorders can negatively influence typical development (Centers for Disease Control and Prevention, 2024; Ismail et. al., 2019).
Although ongoing studies are investigating the origins and heritability of some conditions, the causes of many DDs remain unknown (Centers for Disease Control and Prevention, 2024).

The impairments caused by DDs are pervasive, affecting multiple areas of daily life and presenting various challenges (Centers for Disease Control and Prevention, 2022; Zablotsky et. al., 2019). Moreover, DDs often present with varying symptoms, durations, and prognoses and frequently co-occur with other conditions (DSM-5, 2013; Sherer et. al., 2019). Therefore, early intervention and continuous support and rehabilitation programs are crucial for children with DDs to maintain healthy and active lives, even though the percentage of remission is low (Centers for Disease Control and Prevention, 2024; Thapar et. al., 2017).

Intellectual Disability. According to DSM-5, diagnosing Intellectual Disability requires deficits in intellectual functioning (i.e., reasoning, problem solving, planning, abstract

thinking, judgment, and learning). Additionally, deficits in the adaptive functioning must be assessed, as these impair a child's ability to meet social and developmental standards for independence and responsibility (DSM-5, 2013). The severity levels range from mild (IQ 50-55 to 70) to profound (IQ below 20-25) (DSM-5, 2013).

Autism Spectrum Disorder (ASD). According to DSM-5, diagnosing ASD requires persistent impairments in social communication and interaction, manifested by deficits in socio-emotional reciprocity, nonverbal communicative behaviors, and relationship-building (DSM-5, 2013). Additionally restricted and repetitive behaviors, interests, or activities, along with hyper- or hypo-reactivity to sensory input, must be observed (DSM-5, 2013). Assessing intellectual ability, language skills, and adaptive functioning is also necessary (DSM-5, 2013).

Cerebral Palsy. CP encompasses a group of conditions with varying etiology, characteristics, and severity (Rosenbaum et. al., 2007). These lifelong disorders affect motor and posture development, causing movement difficulties and limited participation in activities, and must occur prenatally or at birth (Rosenbaum et. al., 2007). CP is often accompanied by other disorders such as sensory, perceptual, cognitive, communication, and behavioral deficits, as well as epilepsy and musculoskeletal disorders (Rosenbaum et. al., 2007). CP types include spastic (hypertonicity and resistance to movement), dyskinetic (athetosis or dystonia), ataxic (coordination impairments), and hypotonic (low muscular tone) (McIntyre et. al., 2013). CP can also be classified by the affected body area: hemiplegia (one side, often the upper limb), diplegia (both upper/lower limbs), or quadriplegia (all four limbs) (McIntyre et. al., 2013).

Attention-Deficit/Hyperactivity Disorder (ADHD). ADHD is characterized by patterns of inattention and/or hyperactivity-impulsivity that interfere with both functioning and development (DSM-5, 2013). Inattention symptoms include careless mistakes, deficits in sustained attention tasks, not listening when spoken directly, difficulty in following instructions and in organizing activities, reluctance to engage in activities requiring sustained mental effort, losing items and forgets things to do, and being easily distracted (DSM-5, 2013). Hyperactivity-impulsivity symptoms include an inability to stay still, inappropriate actions, difficulty engaging in quiet activities, excessive talking,

interrupting others, and difficulty waiting one's turn (DSM-5, 2013). ADHD can present with combined or predominant symptoms (DSM-5, 2013).

Specific Learning Disorders (SLD). Diagnosing SLD requires persistent difficulties in learning and using academic skills, grouped in three distinct categories (DSM-5, 2013). Dyslexia is diagnosed with inaccurate and slow reading or difficulties in word comprehension and spelling (DSM-5, 2013). Written expression disorder involves difficulty in writing, characterized by errors, poor organization, and lack of influence (DSM-5, 2013). Dyscalculia is diagnosed when there are deficits in learning number sense, number facts, calculation, or mathematical reasoning (DSM-5, 2013).

Communication Disorders. These include Language Disorders, Speech Sound Disorders, Stuttering, and Social (Pragmatic) Communication Disorder, all of which reduce communication abilities and affect other life areas (DSM-5, 2013). Language Disorders involve difficulties in acquiring and using language due to impairments in comprehension or production (DSM-5, 2013). Speech Sound Disorders involve deficits in producing speech sounds (DSM-5, 2013). Stuttering is characterized by fluency and timing impairments in speech, including repetitions, prolongations, a physical tension when speaking (DSM-5, 2013). Social Communication Disorder involves deficits in social verbal and nonverbal communication (DSM-5, 2013).

Motor Disorders. This category includes Developmental Coordination Disorder, the Stereotypic Movement Disorder, Tic Disorders (Tourette's Disorder, Persistent Motor or Vocal Tic Disorder, Provisional Tic Disorder) (DSM-5, 2013).
Developmental Coordination Disorder involves significant impairments in motor skills acquisition and execution (DSM-5, 2013). Stereotypic Movement Disorder is diagnosed when repetitive, purposeless motor behaviors are present (DSM-5, 2013). Tic Disorders involve motor or vocal tics with varying frequency (DSM-5, 2013).

Sensory Disorders. These include conditions causing atypical sensory information processing (Galiana-Simal et. al., 2020). Sensory Processing Disorder involves deficits in receiving and responding to sensory information, while specific sensory processing disorders affect auditory, visual, tactile, vestibular, proprioceptive, olfactory, and gustatory processing (Miller et. al., 2009).

Fetal Alcohol Spectrum Disorders (FASD). FASD encompasses conditions caused by prenatal alcohol exposure, including Fetal Alcohol Syndrome, Alcohol-Related Neurodevelopmental Disorder, Alcohol-Related Birth Defects, Neurobehavioral Disorder associated with Prenatal Alcohol Exposure. These conditions cause behavioral, learning, and physical impairments (Centres for Disease Control and Prevention, 2024).

Genetic conditions affecting brain development. Genetic mutations that can lead to neurodevelopmental deficits. Down Syndrome, caused by an extra chromosome 21, is characterized by intellectual disability and hypotonia (Centers for Disease Control and Prevention, 2024). Other genetic conditions include Fragile X Syndrome, Rett Syndrome, Angelman Syndrome, Prader-Willi Syndrome, William Syndrome, Tuberous Sclerosis Complex, Neurofibromatosis Type 1, Phenylketonuria, Smith-Magenis Syndrome, Duchenne Muscular Dystrophy, Deletion Syndrome, and Lissencephaly, all characterized by intellectual disruption and other specific impairments (Centers for Disease Control and Prevention, 2024).

Although not classified as DDs or NDDs, preterm birth is a risk factor for these conditions. Preterm infants are born before 37 weeks of gestation and categorized into extremely preterm (before the 28 weeks), very preterm (between the 28 and the 32 weeks), moderate preterm (between the 32 and the 34 weeks), and late preterm (between the 34 and the 37 weeks) (ACOG, 2008; Engle et. al., 2007; WHO, 2012).
Preterm birth can influence development, increasing the risk of developmental and physical conditions (Pignotti & Donzelli, 2015). Preterm infants may later exhibit ADHD, regulatory problems, social interaction difficulties, emotional issues, and ASD (Pignotti & Donzelli, 2015). These conditions may arise form brain trauma or atypical brain development due to premature exposure to environmental stimuli, such as those in the Neonatal Intensive Care Unit (NICU), which can induce structural brain changes (Pignotti & Donzelli, 2015; Spittle et. al., 2014). These deficits often persist, influencing daily activities throughout life (Pignotti & Donzelli, 2015).
Preterm infants also face higher hospital readmission rates due to physical like respiratory issues, necrotizing enterocolitis, and sensory impairments (Pignotti & Donzelli, 2015).

1.3) Mental Health in parents

Carrying a baby is a singular and strong emotional experience for women that induces psychological, physiological, and biochemical changes (Alderdice et. al., 2013). Those changes create vulnerabilities in pregnant woman during both the prenatal and postnatal period, affecting their physical and mental health (Romans & Seeman, 2006). Reactions to those changes and to becoming a mother are influenced by distinct factors, such as age, social supports, background, socioeconomic factors, and the overall state of pregnancy (Romans & Seeman, 2006).

Literature highlights that around 15-25% of pregnant women experience heightened stress, anxiety, and/or depression, even if the true prevalence is unclear since they are frequently perceived as normal symptoms of pregnancy (Figueiredo & Conde, 2011; Ross & McLean, 2006; Lee et. al., 2007). Maternal mental health has been also associated with birth outcomes, impacts on family interactions, and the developmental trajectories of the child (Dennis & Hodnett, 2007; Dunkel-Shetter, 2010; Dunkel-Schetter & Glynn, 2011, Mancuso et. al., 2004; Marcus & Heringhausen, 2009; Talge et. al., 2007).

Depression. Depressive symptoms during pregnancy typically resemble those characterizing the Major Depressive Disorder as describe in DSM-5 (Bowen & Muhajarine, 2006; Slomian et. al., 2019). Diagnosing a depressive episode during the perinatal period requires verifying the presence of lower mood, decrease interest in daily activities, changes in eating behaviors, sleep disturbance, psychomotor changes, loss of energy, feelings of guilt, and suicidal thoughts (DSM-5, 2013). If these symptoms are present during the prenatal period, it is termed Antenatal Depression, which show a higher prevalence of somatic symptoms, though it is not officially recognized due to overlap with typical pregnancy symptoms (Bowen & Muhajarine, 2006; Romans & Seeman, 2006). When symptoms onset after delivery and within the first month postpartum, it is called Postpartum Depression (PPD) (DSM-5, 2013).

Depressed mothers often require more time to engage with their infants, and easily exhibit intrusiveness and withdrawal while interacting (Feldman et. al., 2009; Feldman, 2012) This leads to disrupted parenting quality, characterized by lower coordination and synchronization, hyposensitivity, decrease emotional availability, and bonding, sometimes accompanied by negative perception of the child and the challenges of caregiving (Feldamn, 2012; Lefkovics, et. al., 2014; McLearn et. al., 2006; Murray &

Cooper, 1996; O'Higgins et. al., 2013; Rossen et. al., 2019; Slomian et. al., 2019; Zajicek-Farber, 2008). Such disruption negatively influences the infant's cognitive, behavioral, temperamental, and overall health development (Slomian et. al., 2019).

Anxiety. Despite receiving less attention than depression, anxiety symptoms during the pre- and postpartum occur more frequently (Romans & Seeman, 2006; Zappas, et. al., 2021). Anxiety is often under-diagnosed because its symptoms are mistaken for normal pregnancy-related worries and are not specified in DSM-5 (Romans & Seeman, 2006; Zappas et. al., 2021). Symptoms of General Anxiety Disorder include pervasive and uncontrollable worry, restlessness, fatigue, concentration problems, irritability, muscle tension, and sleep disturbances (DSM-5, 2013; Zappas et. al., 2021).
Anxiety symptoms are linked to an excessively and intrusive parenting style, marked high rhythm of interaction (Feldman, 2012). This mismatch in interaction pace leads to decreased parenting quality, characterized by hypersensitivity, high responsiveness, and lower co-regulation due to a higher control over child's behavior, emotional availability, and bonding (Feldman, 2012; Rossen et. al., 2019; Stein et. al., 2012). These deficiencies negatively affect the infant's cognitive, behavioral, and socio-emotional development (Dubber et. al. 2015; Kendig et. al., 2017; Kingston et. al., 2014; Stein et. al., 2012; Tietz et. al., 2014).

Stress. Psychological stress is defined as a person's reaction to an unpleasant and overwhelming event in its environment (Folkman & Lazarus, 1985). Parental stress arises specifically from family environment due to distress in the parent role (Abidin, 1995; Abidin, 1992; Hayes & Watson, 2012). Based on Abidin's work, parental stress can be subdivided into three subgroups: parental distress, parent-child dysfunctional interactions, and difficult child (Abidin, 1995). Parental distress involves the subjective feelings of wrong parenting skills, loss of prenatal freedom, lower social support, and concurrent depression (Abidin, 1995; Abidin et al., 1992; Deater-Deckard & Scarr, 1996). This distress significantly disrupts parenting skills, resulting in lower responsiveness and sensitivity (Abidin et al., 1992; Gelfand et. al., 1992). Dysfunctional parent-child interactions occur when parents perceive their child negatively, leading to less sensitivity and emotional availability (Abidin, 1995; Cummings & Davies, 1999). Lastly, difficult child component reflects characteristics of

the child's temperament and behaviors that parents find challenging, leading to reduced parenting skills (Abidin, 1995; Gelfand et. al., 1992).
Indeed, caregivers with a prominent level of stress are more susceptible to implement negative parenting behaviors, with a decrease of sensitivity, responsiveness, and an enhance control over child's behaviors (Crinic et. al., 1983; Deater-Deckard & Scarr, 1996). These can lead later to internalizing and externalizing behavioral problems, also affecting temperament, socio-emotional, cognitive, general health development, and regulation skills in the child (Bolten et. al., 2012; Costa et. al., 2006; Higgins et. al., 2011; Korja et. al., 2017).

Even if research focuses on maternal mental health and its effect on child's outcomes, fathers also experience significant mental health challenges in the pre- and postpartum periods (Cameron et. al., 2016; Field, 2018; Paulson & Bazemore, 2010; Ramchandani et. al., 2008). Studies show that around 10% of the fathers develop depression during this time, which can impact the same way their parenting and family dynamics (Paulson & Bazemore, 2010). Paternal depression is linked to adverse child outcomes, including emotional and behavioral problems (Ramchandani et al., 2005). Moreover, fathers' anxiety and stress during the prenatal and postnatal periods can affect their bonding with the child and overall family well-being (Cameron et al., 2016; Philpott & Corcoran, 2018). Therefore, addressing mental health concerns in both mothers and fathers is crucial for the healthy development of children and the family as whole (Cameron et al., 2016; Philpott & Corcoran, 2018; Paulson & Bazemore, 2010¸ Ramchandani et al., 2005).

1.4) Being a parent of a child with Developmental Disabilities

Developmental Disabilities, as described above, include various conditions (i.e., Intellectual Disability, Cerebral Palsy, Autism Spectrum Disorder, Attention-Deficit/Hyperactivity Disorder, Motor and Sensory Disorders, Specific Learning Disorders, Language Disorder; Fetal Alcohol Spectrum Disorder, Genetic Conditions) and are of different etiology, but in common they have an onset early in development and a pervasive disruption of multiple skills required in everyday life (Centers for Disease Control and Prevention, 2024; Sherer et. al., 2019).

But how do the presence of Developmental Disabilities influence parents and their way to interact with the child?

Parent-infant bonding starts growing already during the pregnancy, and keep raising all through it, but also postpartum (Cabrera et al., 2008; Deave et. al., 2008; Tambelli et al., 2020). Through the building of this bonding, the parents also start to create an anticipatory representation and expectations about the child and their new role as parent (Brodén, 2004; Zeanah & Benoit, 1995).
The bond evolved during the waiting time, and it is later used to engage in interactive dance with the child, thanks to which the parents can read infant's cues to mutually regulate each other (Provenzi et. al., 2018). As explicated in the first paragraph, it is through this co-regulated mechanism that parents can implement optimal parenting behaviors, and children develop regulative strategies and healthy developmental trajectories (DiCorcia and Tronick, 2011; Provenzi et. al., 2018).

When there is a diagnosis of DDs, the caregivers experience something close to a destruction of the expectations built on the prenatal period (Fullone et. al., 2023). For instance, the parental experience changes from those situation of typical development (Fullone et. al., 2023). One of the challenges that caregivers face concerns the interaction exchanges with the infant, which is characterized by less responsiveness, emotional signs, and higher unpredictability, which lead to impairment in the communication mechanisms between the interactive partners (Fullone et. al., 2023). Deficit in reading and interpret signals coming from the child due to the presence of the DDs lead to ruptures in the dyadic dance, with a reduction of sensitivity and synchrony in parenting, which start to show more directive and/or intrusive behaviors (Azad et. al., 2013; Bornstein et. al., 2012; Dykens, 2015; Guralnick et. al., 2008; Fullone et. al., 2023).
It is when the asynchronous interaction is experienced multiple times that the representation that the parents had developed about their ability of parenting fall, resulting in a decrease self-confidence (Fullone et. al., 2023; Sayre et. al., 2001). Indeed, they are neither able to implement the parenting model acquired during their childhood nor the parenting model developed during the pregnancy, and it is impossible for them to create new expectations due to the uncertain trajectories that is typical of these conditions (Belsky, 1989; Button et. al., 2001; Fullone et. al., 2023).

These deficits together with the daily challenges that parents and child with DDs face, like frequent hospitalization and medical visit, rehabilitation, financial effort, behavioral difficulties, social prejudice and social isolation, and high demand required in the caring of the child, all play a role in incrementing the affective burden and stress experienced by caregivers (Baird et al., 2000; Bemister et al., 2015; Cianfaglione et al., 2015; Fullone et. al., 2023; Giusti et. al., 2018; Ngo et. al., 2012; Papaeliou et al., 2012; Raina et. al., 2004; Woodman et. al., 2015).

To sum up, the characteristics of developmental disabilities can make it challenging for parents to interact with their children, leading to negative perceptions and increased distress. This heightened distress then further impairs their interaction abilities, creating a vicious cycle of negative perceptions and on-going stress (Fullone et. al., 2023).

The enhanced emotional burden in parents of children with DDs may lead to the onset of mental health disorders, such as parental stress, anxiety, and/or depression (Scherer et. al., 2019; Olsson et. al., 2001). Literature evidence that parents of children with a DDs present a higher prevalence of affective diseases compared to the general population (Scherer et. al., 2019; Olsson et. al., 2001). Indeed, Sherer and colleagues (2019) found that 31% of the parents of DDs' children showed both depression and anxiety above the clinical cut-off, compared to the respectively 7% and 14% in parents of children without DDs. Moreover, they also experience increased level of parental stress (Woodman et. al., 2015).

As already mentioned, the presence of anxiety, stress, and depression negatively influences the interaction between caregiver and infant by enhancing or reducing all the mechanisms that occurs during the exchange, and that make the parenting optimal and supportive for child development, which is fundamental in those cases of children with DDs (Crinic et. al., 1983; Deater-Deckard & Scarr, 1996; Feldman, 2012; Lefkovics, et. al., 2014; McLearn et. al., 2006; Murray & Cooper, 1996; O'Higgins et. al., 2013; Rossen et. al., 2019; Slomian et. al., 2019; Stein et. al., 2012; Zajicek-Farber, 2008). Indeed, it is significantly important for child's growth in different domains (i.e., cognitive, socio-emotional, regulative) to interact with a sensitive, responsive and emotional available caregiver (Ainsworth et al., 1978; Cannella, 2005; De Wolff & van Ijzendoorn, 1997; DiCorcia and Tronick, 2011; Feldamn, 2012; Guney & Ucar, 2019;

Madigan et al., 2019; Provenzi et. al., 2018; Raby et al., 2015; Rodrigues et al., 2021; Tichelman et al., 2019; Valcan et al., 2018; Waal et. al., 2023).

Given that preterm birth is a condition that can contribute to the development of DDs, it is also important to address the potential distress this situation may cause for parents (Pignotti & Donzelli, 2015). For instance, early birth forces the family to stay hospitalized for an unknown period postpartum due to complications and the special medical care that the babies required to survive (Goldberg & DiVitto, 2005). Even in this situation, the representations that the parents built during the pregnancy of becoming a parent and about the child are destroyed, and a lot of fear and distress start to raise, together with a lot of fear and worries about the possible future outcomes for the infant's development (Goldberg & DiVitto, 2005). Moreover, due to the health necessity of preterm infants, they are separated from their parents, which increase the feeling of the caregiver of not being able to care for the baby and decrease the possibility for them to start a shared interaction after the birth, as typically happens (Goldberg & DiVitto, 2005). Consequently, the parents are more prone to the onset of anxiety, depression, and stress (Goldberg & DiVitto, 2005). Even when the hospitalization period is over, the level of distress of these parents do not decrease, due to the continuous worries about caring for the child alone, the more time these children required to reach developmental milestones, and the continuous medical follow-up (Goldberg & DiVitto, 2005). Taking in consideration all these factors, parenting behaviors implemented with preterm infants are characterized by a hyperstimulation interaction, which induce an asynchronous interaction, with less sensitivity and responsiveness to the infant's social signals (Feldman & Eidelman, 2006; Feldman, 2012).

In conclusion, parenting a child with DDs or with at-risk conditions is not easy, since they required higher and more specific care and attention, posing parents in a more stressful and difficult position (Baird et al., 2000; Bemister et al., 2015; Cianfaglione et al., 2015; Fullone et. al., 2023; Giusti et. al., 2018; Goldberg & DiVitto, 2005; Ngo et. al., 2012; Papaeliou et al., 2012; Raina et. al., 2004; Woodman et. al., 2015). The situation, then, may overwhelmed the caregivers, requiring a lot of mental and physical energy that can lead with more probability to the onset of mental health problems (Scherer et. al., 2019; Olsson et. al., 2001). The presence of distress shape also the parenting behaviors use to interact with the child, which can become less optimal and,

instead of working as protective factors for the future development, fundamental in those cases, start to reduce the possibility of ameliorating child's condition and future developmental trajectories (Azad et. al., 2013; Bornstein et. al., 2012; Dykens, 2015; Guralnick et. al., 2008; Fullone et. al., 2023).

Due to the key role that parenting play, it is necessary that early intervention programs that support parents and help them in engaging with the children through positive parents can play a significant role in promoting healthy child development (Kaminski et. al., 2008). For instance, programs that offer parenting education, resources, and support can help parents develop the skills necessary to provide sensitive and responsive caregiving (Kaminski et. al., 2008).

CHAPTER 2

Early Interventions

2.1) Time matters– why is important an early intervention?

As discussed at the beginning of the first chapter, human brain still needs to reach its full potential after birth (Provenzi et. al., 2018). We also explored the impact that interactions between caregivers and infants have on development, and the protective role that parenting has on future trajectories (Ainsworth et al., 1978; Cannella, 2005; Deans, 2020; De Wolff & van Ijzendoorn, 1997; DiCorcia and Tronick, 2011; Feldamn, 2012; Guney & Ucar, 2019; Johnson 2023; Madigan et al., 2019; Provenzi et. al., 2018; Raby et al., 2015; Rodrigues et al., 2021; Tichelman et al., 2019; Valcan et al., 2018; Waal et. al., 2023).

When a child presents an at-risk condition or a DDs, repetitive mismatching in parent-infant interactions can occur, reducing the quality of exchanges and potentially inducing mental health disorders in the caregiver (Scherer et. al., 2019; Olsson et. al., 2001). Given this, it is evident why early intervention is necessary to promote a better understanding of infant communication signals and to encourage optimal developmental trajectories (Azad et. al., 2013; Bornstein et. al., 2012; Dykens, 2015; Guralnick et. al., 2008; Fullone et. al., 2023).

To appreciate the importance of early intervention, it is essential to understand the brain's formation processes. Brain growth arises from numerous factors, including genetic predisposition and social and physical exposure, which interact through epigenetic mechanisms (Sale et. al., 2014; Berardi et. al., 2015). A key characteristic of our brain is its plasticity (Cioni et. al., 2015). Plasticity is the process that allows the brain to modify its structural and functional properties through experience-expectant, experience-independent, and experience-dependent mechanisms (Cioni et. al., 2015). These brain-changing mechanisms remain active even in older ages, although plasticity is particularly enhanced between the ages of 0 to 3 years (Cioni et. al., 2015; Fagiolini et. al., 2009).

The higher plasticity of younger brain is responsible for the occurrence of sensitive and critical periods, first demonstrated by Hubal and Wisel's experiments (Sharon et. al.,

2010). Sensitive periods are times during development when the brain's responsiveness to external experiences is heightened, whereas critical periods are developmental stages during which the presence or absence of specific experiences results in long-lasting changes (Daw, 1997; Newport et. al., 2001; Trachtenberg & Stryker, 2001). These mechanisms occur not through an increase in neuron cell production, but due to a higher presence of synapses between neurons (Hannon, 2003). The overproduction of synapses is followed by a pruning process, which works through experience-dependent shaping mechanisms, following Hebb's principle: connections that are frequently used are maintained and strengthened, while those underused are eliminated (Greenhough et. al., 1992; Hannon 2003; Kolb et. al., 2014). This underscores how environment and experiences during the early stages of life influence brain development and behavior, and how exposure to negative or inadequate stimulation can result in significant, lifelong negative outcomes (Kotulak, 1998).

DDs are all characterized by impairments in various brain functions, including cognitive, motor, language, learning, socio-emotional, and behavioral skills, with a multifactorial etiology (Centers for Disease Control and Prevention, 2024; Scherer et. al., 2019). Considering how plasticity works, exposure to early, appropriate environmental stimulation is crucial for minimizing deficits typically associated with DDs, thereby ensuring better developmental trajectories (Guralnick, 2011).

Literature shows that interventions initiated before the age of three are the most successful and, particularly in cases involving DDs (Doyle et. al., 2009; Ramey et. al., 1998; Shonkoff et. al., 2012). These early interventions act as protective factors for development, providing both children and caregivers with preventive, individualized rehabilitation programs and information that limit later problems and ensure the necessary support and stimulation during this highly receptive phase of life (Doyle et. al., 2009; Ramey et. al., 1998; Shonkoff et. al., 2012). For instance, early interventions yield positive outcomes for the child by promoting better psychomotor development, and for the parents by enhancing their understanding and involvement in interactions with their child (Spittle et. al., 2012).

Given the crucial role parents play in constructing the interaction environment for the child, it is necessary for early intervention programs to directly involve parents

(Hadders-Algra, 2014; Benzies et. al., 2013; Haveman et. al.,1995). This involvement helps parents transfer the activities learned during intervention to everyday life, increases parental education and self-esteem, and enhances the quality of environmental stimulation and interaction required (Hedders-Algra, 2014; Benzies et. al., 2013; Haveman et. al.,1995). Therefore, early parenting interventions often comprise social and behavioral programs aimed at improving caregivers' knowledge, practices, and skills (Britto et. al., 2017; Aboud et. al., 2015; Prado et. al., 2019; Black et. al., 2017; Jeong et. al., 2021). These programs target behaviors and characteristics of the dyadic interaction that may pose risks, in order to improve the cognitive, language, motor, and socio-emotional development of the children (Britto et. al., 2017; Aboud et. al., 2015; Prado et. al., 2019; Black et. al., 2017; Jeong et. al., 2021).

It is also important to consider the economic costs associated with intervention and rehabilitation programs for children with DDs or at-risk conditions (Doyle et. al., 2009). Research indicates that early intervention programs not only enhance the well-being of the child but also lead to more positive social outcome, thereby reducing the costs required for later educational and social services (Carneiro & Heckman, 2003; Doyle et. al., 2009).

In conclusion, due to enhanced plastic processes present early in life, along with economic considerations, interventions delivered early- such as during the pre- and postnatal periods- result in better developmental outcomes and reduced public expenditure compared to later actions (Doyle et. al., 2009). Notably, prenatal programs appear to have a more beneficial effect compared to postnatal ones, even in the long-term (Doyle et. al., 2009). Consequently, it is now believed that early education and preventive programs should begin during the pregnancy, given the significant impact that maternal behavior and environmental exposure during pregnancy have on the child's health and development (Hannon, 2003; Doyle et. al., 2009).

2.2) Intervention

Despite their importance in this population, the number of available interventions for children with DDs and their parents is limited (Hastings & Beck, 2004). One reasons for this could be the lack of a framework in the literature that clinicians can use to select

the most suitable program for the child's condition and the caregivers' difficulties (Fullone et. al., 2023).

The Porridge-Like Framework aims at helping practitioners to engage with parent of a child with DDs and to guide the decision for the best family-centered intervention (Fullone et. al., 2023). According to this model, the first step is to put yourself into the parent's perspective of the child's general functioning to actively engage them in the intervention, following a collaborative approach (Boukydis, 2015; Finn, 2012; Fullone et. al., 2023; Tharinger et al., 2012). The framework posits three primary areas that require the clinician's attention: affect, parenting behaviors, and cognitive representation (Fullone et. al., 2023). These three targets should be all considered when implementing an intervention, together with the child's condition and the developmental trajectory (Fullone et. al.,2023). Theus, by investigating the parents' issues and the child's level of impairment, the clinician can suggest the most tailored intervention to meet the family's needs (Fullone et. al., 2024). For example, if it is hard for the caregivers to fully comprehend the infant's situation, a psychologist may suggest an intervention focused on developing the correct abilities to care for the child and learning the best ways to interact with it (Fullone et. al., 2023).

Interventions can be categorized into three main groups: individual, educational, and relational (Fullone et. al., 2023). These categories encompass various types of interventions, which will be elucidated in the next paragraphs (Fullone et. al., 2023).

2.2.1) Individual Interventions

Individual Intervention are therapies aimed at helping parents decrease emotional burden and stress, develop coping strategies, and improve mental health. These interventions involve individual meetings that focus on the specific problems the caregivers bring up to the clinician (APA, 2011; Fullone et. al., 2023).

In a metanalysis, Sohmaran and Shorey (2019) found that parents who underwent individual interventions reported a significant decrease in parental stress and emotional distress. This may be due to the increased opportunities for parents to discuss their difficulties with a clinician, although the effectiveness results are mixed (Beresford, 2009: Sohmaran & Shorey, 2019).

Psychotherapy. Psychotherapy interventions help parents better understand their child's condition and decrease the distress elicited by that condition (Fullone et. al., 2023). Psychotherapy is divided in two categories based on the intervention's aim (Leichsenring & Leibing, 2007). Interpretative interventions help patients (in this case, parents) gain insight into their situation, while supportive interventions empower patients by enhancing their abilities (Leichsenring & Leibing, 2007). Due to the characteristics of this therapy, sessions can also address personal characteristics influencing the main parenting issue (Fullone et. al, 2023).

An example of individual intervention is Parent-Infant Psychotherapy (PIP), even if present some characteristics of relational approach (Barlow et. al., 2015). Indeed, PIP is a therapeutic intervention designed to improve the quality of the mother-infant relationship and attachment (Barlow et. al., 2015). A psychotherapist observes the mother-infant interaction in real time, helping the parent identify distress and find unique ways to interact with the infant (Barlow et. al., 2015). Achieving those goals can change maternal representations, increase parenting sensitivity and behaviors, and enhance the quality of the interaction and attachment (Barlow et. al., 2015; De Wolff & van Ijzendoorn, 1997). The theoretical framework behind this approach it is psychodynamic (Barlow et. al., 2015). For instance, the goals are reached by changing mother's representational world or by focusing on the influence that her experiences have on how she perceives the infant (Barlow et. al., 2015; Fraiberg, 1980). Although literature on PIP's effectiveness is limited, it has been shown success in fostering secure attachment in infants, improving parental representations, reducing parental stress, and alleviating affective symptoms (Barlow et. al., 2015; Fonagy et. al., 2016).

Cognitive-Behavioral Interventions. Cognitive-Behavioral Interventions (CBIs) is an umbrella term used to indicate different cognitive-based intervention that aim to change behavioral outcomes and reduce distress by working on the cognitive representations, beliefs, and emotional regulation (Li et. al., 2023). CBIs include Cognitive-Behavioral Therapy (CBT), Mindfulness Based Intervention (MBI), and Acceptance and Commitment Therapy (ACT) (Li et. al., 2023).

CBT targets negative cognitive representations, beliefs, and behaviors that contribute to discomfort (Beck, 2011; Li et. al., 2023). Research indicates that CBT significantly

helps reduce parenting-related stress and affective disorders in parents of children with diagnosis of DDs (Bourke-Taylor et. al., 2020).

MBI aim to improve the person's awareness of the present moment non-judgmentally, helping reduce stress (Kabat-Zinn, 2003). MBIs include Mindfulness-Based Stress Reduction (MBSR), which develops present-moment awareness through guided practices like breathing and movement, and Mindfulness-Based Cognitive Therapy (MBCT) which combines MBSR principles with CBT to help patients view negative thoughts and emotions as changeable (Li et. al., 2023). Literature highlighted that MBI significantly reduces stress, depression, and anxiety in parents of children with DDs (Chua & Shorey, 2021). Specifically, Benn and colleagues (2012), found that a 5-week mindfulness program decreased stress and emotional burden in parents of children with DDs, with benefits lasting up to two months after the program, improving well-being and sensitivity to their child's needs (Benn et. al., 2012). However, the training did not increase parental self-efficacy (Benn et. al., 2012).

ACT increases psychological flexibility in parents using mix of concepts, such us mindfulness, acceptance, and valued action (Coyne, McHugh, & Martinez, 2011; Hayes, Strosal, & Wilson, 1999). In the context of DDs, a boosted psychological flexibility helps parents to become more aware of the context and their behaviors, even in stressful situations (Whittingham et.al., 2016). Literature shows a significant reduction in depressive and stressful symptoms, though the effect on anxiety symptoms was absent in parents of children with CP (Whittingham et.al., 2015). Additionally, ACT implementation is associated with decreased parental stress, depressive and anxiety symptoms, psychological inflexibility, and increased overall well-being (Blackledge & Hayes, 2006; Holmberg Bergman et. al., 2022; Gümüş & Öncel, 2022).

Studies testing the feasibility and effectiveness of CBIs have limitations (Li et. al., 2023). Indeed, the overall number of studies on the topic is limited, and the dimensions of the samples are often small (Li et. al., 2023). Furthermore, the various interventions use different techniques and target aspects, making the interventions heterogeneous, so difficult to compare (Li et. al., 2023).

A peculiar individual intervention is the Parent-to-Parent support program (Kerr & McIntosh,2000). As evidenced by literature, social support for parents of children with

DDs is a crucial resource for protecting against stress and feelings of isolation (Ainbinder et al. 1998; Hartman et al. 1992; Kerr & McIntosh, 1999; Telleen et al. 1989). Specifically, when support comes from people who share similar stressful conditions, the outcomes are even more favorable (Matloff & Zimmerman 1996; Phillips 1990; Santelli et. al., 1997).

In response to this need, the Parent-to-Parent program was developed to support parents of children with DDs (Kerr & McIntosh, 1999). In this program, volunteer parents receive training in emotional support and instructional knowledge to effectively assist referred parents (Bray et. al., 2017; Santelli et al., 1997; Santelli et. al., 1993). Typically, supporter parents and the referred parents are matched based on the child's condition (Ainbinder et al. 1998). Interventions can be delivered via phones, in home setting, or in other locations, and are often facilitated through various networks (Ainbinder et al. 1998; Bray et. al., 2017). This intervention has been shown to increase emotional and social support, enhance coping and problem-solving abilities, and foster a sense of belonging, thus enhancing self-efficacy (Kerr & McIntosh, 2000; Law et. al., 2002; Nicholas & Kelity, 2007; Palit & Chatterjee, 2006; Resendez et. al., 2000; Shilling et. al., 2013; Solomon et. al., 2001).

A qualitative study by Ainbinder and colleagues (1998) highlighted that the positive outcomes of Parent-to-Parent support are linked to factors such as perceived similarities between the supported and the caregiver, including the child's disability and personal characteristics, as well as the bidirectional and available nature of the relationship (Ainbinder et. al., 1998). Having a similar background with the supporter helps parents compare their situation and recognize that they are not "abnormal" (Ainbinder et. al., 1998). Knowing that they are not alone and that others share similar experiences can reduce feelings of isolation and helplessness, thereby improving their caregiving and overall well-being (Ainbinder et. al., 1998). Supporting this, a quantitative study examining the efficacy of Parent-to-Parent support for caregivers of preterm babies in the NICU found that maternal anxiety and stress decreased after the intervention, while self-esteem and parental confidence increased (Hunt et. al., 2019).

However, limitations of the Parent-to-Parent support intervention include some barriers for individuals of diverse cultural and ethnical background, since they seem to present a higher level of drop out compared to the Occidental population, suggesting a potential

differentiation of strategies requires to engage population with different origins (Poole et. al., 2023). Mover, families may lose contact or move to a different place, losing the possibility of keep attending the service, and the lack of control-group and of RCT studies, make the effectiveness of the intervention less generalizable (Poole et. al., 2023). Lastly, for parents providing the intervention, discussing specific topics may trigger emotional distress, potentially compromising their ability to build effective relationship with others and maintain appropriate boundaries (Santelli et. al., 1997; Singer, 2002).

2.2.2) Educational interventions

Educational interventions directly involve parents and target parental sensitivity and responsiveness to infants' signals to improve them (Fullone et. al., 2023). These interventions include parenting training, which can also be used as a tool to induce a cognitive change in parents regarding their role and their perceptions of their children (Fullone et. al., 2023). Parent training interventions aim to enhance parenting skills through training, support, and educational methods (Smith et. al., 2002). There interventions can be delivered in various formats, including individual sessions, group sessions, and online formats (Fullone et. al., 2023).

A key component of these interventions is the implementation of contingency management training (Lutzker et. al., 1998). Through this training, caregivers learn how to establish contingencies and provide clear instructions to their children, which increases and improve the sensitivity and the effectiveness of their interactions with their infants (Lutzker et. al., 1998).

Literature highlights the benefits of parent training of various DDs, noting improvements in children's developmental trajectories, particularly for behavioral problems. It also positively influences the relationship between caregivers and their parenting practices, reducing stress and other affective symptoms (Barlow et. al., 2002; Cowan et. al., 2011; Gavidia-Payne & Hudson, 2002; Gross et. al., 2003; Kaminski et. al., 2008; Lundahl et. al., 2006; Nixon et. al., 2003; Sander & McFarland, 2000; Serketich & Dumas, 1996).

The Triple P-Positive Parenting Program is a multilevel behavioral family intervention founded on social learning concepts that aims to teach strategies and support to parents (Sanders, 1999). It targets parental behaviors to promote optimal developmental trajectories by helping parents understand their infant's cues and improve their confidence, focusing on the specific issues of each family (Sanders, 1999). The program integrates knowledge from social learning models, behavioral therapy, analysis of parenting during daily activities, social information processing, and developmental psychopathology research (Sanders, 1999).

Originally developed for children with conduct problems, the Triple P program is now also used to support parents of children with DDs (Barkly et. al., 1992; Schreibman et. al., 1991). As previously mentioned, the Triple P program can be delivered in various formats (Fullone et. al., 2023). In individual interventions, families typically engage in 60-to-90-minutes semi-structures sessions with a clinician (Sanders et. al., 2000). Research by Plant and Sanders (2007) demonstrated that Triple P program is associated with reductions in behavioral problems and improvements in adaptive parenting behaviors and parental knowledge among parents of children with DDs (Plant & Sanders, 2007). Group implementation of Triple P program involves activities such as skill training, role-play, observation, feedback, and demonstration (Au et. al., 2014). This format has also been shown to help reduce behavioral problems and increase parental behaviors and self-efficacy in parents of children with ADHD (Au et. al., 2014). The online version of the Triple P program delivers content via the internet, exposing parents to information and exercises aimed at increasing parental understanding and self-regulation (Sanders, 2008; Franke et. al., 2020). An online self-administrated of Triple-P program to parents of children with ADHD showed reductions in ADHD symptoms and enhancement in parenting skills and satisfaction (Franke et. al., 2020).

Regarding parental well-being, neither the individual nor the group interventions significantly reduced stress, whereas the online delivery of the program improved maternal well-being (Au et, al., 2014; Franke et. al., 2020; Plant & Sanders, 2007).

Another parent-training intervention is the Incredible Year program, which incorporated principles from the Triple P- Positive Parenting Program, along with Piaget's developmental stages, Bandura's modeling theories, and attachments theories

(Webster-Stratton, 2016). This intervention aims to enhance positive parenting and improve the caregiver-infant relationship, considering the child's developmental phases (Webster-Stratton, 2016). The program helps parents to learn coping mechanisms against negative thinking and improves confidence and regulation skills (Webster-Stratton, 2016). It is implemented through videos of a caregiver-infant interactions in various contexts and qualities, along with focus group discussions, activities with feedback, and support (Webster-Stratton, 2016). Delivery of the intervention to parents of children with ADHD has shown reductions in behavioral symptoms and increased confidence in mothers (Azevedo et. al., 2013).

Hohlfeld and colleagues (2018) conducted a metanalysis showing that these interventions can also change parental representations, which helps increase parental self-efficacy and results in better parenting skills (Hohlfeld et. al., 2018; King et. al., 2006). However, there are several limitations to parenting training interventions (Gardner & Leijten, 2017; Plant & Sanders, 2007). Most studies use self-report data, primarily filled out by mothers, and the diverse characteristics of families involved can reduce the homogeneity of results (Gardner & Leijten, 2017; Plant & Sanders, 2007). Additionally, it is challenging to assess how well the information learned is applied at home (Gardner & Leijten, 2017; Plant & Sanders, 2007). The costs of training clinicians in the specific principles and approaches of these interventions are also high (Gardner & Leijten, 2017).

2.2.4) Relational intervention

Unlike interventions that focus on modifying parental behaviors, relational interventions aim to enhance the quality of interactions between caregivers and infants (Barlow et. al., 2015; Fullone et. al., 2023). As discussed in the first chapter, optimal dyadic interactions are crucial for a child's developmental trajectories (DiCorcia & Tronick, 2011; Fullone et. al., 2023; Provenzi et. al., 2018). Promoting functional caregiver-infant interactions can lead to positive outcomes for both child development and parental self-perception and psychological well-being (DiCorcia & Tronick, 2011; Fullone et. al., 2023; Provenzi et. al., 2018). Additionally, relational interventions may help parents modify their cognitive representations of themselves and their child (Fullone et. al., 2023).

For example, the already mentioned Parent-Infant Psychotherapy (PIP) aimed to work and improve the quality of the interaction between caregiver and infant (Barlow et. al., 2015). Indeed, even if originally it was based on psychodynamic concepts, PIP has evolved to incorporate behavioral and representational approach (Cramer, 1998; Fraiberg, 1980). One adaptation, "*Watch, Wait and Wonder*" (WWW), involves the parent waiting for the child's initiative while remaining available, and then discussing this interaction with the clinician to explore parental representation of themselves and their relationship with the infant (Cohen et. al., 1999). Even if it has been shown to be effective on parental representation and psychological well-being, promoting secure attachment in the child, the improvements in parent-child interactions have not always been consistent (Barlow et. al., 2015; Fonagy et. al., 2016).

Another relational intervention used to increase the quality of interactions between parent and infant is the Parent-Child Interaction Therapy (PCIT) (McNeil & Hembree-Kigin, 2010). It is a behavioral program for early childhood with the aim of improving dyadic interactions through the teaching of parenting abilities that help to create a positive environment and may prompt better child's developmental outcomes (McNeil & Hembree-Kigin, 2010). Literature evidenced positive changes in child behaviors and parenting interactional styles, together with a higher self-trust, well-being, and a reduced parental stress (Eisenstadt et. al., 1993; Eyberg & Robinson, 1982). PCIT is now widely used as intervention for families with children diagnosed with ASD (Masse et. al., 2016). Indeed, different research found that mothers who participated in PCIT exhibit more positive parenting behaviors and that their infants show fewer negative behaviors (Masse et. al., 2016). Vess and Cambell (2022) found that after PCIT improved parenting quality and the relationship between the dyads, due to also a higher compliance of the child (Vess & Cambell, 2022).

In addition to in-person interventions, Video-feedback Interventions (VFIs) have emerged as a valuable tool for enhancing parental sensitivity and improving child behavioral and socio-emotional development (Fukkink, 2008; Rusconi-Serpa et. al., 2009). These family-centered interventions, based on infant research, can be delivered in various settings (e.g., home or hospital) and can be combined with other types of parental support (Groeneveld et. al., 2011; Fukkink, 2008; Rusconi-Serpa et. al., 2009). The process involves recording dyadic interactions during activities such as free play, bathing, or eating (Fukkink, 2008). Clinicians then select significant part of the

recorded videos for review and provide feedback to parents on specific behaviors (Fukkink, 2008). Rewatching these videos with the clinician helps parents view their interactions from a new perspective, enhancing their understanding of their child and improving their interaction skills (Fukkink, 2008; Provenzi et. al., 2020). This feedback process increases parental sensitivity and attunement (Bakermans-Kranenburg et. al., 2003).

Clinicians should begin sessions by addressing the parent's curiosities and using a supportive approach to encourage parents to describe what they observe and relate it to everyday challenges (Provenzi et. al., 2020). This fosters a collaborative approach between parent and therapist (Boukydis, 2012; Giusti et. al., 2018).

VFI can be broadly categorized into two main approaches: behavioral-oriented or psychotherapeutic (Fukkink,2008; Provenzi et. al., 2020). The behavioral-oriented approach focuses on exchange behaviors between caregiver and infant, with videos highlighting interaction processes (Fukkink, 2008; McDonough, 2005; Stern, 1985).

The psychotherapeutic approach, on the other hand, targets parental cognitive representations and past experiences, using videos to explore the dyadic relationship and the parent's early experiences (Fukkink, 2008; Lieberman, 2004; Zelenko & Benham, 2000). Although the distinction between these approaches is not always clear, some programs integrate elements of both to improve parenting and interactive skills, as well as child developmental outcomes (Beebe, 2003; Cramer, 1998; Egeland et. al., 2000; Giusti et. al., 2018).

Fukkink's metanalysis (2008) indicates that VFI is effective in improving parenting abilities, interaction quality, parental well-being, and child developmental outcomes (Fukkink, 2008). Although the body of research is still growing, evidence suggests that VFI is also effective with parents of children with DDs (Giusti et. al., 2018).

A systematic review by Provenzi and colleagues (2020) found that various types of VFIs improved both child and parental outcomes (Provenzi et. al., 2020). Specifically, reductions in infant behavioral problems and improvements in cognitive outcomes and interpersonal abilities were noted (Glanemann et al., 2013; James et al., 2013; Lam-Cassettari et al., 2015; Mahoney & Powell, 1988; Phaneuf & McIntyre, 2011; Seifer et al., 1991;). Parents also showed better ability to interpret infant signals, increased reciprocity, and improved interaction with their child (Glanemann et al., 2013; Kim &

Mahoney, 2005; James et al., 2013; Mahoney & Powell, 1988; Sealy & Glovinsky, 2016; Seifer et al., 1991). Observing interactions through video allows parents to better read and respond to their child's cues and assess their own interaction skills (Miron et. al., 2009; Phaneuf and McIntyre, 2007; Poslawsky et al., 2015).

The impact of VFI on parental psychological health remains less clear (Provenzi et. al., 2020). Some studies report reductions in parental stress, particularly for parents of children with motor delays, while other studies show no significant effect (Kim & Mahoney, 2005; Lam-Cassettari et. al., 2015; Platje et. al., 2018).

Specific interventions for parents of infants with DDs are outlined below, based on Provenzi and colleagues review (2020):

Transactional Intervention Program (TRIP). TRIP is a home-based intervention for children between 0 to 3 years of age that enhances parental responsiveness by teaching specific skills, such as turn-taking and matching, occurring every 6-10 weeks (Kim & Mahoney, 2005; Mahoney & Powell, 1988).

Relational-Focused Intervention (RFI). RFI is an intervention that last 3 months involving in-class and home-based, video-feedback, and evaluation, focusing on turn-taking and matching abilities (Kim & Mahoney, 2005).

Individualized Video Feedback (IVF). IVF is 3-session home-based intervention that delivers feedback on parenting behaviors, addressing both strengths and weaknesses (Phaneuf & McIntyre, 2007).

Video Interaction Guidance (VIG). VIG is home- or hospital-based intervention that require three sessions aimed at fostering emotional bonding towards the child, with goal co-defined with caregiver (James et. al., 2013; Lam-Cassattari et. al., 2015).

Developmental Individual-difference Relationship (DIR). DIR is a home-based intervention that focuses on improving caregiver attunement and co-regulation through video-feedback on free-play interactions (Sealy & Glovinsky, 2016).

Video feedback Intervention to promote Positive Parenting (VIPP). VIPP is an intervention designed to enhance parental sensitivity, focusing on exploration vs. attachment behaviors, reading child signals, and improving affective attunement (Juffer et. al., 2008; Juffer et, al., 2017). VIPP has been adapted for specific populations, including parents of children with externalizing behavior problems (VIPP-SD), parents

with learning disabilities (VIPP-LD), and parents of children with visual and/or intellectual disabilities (VIPP-V) (Hodes et. al., 2014; Van Den Broek et. al., 2017; Van Zeijl et. al., 2006).

Muenster Parental Program (MMP). MMP is a hospital-based intervention consisting of six group sessions and two individual sessions targeting parental responsiveness and reducing intrusive behaviors, with themes including waiting for infant initiation and following the child's interest (Glanemann et. al., 2013).

Video-feedback Coaching Program. This intervention is a six-session, hospital-based intervention aimed at improving reciprocal interaction and reducing parental overstimulation (Seifer et. al., 1991).

The COVID-19 pandemic has led to the development of online versions of VFIs, to provide continued support for children with special needs and their families through telecare programs (Camden & Silvia, 2021; Hsu et al., 2021; Murren-Boezem et al., 2021; Provenzi et al., 2021). Emerging evidence suggests that Telecare Video-Feedback Interventions (TVFIs) can be as effective and satisfying for parents as traditional in-person interventions (Provenzi et. al., 2021; Xie et. al., 2013).

Relational interventions present some limitations. PIP requires highly specialized therapist, which may not be accessible to all families and can be demanding in terms of time and commitment (Fonagy et. al., 2002; Lieberman & Van Horn, 2008; Sleed et. al., 2013). More research is needed to fully establish its effectiveness (Baradon et. al., 2008; Lieberman & Van Horn, 2008).

PCIT's highly structured nature can be challenging for families, particularly those with children with DDs, and may not address emotional and relational issues as effectively as behavioral skills (Chaffin et. al., 2004; Eyberg & Bussing, 2010; Nixon et. al., 2003; McNeil & Hembree-Kigin, 2010; Zisser & Eyberg, 2010).

The literature for VFI is still developing, with methodological differences across studies potentially complicating comparisons and the generalization of findings (Fukkink, 2008).

In conclusion, there is a wide range of literature that highlights the importance of early intervention to improve child's developmental trajectories, especially when the infants present a DDs. On the other hand, even it there are already different interventions

based of different approaches that aim to improve parents and children well-being and the quality of their interactions, research on the topic is still needed.

CHAPTER 3

How maternal caregiving behavior may shape temperament in infant at neurodevelopmental risk: Findings from a Video-Feedback Intervention study.

3.1) Introduction

Observing infants can make you quickly understand that they not all behave or respond in the same way (Caspi & Silva, 1995). For example, there may be an infant that prefer to be held by parents, while another may fuss when this happens (Caspi & Silva, 1995). Behind these differences there is the temperament, a concept that has interested research for centuries (Caspi & Silva, 1995; De Pauw & Mervielde, 2010; Prior, 1992). Indeed, Hippocrates already introduced the theory of the humors, which were later linked to specific temperaments by Galen, suggesting that the dominant humor defined the individual's temperament (Prior, 1992). Nowadays the research as refined temperament's definition by putting together findings coming from the main approaches of this topic (Shiner et. al., 2012). For instance, temperament includes traits like activity, affectivity, attention, and self-regulation, biological, and environmental factors, influencing how individuals respond to their environment and affecting the type of environment they select of create (Kiff et. al., 2011; Shiner et. al., 2012). Social interactions and external environments, in turn, shape temperament, with certain traits being more accepted or encouraged than others (Shiner & Caspi, 2003). Researchers like Gartstein and Rothbart (2003) have categorized temperament into three principal components: Surgency, Negativity, and Regulation, each with distinct characteristics that influence developmental outcomes (Rothbart & Bates, 2006).

Temperament plays a significant role in predicting various developmental trajectories, including physical health, psychological wellbeing, and social relationship (Brier, 1995; Chess & Thomas, 1996). For example, children with high negative emotionality and low self-control are more prone to internalizing and externalizing problems, while those with better self-regulation tend to have stronger social skills and higher self-esteem (Eisenberg et. al., 2001). These differences in temperament can also influence later development and may contribute to the risk of psychological and psychiatric disorders (Rutter, 1987).

Neurodevelopmental Disabilities (NDDs) are chronic Central Nervous System disorders that begin during the developmental period, resulting in impairments in motor, cognitive, communication, or behavioral domains (Mullin et. al., 2013). Conditions such as Autism Spectrum Disorder, Attention-Deficit/Hyperactivity Disorder, Intellectual Disabilities, Specific Learning Disorders, Communication Disorders, Motor Disorders, and Genetic Conditions affecting brain development fall under this category (DSM-5, 2013). Although these conditions manifest differently, they share common features like early onset and pervasive impact on daily life (DSM-5, 2013). Risk factors for NDDs are multifactorial, including genetic, neurobiological, environmental, and maternal health factors during the prenatal phase, as well as perinatal and postnatal factors such as birth complications and infections (Shevell, 2009).

Despite research on temperament in children with NDDs is limited, some findings indicate discrepancies in temperamental traits between children with NDDs and typically developing children (Hepburn, 2003). For instance, children later diagnosed with Autism Spectrum Disorder often show lower approach, adaptability, and positive affect, while exhibiting higher distress to limitations and fear (del Rosario et. al., 2014; Garon et. al., 2016).

Maternal caregiving behaviors are crucial not only for an infant's developmental trajectory but also for the strength of the mother-infant relationship (Lindgren, 2001; Medina et. al., 2021). Positive maternal behaviors, such as synchronization, sensitivity, responsiveness, and emotional availability, act as protective factors supporting the healthy development of the child, particularly in at-risk conditions (Biringen & Easterbrooks, 2012; Provenzi et al., 2018).

Research underscores that parental sensitivity and responsiveness are vital for the development of socio-emotional skills, executive functions, and social functioning (Ainsworth et al., 1978; Madigan et al., 2019). However, when parental engagement is either low or excessive, it can interfere with the child's autonomy or emotional regulation abilities (Cooke et. al., 2022). This highlights the importance of the quality of maternal caregiving in shaping not only developmental outcomes but also a child's temperament (Achtergarde et. al., 2014).

Being a parent of a child with NDDs is particularly challenging (Fullone et. al., 2023). Indeed, it is common for these parents to experience an increased parental stress, anxiety and/or depression, which can negatively impact caregiving strategies (Baird et. al., 2000; Fullone et. al., 2023). For instance, the presence of stress may contribute to a more intrusive or directive parenting behaviors, which is associated with socio-emotional and behavioral problems (Azad et. al., 2013). Although literature on the impact of caregiving on children with NDDs is sparse, findings suggest that the interaction between parenting and temperament in these populations is significant and warrants further investigation (Dyches et. al., 2012).

One promising intervention for improving parental sensitivity and child outcomes is the Video-Feedback Intervention (VFI). VFI has been shown to enhance parental sensitivity and improve socio-emotional and behavioral development in infants (Fukkink, 2008; Rusconi-Serpa et al., 2009). By recording dyadic interactions and reviewing selected clips with the parent, the intervention helps them increase their ability to read their child's signals and improve interaction skills (Bakermans-Kranenburg et al., 2003; Provenzi et al., 2020).

After the COVID-19 pandemic, an online version of VFI was developed in order to continue to provide support to children with special needs and their families (Camden & Silvia, 2021; Hsu et al., 2021; Murren-Boezem et al., 2021; Provenzi et al., 2021). Telecare Video-Feedback Interventions (TVFI) have been proved to be as effective as the regular VFI, with the advantages of reducing healthcare costs, reducing waiting lists, and the inequalities between the families that cannot afford to reach the structures for the rehabilitative interventions (Grumi et. al., 2023).

3.2) Aims

Given the lack of research on the relation between maternal caregiving behaviors and infant's temperament with at-risk of Neurodevelopmental Disabilities, the first aim of this research is the investigation of what maternal variables could be used as predictors of child temperament. Given the potential impact of VFI on both parenting strategies and child temperament, we use telecare version of the VFI, investigating its feasibility. The third aim of the study was evaluating the changes induced by the VFI on Parent Stress Index-Short Form, Beck Depression Inventory- II, State-Trait Anxiety Inventory-Y, Infant Behavior Questionnaire-R Short Form, and maternal observational variables.

3.3) Methods

3.3.1) Participants

Thirty mother-infant dyads with Developmental Disabilities or at-risk conditions participated in the SPHERE project. The families were recruited form the Child Neurology and Psychiatry Unit of the IRCCS Mondino Foundation (Pavia, Italy). Inclusion criteria comprised infants ages 1 to 24 months (corrected for infants born pre-term), with a diagnosis of Neurodevelopmental Disabilities or at-risk conditions based on standardized clinical criteria. Parents were required to be over 18 years old, fluent in Italian, and cohabiting with the infant. Exclusion criteria included infant's life-threatening conditions and mothers with psychiatric disorders. The project was approved by the ethic committee of Pavia and all the participants signed a written informed consent.

3.3.2) Measures

Clinical characteristics and diagnosis of the infant were acknowledged from medical records, while infants' neonatal characteristics (i.e., sex, gestational age in weeks, birth weight in grams), socio-demographic variables (i.e., maternal age, educational level, and occupational status), data about maternal well-being and child temperament were collected through the submission to mothers of on-line questionnaires. They were

asked to fill the same questionnaires before and after the Video Feedback Intervention (T0 and T1). The online questionnaire includes the following measure:

Parenting Stress Index-Short Form. Parental stress was assessed through the Parenting Stress Index Short Form (PSI-SF; Abidin, 1983). PSI-SF contains 36 items rated on a 5-point Likert scale, going from “strongly agree” to “strongly disagree”, and it is subdivided in three subscales: Parental Distress (i.e., I fell that I am not as good a parent as I would like to be), Parent-Child Dysfunctional Interaction (i.e., My child rarely does things for me that make me feel good), and Difficult Child (i.e., My child generally wakes up in a bad mood). It helps the identification of areas of stress that may affect parenting and child outcomes. The scores of each scale, can be sum together into the Global Parental Stress score.

Beck Depression Inventory-II. Parents depressive symptomatology was assessed through the Beck Depression Inventory (BDI-II; Beck et al.,1988). It is a widely used self-report questionnaire designed to assesses the severity of depression in adolescents and adults, which consists of 21 multiple-choice questions, each describing a specific symptom or attitude related to depression (i.e., sadness, loss of pleasure, self-criticalness). The patients rate each item on a scale from 0 to 3 based on their experiences over the past two weeks, and the total score indicated the severity of depression.

State-Trait Anxiety Inventory-Y. Parents anxious symptoms were assessed with the State-Trait Anxiety Inventory-Y (STAI-Y; Spielberger et. al., 1983). The STAI-Y is a psychological assessment tool used to measure anxiety in adults. It differentiates between state anxiety (i.e., I feel calm) and trait anxiety (i.e., I worry too much over something that really does not matter) and contains 40 self-report items rated on a 4-point Likert scale.

Infant Behavior Questionnaire-R Short Form. The Infant Behavior Questionnaire Revised Short Form (IBQ-RSF) is a widely used, standardized parent-report measure used to assess the temperament of infants aged 3 to 12 months (Putnam, et. al., 2014). The IBQ consists of different scales that evaluate different dimensions of the infant’s temperament. The three main dimensions of the IBQ has different subscales. The Surgency dimension indicate infant’s level of activity, impulsivity, and positive anticipation of pleasurable activities. This subscale includes Activity Level (i.e., level of

motor activity of the child), High Intensity Pleasure (i.e., child's pleasure derived from high sensorial stimulation), Smiling (i.e., how much the child enjoys social interaction), Approach (i.e., tendency to move towards stimuli), and Vocal Reactivity (frequency of vocalizations).

The Negativity assesses the frequency and intensity of negative emotions such as fear, frustration, and sadness, and the subscales included are Sadness (i.e., expression of low mood), Distress to Limitations (i.e., negative emotions displayed when the movements are restricted), Fear (i.e., child shows distress when new stimuli are presented), and Falling Reactivity (i.e., how the child recovers from distress),

Lastly, the Regulation evaluates the child's ability to regulate their attention and behavior. The categories included: Duration of Orienting (i.e., time that the child spends interacting with the caregiver), Low Intensity Pleasure (enjoy low-intensity stimulation), Cuddliness (i.e., enjoy physical contact with caregivers), Soothability (i.e., how easily the child can be calmed), and Perceptual Sensitivity (i.e., detection of slow stimulation).

Parents rate the frequency of these behaviors on a scale that goes from "never" to "always", providing a comprehensive overview of infant's typical behavioral response in different situations.

An ad hoc questionnaire was developed to assess satisfaction and feasibility of the video feedback intervention. The questions explored the efficacy of the intervention for both parenting and the child's development that were perceived by the parents, the relation established with the psychologist, and the technical difficulties and organizational issues experienced in planning the sessions.

3.3.3) Procedures

Video recording. The project involved a 15-minutes mother-child dyadic interaction videotaped during a videoconference before (T0) and after the intervention (T1). The interaction consisted of 10 minutes of play interaction followed by an adapted version of the Face-to-Face-Still-Face procedure (Tronik et. al., 1978). Mothers were asked to play with their infant as the usually do, using the child's toys if desired. During the Still-Face episode, mothers were asked to stop all communication and to maintain a neutral, expressionless face. Since the recordings were conducted online, mothers were asked

to position the webcam or smartphone to capture the widest possible view of the play area, ensuring the entire body of both mother and infant. Due to the nature of the recordings, it is possible that the infant may move out of the frame or that the face may not always be visible. Additionally, technical issues such as internet connectivity problems could affect the video quality.

Intervention. The TVF interventions provided to the engaged dyads were standardized according to previously RCTs (Høivik et al., 2015; Juffer et al., 2005) as a flexible intervention, and an adaptable to specific family needs and priorities. Specifically, a 6-weeks TVFI of 1-hour long session based on the Zack Boukyds' Collaborative Consultation approach were delivered to all the dyads in two different subsequent phases (Boukydis, 2015). The first four sessions were focused on the discussion between the mother and the psychologist about specific themes related to parenting and parent-child interaction, like physical stimulation, responsiveness, teaching, and parenting experience (**Table 1**). The sessions occurred in videoconference and were conducted as a dialogic interactive session, using the videotaped interaction recorded at T0 as starting point. Specifically, the T0 videotaped interaction were segmented in different videos lasting up to 10s and labelled as one of the thematic contests reported in **Table 1**. During these sharing focus sessions, the psychologist proposes to the mother to see and review together some of the segments, usually starting from the curiosity, comments, or request from the mother herself. This makes the order for the discussion of each theme tailored to each specific case. The goal of this sharing focus sessions is to develop together insights about the infants' behavioral signals, suggesting optimal ways to provide stimulations and to get in touch with the child, strategies to promote emotion regulation, and to sustain cognitive and behavioral achievements.

Following these four sessions are two integration sessions during which the mother is asked to play with the infants while the psychologist provides dyadic-tailored guidance based on topics previously discussed during the first four sessions. The goal of the integration sessions is to promote a translation of the previous insights developed into the interactive exchanges between the mother and the infant. This integration helps the mother to introduce variations in her caregiving behavior, while still being in a safe environment, under the supervision of a specialist.

Coding. The mother-infant interaction was coded with a micro-analytical ad-hoc coding system (**Table 2**), which focused on specific behaviors of both infant and mother (Grumi et al., unpublished), using the Noldus Observer XT. For each variable, a frequence (for point events) or a percentage of time (for state events) during the first 5 minutes of free play was extracted.

Table 1. Description of the TVFI sharing the focus sessions' themes.

Theme	Sub-themes	Description
Stimulation	Type of stimulations	Type of stimulations (e.g., auditory, tactile) preferred by the infant
	Intensity of stimulations	Infant's sensitivity to the intensity of stimulations
	Social touch	Maternal touch in promoting infant's body awareness and attentional orientation
	Sensory integration	Infant's sensory integration and body awareness
Responsiveness	Sense of agency	Supporting the infant's initiative to promote the development of his sense of agency
	Sensitivity	Perceiving and interpreting child's signals and responding in a prompt and appropriate way
	Exploration	Supporting the child's exploration and his use of the parent as a secure base
	Reparation	Repairing communicative ruptures
Teaching	Attention skills	Supporting the infant's attention orientation
	Modelling	Providing a model to the infant to foster the observational learning
	Scaffolding	Parental guidance to allow the infant to solve a task that he cannot yet carry out on his own
	Proximal development zone	Encouraging learning in the infant's proximal development zone
Parenting experience	Representations of the baby	Maternal representations of the infant and curiosity about his mind
	Self-regulation	Taking care of herself
	Self-efficacy	Mother's sense of efficacy and trust in her own experience

3.3.4) Statistics

For the statistical analysis, IBM SPSS version 25 was used. Preliminary descriptive statistics (i.e., frequence and percentage, or mean and standard deviation) were computed for all the study variables.

To identify the predictive factors of the child's temperament, we first conducted Pearson's r correlation analyses to determine which maternal variables had a significant correlation with the three main indices of the IBQ. Based on the results of the correlation analysis, we performed three linear regression analyses with Surgency, Negativity, and Regulation as the dependent variables, including all variables that showed a significant correlation with them in the preliminary bivariate analyses.

The feasibility of the intervention was assessed using an ad hoc questionnaire, with which were calculated the mean and standard deviation of each answer provided by the parents.

For the assessment of the impact that the intervention had on both maternal well-being and on the interaction style of the dyad, we conducted a paired sample t-test to compare pre-intervention and post-intervention variables. This allowed us to evaluate whether there was a significant change on those following the TVF intervention.

Table 2. SPHERE ad-hoc coding system.

DOMAIN	CODE	DESCRIPTION
Interactive sensory attunement	Vocal stimuli	Calling the child's name, requests, comments, singing, etc.
	Tactile stimuli	Tapping, stroking, patting, etc.
	Vestibular stimuli	Throw the child in the air, making the child jump, etc.
	Visual stimuli	Showing objects, using gestures, etc.
	Touch mode	Type of maternal touch
	Vocal content	Content of maternal vocal productions
Interactive behavioral attunement	Reciprocal vital affect moments	Moments in which both are smiling and/or laughing together
	Leading parent	The parent is leading the interaction
	Leading child	The child is leading the interaction
	Following parent	The parent is following the interaction
	Following child	The child is following the interaction
Cognitive sensitivity	Teaching	Parent shows, models, shadows, explains, etc.
	Play proposal level	Level of play proposed by the parent, according to the child

Note. The coding manual is unpublished (Grumi, Anceresi, Fullone, Parsanejad, & Provenzi, 2022) and can be requested to the corresponding author of this contribution.

3.4) Results

This section presents the results of the statistical analyses. The aims of the study were to understand what maternal variables could be used as predictors of child temperament, to investigate TVF interventions feasibility, and the changes induced by it on maternal self-report questionnaire.

Sample characteristics.

Thirty mother-infant dyads were enrolled in the study. The descriptive statistics are reported in **Table 3**.

Table 3. Descriptive statistics of participants

	M(DS) / f (%)
Infant's Sex	Male: 17 (56,6%) Female: 13 (43,3%)
Infant's Age	15.31 months (8.91)
Infant's Clinical Conditions	Pre-term birth: 9 (30%) Risk for Autism Spectrum Disorder: 8 (26,6%) Psychomotor Delay: 7 (23,3%) Regulation Problem: 5 (16,7%) Rare Syndrome: 3 (10%) Post-Natal Cerebral Infection: 1 (3,3%)
Mother's Age	36.5 (4.39)
Parents' Education	University Degree: Fathers 10 (33,3%), Mothers 15 (50%) High School Diploma: Fathers 12 (40%); Mothers 11 (36,7%) Middle School/ Third Grade of High School: Fathers 8 (26,7%); Mothers 4 (13,3%)
Parents' Occupation	Fathers: 30 (100%) Mothers: 19 (63,3%)

Predictive factors of the child's temperament.

For our first aim we conducted Pearson's r correlation analyses to determine which maternal variables significantly correlated with IBQ categories.

As shown in **Table 4**, the correlations between self-report questionnaire and IBQ highlighted that there is a significant positive correlation between BDI and Negativity, a significant negative correlation between STAI trait and Surgency, and between STAI trait and Regulation, and a significant negative correlation between STAI state and Regulation.

In **Table 5**, instead, are shown the correlation between maternal observative variables and IBQ. A significant negative correlation was highlighted between Touch Affective and Surgency, which also showed to have a significant positive correlation with Child Initiative Followed.

A significant positive correlation has been found between Touch Negative and Negativity. Negativity showed also to have a significant negative correlation with Touch Affective, and a significant positive correlation with Verbal Negative and with Child Initiative Unfollowed.

Only a significant negative correlation between Regulation and Action Guidance Effective was found.

Table 4. Correlations between self-report questionnaire and IBQ.

	SURGENCY	NEGATIVITY	REGULATION
BDI	-0,089	**0,450***	-0,344
STAI trait	**-0,408***	0,151	**-0,525****
STAI state	-0,155	0,141	**-0,369***
PSI PD	-0,057	0,276	-0,199
PSI CDI	-0,115	0,315	-0,237
PSI DC	0,295	0,313	-0,068
PSI tot	0,025	0,361	-0,212

* Significant correlation for 0,05 (2-tailed)

** Significant correlation for 0,01 (2-tailed)

Based on the correlation findings, we selected those variables with a significant Pearson's r and used them as the independent variables for Surgency, Negativity, and Regulation (**Table 6**) for the linear regression analyses.

The result showed that the predictor factors for Surgency are Touch Affective and Child Initiative Followed, for Negativity, Touch Affective and BDI scores, and for Regulation, STAI trait and BDI scores.

Table 5. Correlations between maternal observative variables and IBQ.

	SURGENCY	NEGATIVITY	REGULATION
Touch Negative	0,015	**0,471***	-0,278
Touch Pragmatic	-0,035	-0,125	-0,298
Touch Affective	**-0,568****	**-0,513****	-0,145
Verbal Negative	0,015	**0,471***	-0,278
Verbal Cognitive	0,049	0,175	-0,008
Verbal Affective	-0,034	-0,091	-0,075
Parent Lead Ineffective	-0,259	-0,098	-0,267
Prent Lead Effective	0,303	0,015	0,297
Child Initiative Unfollowed	0,141	**0,463***	-0,365
Child Initiative Followed	**0,530****	0,027	0,365
Action Guidance Ineffective	-0,142	-0,211	-0,146
Action Guidance Effective	-0,201	0,222	**-0,510****
Play Proposal Inappropriate	-0,04	-0,076	-0,251
Paly Proposal dpz	-0,192	-0,099	-0,232
Play Proposal Appropriate	0,186	0,076	0,007

* Significant correlation for 0,05 (2-tailed)

** Significant correlation for 0,01 (2-tailed)

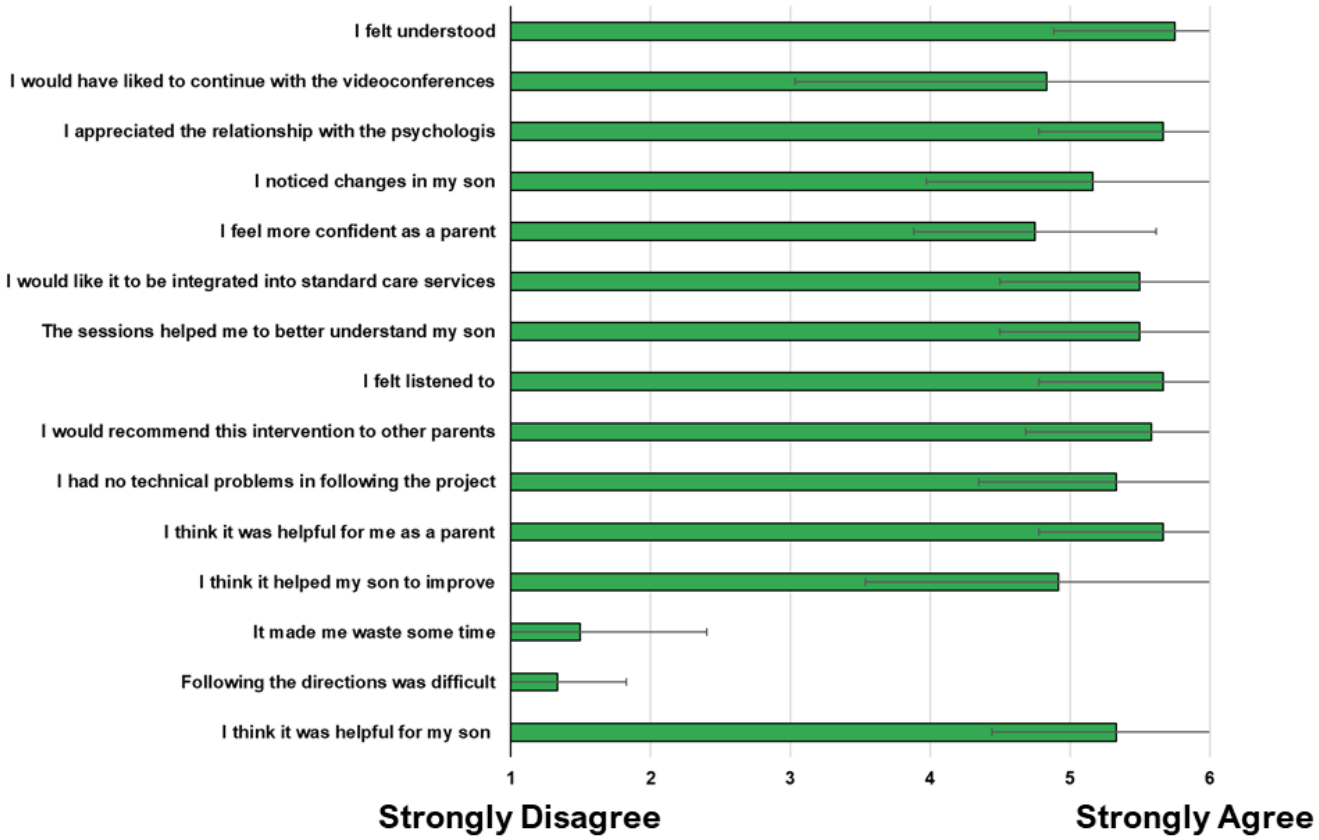
Table 6. Linear regression models.

Outcomes	R2	f	Sig	B	Beta st	p-value
Surgency	0,3987	9,287	0,000			
Touch Affective				-0,0621	-0,4351	0,0151
Child Initiative Followed				0,0718	0,3765	0,0328
Negativity	0,4519	11,31	0,000			
Touch affective				-0,0946	-0,5569	0,0011
BDI				0,0813	0,484	0,484
Regulation	0,355	7,875	0,002			
STAI trait				-0,034	-0,41	-2,383
BDI				-0,126	-0,364	-2,12

Feasibility of the intervention.

The second aim was the assessment of the feasibility of the intervention of the SPHERE Project through the submission of a questionnaire to the parents. The answers given to the questionnaire were then qualitatively analyzed to establish its efficacy and practicability of it. Mean and Standard Deviations of the answers are reported in **Figure 1**. Overall, the TVF intervention has been perceived by parents like a helpful and efficient intervention to get to know their child, improving the dyadic relation, also showing the interest in implementing the services as regular in the standard care service. Moreover, there was no technical problem during the sessions and a positive relationship was built with the psychologist.

Figure 1. Feasibility of the TVF intervention.



Intervention impact.

For our third aim we conducted a paired sample t-test to compare all the variables pre- and post-intervention (**Figure 3**, **Figure 4**, **Figure 5**). For what concern the self-report questionnaires, the TFVI intervention induce a decrease of the Parent-Child Dysfunctional Interaction scores (t (21) = 2,472; p = ,022), while an increase in Duration of Orienting (t (21) = -2,175; p = ,041), in Cuddliness (t (21) = -2,666; p = ,014), and in Regulation (t (21) = -2,982; p = ,007). Looking to maternal observative variables, the TVFI intervention was effective in reducing Child Initiative Unfollowed (t (22) =1,838; p = ,08), and in increasing Child Initiative Followed (t (22) =-2,18; p = ,04) and Action Guidance Effective (t (22) = -2,226; p = ,037).

Figure 2. Pre-post intervention of self-report questionnaire.

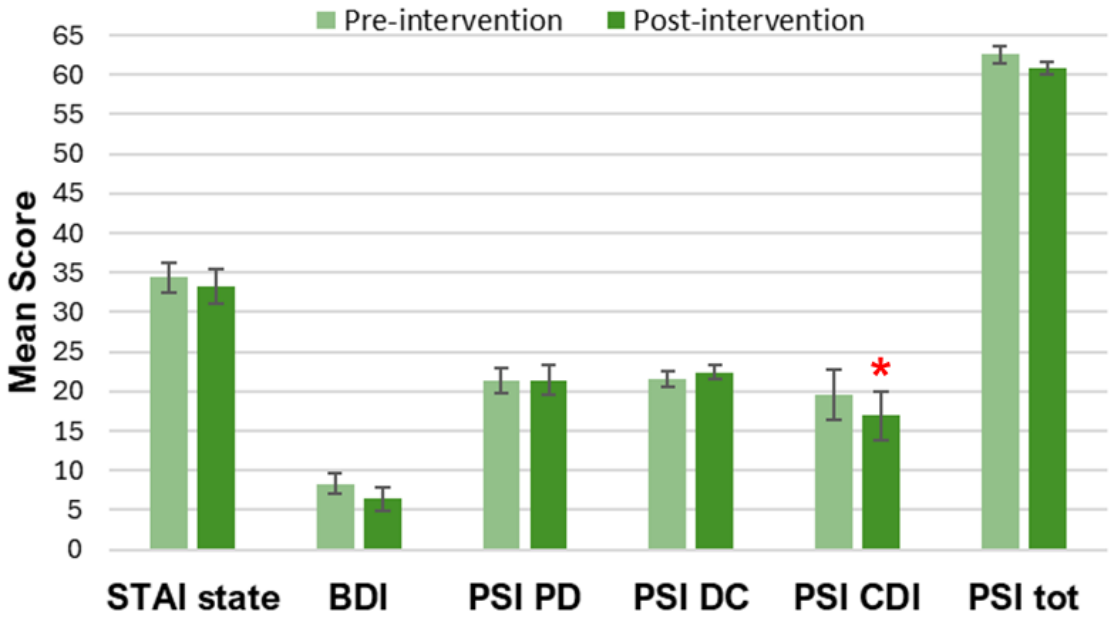


Figure 3. Pre-post intervention of IBQ.

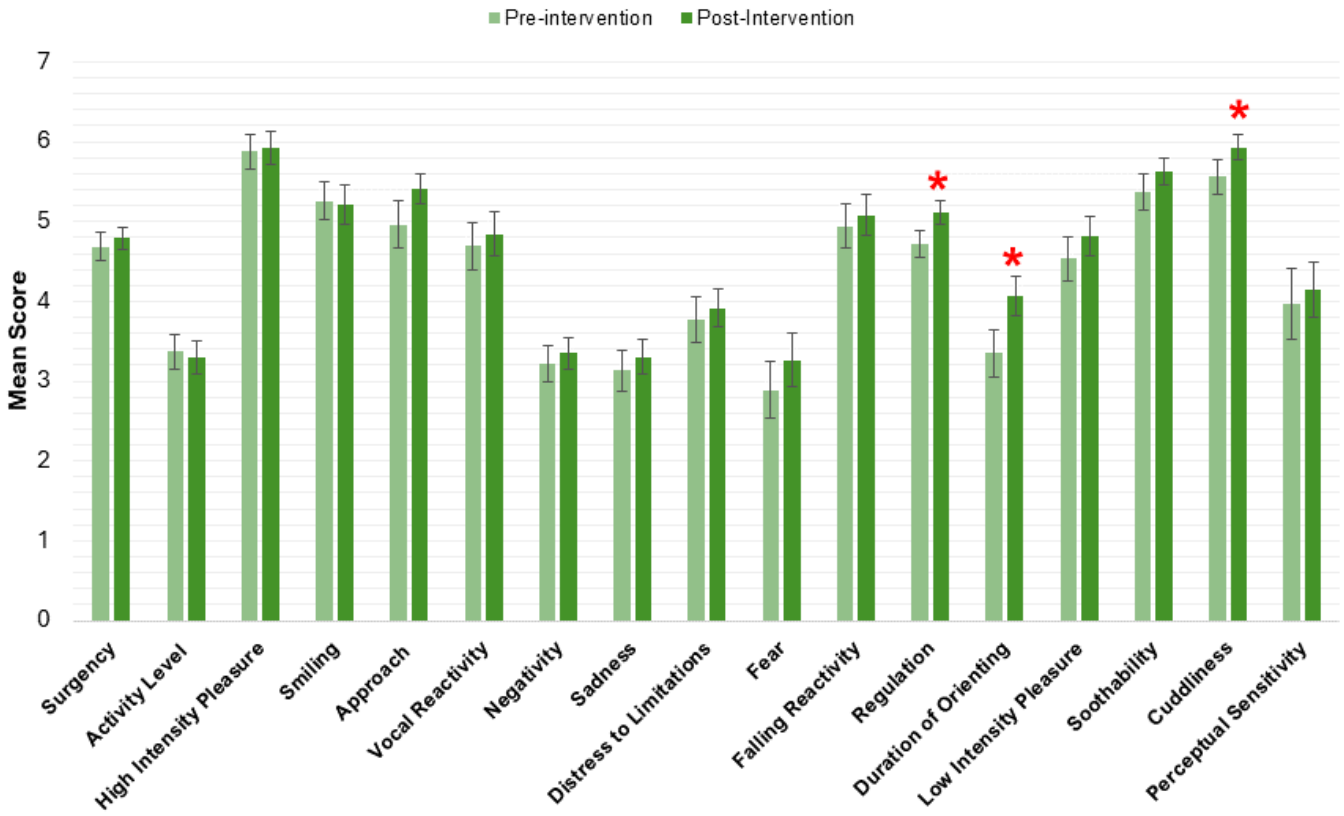
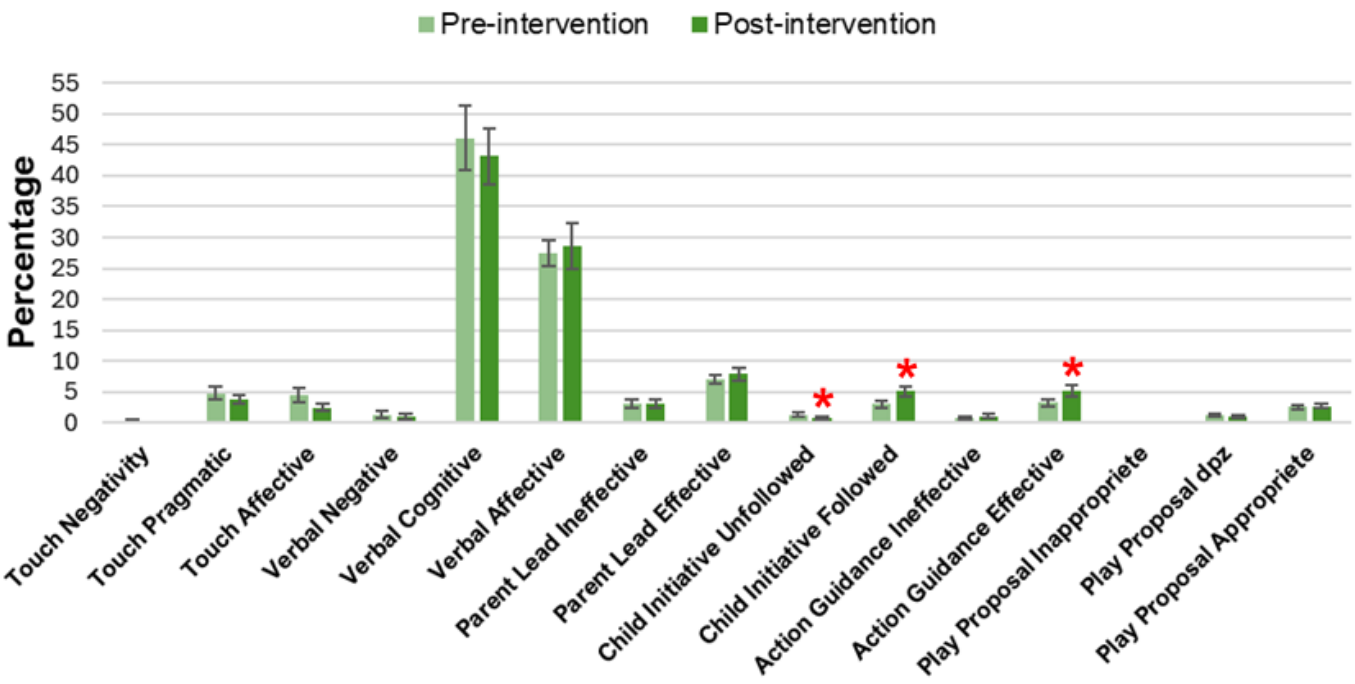


Figure 4. Pre-post intervention of maternal observative variables.



3.5) Discussion

To investigate our first aim of identifying which maternal caregiving behaviors may predict infant temperament in a population at-risk for NDDs, we examined the correlation between the three main dimensions of the IBQ and both maternal self-report questionnaires (i.e. Parent Stress Index-Short Form, Beck Depression Inventory- II, and State-Trait Anxiety Inventory-Y) and maternal observational variables.

Firstly, the significant positive correlation evidenced between BDI scores, and the Negativity dimension may suggest that higher levels of maternal depressive symptoms are associated with increase displays of Negative Affectivity in the infant. This finding aligns with existing literature, which indicates that maternal depression can influence emotional development of infants, due to decreased sensitivity and responsiveness in caregiving behaviors and an increase in rejective caregiving responses to emotional cues or temperamental traits (Cooke et. al., 2022; Feldman, 2012). Both Surgency and Regulation negatively correlated with STAI trait scores which may indicate that mothers that are more anxious are associated with lower levels of infant activity and poorer self-regulation. These findings are aligned with previous research, which show

that maternal anxiety influences caregiving practices by increasing the sensitivity and the rhythm of the interaction, which in turn decreases infant's autonomy and self-control (Feldamn, 2012; McLeod, et al., 2007 Pinquart, 2017). Additionally, Regulation was negatively correlated with STAI state scores, suggesting that maternal state anxiety specifically linked to interactions with the infant may disrupt the quality of that and the types of parenting styles employed, further reducing the infant's ability to self-regulate (Feldamn, 2012; McLeod, et al., 2007; Pinquart, 2017).

Regarding observational maternal behaviors, Surgency negatively correlated with both Touch Affective and Child Initiative Followed. While affective touch may be considered as a positive form of interaction, it might be perceived as intrusive if overused, potentially limiting infant's opportunities to explore and exhibit surgent behaviors, as supported by literature (Feldman, 2007; 2012; Jean et. al, 2009; Tronick & Cohn, 1989). On the other hand, when the mother can read and follow child's intention- being sensitive and responsive to infant's cues- she supports child's exploration and activities (Feldman, 2007; Kiff et. al., 2011; Rothbart & Bates, 2006). Negativity was positively correlated with Negative Touch, Negative Verbal Interactions, and Child Initiatives Unfollowed. Additionally, it negative correlated with Touch Affective. These findings suggest that maternal negative touch and verbal interactions are linked to higher negative affectivity in infants, possibly due to child feeling less supported or secure (Braungart-Rieker et. al., 2001; Davidov & Grusec, 2006; Weinberg & Tronick, 1994). Moreover, the failure to follow the child's initiatives could exacerbate negative emotions through the implementation of intrusive and directive behaviors, limiting child's autonomy and expression of preferences (Ainsworth et. al., 1978; Barber, 1996).
Lastly, Regulation was negatively correlated with Action Guidance Effective. Even though action guidance might be seen as positive, excessive direction or control could hinder infant's ability to self-regulate by reducing opportunities for the child to practice and develop regulative skills, as is evidenced in literature (Ainsworth et. al., 1974; Cooke et. al., 2022; Feldamn, 2012; McLeod, et al., 2007; Pinquart, 2017)

Through linear regression, we were able to establish what variables predicted infant temperament among those associated with it in the bivariate analyses. Specifically, Surgency was predicted negatively by Touch Affective and positively by Child Initiative Followed. This reinforces the earlier notion that excessive touch, even if affective, could reduce child's exploration and activities, whereas following the child's intentions

promoted a more active and energetic temperament (Feldman, 2007, 2012; Kiff et. al., 2011; Rothbart & Bates, 2006). Negativity was predicted negatively by Touch Affective and positively by BDI scores. For instance, non-intrusive affective touch may help the infant reduce negative emotions and down regulate stress, while a mother's mental health plays a crucial role in shaping the infant's negative affectivity. As previously mentioned, depressive symptoms disrupt caregiving behaviors by reducing responsiveness and sensitivity to the infant's social signals, which may decrease the use of positive touch and increase negative emotionality (Cooke et. al., 2022; Feldamn,2007; 2012). Lastly, Regulation was negatively predicted by both STAI trait and BDI scores, suggesting that maternal anxiety and depression are risk factors for the developmental of regulatory skills in infants, since both shape the intensity of responsiveness and sensitivity, either increasing or decreasing them (Cooke et. al., 2022; Feldamn 2012).

Our second goal was to evaluate the feasibility of the VFI administers though telecare. This was assessed using an ad-hoc questionnaire delivered to the participating mothers. Overall, the interventions were perceived as valuable and effective, helping mothers better understand their child's needs and communication skills. Indeed, the majority of mothers noticed changes and improvements in their child. Additionally, mothers felt more confident as parents, felt listened and understand by the psychologist, appreciated the relationship established with the clinician, and expressed a desire to continue the intervention or implement it alongside regular standard care. Lastly, they reported no significant technical problems during the video-call sessions. These findings align with the literature on VFIs and TVFIs, which consistently suggest an empowerment of caregiving skills, improved parent's self-esteem, enhanced the relationship with the child, and better child developmental outcomes (Bakermans-Kranenburg et. al., 2003; Fukkink, 2008; Grumi et. al., 2023; Rusconi-Serpa et. al., 2009; Provenzi et. al., 2020).

The third aim of the study was to evaluate the effectiveness of the TVFI. We investigated this by examining changes in both self-report and observational variables through t-test analyses, comparing pre- and post-intervention scores. The results highlighted significant changes in several variables. Firstly, a significant decrease in Paren-Child Dysfunctional Interaction scores form the Prent Stress Index was found, suggesting that TVFI reduced maternal perceptions of difficulties in the parent-child

relationship. This finding is consistent with literature indicating that VFIs are effective in empowering parental sensitivity and responsiveness, enhancing the quality of the dyadic relationship, and improving parental well-being (Fukkink, 2008; Glanemann et al., 2013; Kim & Mahoney, 2005; James et al., 2013; Mahoney & Powell, 1988; Sealy & Glovinsky, 2016; Seifer et al., 1991).

Regarding the infant's temperamental traits, significant increases were observed in Duration of Orienting, Cuddliness, and Regulation after the intervention. The increase in orienting suggests that the infants become more engaged and attentive while interacting with the mother after the TVFI. This finding may reflect TVFI's promotion of a more interactive and stimulating environment, known to support cognitive and emotional development in infants, particularly in populations at-risk for NDDs (DiCorcia & Tronock, 2011; Provenzi et. al., 2018). The enhancement Cuddliness may indicate that infants become more affectionate and comfortable with close physical contact after the interventions, possibly reflecting improved emotional attunement and bonding between the mother and the child (Biringen & Easterbrooks, 2012; Saunders et. al., 2015). The increase in Regulation scores suggests that the TVFI helped infants develop better emotional and behavioral regulation, probably due to the promotion of maternal responsiveness and sensitivity, which are critical for the development of self-regulation in infants (Cooke et. al., 2022; Feldman, 2012).

These improvements of infant temperament traits may also be link to enhancements in maternal observational caregiving behaviors. For instance, there was a decrease in Child Initiative Unfollowed and an increase of Child Initiative Followed, indicating an improvement in maternal sensitivity, responsiveness, and attunement to the child's intentions after the intervention. These changes are important since responsive and sensitive parenting is associates with positive developmental outcomes and serve as a protective factor for NNDs (Ainsworth et al., 1978; De Wolff & van Ijzendoorn, 1997; Madigan et al., 2019; Raby et al., 2015; Rodrigues et al., 2021; Valcan et al., 2018). Finally, the increase ineffective action guidance suggests that mother improved their ability to guide their child's actions, reflecting enhanced parental abilities in scaffolding their child's behavior, which is important for promoting autonomy and problem-solving abilities (Neitzel & Stright, 2003; Vygotsky, 1978; Wood et. al., 1976).

3.5.2) Limitations

The present study has some limitations. Firstly, the sample is small and there were not control group, and the conditions of the participants was not homogenous. Secondly, the measures for maternal well-being and infant's temperament are self-report. Involving a direct assessment of infant's temperament may be more comprehensive, since sometimes NDDs symptoms are mistaken for temperamental traits. Additionally, the videotaped interaction sometimes was difficult to code due to several factors, such as audio problems, infant distracted by the phone, or moved out from the frame. Lastly, overall, the intervention was short, just six sessions, and the maintenance of the improvement made by the dyads were not assessed by a follow-up.

3.5.2) Future directions

These findings suggest that maternal caregiving behaviors and mental health can be predictive factors for an infant's temperament in a population at-risk for NDDs. Additionally, the study shows that TVFI could be a valuable tool for administering early and accessible interventions to enhance dyadic interactions.

However, due to the small and heterogeneous nature of our sample, future research should explore the dynamic interaction between caregiving behaviors and infant temperament in larger and more diverse populations, including typically developing infants and fathers. Since the literature on the topic is still limited, it would be beneficial to study populations where mothers suffer from affective disorders, as our sample did not include clinically depressed, anxious, or stressed mothers. This would allow for the assessment of the feasibility of the TVFI in different populations and the generalization of our findings.

Furthermore, given the limited literature but promising findings regarding the feasibility and effectiveness of TVFI, future research could explore the long-term effects of this intervention on both parenting and child outcomes. Including quantitative measures would also provide a more objective assessment of the impact of TVFI.

3.6) Conclusion

This study aimed to examine whether maternal caregiving behaviors could predict an infant's temperament in a population at-risk for NDDs, using TVFI as an early intervention tool to improve interactive behaviors.

The findings demonstrated that specific maternal caregiving behaviors- such as the type of touch, the ability to follow the child's intentions, and maternal mental health- are predictive of temperamental traits in the child. Additionally, the mothers provided positive feedback on the intervention, reposting a good relationship with the clinician, which helped to create a safe environment conducive to learning how to better understand and interact with their children.

Mothers also observed overall improvements in their children following the intervention. Specifically, they reported enhancements in certain temperamental traits of their children, and we recorded an increased level of maternal attentiveness to the child's intentions and improved scaffolding in caregiving behaviors.

These results underscore the potential of TVFI as a valuable tool for supporting at-risk populations by fostering positive maternal caregiving behaviors and promoting healthier child development.

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Acknowledgements

There are a lot of people that made it possible for me to reach my goals, by fostering trust in me, by giving me opportunities to gain experience, and, at the same time, have always been there to support me in every moment of this beautiful journey.

Firstly, I would like to express my deepest gratitude to Livio, whom I consider one of the best professors I have encountered throughout my academic career. Thank you for believing in me and for giving me the opportunity to be a part of the wonderful and inspiring world of the DPB lab. The opportunities you have provided not only allowed me to grow professionally, but, perhaps more importantly, helped me develop personally. It is not easy to find someone who cares so deeply about students, who truly listens and tries to understand their interests, guiding them towards the most suitable contexts for what they are interested in. Thank you for introducing us to people and projects from all over the world, further enriching our passion for what we do. I am particularly grateful for the opportunity I had to attend my first international conference at such an early stage in my career, presenting a poster together with professionals who have been working in the field of development for years. This experience has profoundly shaped me, and I will always carry it with me.

A special thanks goes to Serena, who guided me through the writing of this thesis, providing valuable advice on how it should be done, how to cope with the anxiety of the blank page and the difficulty of not being able to write the perfect version of the thesis right away. Thank you for your patience and for taking the time to answer the countless questions, even the most trivial ones, which arose during my work.

I am so grateful to Elena for having taught me how to conduct a data collection and deal with parents and children, and for trusting me and letting me present her study at the conference. Thank you also for listened to me when I expressed my interest in learning how to administer the Griffiths and for, together with Alessandra, thought me how to do it. You allowed me to observe many sessions and, ultimately, to conduct one on my own. It was a very exciting moment, and I truly do not know how to thank you.

Finally, even though I did not work directly with you, a big thanks to Sarah and Miriam for always being positive and available, trying to help us in moments of difficulty and doubt.

Then, a huge thank you goes to my family, who have always been there by my side throughout this academic journey.
First, I want to thank my parents for having supported my decision to pursue a course of study far from home, and all the consequences that come with it, but in general, to support me in everything and always trying to not make me lose opportunities that are important for my future. Thank you for believing in me and giving me the strength to face my fears and worries about being away from home.
Then, thanks to my brother. Even though we do not talk that much when I am away, I know I can always count on you. You have all the capacities to reach your dreams, do not anyone force you to do something you do not want. Just remember that I believe in you.
I am deeply grateful to my grandmother, who has supported me during this experience both financially and emotionally, always thinking of me intensely during exams, helping me succeed in everyone. Thank you for the beautiful moments we had, from infancy to now. I will always remember everything, from the stories I forced you to tell me before going to bed about Vera the duck, to all the summers spent together at the beach or at Sestola, where you taught me to play cards. Thank you, granny.
Lastly, a thank you to my aunt Betti, for calling me every evening during these years to keep me company, also when I was not feeling good, reassuring me in times of sadness.
A special thought goes to my grandfather, to whom I dedicate this work. I cherish all the moments we spent together, from when I would make you play with me and my imaginary horses, all the drawings we made, when we used to go fishing together, and every boxing match or opera play we watch together.
Again, thank you all for being a constant and essential presence on this journey.

A big thank you goes to my boyfriend, Alessandro, for having been by my side throughout this journey, from the moment I received the email confirming my acceptance into the program until today, my graduation day. These past two years have not been easy, especially with the distance between us, but we managed to stay

together and nurture our relationship, always looking forward to the day we would be ruined.

Thank you for being there for me in every moment, whether good or bad, always making sure I was okay and happy. Thank you for challenging my worries about everything, from not being able to reach my goals to feeling out of place in any situation, and for encouraging me to face them. We have our ups and down, but we always manage to push through and continue this adventure together. All relationships have their mismatches, it is normal, what is important is to be able to solve them and reconnect, in order to grow together. I am so lucky to have someone like you by my side, there is nothing else to add. Thank you for everything.

I would also like to thank all the friends I have met over the past two years, with whom we have built this wonderful family, who make me feel like home. Thank you for having made this journey unique. It was a fantastic experience being able to connect with people coming from all around the world, come together and blend with different cultures, learning something new from one another, whether it was a typical dish, a custom, a word, or a dance. It has been a pleasure sharing these experiences and growing with all of you.

Specifically, I want to thank the first people I connected with on the first day of class, Valentina and Stefano, with whom we are 1/3 of the Fantastic Four, the superheroes of presentations.

Thank you to Matteo and Naman, the best duo around, for all the laughs and carefree nights. To Merve, one of the gentlest and kind persons I have met. To Silvia, who quickly became a person who I can rely on and who is one of the most profound persons I know. To Salma, that with her laugh and personality can make your darkest day brighter.

Thanks to Bri for inviting me, without knowing me yet, to that trip to Venice with her, which made this great friendship started, and for whom I will always be there for.

Thanks to Alessia, whom I met on the first day of lab and with whom we instantly became inseparable, literally, always going to code in the lab together as twins, and not only. Indeed, even for the thesis, we constantly texted each other for exchanging information and advice, to be sure to make the right things.

Thanks to my comrade Elise, the little one who arrived this year, but with whom I felt instant connection. We are ready for revolution.

Well, not it is your turn sfrizzy friend. I know these words will not be at the same level of what you will write, bit still try. Thanks, Giorgia for all the moments we shared together these years, and we have spent a lot of time with each other. We had class, lab, exams together, even to Glasgow you followed me, and we have an all year in front of us, during which I can make you even more jealous for the sea that you do not have in Milan. I will never forget all the pre-exam nights where you repeated even the commas of your notes, how slow you are in the morning or at eating, but also the free psychological session you provide me, and, on top of all, all the useless paranoia we create together, which neither one of us bothers to dismantle because, deep down, it's nice to have a folie à deux sometime.

Last, but not least, thanks to Yaren.
It all started with me asking for a pen during a PCL, and it ended with you becoming my partner in crime. I guess it was *the start of something new*.
The time passed so fast, and it is already our *graduation day and time to get the future started*. We both *knew that this day would come,* where *we would stand one by one with our future in our hands, and so many dreams and plans*. *Who knows what we are heading towards*, but *we are all in this together*, and we are *going to turn the world into our dance floor, determinate* to reach all the things we planned.
I am so thankful for the moments we had, and *so glad I got to know you*. Thank you for all the things you have done for me during these years, for being part of the little group of people with whom I feel safe to open and free to talk about everything. *I have never had someone that knows me like you do, or as good as you.* You are the friend that *I've been looking for*.
All the time spent together, all the laughs that we had, in class and in the lab, all the pesto lasagna and tiramisù cooked together, while singing and dancing. Actually, we do everything while singing and dancing, reaching our teenage dream of living in a musical.
But also, the sadder moment that we had to face, both for personal reasons and for little incomprehension occurred in our interactions. I guess that all these taught us that *there's always going to be always another mountain or an uphill battle*, and that

sometimes we have to lose, to *not care how fast we get* to our aims, what counts *is the climb*. And our climb to get here was the best I could hope for.

I know one day *we will be looking back* to these *memories we've had*, *all the songs that we lived through*, *all the time that we shared* and laugh, even if now we are just crying *because it is hard to say goodbye*. *You can bet on it*.

Ringraziamenti

Ci sono molte persone che hanno reso possibile per me raggiungere i miei obiettivi, dandomi fiducia, opportunità di crescita, e, allo stesso tempo, supportandomi in ogni momento di questo bellissimo percorso.

Per prima cosa, vorrei esprimere la mia più profonda gratitudine a Livio, che considero uno dei migliori professori che ho incontrato durante la mia carriera accademica. Grazie per aver creduto in me e per avermi dato la possibilità di far parte del meraviglioso mondo del DPB lab. Le opportunità che mi hai offerto mi hanno permesso di crescere professionalmente, ma, forse ancora più importane, personalmente. Non è facile trovare un professore che sia davvero interessato agli studenti, che li ascolti e cerchi di comprendere i loro interessi. Grazie per averci fatto conoscere persone e progetti provenienti da tutto il mondo, aumentando la passione che abbiamo per quello che stiamo facendo. Sono particolarmente grata per la possibilità di partecipare al mio primo congresso internazionale già a questa fase precoce della mia carriera, presentando un poster insieme a persone che lavorano nel campo dello sviluppo infantile da anni. Quest'esperienza mi ha formato molto e la porterò sempre con me.

Un ringraziamento particolare a Serena, che mi ha guidato nella scrittura di questa tesi, fornendomi preziosi consigli su come strutturarla, su come gestire la paura della pagina bianca e la difficoltà di non riuscire a scrivere subito una versione perfetta. Grazie per la pazienza e per aver trovato il tempo di rispondere alle innumerevoli domande che ti ho posto, persino alle più banali.

Grazie a Elena, che mi ha insegnato come raccogliere i dati e come relazionarmi con i genitori e i bambini, ma anche per essersi fidata di me lasciandomi presentare uno dei suoi progetti alla conferenza. Grazie per avermi ascoltata quanto ho espresso la mia curiosità nell'imparare a somministrare le Griffiths e per, insieme ad Alessandra, avermi insegnato a farlo. Mi avete dato la possibilità di assistere a molte sessioni e, in fine, di somministrarne una da sola. È stato un momento molto emozionante per me, e non so come ringraziarvi.

In fine, anche se non ho lavorato direttamente con voi, grazie a Sarah e a Miriam per essere sempre positive e disponibili, cercando di aiutarci in momenti di difficoltà.

Vorrei ringraziare la mia famiglia, che è sempre stata al mio fianco durante quest'avventura.

Per prima cosa, vorrei ringraziare i miei genitori per avermi supportata quanto ho preso la decisione di intraprendere un percorso di studi lontano da casa, con tutte le conseguenze che ciò comporta, ma, in generale, per avermi sempre appoggiata e per aver fatto in modo che non perdessi importanti occasioni per il mio futuro. Grazie per aver creduto in me e avermi dato la forza di affrontare le mie paure e preoccupazioni per essere lontana da casa.
Grazie a mio fratello. Anche se non parliamo molto quando sono via, so di poter sempre contare su di te. Hai tutte le capacità per raggiungere i tuoi sogni, non lasciare che nessuno ti costringa a fare cose che non vuoi. Ricordati che io credo in te.
Un enorme grazie a mia Nonna, che mi ha supportato economicamente ed emotivamente, pensando intensamente a me durante gli esami, aiutandomi a superarli tutti. Grazie per tutti i bei momenti che abbiamo condiviso, dalla mia infanzia fino ad adesso. Mi ricorderò sempre tutto, dalle storie che ti costringevo a raccontarmi della papera Vera, a tutte le estati passate al mare o a Sestola, dove mi hai insegnato a giocare a Burraco. Grazie nonna.
Grazie alla Zia Betti, per avermi chiamato tutte le sere durante questi anni per tenermi compagnia, anche quando non stavo bene, rassicurandomi nei momenti di tristezza.
Un grazie speciale a nonno, al quale dedico questa tesi. Custodisco con molta cura tutti i nostri momenti, da quando ti costringevo a giocare con i miei cavalli immaginari, a tutti i disegni che abbiamo fatto, le giornate di pesca, gli incontri di boxe o le opere che abbiamo guardato insieme. La tu' bimba ce l'ha fatta.

Di nuovo, grazie per essere stati una presenza costante ed essenziali in questo percorso

Un enorme grazie al mio ragazzo, Alessandro, per essermi stato vicino in questo viaggio, dal momento in cui ho ricevuto la mail di conferma per il programma fino a oggi, il giorno della mia laurea. Questi due anni non sono stati facili, soprattutto con la distanza che ci ha separati, ma siamo riusciti a rimanere uniti e a coltivare la nostra relazione, sognando il giorno in cui potremmo riunirci.
Grazie per esserci sempre, nei momenti positivi e un quelli difficili, assicurandoti sempre che io stia bene e che sia felice. Grazie per sfidare le mie preoccupazioni su

qualsiasi cosa, dalla paura di non raggiungere i miei obiettivi alla sensazione di essere sempre di troppo, incoraggiandomi ad affrontarle. Abbiamo i nostri alti e bassi, ma riusciamo ad affrontarli e a proseguire questo cammino insieme. Tutte le relazioni hanno le loro difficoltà, è normale, l'importante è saperle superare e riconnettersi per crescere insieme. Sono fortunata ad avere qualcuno come te al mio fianco. Non ho niente da aggiungere. Grazie di tutto.

Vorrei anche ringraziare tutti gli amici che ho incontrato in questi due anni, con cui abbiamo costruito questa bellissima famiglia che mi ha sempre fatto sentire come a casa. Grazie per aver reso questo percorso unico. È stata un'esperienza fantastica avere l'opportunità di conoscere persone provenienti da tutto il mondo, unendo culture diverse e imparando qualcosa di nuovo l'uno dall'altro, che fosse un piatto, un'usanza o un ballo. È stato un piacere condividere con voi questa esperienza e crescere insieme a voi.

In particolare, vorrei ringraziare le prime persone che ho incontrato il primo giorno di lezione, Valentina e Stefano, con cui formiamo 1/3 dei Fantastici Quattro, supereroi delle presentazioni.

Grazie a Matteo e a Naman per essere il miglior duo in circolazione, per tutte le risate e le serate spensierate. A Merve, una delle persone più gentili e educate che abbia mai incontrato. A Silvia, che è velocemente diventata una persona su cui poter contare, una delle persone più profonde che conosca. A Salma, che con la sua risata e la sua personalità è capace di rendere anche le giornate più tristi luminose.

Grazie a Bri per avermi invitato, senza ancora conoscermi, a quella gita a Venezia con lei, che ha dato inizio a questa fantastica amicizia, per la quale ci sarò sempre.

Grazie ad Alessia, che ho incontrato il primo giorno di laboratorio diventando immediatamente inseparabili, letteralmente andando sempre a codificare insieme, come gemelle. Anche per la tesi ci siamo scritte giornalmente per scambiarci informazioni e consigli, per essere sicure di fare le cose bene.

Grazie alla mia compagna Elise, la piccolina che è arrivata quest'anno, ma con la quale ho sentito una connessione immediata. Pronte per la rivoluzione.

Bene, adesso è il tuo turno amica sfrizzy. So che le parole che scriverò non saranno all'altezza delle tue, ma ci provo lo stesso. Grazie, Giorgia, per tutti i momenti condivisi

questi anni, e il tempo passato insieme non è stato poco. Lezioni, lab, esami, persino a Glasgow mi hai seguita, e abbiamo ancora un anno davanti a noi, durante il quale posso farti ingelosire ancora di più per il mare che non hai a Milano. Non dimenticherò mai tutte le sere pre-esame in cui ripetevi persino le virgole dei tuoi appunti, quanto sei lenta la mattina e quando mangi, ma anche le sedute di consulenza gratuite che mi hai offerto e, soprattutto, tutte le paranoie inutili che ci siamo create insieme e che nessuna delle due ha cercato di distruggere, perché, in fondo, è bello avere una folie à deux qualche volta.

Ultima, ma non per importanza, grazie a Yaren. Tutto è iniziato quando ti ho chiesto una penna durante un PCL, e si è concluso con te diventata la mia complice. Credo sia stato l'inizio di qualcosa di nuovo. Il tempo è passato così in fretta, ed è già arrivato il giorno della nostra laurea, il momento di iniziare il nostro futuro. Sapevamo entrambe che questo giorno sarebbe arrivato, che ci saremmo trovate una accanto all'altra, con il futuro nelle nostre mani, e tanti sogni e progetti. Chissà dove ci porterà il futuro, ma siamo insieme in questa avventura, pronte a trasformare il mondo nel nostro palcoscenico, determinate a realizzare tutte ciò che abbiamo pianificato. Sono così grata per i momenti che abbiamo vissuto e così grata di averti conosciuta. Grazie per tutto ciò che hai fatto per me in questi anni, per aver fatto parte di quel piccolo gruppo di persone con cui mi sento al sicuro, libera di aprirmi e di parlare di tutto. Non ho mai avuto qualcuno che mi conoscesse come te o che mi capisse bene quanto te. Sei l'amica che stavo crescendo.
Tutto il tempo passato insieme, tutte le risate che abbiamo fatto, in classe e in laboratorio, tutte le lasagne al pesto e i tiramisù cucinati insieme, cantando e ballando. In realtà, facciamo tutto cantando e ballando, realizzando il nostro sogno di vivere in un musical.
Ma anche i momenti più tristi che abbiamo affrontato, sia per motivi personali che per piccole incomprensioni tra di noi. Credo che tutto ciò ci abbia insegnato che ci sarà sempre un'altra montagna o una battaglia in salita, e che a volte dobbiamo perdere, senza preoccuparci di quanto velocemente raggiungiamo i nostri obiettivi, perché ciò che conta è il percorso. E il nostro percorso per arrivare fin qui è stato il migliore che potessi sperare.
So che un giorno guarderemo indietro e rideremo pensando a questi ricordi che abbiamo condiviso, tutte le canzoni che abbiamo vissuto, tutto il tempo trascorso

insieme ridendo, anche se adesso siamo tristi perché è difficile salutarci. Puoi scommetterci.