UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Psicologia Generale

Dipartimento di Psicologia dello Sviluppo e della Socializzazione

CORSO DI LAUREA MAGISTRALE IN

PSICOLOGIA DELLO SVILUPPO E DELL'EDUCAZIONE

Tesi di Laurea Magistrale

The association between maternal gesture use and children language outcomes in infants at elevated likelihood for developing Autism Spectrum Disorder.

Relatore

Prof.ssa Irene Mammarella

Correlatori esterni

Prof. Herbert Roeyers

D.ssa Jasmine Siew

Laureando: Matteo Fenner

Matricola: 1104796

Anno Accademico 2022/2023

Acknowledgments

I would like to thank everyone who has helped me, even in the smallest part, writing this thesis in the past months, both in Italy and in Belgium.

I'd like to thank my promotor, prof. Mammarella for giving me the chance and contacts to start working on the thesis and internship in Gent in the first place.

In addition, I want to thank my co-promotor, prof. Roeyers, for giving me access and providing me with splendid people to work with at the TIARA project at Gent University, also for the valuable final feedback.

Furthermore, the biggest thanks of all goes to my second co-promotor, Jasmine Siew, for helping me throughout the whole process, providing me with useful feedback constantly and with the access to the necessary data and information any time I needed it.

Finally, I want to sincerely thank my family and friends for supporting me mentally and not, trough the months and days of work, especially my mother, who always believed in me and has spurred me on for all this time.

Thank you.

Index

Introduction

Knowledge of alternative methods of communication, as a precursor to language development in autism, has grown exponentially in the past twenty years. Many different studies have explored the influence of gestures – including both maternal and infant gestures. In the third chapter an in-depth description y on gesture definitions will be provided, but in general, a gesture can be defined as: "a movement, such as the clenching of a fist, the waving of a hand, or the stamping of a foot, that communicates a particular meaning or indicates the individual's emotional state or attitude" (APA dictionary, 2022).

It has been indicated extensively in the literature that young children use gestures in word-like ways before producing their first words, and these gestures predict the content and size of their vocabularies in speech. (Dimitrova et al., 2015). Furthermore, researchers have attempted to investigate early deictic gestures (e.g., showing, pointing gestures) (in children with Autism Spectrum Disorder (ASD) and their relationship with expressive vocabularies in speech – with findings suggesting that deictic gesture are linked to more expressive language abilities in these children (Gulsrud et al. 2014; O¨ zc¸alıs¸kan et al. in press)

Moreover, parent gestures have been extensively studied in relation to child gestures and language in typical development – with findings demonstrating that non-verbal parent child communication is indeed a mediating factor in the relation between child gesture and child later language development (Iverson et al. 1999).

For this purpose, this thesis is going to be divided in six chapters.

The first chapter concern Autism – specifically, the main definition of autism and its clinical diagnostic criteria, key age points and features of autism.

Chapter number two is subsequently going to be focused on the literature about language learning development, with a narrower eye on how it can be a precursor of ASD but also how it is affected by it.

Chapter three shifts the attention to the parental figure, in this case the mother, and on how the gestures towards the child are positively related to the size of expressive vocabularies in speech later on (Gulsrud et al. 2014; O¨ zc¸alıs¸kan et al. in press).

Tying all of this together, in chapter four, there is the main research that this paper is based on, which is TIARA, an ongoing study conducted in the University of Gent, Belgium, which provided the cue as well as the data to be able to advance the theories proposed in this paper. In the chapter both the methods and the data will be critically analyzed to evaluate the research and to find a solid foundation for the thesis.

In the fifth and sixth chapter, "the results" and "the discussion", there will be a dedicated space to converge the data and the literature found, trying to answer the research questions.

In conclusion, within this master's thesis, this study has multiple objectives. First, to examine the frequency of maternal gesture use between two groups of EL (elevated likelihood) infants for ASD. In second place, to analyse associations between maternal gesture use and subsequent infant language development. Finally, to determine whether infant gesture development moderates the language development and if it can be used to support parents of ASD infants on how to communicate with them.

Introduzione Italiana

La conoscenza dei metodi alternativi di comunicazione, come precursori dello sviluppo del linguaggio nell'autismo, è cresciuta esponenzialmente negli ultimi vent'anni. Molti studi hanno esplorato l'influenza dei gesti, sia materni che infantili. Nel terzo capitolo si parlerà più approfonditamente di cosa sono i "gesti", ma per ora è utile dire che sono definiti come: "un movimento, come stringere il pugno, agitare la mano o battere il piede, che comunica un particolare significato o indica lo stato emotivo o l'atteggiamento dell'individuo" (dizionario APA, 2022). È stato ampiamente dimostrato che i bambini piccoli usano gesti con intento comunicativo prima di produrre le prime parole e che questi gesti predicono il contenuto e la dimensione del loro vocabolario nel parlato. (Dimitrova et al., 2015) Altri hanno cercato di approfondire come la quantità di gesti deittici precoci (i cosiddetti gesti che si verificano in culture diverse e che indicano che i bambini sono consapevoli dell'attenzione rivolta ai propri gesti) prodotti da bambini con Disturbo dello Spettro Autistico (ASD) fosse positivamente correlata alla dimensione del vocabolario espressivo nel parlato (Gulsrud et al. 2014; O¨ zc¸alıs¸kan et al. In press) e lo hanno fatto con risultati positivi.

Ora, la gestualità dei genitori è stata ampiamente studiata in relazione ai gesti e al linguaggio del bambino nello sviluppo tipico, poiché è noto anche grazie ad altre ricerche (Iverson et al. 1999) che la comunicazione non verbale genitorefiglio è effettivamente un fattore di mediazione nella relazione tra i gesti del bambino e il suo successivo sviluppo linguistico.

A tal fine, la presente pubblicazione sarà suddivisa in quattro capitoli.

Nel primo capitolo si parlerà di cos'è l'autismo, della sua definizione principale, di quali sono le caratteristiche e i punti chiave dell'età e degli studi più recenti.

Il secondo capitolo si concentrerà successivamente sulla letteratura relativa allo sviluppo dell'apprendimento del linguaggio, con uno sguardo più ristretto a come questo possa essere un precursore dell'ASD ma anche come ne sia influenzato.

Il terzo capitolo richiama l'attenzione sulla figura genitoriale, in questo caso la madre, e su come i gesti verso il bambino siano positivamente correlati alla quantità di vocaboli espressivi più avanti nell'età (Gulsrud et al. 2014; O¨ zc¸alıs¸kan et al. In press).

Nel quarto capitolo viene presentata la ricerca principale su cui si basa il presente lavoro, ovvero TIARA, uno studio in corso condotto presso l'Università di Gent che ha fornito lo spunto e i dati per poter avanzare le teorie proposte nell'elaborato. Nel capitolo verranno analizzati criticamente sia i metodi che i dati per valutare la ricerca e trovare una solida base per questa tesi.

Nel quinto e sesto capitolo, "i risultati" e "la discussione", ci sarà uno spazio dedicato a far convergere i dati e la letteratura analizzati, cercando di rispondere alla domanda di ricerca.

In conclusione, all'interno di questa tesi di laurea magistrale, lo studio si pone molteplici obiettivi: in primo luogo, esaminare la frequenza dell'uso dei gesti materni tra due gruppi di neonati EL (Elevated Likelihood = ad alta probabilità) per ASD, in secondo luogo, esaminare le associazioni tra l'uso dei gesti materni e il successivo sviluppo del linguaggio infantile; infine, determinare se lo sviluppo dei gesti infantili influenza lo sviluppo del linguaggio e può essere utilizzato per supportare i genitori di bambini ASD in una comunicazione con i loro figli più efficace e formativa.

Chapter 1

Autism Spectrum Disorder

1.1 Definition of ASD (Autism Spectrum Disorder) and DSM-5 Criteria

Autism spectrum disorder (ASD) is a developmental disorder that affects social interactions and behavior development and is typically recognized in the first few years of life. It is a behaviorally defined disorder that relies on child observation and parent report to differentiate from other childhood conditions (Wiggins et al., 2019). The observations that form the diagnosis are focused on disorders of communication and social interaction and on limited and repetitive patterns of behavior, interests, or activities.

In the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (American Psychiatric Association, 2013), ASD is described as a series of symptoms that cause the subject's communication and their development, difficulties in the early years of life, i.e., those within which the diagnosis is made. The new criteria brought by the DSM-V, implemented in 2013, following the previous rendition and 4th edition, enabled a broader standardization of diagnosis. According to some of these new introductions to the manual, children with autism spectrum disorder generally have symptoms that are manifested by difficulties in social communication and interaction, and on top of that problems in understanding the thoughts of other people, empathizing, and expressing themselves with words, through gestures or facial movements.

In addition, individuals diagnosed with ASD can experience hyper-sensitization to noises and sounds, and repetitive or stereotyped body movements, such as rocking, self-stimulation or clapping. Moreover, a range of other symptoms may manifest, such as unusual responses to people, attachments to objects, resistance to change in their routine, or aggressive or self-injurious behavior. Sometimes these individuals may appear not to notice people, objects or activities in their surroundings. Some children with autism may also develop seizures, because of the hyper/hypo reactivity to the environment.

In an ASD diagnosis, it is also necessary to specify whether this disorder is accompanied by, or without, intellectual or language impairment, associated with a known medical or genetic condition or environmental factors, and associated with another neurodevelopmental or behavioral disorder (DSM-5; 2011). In particular the classification of ASD severity is based on the required levels of support to assist with impairments in social communication and social interaction, and restricted, repetitive patterns of behavior, interests, or activities (APA 2013).

The first level is defined as "requiring support", characterized by difficulty in initiating social interactions, and clear examples of atypical or unsuccessful responses to social overtures of others, also with possible decreased interest in social interactions. While on the restricted, repetitive behaviors side there might be difficulties in switching between activities and problems of organization and planning that may hinder independence.

When it comes to requiring substantial financial support, which is the second level, the DSM states that marked deficits in verbal and nonverbal social communication skills might be present, as well as social impairments evident even in the presence of support, limited initiation of social interactions and reduced or abnormal responses to social solicitations from others.

Finally at the third level of severity, which requires “very substantial support”, the symptoms can be: severe deficits in verbal and nonverbal social-communication skills that cause limitations in functioning, very little initiation of social interactions, and minimal responses to social solicitations from others.

This is a useful scale to determine the level of severity of the spectrum that is ASD, however, an in-depth review of these conceptualizations concludes that the onset of the disorder, or symptom emergence, is better considered a dimensional process and a continuum in which the early onset and regression patterns describe two extremes (Masi, 2019).

1.2 Prevalence

ASD is a disorder that exists and is diagnosed daily all over the world, across gender, nationality and ethnicity, and different studies demonstrate the pace at which the prevalence is largely increasing (Lyall et. al, 2016).

From 2007 to 2011-2012, the incidence of ASD increased from 1.16% to 2.00% in the United States of America, showing rapid growth, not only in the US, but also in other parts of the world, for example in the United Kingdom, the prevalence has risen from 4.4 per 10,000 between 1966 and 1991 to 12.7 per 10,000 between 1992 and 2001, with a current estimate as high as 157 per 10,000 (Quaak, Brouns, & van de Bor, 2013). More recent research done by Hodges et al. (2016) explains how the prevalence of ASD in the US has appeared to stabilize with no statistically significant increase from 2014 to 2016, but it is important to take into account that the new criteria imposed by the DSM-5 may impact and have impacted prevalence in a significant way in recent and future analysis, and that has yet to be seen.

As far as gender prevalence, ASD was found out to be more common in males (Demily et al. 2017). However, in a recent meta-analysis by Looms et al. (2017), the male-to-female ratio was found to be closer to 3:1 than the previously reported 4:1, though this study was not done using the DSM-5 criteria. It is possible that female subjects tend to be misdiagnosed or overlooked, partially because the bias of considering ASD as a male disorder, and at the same time they are less likely to present explicit symptoms and they tend to mask their social deficits with the process called “camouflaging” (Volkmar et al., 2014).

1.3 Etiology

1.3.1 Genetic

The elevated likelihood of recurrence for autism in siblings and the even higher concordance for it in identical twins provided strong support the importance of genetic factors. Specifically, estimates of recurrence risk among non-twin siblings of autistic children range from 3% to 18% (Gronborg et al., 2013). The marked heterogeneity of ASDs has led to the suggestion that rather than a single disorder, it might be constructive to take into account multiple etiologies and distinct clinical entities. The heterogeneity of clinical entities is in part a function of the multiple genes involved, in part of the myriad of environmental factors impacting the developmental course of symptom expression, and the co-occurrence of medical and mental health dysfunctions in ASDs (DH Geschwind, P. Levitt, 2005).

Some children may have a predisposition for ASD. One type of genetic influence includes maternal genes that are associated with the placenta and uterus environment. It is possible that these genetic characteristics interact with some prenatal complications and are associated with an increased risk of developing ASD. This was also the criteria behind the choice of one of the two main groups of children overlooked in the study analyzed in this paper, the preterm born (TIARA study, 2022).

1.3.2 Environmental

As seen, the influence of genetic factors in the development of ASD is well established, yet many studies support the multifactorial etiology of ASD. Despite the few studies on the interaction between genetic and environmental factors, it is important to take the latter into consideration in order to join data from a heritable and nonheritable shared environment.

Biological-environmental risk factors investigated in ASD include maternal and paternal age, fetal environment, perinatal and obstetrical events (e.g., hypoxia), medications, smoking and alcohol usage, nutrition, and toxic exposures (pollution, organic pollutants). The evidence, both positive and negative, lies on the role of these risks in the etiology of ASD.

The limitation on studies about these factors is that the majority of current research is preclinical in design, limiting its ability to inform prevention and intervention strategies in the real world. Today, up to 15% of autism variants can be linked to genetic determinants. Thus, a proportion of the variability is likely linked to interactions between environmental factors and genes acting to increase ASD risk (Bolte et al., 2018).

1.3.3 Epigenetic

Epigenetic mechanisms regulate chromatin structure and gene expression without altering the DNA sequence (Adalsteinsson, B.T.; Ferguson-Smith, A.C., 2014), including imprinting, gene expression, and development of the organism. In recent years, the interest in examining epigenetic signs in ASD has grown exponentially because of their likely implication in etiology, to also explain the effects of environmental exposure, or G(genetic) × E(environmental), associations with Autism. Epigenetic changes have been looked at in the cortex of subjects with ASD, including hypo- and hypermethylation (Ladd-Acosta et al., 2014) and spreading of histone 3 lysine 4 trimethylation marks (Shulha et al., 2012), and also in DNA coming from a range of more accessible tissues. These studies highlight the importance of epigenetic factors as potential biological indicators of ASD,

1.5 Children at Elevated Likelihood for ASD

The first signs of Autism Spectrum Disorder in infancy are related mostly to the social interactions and communication of the babies, this is why those areas of behavior are to be monitored very closely, especially in children at elevated likelihood at a young age. It was shown in previous paragraphs that the heritability is an important factor in the diagnosis and study of ASD, which is why one of the two groups of children analyzed are those with diagnosed siblings. The sibling recurrence rate, as discussed in the previous paragraph, is defined as the probability of a child having ASD with 1 or more siblings with ASD, it has been estimated to be 6.1% to 18.7% (Gronborg et al., 2013), resulting in a likelihood of receiving an ASD diagnosis in siblings of children with ASD from 7 to 14 times higher, compared to non-siblings.

The other group of children viewed in this research are the preterm born, since prematurity is one of the main risk factors of developing ASD. Keeping the focus on prematurity, preterm infants and children as a group are at risk for poor neuro-developmental outcomes due potentially to the immature nervous system and the suboptimal early extra-uterine environment after the early birth and its effects on developmental processes (Yaari et al. 2014). The prevalence of ASD in preterm infants and young children has been assessed in several studies in recent years with screening tools designed specifically to detect the risk of ASD in the general population of infants and young children using for example the Modified Checklist for Autism in Toddlers (M-CHAT;(Robins, et al., 2001)).

4.5 Comorbidity

One of the possible issues when considering comorbidities in ASD analysis is the potential overshadow created by the focus on the more evident disorders (in this case ASD), that may interfere with other concurring diagnoses.

In most epidemiologically based samples of people with ASD, approximately 50% exhibit severe or profound intellectual disability, 35% exhibit mild to moderate intellectual disability, and the remaining 20% have QIs in the normal range (Fombonne, 2015).

One main difference in the spectrum of Autism is that for low functioning autistic children there could be a more prevalent concurrence with verbal skills issues rather than non-verbal, which is reversed in high functioning autism (previously Asperger's Syndrome).

The Genetic related factor in ASD has been already addressed in this document, however precisely because of this it can be said that other genetic disorders are usually associated with an increased risk of ASD, including but not only: Fragile X syndrome (FXS), Down syndrome (DS), Duchenne muscular dystrophy, neurofibromatosis type I (NF1), and tuberous sclerosis complex (TSC). Out of these disorders Fragile X syndrome is the more prevalent and frequently associated with ASD, in a ratio of 2%-3% of all children with ASD cases have FXS, and about 25%-33% of FXS patients have ASD.

Children with ASD are also more likely than the rest of the population to have different neurological disorders like epilepsy, macrocephaly, hydrocephalus, migraine or headaches. Sleep disorders are also significant problems in individuals with autism, present in about 80% of them (Al-Beltagi, 2021).

Finally, the most common comorbidity in ASD diagnosed infants is related to the attention and hyperactivity sphere of disorders, in particular ADHD, with the modifiers of inattentive, hyperactive, combined type, or not otherwise specified. As to how prevalent it is Ashwood et al. (2015) estimated that a total of 40-80% clinically ascertained individuals with ASD meet the criteria for an ADHD diagnosis. Before the DSM-5 there wasn't the possibility of diagnosticating both diseases as comorbidity but now things have changed, and it was suggested that a genetic overlap between the two exists.

Chapter 2

Infant Language Development

2.1 Definition of Language

Language can be defined as a system for expressing or communicating thoughts and feelings through speech sounds or written symbols (APA Dictionary of Psychology (2022). In this section of the research there's going to be a more in-depth look at how this system of communication develops in infancy, how to measure it, observe it and how it interacts with typical developing children or elevated likelihood for ASD ones.

The language learning capacity is universal. The child possesses in fact an innate language acquisition device, by learning a language with the exposure to it in the social context and by unconsciously creating certain assumptions about it, that are then modified until it arrives at the model which it listened to at first, the adult one. So, the child continues to construct an innate grammar, operating on generalized rules.

2.2 Language Development

2.2.1 Stages of Language Development

Language development comes into play first of all as what is defined as language acquisition, which is as Chomsky (2009) states, a matter of the growth and maturation of relatively fixed capacities under appropriate external conditions. The attainment of the skills guaranteed by the acquisition of the language is greatly determined by internal factors, connected to critical points and ages of development. Language acquisition at age 1-3 years old occurs naturally. It is meant that a child is insensibly acquiring the language, but then he/she can produce the language for communication (Hutauruk, 2015). Depending on what is defined as a stage or as language development there have been four to six stages discussed in children's first language acquisition, namely:

1. *Pre-talking stage (0-6 months)*

   This stage is often considered more like "stage zero", since there is no proper language production, but only the beginning of development. It is the stage of what is called cooing, which means producing some vowel sounds, with the addition of some form of research of the speaker, with head-turning movement towards them.

2. *Babbling stage (6-8 months)*

   Babbling is the sounds which infants produce as consonant-vowel combinations, Steinberg (2003:147). Babbling development happens in the child's first year of life. This development is responsible for a number of changes in the abilities and in sounds that the babies can produce.

3. *Holophrastic stage (9-18 months)*

   Also known as the "one word stage", like the Greek word suggests holo(complete) and phrastic(phrase). This means that children at this age use the single words they know as a sentence, with the intent of explaining their emotions and goals. This and the following one are also the main focus of this research paper.

4. *The two-word stage (18-24 months)*

   At this stage children can produce meaningful two-word sentences that make sense grammatically, dense in content words, but scarcer in function words, the one that hold the phrases together.

   Some development of a child's syntax can be seen at this stage by the increasing in word complexity they say to communicate with adults. They begin to learn to express semantic relationships with words representing and describing actions, objects, entities and places and trying to formulate commands and questions.

5. *Telegraphic stage (24-30 months)*

The name of this stage comes from the telegraph style of writing, which is very similar to how infants talk at this age, when they learn to use more than two-word phrases, until up to four or five at the time. Pronouns, conjunctions, prepositions still tend to be typically absent by this stage.

6. *Later multiword stage (30+months)*

   From this stage on, especially in the first months and years after the start, there is a major and fast increase in vocabulary, with many additions every day. There is a great variation among children, they seem to understand everything said within hearing and directed to them (Hutaruk, 2015).

2.2.2 Language Comprehension

The second big topic in language development, after the acquisition and use of it, is certainly language comprehension. The main difference between the two though, is that there is very little data on language comprehension compared to acquisition. With very few exceptions, most of what we know about the first stages of language development is based upon the child's stumbling efforts to produce and reproduce meaningful speech (Bates, 1993). The reasons behind this are multiple, first of all it is a difficult area to do research on children at this age (0-2 years old) since it's hard to get them to cooperate and this often results in a too large proportion of false negatives. In this case there are no clear stages, however, it is known that it is influenced heavily by gender, socioeconomic background, and birth order. It has been seen in different studies for example how there is a clear stability in the fact that girls tend to score much higher than boys, even if boys develop earlier, and this happens until the third year of life when the difference starts to decrease.

Maternal education also has a substantial effect on the change from 18 to 36 months of age. Birth order has an impact on all outcomes of Language Comprehension, but still not as large as maternal influence (Zambrana et al., 2012).

In general, language comprehension as a skill is key to predict and intervene in children's future language development, it can predict later comprehension and production skills in children with typical and atypical development, and also which children with early expressive language delays are most likely to display social and other behaviors similar to typically developing age-matched (Paul, Looney, & Dahm, 1991).

2.2.3 Language Development in children at Elevated Likelihood for ASD

Before diving into how the language development is affected and influenced by maternal gestures in EL children, it is necessary to better explain what language development is for EL-Children

The first steps of the development of this set of skills begins even before the first words are spoken, meaning that the age between 10 and 24 months is of significant relevance to identify speech or language problems, before they have a significant impact on the child educational skills. Researchers, as seen before, have put their attention into the socio-cognitive area as a possible precursor of language or vocabulary delays in development.

In particular in ASD elevated likelihood children, it is important to investigate how these skills evolve and change, to later apply the correct therapy or treatment.

In this regard, parents of infants at elevated likelihood for ASD may start to have concerns within the first 2 years of life. However, at a very early age it is difficult to differentiate ASD from other developmental disorders trough language development, even if the likelihood is high due to factors such as prematurity or siblings with ASD. That is because children with ASD can show a heterogeneous pattern of language competences, which range from the almost complete absence of language to an adequate linguistic ability (DSM-5; APA, 2022).

Comparing typical and atypical development it is worth noting that the predictors of language development in preschoolers has yielded intriguing results, generally suggesting that the factors that are important for language development in ASD are similar to those observed in typical development (Luyster et al., 2008).

Chapter 3

Parent gestures and development

3.1 Gestures

3.1.1 Definition

One of the first signs of potentially developing ASD in young children is to exhibit delays in the emergence of gestures, which are part of the non-verbal communication skills acquired at that age.

Gestures can enhance, clarify, or moderate the meaning of verbal communication. They constitute of a movement, such as the clenching of a fist, the waving of a hand, or the stamping of a foot, that communicates a particular meaning or indicates the individual's emotional state or attitude (APA Dictionary of Psychology, 2022). Gestures can be divided into two main categories: deictic and representational.

Deictic gestures indicate a referent in the immediate environment (Bates, Camaioni, & Volterra, 1975), and are defined as gestures aimed to express communicative intent, some examples are: pointing, showing, giving, reaching for.

On the other hand, representational ones are showed as hand or body actions on objects, with the objective of conveying the meaning of actions or features associated with that object, and they must be in view of the potential receiver's line of sight. They are typically evocative, and convey actions or attributes (e.g., moving arm in towards the door to indicate someone is entering), or common, with a cultural meaning. The importance of gestures on language development is particularly highlighted by work with typically developing children, in which the diversity of meanings they express trough gesture usage, and their combination with early vocabulary development, are good predictors of specific measures of language development, e.g., vocabulary size and sentence complexity.

3.1.2 Deictic Gestures

Given the importance of deictic gestures in the study, and the larger variety of symbolism and number of them, compared to the simpler representational ones or others, they need a more in-depth analysis.

The tier of deictic gestures comes into the forms that have been mentioned before, pointing, showing, giving and reaching. These, however, can themselves be classified in the Imperative and Declarative categories. The first ones are simple acts of communication, where the speaker directs the receiver's attention toward an object they need. Opposed to this, the declarative one is the worldliest and addresses the kind of communications infants, in this case, make to direct the caregiver's attention to something that they want to show or direct their parents' attention to. The main distinction, however, is based on the intention driving each specific gesture. While the motive of imperative gestures is to obtain something from the addressee, the main motivation for infants to use declarative gestures is to share experiences/thoughts/emotions about a referent, that is, declarative pointing is communicative in its nature (Ramos-Cabo et al. 2019).

3.2 Maternal gesture use in infants at elevated likelihood for ASD

in this study, the focus will be on gesture produced within the context of mother-child interactions – given the small sample of fathers in the study,

The correlation between maternal gestures in particular and infant language development is of particular interest for infants at risk for ASD given the difficulties infants and children with ASD demonstrate in social communication, including gaze, social orienting, and attention shifting.

In mothers of EL infants there is also the possibility that their gesture production itself may be altered, given the importance of the exchange of gestures between the two parts of the interaction, in the resulting temporal amount of production of the dyad, meaning that mothers with a non-responsive child in term of non-verbal conversations, may respond in the same way, by reducing the amount of gestures used.

Mothers of EL infants may also differ in the distribution of the types of gestures they produce. Such alterations in gesture distribution have been identified in other clinical populations such as Down Syndrome, where mothers produce a greater proportion of deictic gestures than mothers of typically developing infants matched on language level (Talbott, Tager-Flusberg, 2014). In a scale, the first type as already stated would be deictic gestures, as the most produced by the parents, followed by conventional and than representational, both in typical and EL for ASD. The reason behind deictic gestures being so prevalent, even in mothers of EL children, is that they may represent a simpler form of communication, able to scaffold children into language development and dyadic interactions.

Controlling for the differences in parental gestures, Choi et al. (2021) found that infants responded comparably to parents' gestures regardless of their ASD risk and eventual diagnosis at 12, 18, and 24 months. This analysis on the child responsiveness may imply that maybe infants' comprehension of the gestures was comparable even at a younger age, regardless of the Elevated Likelihood.

3.3 Maternal gestures and language development

Previous research shows that mothers provide patterns and examples for the different kinds of gestures and gesture-speech combinations that the child produces, patterns that will definitely play a role in language learning. Gesture accounts for a higher percentage of total communications for children than for parents; 70% of the communicative acts produced by 14-month children include gestures, compared to only 10% of communicative acts produced by parents even though the two groups remain comparable in terms of absolute numbers of gestures that they produce at this early age (Özçalışkan, Dimitrova, 2013).

An interesting observation to point out on this regard is how children growing up in other cultures, in which parents produce a larger index of a particular gesture type such as iconic gestures (e.g., Italy), tend to develop more representational gestures themselves compared to cultures in which the adult repertoire of such iconic gestures is smaller.

In the newborn sibling literature, Talbott et al. (2013) reported that parent gestures at 12 months were significantly and positively correlated with general language skills at 18 months, as measured by the Mullen Scales of Early Learning, in elevated likelihood infants who did not have a diagnosis of ASD and in low-risk infants with typical development. However, the infants' prior use of gestures or language was not controlled for in these analyses. In the ASD literature, regarding the correlation between parental gestures, child gestures and child language development there are not many studies focusing on the longitudinal associations of these factors.

The general assessment regarding this argument is that infants whose parents use more gestures also produce more gestures, potentially facilitating their own language development. A study by Choi et al. (2021), found that parent gesture at 12 months was associated with child vocabulary at 36 months, even when controlling for the covariates (i.e., infant gesture, parent education, infant sex, and parent speech), suggesting that parent gesture at 12 months predicted later child vocabulary above and beyond the other predictors previously identified in the literature.

As for what exactly influences the amount of gestures, or words respectively, used by parents there have been some studies regarding how this differs in separate social classes and income of the mothers.

Although it was tested that the amount how words certainly differs in distinct social backgrounds, it was established that sheer quantity of linguistic input is not the only predictor of children language development, for example in a recent study Pan et al. (2001) made a comparison of a subsample of these low-income mothers with middle-class mothers and with mothers of children with otitis media showed that mothers from the low-income group produced significantly more points per minute than the other two groups of mothers during interaction with their 14-month-old children. Thus, indicating that even with less variety or quantity of vocabulary the help a parent can give to adjust and teach their children language can be compensated, at least partially, by gesture use.

In conclusion, precedent studies indicate that at the early stages of language development children use gesture to improve their linguistic resources, both at the lexical and the sentence level. Mothers in this regard, provide models for the different kinds of gestures and combinations that the children produce, models that could help children learn new words and sentence structures. The explanations, as seen before, might be that the children, seeing the gestures produced by the caregivers, tend to imitate them, which results in a better language development, and on the other hand, mothers regulate their gestures production providing children with the right target word and gesture at the appropriate time. This is because it is known that, on top of the gesture production, parents also translate the children's ones, giving them the opportunity to advance to the next stage of language production.

The clinical implications of these findings are multiple. First of all, by knowing that children communicate their readiness to take the next step in language development first with gestures; parents, teachers and clinical experts should rely on this indicator to judge the readiness of the child in moving to a later stage of development. In second instance, adults working or just interacting with children in this phase should know how impactful the use of gestures can be for the infant's language trajectory and gesture production, and so be mindful of how powerful of a tool this can be.

Chapter 4

Research and Methodology

4.1 Study design and participants

In this paper and research, a longitudinal study (TIARA) is going to be used to gather the data necessary for the analysis of the research questions. The study's name means Tracking Infants at Risk for Autism, a wider prospective cohort study examining infant development between the age of 5 and 36 months, across two sites in Belgium (Ghent University and KU Leuven).

The aim of TIARA was to identify and understand the interplay and the predictive value of a wide range of parameters in the children at Elevated Likelihood (EL) of developing ASD, particularly focusing on two sub-groups: EL-SIBs and EL-Pre-terms. The participants in the study are Belgian only, since it is based there, and they are followed up at the age-points of 5, 10, 14, 24 and 36-months.

4.1.1 Eligibility

The study population included for EL-SIBs the presence of at least one older full sibling with ASD (community or clinical diagnosis) and the absence of genetic syndromes related to ASD in both the child at elevated likelihood for developing ASD, and their older sibling (e.g., Fragile X syndrome or FXS, Cornelia de Lange syndrome or CdLS and Tuberous Sclerosis Complex.) (Moss et. Oliver, 2012). Inclusion criteria for the pre-term born infants were to be born prematurely under 30-weeks' gestation and as cited before the absence of linked genetic syndromes. In addition, for both the EL-pre-term and TL (Typical Likelihood)-infants group parents must have had a working knowledge of the Dutch language and no first-degree relative with an ASD diagnosis.

4.1.2 Recruitment

Infants in the EL-SIBs group were recruited from centers for developmental disorders, rehabilitation and home guidance centers, as well as parent support groups, while pre-term born infants were recruited in conjunction with the Centre for Developmental Disorders (COS) at University Hospital in Ghent and the Neonatology department at Sint-Jan Bruges General Hospital. Parents of infants who were enrolled in the study and had an infant with less than 30 months of gestation were eligible to take part in the research and during their first routine check-up they were informed about the study and invited to participate (at the corrected age of 4 months). Furthermore, the Neonatal Follow-up program aimed at systematically following-up the pre-term born (< 32-weeks' gestation) at fixed time-points, throughout the first five years of life. Parents who volunteered to participate in the study received a small gift in the form of an age-appropriate toy. The study was also approved by the Faculty of Psychology and Educational Sciences of Ghent and written informed consent for participation was asked and required from one parent. Information about the study could also be found at the Facebook website: https://www.tiara-onderzoek.be/ .

4.1 Study Sample

The study's sample characteristics are displayed in Table 1 (page 41), for the total number of subjects and split by different groups (i.e., EL-SIBs, EL-pre-term and TL-infants). Group differences were analyzed using One-way-ANOVA with an F-distribution for the numeric variables and a Chi Square (χ^2) test for the categorical variables.

The total sample included 120 10-month-old infants at elevated likelihood for developing ASD– including 54 younger SIBs of children with a diagnosis of ASD (EL-SIBs) and 61 pre-term born infants, matched for chronological age (EL-pre-terms). Of this total sample, 40 infants were excluded due to the following reasons: 1): 1) missing mother-infant interactional data (*n* = 34); 2) encodable data (*n* = 3), 3) interactions with fathers (*n* = 3). Father-infant interactions were excluded from the study given the sample size and since there is evidence suggesting that mothers and fathers independent influence their child's development (Kok et al., 2015; Sethna et al., 2017b; Sethna, Siew et al. 2019). . Therefore, the final sample comprised of 80 mother-infant dyads with complete data on mother-infant interaction assessments at 10-months (*n* = 40 EL-SIBS and *n* = 40 EL-pre-terms).

4.2.1 Sample descriptive characteristics

Descriptive characteristics of the study are presented in Table 1 and 2 (page 41,42), for the total sample, and divided by infant group (EL-SIBs, E and EL-preterm groups). Statistics on differences between groups were analysed using independent samples t-tests for continuous variables and a Chi Square (χ^2) for categorical variables.

Regarding the descriptive characteristics of the new-borns, as predicted, a significant mean difference was found in gestational age ($t(74) = -32.03$, $p < .001$) and birth weight ($t(74) = -22.31$, $p < .001$) between the EL-SIBs and EL-preterm groups of new-borns respectively. No significant differences were found in any of the other descriptive variables of the infants (age and sex) between the two groups of infants. Similarly, regarding maternal descriptive statistics, no significant differences were found in any of the maternal descriptive variables (mother's age, education and marital status) between the two groups of infants.

Bivariate correlations between the two main study outcome variables, being language comprehension and production, and potential study confounder variables (i.e., infant age, infant gestational age, infant birth weight, infant sex, maternal age, education status and marital status) are displayed in Table 1 (*page* 41) for the EL-SIBs group, and Table 2 (*page* 42) for the EL-preterm group. The criterion threshold was set at $p < 0.25$ with an $r > 0.20$ for potential study confounder variables to be included in multivariate models (Chowdhury & Turin, 2020).

In the first group, infant language production for 10-months data collection was associated with maternal age ($r = -0.25$, $p = .21$). However, no other correlations were found to reach the critical threshold ($p < 0.25$) between the infant language variables at 10 months and the potential confounding variables in the study. Therefore, maternal age was the only confounding variable included in the multivariate models run in the EL-SIBs group at 10 months.

The same analysis made for 14-months language production results in a different outcome, again there is an association with maternal age (r=0.27) but also with the infant birth weight (r=0.21) and a strong correlation with the confounding variable of maternal educational status (r=0.24, p=.18). Thus, with the increasing of the age there are multiple confounding factors observed interacting with language development. Also, at 14-months there appears to be a strong correlation between language comprehension and infant gestational age (r = 0.28, p = 12).

In the EL pre-term group, shown on table 2, when looking at language production there are similar outcomes for the correlation between 10-months and maternal age (r=0.27, p=.19). And just like in the EL-SIBs group, there are no other correlations that reached the threshold at this age point, except if it is considered also language comprehension as it is one of the two main outcome variables, in that appears to be a correlation both with maternal age (r = -0.25, p = .21) and maternal educational status, already at the age of 10 months.

As for correlation between the language development and comprehension at age 14-months, the analysis results in a correlation between marital status and language comprehension (r = -0.26, p = .15). With language production the only confounding value that correlates is the infant sex (r = -0.22, p = .23).

Table 1

EL-SIBs group: bivariate correlations between the main outcome variables and potential study confounder variables

Study variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Outcome variables:					-	-	-	-	-	-	-
1. Language comprehension_10-months	-	-	-	-	-	-	-	-	-	-	-
2. Language production_10-months	-	-	-	-	-	-	-	-	-	-	-
3. Language comprehension_14-months	-	-	-	-	-	-	-	-	-	-	-
4. Language production_14-months	-	-	-	-	-	-	-	-	-	-	-
Potential confounder variables					-	-	-	-	-	-	-
5. Infant age (days)	0.13	0.11	0.10	-0.01	-	-	-	-	-	-	-
6. Infant gestational age (weeks)	0.03	0.06	0.28[a] (p = 12)	-0.07	-	-	-	-	-	-	-
7. Infant birth weight (grams)	-0.02	-0.10	0.17	0.21[a]	-	-	-	-	-	-	-
8. Infant sex	0.10	0.03	0.02	-0.01	-	-	-	-	-	-	-
9. Maternal age (years)	-0.13	-0.25[a] (p = .21)	0.25[a] (p = .16)	0.27[a]	-	-	-	-	-	-	-
10. Maternal education status	0.08	0.14	0.10	0.24[a] (p = .18)	-	-	-	-	-	-	-
11. Marital status	-0.10	-0.04	0.17	-0.02	-	-	-	-	-	-	-

[a] = correlation reached cut-off p value threshold set at < 0.25 (Chowdhury & Turin, 2020)

Table 2

EL-preterm group: bivariate correlations between the main outcome variables and potential study confounder variables

Study variables	1	2	3	4	5	6	7	8	9	10	11
Outcome variables:					-	-	-	-	-	-	-
1. Language comprehension_10-months	-	-	-	-	-	-	-	-	-	-	-
2. Language production_10-months	-	-	-	-	-	-	-	-	-	-	-
3. Language comprehension_14-months	-	-	-	-	-	-	-	-	-	-	-
4. Language production_14-months	-	-	-	-	-	-	-	-	-	-	-
Potential confounder variables					-	-	-	-	-	-	-
5. Infant age (days)	-0.13	0.11	-0.04	-0.03	-	-	-	-	-	-	-
6. Infant gestational age (weeks)	-0.01	-0.10	0.16	0.10	-	-	-	-	-	-	-
7. Infant birth weight (grams)	0.02	-0.10	0.16	-0.00	-	-	-	-	-	-	-
8. Infant sex	0.01	-0.02	-0.16	-0.22 (*p* = .23)[a]	-	-	-	-	-	-	-
9. Maternal age (years)	-0.25 (*p* = .21)[a]	0.27 (*p* = .19)[a]	-0.14	0.11	-	-	-	-	-	-	-
10. Maternal education status	-0.41 (*p* = .04)[a]	-0.17	-0.12	0.05	-	-	-	-	-	-	-
11. Marital status	0.09	-0.12	-0.26 (*p* = .15)[a]	0.02	-	-	-	-	-	-	-

[a] = correlation reached cut-off *p* value threshold set at < 0.25 (Chowdhury & Turin, 2020); - = irrelevant correlations.

4.3 Study Procedure

The present study reports data collected as part of a larger prospective follow-up study of infants with EL for developing ASD (i.e., EL-SIBs and preterm EL) and a group of infants with TL, over the first 3 years of life. The data presented in this report are based on the outcome of 10-month mother-child interaction data and 14- and 24-month language data. Before each laboratory visit, mothers were contacted by telephone to arrange the date and time of the visit, with a reminder the day before the visit. Parents were also sent self-report questionnaires prior to the visit, which were to be returned during the session. On top of that at the beginning of each session they were asked to complete the informed consent and sociodemographic form.

Standardized developmental assessments, behavioral observations, neurophysiological evaluations, and a variety of self-report measures were administered during each session.

The study reports data from videotaped observations of mother-infant interaction. For this procedure, the mother and her baby were invited to participate in the recorded observations of mother-infant interaction (better described in the 3.3 chapter at page 31).

4.4 Study Measures

4.4.1 Mother-child interaction at 10 months (independent variable)

The first part of the Study comes from observation data, gathered from the MCI, at 10 months the dyads were asked to conduct an unstructured play session for 10 minutes, on a floor map setting, prepared to avoid distractions from external stimuli other than the mother or preselected toys. Before the start of the 10 minutes, mothers were instructed by the researcher in charge to interact and play with their child as they would normally do in a home daily activity, using only the standardized toy set, chosen to be equal for all subjects and age appropriate (plush toy, blocks, toy telephone, etc..).

Interactions were recorded with three different cameras from three angles, with one of them being a movable camera, so as to be sure to always capture the faces and gestures of mother and child, recording the behavior of both, as well as the dyadic (mother-child) or triadic (mother-child-object) interactions between them. The first five minutes of every session where then selected and sent to students or researcher for coding.

Coding manual and software – mother-infant interactions.

The interactions between mother and child were than coded under the gestures dimension of the MMIB (Multimodal Mother and Infant Behavior coding Framework) coding manual (Siew et al., 2021)

Mother-child interaction is the key independent variable of this study, and in this case the variable used to code it were the gestures utilized only by the mothers themselves, they have been already analysed in chapter 3, but it feels necessary to make a point during this coding section to delve deeper in which items were coded during these sessions. As mentioned all of these come from the main coding source, which was the MPIB, that states the four dimensions of gestures: deictic (i.e., pointing, showing, giving, reaching/requesting), (ii)representational, (iii) other and (iv) encodable gestures – across both the parent and infant. The deictic and representational gestures are the one that were coded in the video recordings. The four deictic gestures, recognized in the manual are: pointing, showing, giving and requesting.

Coding procedure – mother infant interactions

Mother-infant interactions were coded by undergraduate psychology students, including the author of this thesis, as part of an internship program offered by Gent University and other institutes, trained on the MPIB (until a training threshold of 85% agreement per video was reached). In the training phase, 85% agreement was calculated for each video and calculated for the three groups (i.e., EL-SIBs, EL-pre-term and TL-infants). These factors were coded, in addition to the coding manual, with the use of a coding program called ELAN. With ELAN a user can add an unlimited number of textual annotations to audio and/or video recordings. An annotation can be a sentence, word or gloss, a comment, translation or a description of any feature observed in the media. Annotations can be created on multiple layers, called *tiers*. Tiers can be hierarchically interconnected. An annotation can either be time-aligned to the media or it can refer to other existing annotations. The content of annotations consists of Unicode text and annotation documents are stored in an XML format (The Language Archive, 2021). The students learned the use of this tool trough the help of a training blog curated by PhD candidate Jasmine Siew. The functions discussed in the blog are applicable to coding interactions related to a specific type of video-based dyadic interaction coding. Thus, it is not a complete encyclopedia of all ELAN functions and neither of all types of dyadic interaction coding. Dyadic reciprocity refers to the interaction that forms around the mother and the child during these sessions, as they influence each other behavior. Furthermore, inter-rater reliability (IRR) was established using Intraclass Correlations (ICC, Shrout & Fleiss, 1979). A random 20% of the sample were double coded for reliability purposes - across the three groups. As a rule of thumb, ICC coefficients between .40 and .59 represent fair reliability, coefficients between .60 and .74 are indications of a good reliability and coefficients between .75 and 1.00 are indications of an excellent reliability. In this study, reliability coefficients indicate good reliability across the three groups for both maternal deictic gestures (ICC > .66) and representational gestures (ICC = .64).

4.4.2 Infant language development at 18-months *(*outcome variable)

Infant language development was assessed using the Bayley-3 (Netherlands version) scale. The Bayley III is a tool used to assess the overall development of infants 1-42 months of age. The test consists of cognitive, language (receptive/ expressive), motor (fine/gross), active emotion, and adaptation behaviors, and was conducted according to manual guidelines (Ryu, Sim, 2019).

The previous rendition of the Bayley Scales of Infant Development (BSID-II) has a history of being one of the most frequently used, standardized tools for assessing child language development in infants, especially preterms under 3 years of age (Bayley, 1993). Then a few years ago the Bayley scale was revised and reformed as Bayley-III, remaining consistent in function but with a substantial structural difference, with the inclusion of a newly created Language Index and five new subscales. The two sections of interest for this study, contained in the Bayley-III, are the Bayley III-receptive language sector (BRLS) and the Bayley III-expressive language sector (BELS). The high sensitivity and specificity of the BELS suggests that the Bayley-III expressive language sector might be the most useful test for children suspected of delayed language development, also because in the receptive/expressive language areas of the Bayley III it showed statistically significant positive Pearson correlations.

Several items on the Bayley-III improve practitioners' ability to assess prelinguistic (and linguistic) communicative skills, particularly the child's intentionality or communicative functions. They include examining the child's ability to gain attention (social interaction), use of consonants, use of gestures (behavior regulation), to direct the attention of others (joint attention), and to use words or combining words and gestures to meet personal needs.

One of the reasons the Bayley-3 scale was chosen as a test for this variable is that it is child- and family-friendly, and easy to administer. Most Bayley-III items allow the examiner and/or caregivers to encourage the child to respond if he or she initially refuses to do so, as long as basic standardization procedures are followed. Some children, especially those with communication deficits, may be shy or hesitant. In these instances, professionals may elect first to play briefly with the child to encourage rapport, communication, and cooperation, and later to begin testing (Crais, 2010).

One of the strengths of the Bayley-III is the possibility to analyze the child's abilities across domains, using growth charts, and comparing scores across times. The scoring process and recording form are additional strengths of the Bayley-III. Using the information gained on one item to complete other items without having to administer them. Is another advantage. This is particularly useful for the Language Scale, since children do not always "produce language when asked or prompted by an examiner but may do so spontaneously at other points in the test.

4.5 Statistical Analysis Plan

Model Assumption

Statistical analysis was performed using the open-source statistical package JASP version 0.16.3 (JASP Team, 2022) with a significance level set at $p < 0.05$. All tests were two-tailed. Based on the central limit theorem (Kwak, Kim, 2005) which indicates that sufficiently large samples ($n > 30$) are approximately normally distributed, analyses were conducted using parametric tests as the sample size of each group included in this study is sufficient, i.e., EL-SIBs ($n = 40$), EL-pre-term ($n = 40$). In addition, outliers were visually assessed for the main study variables (maternal gestures and infant language) by the interquartile range method, without identifying extreme outliers. The main analyses in this study were divided into descriptive and inferential analyses.

Descriptive analyses

Descriptive analyses include three main steps: (i) descriptive analyses for the study sample, (ii) for the main study variables, and (iii) analysis of potential study confounders.

First, the statistics for the study are analyzed and reported using means (*M*) and standard deviations (*SD*) for the total sample, and across the two infant groups, separately (i.e., EL-SIBs group and EL pre-term groups). Statistical differences between the two infant groups were computed using independent samples t-tests and Chi Square tests for categorical variables.

Additionally, descriptive statistics are analyzed and reported using mean (M) and standard deviation (SD) for the main study variables (i.e., maternal gestures and infant language) for the total sample and separately for each infant group (EL-SIBs group and EL preterm group). A t-test for independent samples is also used to calculate group differences between the two infant groups.

Third, bivariate correlations between the study's main outcome variables (i.e., infant language measures at 10 and 14 months of age) and potential study confounding variables (i.e., infant age, infant sex, gestational age, birth weight, maternal age, maternal education, and marital status) were analyzed separately for the two groups of infants. Potential confounding variables in the study were included in multivariate models (for inferential analyses only) if they were associated with the outcome variables (i.e., infant language measures at 10 and 14 months of age) at a p value of < 0.25 (Chowdhury & Turin, 2020) and an effect size of at least $r > 0.20$. Given that individual variables may be only weakly associated with the outcome variable but make a significant contribution when combined, a higher significance threshold was set to allow more variables to show significance in the univariate analysis (Chowdhury & Turin, 2020). The bivariate correlations between the outcome variables and the potential confounder variables in the study are shown in Table 1,2 (page 41,42).

Chapter 5

Results

5.1 Descriptive analyses: main study variables

Descriptive statistics for the main variables of the study (i.e., maternal gestures and infant language outcomes) are presented in Table 3 (page 53) for the total sample and divided by infant group status (i.e., EL-SIBs and EL-preterm groups), with group difference statistics analyzed with t tests for independent samples.

In this regard, it is crucial to remember that these comparisons do not take into account potential covariates (i.e., infant chronological age, infant gestational age, infant birth weight, infant sex, maternal age, socioeconomic status, or marital status) such as infant chronological age, infant gestational age, infant birth weight, infant sex, and maternal age. In general, ANCOVA is appropriate when the groups do not differ on the covariate, when inclusion of the covariate serves merely to re-move noise variance unrelated to the grouping variable (Miller, Chapman, 2001).

For maternal gestures (i.e., independent variable), there was a significant mean difference in the frequency of showing gestures ($t\ (78) = 2.40$, $p = 0.02$) between the EL-SIBs group and the EL-preterm groups; this indicates that mothers of infants in the EL-pre-term group ($M = 6$, $SD = 5$) showed a higher frequency of showing gestures during observations of mother-infant interactions compared with mothers of infants in the EL-SIBs group ($M = 4$, $SD = 3$). However, there were no significant differences in the frequency of other maternal gestures (i.e., pointing, giving, total deictic, and representational gestures) between the two infant groups.

For infant language (i.e., dependent variable), assessed with the aforementioned Bayley scale, both language production and language comprehension were significantly different on a mean basis (respectively: t (65) = 4.27, $p < .001$, t (65) = 2.65, p = .001) between the two EL groups. Indicating that the language comprehension at 10 months for the EL-SIBs group (M = 10, SD = 1) was found to be less developed than in the EL-preterm group (M = 11, SD = 2), resulting in the most significant difference in all of this part of the descriptive analysis. A similar result can be seen in the 10-months language production, where once again the EL-SIBs group (M = 11, SD = 2) scored significantly lower than the EL-preterm one (M = 12, SD = 2).

Nonetheless, at age 14-monts, both of these differences in language are meaningless since they lose all of the significant mean difference with only language production getting closer to it with a p-value of .19.

Table 3

Descriptive statistics for the main study variable, for total group, and split by infant group status

Study variables *M (SD)*	Total group (N = 80)	EL-sibling *n* = 40	EL-preterm *n* = 40	Statistic[a]
	Infant group status			
Maternal gestures[c] (Independent variable):				
Deictic gestures:				
Point	1.06 (1.67)	1.30 (2.00)	0.83 (1.24)	t (78) = -1.28, p = 0.21
Give	6.15 (3.22)	6.15 (3.32)	6.15 (3.33)	t (78) = 0.00, p = 1.00
Show	5.31 (4.00)	4.28 (2.96)	6.35 (4.61)	**t (78) = 2.40, p = 0.02**
Total deictic	13.04 (6.50)	12.35 (5.74)	13.73 (7.19)	t (78) = 0.95, p = 0.35
Representational gestures	15.06 (6.32)	14.65 (5.96)	15.78 (6.72)	t (78) = 0.58, p = 0.56
Infant language (Outcome variable):				
Language_10-months				
Comprehension	10.27 (1.62)	9.65 (1.33)	11.19 (1.59)	**t (65) = 4.27, p < .001**
Production	11.16 (1.92)	10.68 (2.03)	11.89 (1.50)	**t (65) = 2.65, p = 0.01**
Language_14-months				
Comprehension	11.96 (2.36)	11.82 (2.59)	12.09 (2.13)	t (65) = 0.46, p = 0.65
Production	14.30 (2.55)	14.71 (2.76)	13.88 (2.27)	t (65) = -1.34, p = 0.19

Note: M = mean; *SD* = standard deviation; ***t*** **=** independent sample t-test; **; BOLD=** significant mean difference < .05

[a] Group difference statistic between EL-sibling and EL-pre-term

[b] There was missing data for language measures at 10-months (n = 13) and 14-months (n = 13).

[c] Maternal gestures coded using the Multimodal Mother and Infant Behaviours during Observed Mother-Infant Interactions: a frequency based coding manual (unpublished coding manual; Siew et al. 2021)

[d] Infant language was assessed using the Bayley Scales of Infant and Toddler Development-Third Edition-NL (Bayley 2006).

5.2 Inferential Analysis

5.2.1 EL-SIBs: relationship between maternal gestures and infant language outcomes

Only at 10 months did mother's total deictic gestures (pointing, giving, and showing) significantly affect infant language comprehension ($r = 0.38$, $p = 0.02$). This indicates a higher level of language comprehension at 10 months is associated with a higher frequency of mother's total deictic gestures. Additionally, when adjusting for covariates related to infant language outcomes at 10 months (e.g., maternal age), the association remained statistically significant ($\beta = 0.37$, $p = 0.02$), with a mean effect size (Cohens $f2 = 0.17$). A visual representation of the association between total deictic gestures and language comprehension at 10 months is shown in Figure 1.

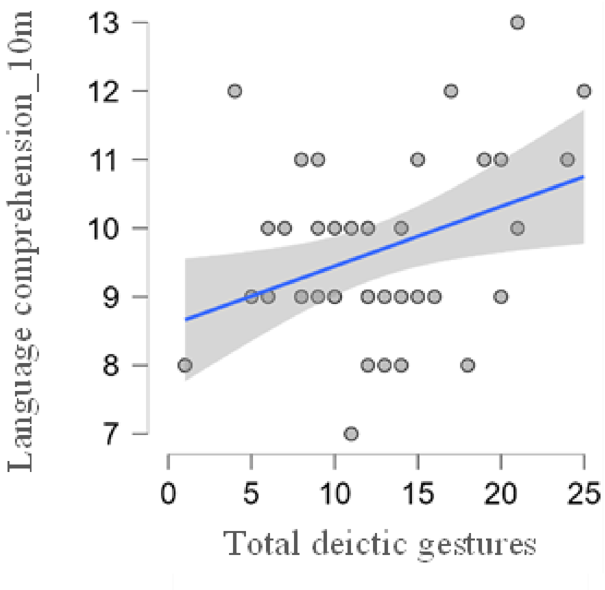


Figure 1: The association between total deictic gestures and language comprehension at 10-months – with a 95% confidence interval

On top of that, a significant trend for the association between maternal showing gestures and language comprehension was not evident until 10 months of age ($r = 0.31$, $p = 0.06$). Similarly, maternal gestures were associated with language comprehension only at 14 months of age ($r = 0.34$, $p = 0.07$). However, because these associations did not reach statistical significance ($p < 0.05$), no further multivariate analyses were performed. None of the other maternal gesture indices (i.e., point and representational gestures) were associated with language comprehension at 10 or 14 months of age.

As for the association between mother's gestures and children language production, there was a trend towards significance for the association between give gestures and speech production only at 14 months of age ($r = 0.31$, $p = 0.07$). However, no further multivariate analyses were performed because these associations did not reach statistical significance ($p < 0.05$). None of the other maternal gesture indices (i.e., pointing, show, total deictic, and representative) were associated with speech production at 10 or 14 months of age.

On pages 56, 57, Tables 4 and 5 illustrate the Pearson correlation between maternal gestures (i.e., point, give, show, total deictic gestures and representational gestures) and infant language outcomes (language comprehension and language production). This study evaluates the unadjusted association between EL-SIBs and EL-preterms at different time points (10 and 14 months) for each group.).

Table 4

Multivariate regression models between maternal gestures and infant language comprehension

Study variables	10-months				14-months			
	EL-sibling *n* = 34		EL-preterm *n* = 33		EL-sibling *n* = 34		EL-preterm *n* = 33	
Infant language comprehension (outcome variable)								
Maternal gestures (Independent variable)								
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Deictic gestures:								
Point	0.16	0.34	-0.02	0.91	0.03	0.86	-0.16	0.38
Give	0.24	0.14	0.47	**0.01**	0.34	0.07†	0.31	0.08†
Show	0.31	0.06†	-0.02	0.92	-0.10	0.58	-0.02	0.91
Total deictic	0.38	**0.02**	0.23	0.25	0.17	0.35	0.21	0.24
Representational gestures	0.10	0.55	0.24	0.24	0.03	0.89	0.02	0.92

Note: ***r*** = Pearson correlation statistic mean; **BOLD =** significant association < .05; † = trend level significance
[b] There was missing data for language comprehension at 10-months (*n* = 6) and 14-months (*n* = 7).

Table 5

Pearson correlations between maternal gestures and infant language production

Study variables	10-months				14-months			
	EL-sibling *n* = 34		EL-preterm *n* = 33		EL-sibling *n* = 34		EL-preterm *n* = 33	
Infant language production (outcome variable)								
Maternal gestures (Independent variable)								
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Deictic gestures:								
Point	0.11	0.49	0.04	0.84	-0.11	0.53	0.09	0.63
Give	-0.06	0.73	0.07	0.73	0.31	0.07†	-0.20	0.28
Show	0.12	0.47	-0.01	0.95	-0.11	0.53	0.58	0.75
Total deictic	0.11	0.49	0.08	0.68	0.03	0.87	0.04	0.84
Representational gestures	0.15	0.36	-0.06	0.78	-0.13	0.47	-0.08	0.67

Note: ***r*** = Pearson correlation statistic mean; **BOLD =** significant association < .05; † = trend level significance
[b] There was missing data for language comprehension at 10-months (*n* = 6) and 14-months (*n* = 7).

EL-preterms: relationship between maternal gestures and infant language outcomes

The maternal give gestures at 10-months were significantly associated with infant language comprehension for the EL-preterm group (r = 0.47, p = 0.01). Thus, maternal give gestures are associated with higher levels of language comprehension among infants at 10-months. In addition, this association remained statistically significant (β = 0.44, *p* = 0.02), when controlling for covariates associated with infant language outcomes at 10-months (i.e., maternal age) - with a large effect size (Cohen's f2 = 0.35).

EL-SIBs: relationship between maternal gestures and infant language outcomes

For the EL-SIBs group, total deictic gestures of the mothers were significantly associated with infant language comprehension at 10-months only (*r* = 0.38, *p* = 0.02); suggesting that a higher frequency of maternal give gestures is associated with a higher level of language comprehension at 10-months. Next, when adjusting for covariates linked to infant language outcomes at 10-months (i.e., maternal age), this association remained statistically significant (β = 0.44, *p* = 0.02) - with a large effect size (Cohens *f*2 = 0.35).

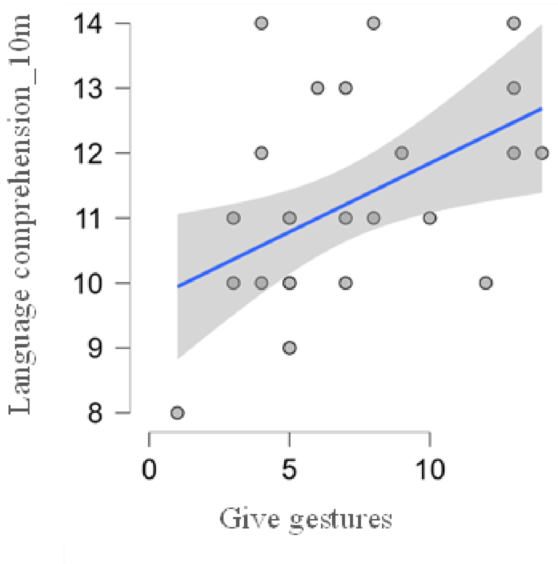


Figure 2: The association between maternal gestures and language comprehension at 10-months – with a 95% confidence interval

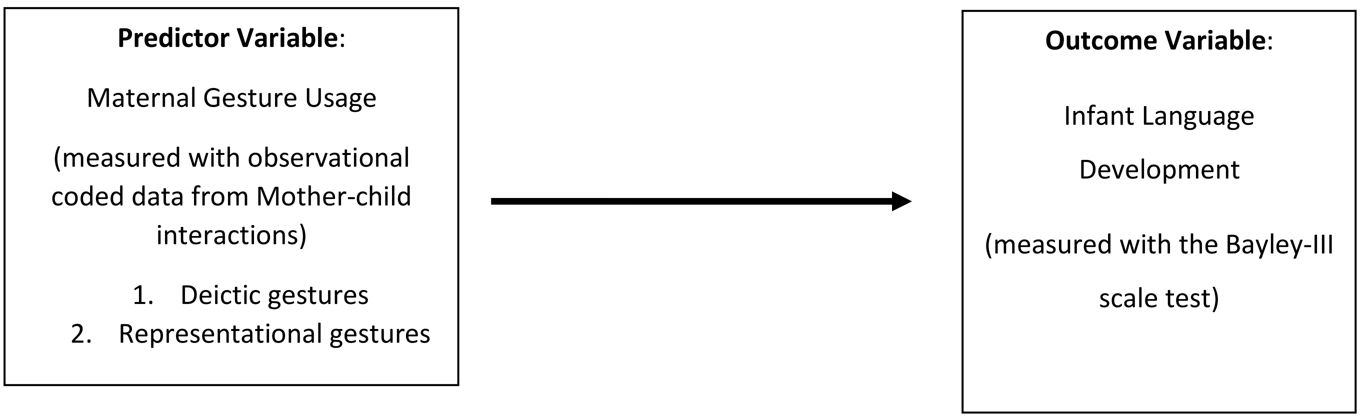
In figure 2 it is shown a visual representation of the coordinate association between maternal gestures and language comprehension at 10-months, demonstrating a really high confidence interval (95%), that shows how much influence these gestures can have on the child development.

Chapter 6

Discussion

Following the knowledge that both prematurity and having a siblings diagnosticated with ASD are factors that could influence the development of children putting them at EL (elevate likelihood) of Autism (Rogers et. al., 2014, Lin et al., 2021), this study used these two groups of children, to analyze the effect of mother's gestures on the language development.

As shown in figure 3 below, the predictor variable of this paper was maternal gestures (deictic and representational) and the outcome variable was infant language development (comprehension and production).



The primary objectives of this thesis were three: to examine the frequency of maternal gesture use between two groups of EL infants for ASD at the age points of 10 and 14 months, to examine the associations between maternal gesture use and subsequent infant language development and finally to determine whether infant gesture and language development can be used to support parents of ASD children in more effective and formative communication with their children.

Chapters Supporting Literature

The research examined in chapter 1 on this subject provided proof of the possible early predictors of ASD (Wheterby et al., 2004). On the two groups taken into account for this study both were found to be relevant according to the literature for being early indicators of Autism.

Several studies supported in fact the idea that EL-preterm and EL-SIBs children present a number of common precursors to ASD such as: slower in disengaging from eye contact, fewer combination gestures and gazes, poor imitation or joint attention skills, and less responsivity to their names. (Schumyer et al., 2011).

On top of that, in chapter 2 it was also made clear how the language development, especially in its third and fourth phase, can be influenced by the elevated likelihood for ASD, since the factors that are important for language development in children at risk for autism, are similar to those observed for typical developments (Luyster et al., 2008). Children’s own gestures were also seen to be changed by ASD, as they tend to produce a lower amount in the interactions with the mothers, also because 14-month-old infants who show signs of ASD and have a 30–36 month diagnosis have a smaller inventory of gestures (Zwaigenbaum et al., 2009).

The consequent move in the study was then to direct the attention to mother’s gestures, what they are, and how can they be of influence for infant language. The gestures that are considered are the deictic ones like pointing, showing, giving, as well as representational ones.

The findings from this study suggests a link between maternal gesture use and the later development of a broader vocabulary in their children, as well as better language comprehension and general production. This finding was really important to determine the utility of the later research and validity of the results and data. It was also in line with Masur (1982) research that explains how the verbal responses parents provide to their children’s gestures benefit children’s subsequent language development as parents do not only translate the majority (71 %) of their children’s pointing gestures into words but also into their own gestures (Goldin-Meadow et al. 2007).

Maternal Gestures in EL groups

From the first research question: “what is the frequency of maternal gestures and the two EL groups”, the most relevant finding concerned differences in the frequency of showing gestures. Results demonstrated that show gesture were significantly more frequent in the EL-preterm group, compared to the EL-SIBs group, However, there was no significant difference in the frequency of other gestures between groups elevated likelihood.

In examining the hypothesis made in this study, concerning maternal gestures these were confirmed.

The literature on these findings is also consistent with studies showing less maternal “show” gestures during the interaction towards their EL-SIBs compared to the EL-preterm ones (Muller-Nix et al., 2004).

Different explanations for these observations can be found in research literature; at the age of 10 months, mothers and EL-infants have greater difficulties in interpreting and responding to their interaction partners' cues (Harel-Gadassi, et al., 2020).

The fact that only showing was found to be relevant in this analysis, and not the other deictic gestures is definitely a relevant point to be made, some studies have tried to find an answer to this and the hypothesis is that first of all the scoring method needs to be discussed, as the scoring manual used in this research uses one definition of showing: “Show gestures must be accompanied with a change in object position towards the interactive partners potential line of sight - with the probable intent of presenting the object to the interactive partner.

In addition, the showing must include a moment of stability". On the other hand, if we take the ADOS (another instrument used in TIARA scoring data) from the children point of view it describes showing as deliberately orienting or placing an object where it can be seen by another person, such as holding up a toy truck to show the parent or examiner. This does not include instances where the child orients the object for the purpose of getting help or participating in a routine. (ADOS, 2013). Those two description are already very distinct, and might be one of the reasons behind the significance of this difference in the analysis presented, as it is also proven by Ellawadi and Weismer (2014) that hypothesize that showing is less likely to be observed during a single time point, which might expand on why in this paper it was relevant only at 10 months while losing the correlation at a later age.

The results of this research question pose an interesting point in underlining the importance of early mother-child gesture interactions, to facilitate a later similarity even in different EL groups of children.

These findings also consider the infants as groups, but since EL-infants are not assumed to be homogeneous, individual differences can also be significant. It is possible for some EL-infants to develop autism spectrum disorder, while other EL-infants may not. These individuals may experience different associations between maternal behavior and joint attention such as showing. A prospective study of this association can be conducted in the future.

The association between Gestures and Infant language Development

The analysis of the second main research question "The associations between maternal gesture use and subsequent infant language development" demonstrated a relationship both between deictic and general mother gestures in relation to infant language development.

It must be specified that analyzing this kind of associations in groups of EL children is not an easy task (Pijl et al., 2021), but this thesis tried to simplify the question by restricting the query by narrowing the field, focusing on specific kinds of gestures, and on fixed age points, just before the relation between gesture and speech in children's communicative systems is reorganized, which happens sometime between the ages of 16 and 20 months, just prior to the transition to two-word speech (Caselli, 1995, Goldin-Meadow, 1998).

The main finding was in the deictic gestures (pointing, showing, giving), for these values findings demonstrated that a higher frequency of maternal total deictic gestures was linked to better language comprehension at 10-months only. Similarly, a higher frequency of maternal "give" gestures were linked to better language comprehension at 10-months only.

With a 95% confidence interval it is a safe assumption that the independent and outcome variable of the research are indeed correlated.

As for language production the results indicate that the language comprehension at 10 months for the EL-SIBs group was found to be less developed than in the EL-preterm group, also the language production as a whole measure was not associated enough with any of the deictic gestures or the total of them to be considered relevant in the study.

It is worth noting that nonetheless, at age 14-monts, both of these last viewed differences in language development between the two groups are meaningless since they lose all of the significant mean difference in the data analysis.

Some of these findings correlate with the literature on typical and EL developing children, such as Talbott et al. (2015) that reported that 12-month parent gesture significantly, positively correlated with 18-month general language skills, measured on the Mullen Scales of Early Learning (Mullen 1995), in EL infants who were not yet diagnosed with ASD and typically developing low-risk infants.

Clinical Implications

There are multiple uses of these finding in a possible clinical application. First of all, it is known that the early detection of ASD, as a neurodevelopmental disorder, is very important (Lord et al., 2006, Martinez-Pedraza, Carter, 2009). Being able to find strong precursors like prematurity and diagnosed siblings before the standard age of just before 3 years old could be a great instrument for early interventions.

Furthermore, the early detection combined with the knowledge that gestures have such an impact on language development can be an important piece in the early training of the skills such as language.

Study Limitations and Strength points

As a longitudinal study, this research has the advantage of allowing us to learn more about cause-and-effect relationships. These types of studies allow connections between events to be made more clearly. Results can be improved and be more concise with more data collected over a longer period of time. Studies like these are great for detecting long-term trends.

This study also facilitates explaining the complex interaction between mother and children characteristics, behaviors and development.

Moreover, most studies focus on one EL-infants group (i.e. EL-SIBs or EL-pre-terms) but this chose to consider not only both but also comparing them. This could help to understand different developmental pathways in relation to language development and ASD in different groups. The results indicate possible phenotypic differences between the two EL groups. On top of that, the instruments used are all well validated hypothesis testing instruments.

One other strong value to this study is that it is one of the first to examine the association between maternal gestures and child language development at the early age of 10-14 months, especially in the two groups that are EL-SIBs and EL-preterms.

A first limitation to this study may be the fact that not all of the instruments used were specific to preterm or siblings' samples, for example the parent-child recordings, with only the exception of the BSID-III.

In addition, the current study has the restriction of investigating a limited number of variables. A lot of variables are also not considered in this study because of the complexity of the mother-infant interaction.

This research was merely exploratory and the sample subjects that completed the program might have been too little to examine all these possible variables. Compensating that, is the fact that this is not the only research being done currently on the TIARA study data and material, many other students and PhD students are investigating different measures and variables with the same sample children used for this paper, with maybe different age points or objectives.

Future Indications

The first suggestion for future research comes from the current study's point of strength. As mentioned, this paper only focuses on the 10-month time-point but it could be useful to include different ages in their studies to provide insight in different developmental pathways of the language development and the dyadic relationship between mother and children.

Some other studies already investigated the efficiency of maternal gestures in typically developed children, but at this age point, with the same measures, without considering the two EL-groups, could be an interesting addition to the data of this area. On the same theme, having a more consistent control group composed of typical-development children could be an optimal comparison and insight in the difference with the EL-children analyzed here.

One thing the study did not investigate at all, even if there was some data collected about it, was the father-child relationship and connection to the development, unfortunately the amount of statistic material wasn’t enough to make it relevant here, but a further investigation could result in interesting findings, also because it is assumed and partially observed that fathers interact differently with their children.

At last, since this study stops at the age of 14-months, with children at Elevated Likelihood for ASD, but never reaches the age point for a proper diagnosis, it would be compelling to take the individual differences into account as the TIARA is a much bigger cohort study.

Conclusion

We can conclude that, although there are studies demonstrating that symptoms of ASD only start to emerge at a later age, in preterm and siblings' children there were some clear indicators of ASD symptomatology were found in the first 14 months of life.

In the chapters set out above, it is found that although language is not a direct ASD symptomatology, it is important to make a parallel evaluation of linguistic and social-communicative skills, as it is important to find how it develops in this age and how it does so, to be able to provide the right support to parents and specialists, this also because language impediments are one of the first concerns that the caregivers themselves notice in a child that later may develop ASD symptomatology.

In the end, the results of the study were all in line with the initial research questions, providing useful information for future analysis and hopefully being of help in the treatment of this disorder and language development.

References

Adalsteinsson, B.T., Ferguson-Smith, A.C. (2014) Epigenetic control of the genome, Lessons from genomic imprinting, *Genes 5*, 635–655

Ashwood, K. L., Tye, C., Azadi, B., Cartwright, S., Asherson, P., & Bolton, P. (2015), Brief Report: Adaptive Functioning in Children with ASD, ADHD and 75 ASD + ADHD. *Journal of Autism and Developmental Disorders, 45(7),* 2235–2242

Bates, E. (2008). Comprehension and production in early language development. *Monographs of the Society for Research in Child Development*, 58(3-4), 222–242.

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

Bayley III. (2006a), Bayley Scales of Infant Development. 3rd edition: Administration manual. *San Antonio, TX: Harcourt Assessment*

Bayley III. (2006b), Bayley Scales of Infant Development. 3rd edition: Technical manual. San Antonio, *TX: Harcourt Assessment*

Bayley, N. (1993), Bayley Scales of Infant Development (2nd ed.). *San Antonio, TX: The Psychological Corporation*

Bolte, S., Girdler, S., Marshick, P. B. (2019), The contribution of environmental exposure to the etiology of autism spectrum disorder, *Cellular and Molecular Life Sciences 76*, 1275–1297

Caselli, M. C., Elizabeth Bates, Paola Casadio, Judi Fenson, Larry Fenson, Lisa Sanderl, Judy Weir, (1995), A cross-linguistic study of early lexical development, *Cognitive Development, 10, Issue 2*, 159-199,

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Drew, A., Cox, A. (2003) Predicting language outcome in infants with autism and pervasive developmental disorder, *Int. J. Lang. Comm. Dis. 3*, 265–285

Choi, B., Castelbaum, L., Mc Kechnie, R., Rowe, M. L., Nelson, C. A., Tager-Flusberg, H. (2021) Brief Report: Parents' Declarative Use of Deictic Gestures Predict Vocabulary Development in Infants at High and Low Risk for Autism Spectrum Disorder, *Journal of Autism and Developmental Disorders 52,* 914–922

Choi, B., Shah, P., Rowe, M. L., Nelson, C. A., Tager-Flusberg, H. (2021), A Longitudinal Study of Parent Gestures, Infant Responsiveness, and Vocabulary Development in Infants at Risk for Autism Spectrum Disorder, *Journal of Autism and Developmental Disorders 51,* 3946–3958

Chowdhury, M. Z. I., Turin, T. C. (2020), Variable selection strategies and its importance in clinical prediction modelling, *Fam Med Com Health* 10.1136/fmch-2019-000262

Crais, E. R., (2010), The Bayley-III Language Scale, *BAYLEY-III Clinical Use and Interpretation,* Elsevier Inc.

De Schuymer, L., De Groote, I., Beyers, W., Striano, T., Roeyers, H. (2011). Preverbal skills as mediators for language outcome in preterm and full term children, *Early Human Development* 87, issue 4, 265-272

Demily, C., Poisson A., Peiroux, E., Gatellier, V., Nicolas, A., Rigard, C., Schluth-Bolard, C., Sanlaville, D., Rossi, M. (2017), Autism spectrum disorder associated with 49, XYYYY: case report and review of the literature, BMC Medical Genetics, 18:9

Dimitrova N., O¨ zc¸alıs¸kan, S., Adamson, L. B. (2016), Parents' Translations of Child Gesture Facilitate Word Learning in Children with Autism, Down Syndrome and Typical Development, *J Autism Dev Disord 46*, 221-231

Doussart-Roosvelt, J. A., Joe, C. M., Bazhenova, O. V., Porges, S. W. (2003), Mother–child interaction in autistic and nonautistic children: Characteristics of maternal approach behaviors and child social responses, *Development and Psychopathology 15*, 277–295

Ellawadi, B. A., Weismer, S. E., (2014), Assessing Gestures in Young Children with Autism Spectrum Disorders, *J Speech Lang Hear Res. ; 57(2)*: 524–531

Fombonne E. (2005), Epidemiological studies of pervasive developmental disorders. In: Volkmar FR, Klin A, Paul R, Cohen DJ, eds. *Handbook of Autism and Pervasive Developmental Disorders. 3rd ed*.

Goldin-Meadow, S., Goodrich, W., Sauer, E. and Iverson, J. (2007), Young children use their hands to tell their mothers what to say. *Developmental Science, 10*: 778-785.

Goldin-Meadow, S., & Mylander, C. (1998). Spontaneous sign systems created by deaf children in two cultures. *Nature, 391*(6664), 279–281

Greene, M. M., Patra, K., Nelson, M. N., Silvestri, J. M. (2012). Evaluating preterm infants with the Bayley-III: Patterns and correlates of development, *Research in Developmental Disabilities* 33, Issue 6, 1948-1956

Grønborg T.K., Schendel D.E., Parner E.T. (2013), Recurrence of autism spectrum disorders in full- and half-siblings and trends over time: a population-based cohort study, *JAMA Pediatr. 167(10)*, 947-953.

Harel-Gadassi, Edwa Friedlander, Maya Yaari, Benjamin Bar-Oz, Smadar Eventov-Friedman, David Mankuta, Nurit Yirmiya, (2020), Do developmental and temperamental characteristics mediate the association between preterm birth and the quality of mother-child interaction?, *Infant Behavior and Development, 58*, 0163-6383, Iverson, J. M., Capirci, O., Longobardi, E., Caselli, M. C. (1999). Gesturing in Mother child interactions, *Cognitive Development*, 14, 57-75

Jang, J., Matson, J. L., Williams, L. W., Tureck, K., Goldin, R. L., Cervantes, P. E., (2019), Rates of comorbid symptoms in children with ASD, ADHD, and comorbid ASD and ADHD, *Research in Developmental Disabilities 34,* issue 8, 2369-2378

Kwak ,S. G., Kim, J. H. (2017), Central limit theorem: the cornerstone of modern statistics, *Korean Journal of Anesthesiology 70(2)*, 144-156

Ladd-Acosta C., Hansen K.D., Briem E., Fallin M.D., Kaufmann W.E., Feinberg A.P. (2014). Common DNA methylation alterations in multiple brain regions in autism, *Mol. Psychiatry 19*, 862–71

Lin, C. H., Lin, W. D., Chou, I. G., Lee, I. C., Hong, S. Y. (2021), Is Preterm Birth a Risk Factor for Subsequent Autism Spectrum Disorder and Attention Deficit Hyperactivity Disorder in Children with Febrile Seizure?—A Retrospective Study, *Life 11*, 854

Lord C., Risi S., DiLavore P.S., Shulman C., Thurm A., Pickles A. (2006) Autism From 2 to 9 Years of Age. *Arch Gen Psychiatry, 63(6),* 694-701. doi:10.1001/archpsyc.63.6.694

Luyster, R. J., Kadlec, M. B., Carter, A., Tager-Flusberg, H. (2008), Language Assessment and Development in Toddlers with Autism Spectrum Disorders, *J Autism Dev Disord 38*, 1426–1438

Lyall, K., Crohen, L., Daniels, J., Fallin, M. D., Ladd-Acosta, C., Lee, B. K., Park, B. Y., Snyder, N. W., Schendel, D., Volk, H., Windham, G. C., Newschaffer, C. (2017), The Changing Epidemiology of Autism Spectrum Disorders, *Annu. Rev. Public Health*, 38:81–102

Manwaring, S. S., Stevens, A. L., Mowdood, A., Lackey, M. (2018), A scoping review of deictic gesture use in toddlers with or at-risk for autism spectrum disorder, *Autism & Developmental Language Impairments 3*, 1–27

Martinez-Pedraza, F. L., Carter, A. S. (2009), Autism Spectrum Disorders in Young Children, *Child Adolesc Psychiatr Clin N Am. 18(3)*, 645–663

Masur, E. F. (1982). Mothers' responses to infants' object-related gestures: Influences on lexical development. *Journal of Child Language, 9*(1), 23–30

Miller, G. A., Chapman, J. P., (2001), Misunderstanding Analysis of Covariance, *Journal of Abnormal Psychology 110,* 40-48.

Moss, J., Oliver, C., (2012), Autism in genetic syndromes: Implications for assessment andintervention, *Cerebra Centre for Neurodevelopmental Disorders (CNDD)*

Mullen, E. M. (1995). Mullen scales of early learning (AGS ed.). *Circle Pines, MN: American Guidance Service Inc.*

Muller-Nix C, Forcada-Guex M, Pierrehumbert B, Jaunin L, Borghini A, Ansermet F. (2004), Prematurity, maternal stress and mother-child interactions. *Early Hum Dev. Sep;79(2):*145-58

Özçalışkan, S., Dimitrova, N. (2013), How Gesture Input Provides a Helping Hand to Language Development, *Seminars in Speech and Language, 34(4)*, 227-236

Paul, R., Looney, S. S., Dahm, P. S. (1991), Communication and Socialization Skills at Ages 2 and 3 in "Late-Talking" Young Children, *journal of Speech and Hearing Research* 34, 858-865

Pijl, E.K., Vanneste, Y.T.M., de Rijk, A.E. et al. (2021*)* The prevalence of sickness absence among primary school pupils – reason to be worried?. *BMC Public Health* 21, 170

Quaak, I., Brouns, M. R., Van de Bor, M. (2013), The Dynamics of Autism Spectrum Disorders: How Neurotoxic Compounds and Neurotransmitters Interact, *Int. J. Environ. Res. Public Health 10,* 3384-3408

Ramos-Cabo, S., Vulchanov, V., Vulchanova, M. (2019), Gesture and Language Trajectories in Early Development: An Overview From the Autism Spectrum Disorder Perspective, *Front. Psychol*. 10:1211

Robins, J. M. (2000) Data, Design, and Background Knowledge in Etiologic Inference, *Epidemiology 11*.

Roemer, E. J., Kushner, E. H., Iverson, J. M. (2022), Joint Engagement, Parent Labels, and Language Development: Examining Everyday Interactions in Infant Siblings of Children with Autism, *Journal of Autism and Developmental Disorders 52*,1984–2003

Rogers, S. J., Vismara, L., Wagner, A. L., Mc Cormick, C., Young, G., Ozonoff, S. (2014), Autism Treatment in the First Year of Life: A Pilot Study of Infant Start, a Parent-Implemented Intervention for Symptomatic Infants, *J Autism Dev Disord 44*, 2981–2995

Ryu, S. H., Sim, Y. J. (2019), The validity and reliability of DDST II and Bayley III in children with language development delay, *Neurology Asia 24(4)*, 355–361

Sethna, W., Siew, J., Pote, I., Wang, S., Gudbrandsen, M., Lee, C., Perry, E., Adams, K. P. H., Watson, C., Kangas, J., Stoencheva, V., Daly, E., Kuklisova-Murgasova, M., Williams, S. C. R., Craig, M. C., Murphy, D. G. M., Mc. Alolan, G. M. (2019) Father-infant interactions and infant regional brain volumes: A cross-sectional MRI study, *Developmental Cognitive Neuroscience 40,* 100721

Shulha H.P., Cheung I., Whittle C., Wang J., Virgil D., et al. (2012), Epigenetic signatures of autism: trimethylated H3K4 landscapes in prefrontal neurons, *Arch. Gen. Psychiatry 69*,314–24

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, *86*(2), 420–428. https://doi.org/10.1037/0033-2909.86.2.420

Steinberg, Danny D. (2003), Psycholinguistics: Language, Mind and World. *America: Longman Inc*

Talbott, M. R., Nelson, C. A., Tager-Flusberg, H. (2015), Maternal Gesture Use and Language Development in Infant Siblings of Children with Autism Spectrum Disorder, *J Autism Dev Disord 45*, 4–14

Volkmar, F., Siegel, M., Woodbury-Smith, M., King, B., McKraken, J., State, M., and the American Academy of Child and Adolescent Psychiatry (AACAP) Committee on Quality Issues (CQI) (2014), Practice Parameter for the Assessment and Treatment of Children and Adolescents With Autism Spectrum Disorder, *Journal of the american academy of child & adolescent psychiatry 53 (2)*

Wai Wan, M., Green, J., Scott, J. (2019), A systematic review of parent–infant interaction in infants at risk of autism, *Autism 23*, 811–820

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., Lord, C. (2004), Early Indicators of Autism Spectrum Disorders in the Second Year of Life, *Journal of Autism and Developmental Disorders 34.*

Wiggins, L. D., Rice, C. E., Barger, B., Soke, G. N., Lee, L. C., Moody, E., Edmondson-Pretzel, R., Levy, S. E. (2019), DSM-5 criteria for autism spectrum disorder maximizes diagnostic sensitivity and specificity in preschool children, *Social Psychiatry and Psychiatric Epidemiology 54*, 693–701

Yaari, M., Eventov-Friedman, S., Mankuta, D., Bar-Oz, B., Yirmiya, N. (2014). Prematurity and Autism Spectrum Disorders. 10.1007/978-1-4614-4788-7_75.

Yoon, S. H., Choi, J., Lee, W. J., Do, J. T. (2020), Genetic and Epigenetic Etiology Underlying Autism Spectrum Disorder, *J. Clin. Med. 9*, 966

Zwaigenbaum, L., Bryson, S., Lord, C., Rogers, S., Carter, A., Carver, L., Chawarska, K., Constantino, J., Dawson, G., Dobkins, K., Fein, D., Iverson, J., Klin, A., Landa, R., Messinger, D., Ozonoff, S., Sigman, M., Stone, W., Tager-Flusberg, H., Yirmya, M. (2009), Clinical Assessment and Management of Toddlers With Suspected Autism Spectrum Disorder: Insights From Studies of High-Risk Infants, *Pediatrics 123(5)*, 1383–1391