1 Hearing impairment and language acquisition

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1.1 Introduction

Children acquire language spontaneously and effortlessly and can completely master the language to which they are exposed within a period of few years.

Children have innate language-specific abilities that allow language acquisition to take place in the first years of life during which environmental exposure is fundamental to stimulate this innate proclivity (Chomsky 1975; Pinker 1994). It is therefore necessary for this innate component to be stimulated within a time window known as 'critical period', which as Lenneberg (1967) pointed out, extends from early infancy until puberty, when it becomes more difficult to acquire a language naturally. In this time window, children's brain is predisposed to build mental grammars.

As a matter of fact, several studies after Lenneberg revealed the existence of many time windows depending on the linguistic component considered (e.g. Ruben 1997; Meisel 2013; Friedmann, Rusou 2015). Moreover, the acquisition process was proven to start from birth, or even in the last months of pregnancy, and it is not clear at what age the critical period(s) should be considered closed.

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Friedmann and Rusou (2015) pointed out that different language components have different critical periods. New words can be learned at any age, even in adulthood, while for syntax, the input accessed during the first year of life is fundamental to adequately set the parameters of the language(s) to which each child is exposed. It is during this period that infants use the information they obtain from prosody, phonology, and words frequency to build up their syntax.

Some cases of late exposure to the linguistic input have indeed supported the existence of such a critical/sensitive period, as demonstrated by the children who lived socially isolated, who have grown in socially compromised conditions, or who were not diagnosed as hearing impaired (Friedmann, Rusou 2015). Two well-known examples of late exposure to the linguistic input are the cases of Genie (Curtiss 1977) and Chelsea (Curtiss 1989). Chelsea was born deaf from hearing parents in a town in California, but doctors and clinicians did not recognize her disability and diagnosed her as mentally retarded. Only when she was thirty-one, her hearing loss was finally diagnosed. She was fitted with hearing aids and began linguistic training. However, despite the hard rehabilitation period she endured, linguistically, she was compared to a ten-year-old child: even if she acquired the vocabulary of the language she was exposed to and developed communication skills easily, her mental grammar remained quite underdeveloped, allowing her to only produce ungrammatical sentences.

Hearing impairment inevitably affects the normal development of speech and language acquisition, because of the drastically reduced quantity and quality of linguistic input accessible to individuals with hearing impairment (Furth 1966). The difficulties that these people experience are essentially limited to the language domain.

Hearing impairment is among the most common disabilities of human beings. In 2018, the World Health Organization estimated that about 5.3% of the world's population was affected by hearing impairment. In our country, the number of Italians who was suffering from hearing loss at different degrees were about 8 million (about 12% of the country's population).

Approximately one child out of 1000 newborns is born with hearing impairment (Maragna 2000; Govaerts, Schauwers, Gillis 2002; Fabbro 2003), which seriously interferes with language acquisition and speech development, and hinders the full integration in school and society. Over half of early onset hearing loss and at least one third of late onset hearing loss, are to be attributed to genetic factors (Nadol, Merchant 2001).

This chapter introduces some general issues on hearing and hearing impairment. It gives an overview on how the ear works and how some peculiarities of hearing impairment may affect language acqui-

sition. A survey on how language is acquired in people with hearing impairment is also offered, with a focus on language development by Italian individuals with hearing impairment.

1.2 The hearing loss and the variables influencing language development

When damage occurs to the ear, individuals may suffer from hearing loss, sometimes with strong consequences on the development of linguistic abilities. The population of individuals with hearing impairment is extremely heterogeneous. Basically, the factors that influence language development in individuals with hearing impairment are numerous and complex: among them are the site of lesion, the age of onset of deafness and age of diagnosis, the severity of hearing loss, the age of first intervention, the parents' linguistic background and their choice on the educational approach to adopt in intervention in order for the child to access linguistic input. In the following sections, a brief description of all these variables will give the possibility to better understand hearing impairment and its consequences on language acquisition.

1.2.1 The human ear and the site of lesion

One of the variables that may influence language development is the area where the auditory damage is localized. For a better understanding of the damage localization, it is important to briefly sketch the structure of the human ear.

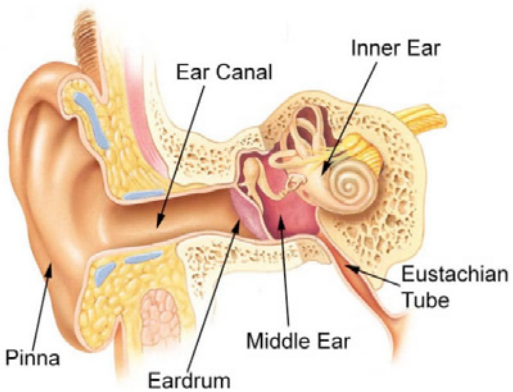

Figure 1 The human ear (https://slocountyhearingaids.com/how-the-ear-works/) (2019-10-07)

The human ear can be divided into three main sections: the outer ear, the middle ear, and the inner ear. Sound, which is transmitted as sound waves (vibration of the air), enters the outer ear *(pinna)*, and reaches the eardrum (tympanic membrane) after travelling through the external auditory canal. The eardrum is a delicate membrane that separates the outer ear from the middle ear and vibrates to sound waves, thus also causing the vibration of the three small bones behind it in the middle ear: the hammer *(malleus)*, the anvil *(incus)*, and the stirrup *(stapes)*. The vibration waves in the inner ear fluid causes the sensory (hair) cells in the inner ear (*cochlea* – a snail-shaped organ) to bend. The hair cells convert mechanical sound vibrations into electrical signals. These electrical signals are transmitted through the auditory nerve up to the brain, where they are interpreted as sounds.

Four types of hearing loss are identified, depending on the site where the lesion or the damage is localized (Quigley, Paul 1984):

- Conductive hearing loss: it is caused by diseases or obstructions in the outer or middle ear. It usually affects all frequencies of hearing to the same degree, and typically hearing impairment is moderate.
- Sensorineural hearing loss: it results from damage to the sensory hair cells of the inner ear or the nerves which supply it. Hearing impairment may range from mild to profound. It does not affect all frequencies in the same way. Certain frequencies are less affected than others.
- Combined hearing loss: it is attributed to a combination of conductive and sensorineural losses; therefore, the hearing deficit occurs in both the outer or middle and the inner ear.
- Central hearing loss: it results from damage either along the pathways to the brain or in the brain itself.

Among the four types of hearing impairment, the most frequent form is the sensorineural one (Soi, Brambilla 2003), while the central hearing loss is the rarest type.

1.2.2 Degree of hearing loss

Sound is measured by its loudness or intensity on a logarithmic unit called decibels (dB). Its frequency or pitch is measured in units called hertz (Hz).

Hearing can be measured from -10 to 120 dB. It is usually measured across a range of frequencies from 125 to 8000 Hz. Hearing thresholds refer to audiological measurement of unaided hearing in the better hearing ear. According to the BIAP (Bureau International d'Audiophonologie), normal hearing and degree of hearing loss fall into the following categories:

- 0 dB – 26 dB — normal hearing
- 26 dB – 40 dB — mild hearing loss
- 40dB – 70 dB — moderate hearing loss
- 70 dB – 90 dB — severe hearing loss
- >90 dB — profound hearing loss

The hearing threshold level for each ear is reported on an audiogram by plotting an individual's response threshold for each measured frequency. Here are two examples of audiograms, one for a person with normal hearing and one for a person with profound hearing loss:[1]

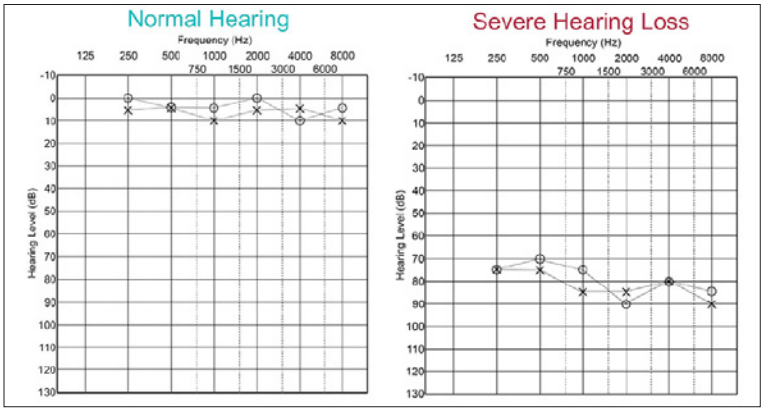

Figure 2 Audiograms of a person with normal hearing (left) and of a person with severe hearing impairment (right) (https://www.babyhearing.org/what-is-an-audiogramon, 2019-10-07)

The degree of hearing impairment is often represented as the average of the hearing thresholds for the four frequencies considered to be the most important for the reception of speech: 500, 1000, 2000 and 4000 Hz.

1.2.3 Types of hearing devices

Conventional hearing aids and cochlear implants are the devices available to individuals with hearing impairment in order to get access to the acoustic and linguistic input. These two hearing devices are different in their functions and use.

Conventional hearing aids (either analog or digital) usually amplify

1 The two audiogram examples are taken from: `http://www.schooltrain.info/deaf_studies/audiology2/levels.htm`. The line with 'x' identifies the left ear and the line with 'o' identifies the right ear.

sounds and perform much better in the coding of low sound frequencies, which contain mainly information related to tonality, musicality, timbre (temporal content). Conventional hearing aids are external devices helping people with hearing impairment to exploit their residual hearing and are more suitable for treating mild-to-moderate and severe hearing loss.

Cochlear implants are instead auditory devices that are surgically implanted in the inner ear (in the cochlea) and are activated by an external device, worn outside the ear. They stimulate the auditory nerve, thus allowing individuals with hearing impairment to perceive sounds, and are mainly conceived to code the mid and high sound frequencies (spectral content), since speech information is mainly contained in the range of these frequencies. Cochlear implants are more intended for children and individuals who suffer from severe to profound hearing loss (De Filippis Cippone, 2002; Govaerts 2004). Cochlear implants make it possible to reach high levels of speech intelligibility. They are however not suitable for music perception.

Individuals with sensorineural hearing loss may be fitted with either classical hearing aids (exploiting acoustic stimulation) or cochlear implants (exploiting electric stimulation) depending on the degree of hearing loss.

Various studies addressing the important issue of language acquisition in individuals with hearing impairment found that in children with cochlear implants, language develops faster than in deaf children without the cochlear implant (Tye-Murray, Spencer, Woodworth 1995; Miyamoto et al. 1999; Svirsky et al. 2000; Blamey et al. 2001), in some cases, with linguistic performance comparable to that of normal hearing children (Tomblin et al. 1999; Svirsky et al. 2000). For first language acquisition by English-speaking pre-lingually deaf children, cochlear implants have been proven to be much more efficient than hearing aids to enhance production skills (Kirk, Hill-Brown 1985; Parsier, Chute 1991; Chin, Pisoni 2000).

Regardless of the type of hearing device that individuals with hearing impairment receive, steady acoustic and linguistic training sessions are necessary for language development.

1.2.4 Age at onset of deafness

Onset of hearing loss is another important factor that may have consequences on the development of linguistic abilities.

Hearing impairment which is due to pre-birth causes is referred to as congenital and can be genetically inherited or acquired during pregnancy. Hearing impairment may also occur after birth. In this case, if it occurs before the age of three, namely before oral language is acquired, it is referred to as pre-lingual. If it occurs after that span

of time, it is defined as post-lingual. The distinction between pre-lingual and post-lingual deafness is crucial for the acquisition of oral languages. Although a child whose hearing impairment is diagnosed, for instance, at the age of six or seven and suffers from profound sensorineural hearing loss has the same degree of hearing impairment as a child who suffers from a congenital profound impairment, consequences on language development and communication are very different. Indeed, differently from pre-lingually deaf children, a child deafened at the age of six has had enough auditory experience to access linguistic input and fix most properties of the oral language in a natural way. Therefore, in most cases, post-lingual hearing impairment makes it possible to develop oral first language normally.

1.2.5 Parental background and approach to language development

The hearing status of parents is a crucial factor that influences the form of language or communication to which the deaf child is exposed during infancy and early childhood. Depending on the linguistic background and on the educational philosophy of his/her parents, a person with hearing impairment may be exposed to linguistic input consisting of oral speech, sign language, and/or some form of manually coded language. The possibilities available to make language accessible to people with hearing impairment are:

- the oralist method
- the sign language
- the bimodal method
- bilingual education

For children with hearing impairment born to hearing parents, the oralist approach is most frequently chosen. This approach exclusively exploits written and oral language modalities, without any use of signs. It aims at developing acoustic training and lip-reading, by means of conventional hearing aids or cochlear implants.

Sign languages are visual-gestural languages, which are considered full-fledged linguistic systems (Caselli et al. 1994; Newport, Supalla 1999). They have the same degree of expressiveness and grammatical complexity as any other language in the world (Klima, Bellugi 1979). The development of grammar rules in sign languages follows the same processes as acquisition of oral languages by children with normal hearing. Indeed, individuals with hearing impairment who are exposed to a sign language only at adulthood never perform as well as those who acquired it at very early stages of acquisition. Sign languages are the most natural languages of deaf communities. In Italy, children born to parents with hearing impairment (only 5-10%) are exposed to Italian Sign Language (LIS, henceforth) and can ac-

quire it naturally from their parents. On the other hand, children with hearing impairment born to hearing parents are hardly exposed to sign language from birth, and for them the oral education is mainly preferred. They might acquire the sign language later.

The bimodal approach combines the oral and the visual-gestural modalities, but it fundamentally follows the grammar rules of the oral language (in the case in point, Italian) (Beronesi, Massoni, Osella 1991). Thus, words are accompanied by signs, keeping the word order of the oral language. Some invented signs supported by the fingerspelling alphabet are used to mark those functional elements that do not have an equivalent sign (i.e., articles, prepositions, plural markers, inflected morphemes).

Bilingual education involves the simultaneous exposure to both the sign language and the oral language (in its written and oral modalities). Bilingualism is the knowledge and regular use of two (or more) languages. In the case of individuals with hearing impairment, it involves the simultaneous acquisition of both the oral and the sign language. The main assumption of this kind of approach is that children with hearing impairment acquire the sign language spontaneously, unlike what happens with a spoken language. Bilingualism must be considered a great resource for children with normal hearing who speak two oral languages. It is an even bigger richness for children with hearing loss. Indeed, it represents the only way for a child with hearing impairment to satisfy his/her own needs, that is, to be able to communicate early with his/her parents, develop his/her cognitive abilities, acquire knowledge of the world, communicate and interact with people with either normal hearing or hearing impairment.

The importance of a bilingual approach has been highlighted by different studies (a.o., Wie et al. 2007; Bertone, Volpato 2009; Jiménez, Pino, Herruzo, 2009; Grosjean 2010; Davidson, Lillo-Martin, Chen Pilcher 2014; Rinaldi, Caselli 2014). Wie et al. (2007) showed that Norwegian-speaking children with hearing impairment who were exposed to both sign and oral language had very good outcomes in activities assessing oral language speech perception. A study carried out on Spanish-speaking children directly compared children with cochlear implants who exclusively received an oralist education and children who followed a bilingual approach. The group of bilingual children obtained significantly higher scores than the other group of children in verbal fluency favoured by the easy access to lexicon thanks to the use of sign language (Jiménez, Pino, Herruzo 2009). Davidson, Lillo-Martin, Chen Pilcher (2014) compared 5 children with cochlear implants born to deaf signing parents with a group of hearing children born to deaf parents and exposed to both American Sign Language (ASL) and English. The children with cochlear implants were exposed to ASL from birth, and to English after implantation. The group of children with cochlear implants and the group of nor-

mal hearing children showed comparable performance on different standardized language measures. Improvement in vocabulary skills was observed for an Italian-speaking deaf child exposed to Italian Sign Language and spoken Italian (Rinaldi, Caselli 2014). The number of signs and words used by the child increased as the child progressively grew older, showing a level of lexical development comparable to that of hearing peers. Bertone and Volpato (2009) focused on the linguistic competence and morpho-syntactic abilities in Italian of four groups of participants with hearing impairment: a group of children with cochlear implants, a group of adolescents who are native LIS signers, a group of non-native LIS signers, and a group of foreign students who arrived in Italy at a later stage of language acquisition. The group of children with cochlear implants obtained the highest scores in comparison with the other three groups. However, among the other three groups, native LIS signers showed the best performance. Results confirmed that an educational system combining both an oral and a signed approach would make it possible for a child with hearing impairment to fully develop the grammar of the oral language.

The coexistence of both experiences, although much debated, does not hinder the development of the oral language (as people which favour an oralist approach would point out); instead, it facilitates children's development of linguistic, cognitive, and communication skills.

1.3 The relationship between clinical variables and linguistic outcomes

The population of individuals with hearing impairment is very heterogeneous, with consistent inter-individual differences. Linguistic outcomes of individuals with hearing impairment are very heterogeneous. In some cases, atypical and delayed linguistic profiles are identified; in other individuals, language skills develop normally and comparably to age peers. As shown in the preceding sections, many variables may interact with each other and explain the variability of linguistic outcomes, among them age of hearing-loss onset, age of diagnosis, degree of hearing loss, age of intervention, type and length of use of the hearing device, family background, and type of education, mainly depending on the family background. Many studies have tried to find out whether a correlation exists between the level of linguistic competence attained by individuals with hearing impairment and their clinical data. However, which factors predict accuracy in language skills and how all these variables interact with each other and influence language development is still highly debated.

Although it is generally acknowledged that hearing impairment may hinder the development of normal linguistic abilities, the role

of the degree of hearing loss in language acquisition is still unclear. Various studies investigating the relationship between the degree of hearing loss and receptive or productive skills across different oral languages have not yet found any correlation between the two factors (Fry 1966; Gilbertson, Kahmi 1995; Wolgemuth, Kamhi, Lee 1998; Blamey et al. 2001; Norbury, Bishop, Briscoe 2001, 2002; Tuller, Jakubowicz 2004; Friedmann, Szterman 2006).

Blamey et al. (2001) investigated speech perception and linguistic skills in a group of 87 children with moderate, severe, and profound hearing loss, in order to identify whether the degree of hearing loss and the age at which hearing impairment occurs might influence performance. The degree of hearing loss only correlates with abilities in speech perception, but not with language scores. Similar findings were also offered by Norbury, Bishop, Briscoe (2001, 2002) for English-speaking children with mild-to-moderate hearing loss. These authors demonstrated that a relation could be established between age and language performance (older children performed better than younger children), but again no correlation was observed between language scores, degree of hearing loss, and age of hearing loss detection.

For French, Tuller and Jakubowicz (2004) explored the comprehension and production skills of 20 children with degrees of hearing loss ranging from 37 to 64 dB. Different grammatical aspects of French were investigated, namely the use of determiners, clitic pronouns, and verbal morphology. High inter-subject variability was found. Hence, in the individuals with hearing impairment, some properties were deficient, and some others were less or not at all affected, but these phenomena were not correlated with the degree of hearing loss, nor with the age of detection of hearing loss, nor with the age of fitting of hearing aids.[2]

Friedmann and Szterman (2006) investigated the comprehension and production of relative clauses and topicalization sentences in Hebrew-speaking children with moderate, severe and profound hearing loss ranging from age 7;7 to 11;3. Results demonstrated that children with hearing impairment failed to understand object relatives and topicalization sentences, but, as in other studies, these difficulties were not associated to the degree of hearing loss. Interestingly, a positive relationship was observed between early detection of hearing loss, early intervention and fitting of hearing aids and performance on comprehension tasks.

Different findings were obtained by Delage and Tuller (2007), who explored the relationship between hearing loss and language out-

2 In Tuller and Jakubowicz (2004), only an age effect was found, therefore younger children showed more linguistic difficulties than older children.

comes measured using standardized and non-standardized tasks. Difficulties with the French language were found especially in the domain of phonology and grammar. The scores obtained by the adolescents with mild-to-moderate hearing impairment significantly correlated with degree of hearing loss.

Much recent research showed that many English-speaking children with hearing loss may achieve skills comparable to those of their hearing peers in both receptive and expressive language, if inclusive intervention programs are provided very early, by 6 months of age (Apuzzo, Yoshinaga-Itano 1995; Yoshinaga-Itano et al. 1998).

Moeller (2000) investigated the relationship between age of enrolment in intervention and vocabulary skills at the age of 5 in a group of 112 children with mild to profound sensorineural hearing loss. She found a significant negative correlation between the two factors, namely children undergoing early intervention programs (before 11 months of age) demonstrated better language scores at 5 years of age as opposed to children enrolled later (e.g. after 11 months of age). The level of vocabulary development was comparable to that of their hearing peers. Another variable that significantly contributed to explaining a large amount of variance in the linguistic competence was the involvement of family. Parents involved in the intervention program were found to communicate better with their children and to contribute more to the child's progress than parents who did not participate in the program.

While severity of hearing loss was not found to correlate with linguistic results, age of intervention, and especially early intervention is the variable that seems to play the major role. Boothroyd et al. (1991) observed that about 43% of children who received the cochlear implant at the age of 2 managed to reach a good level of linguistic competence at the age of 8-9, whereas only 16% of children fitted with a cochlear implant before the age of 4 manage to attain a good linguistic competence. Friedmann and Szterman (2006) pointed out that children (either wearing conventional hearing aids or using a cochlear implant) whose hearing loss was detected before the age of 8 months showed good performance in the comprehension of complex syntactic structures.

Focusing primarily on individuals using a cochlear implant, early intervention and early activation of this device are two factors that contribute to account for the variability observed in this population as far as linguistic outcomes are concerned. Some studies report that children who received a cochlear implant early in their life and had prolonged experience with cochlear implants achieve spoken language abilities comparable to those of normal hearing children (Svirsky et al. 2005; Connor et al. 2006; Geers 2006). The importance of early intervention and early device application was confirmed by Oller and Eilers (1988), Moeller (2000), Schauwers, Gil-

lis, and Govaerts (2005), and Johnson and Goswami (2010). These authors show that early intervention favours the achievement of phonological awareness and receptive vocabulary growth, and in general reduces the linguistic delay of individuals with cochlear implants. According to Yoshinaga-Itano, Baca, Sedey (2010), some early implanted children do even learn language more quickly than typically developing children. Hammes et al. (2002) showed that children who received a cochlear implant before 18 months of age showed spoken language skills comparable to age-peers. The need for early intervention is also supported by Ledeberg and Spencer (2005) and Nicholas and Geers (2006), who suggest the existence of a critical period for implantation according to the age-related plasticity of the brain. Spencer (2004) claims that such plasticity must be exploited before the age of three years and a half.

There is no agreement on what "early" means, since different ages for implantation are identified depending on the domain and the linguistic properties investigated (Guasti et al. 2014). Using a perception test, Fryauf et al. (1997) found that children implanted before five years of age performed better than children who received the implant after that age. Hayes et al. (2009) found that children receiving early cochlear implantation, namely by the age of two years, show a substantial vocabulary growth which allows them to achieve receptive lexical skills within the average range for normal hearing children. Similar good outcomes in vocabulary development are reported by Geers et al. (2009).

Miyamoto et al. (2008) concluded that implantation occurring before the age of 2;6 years has positive effects on the development of general language abilities. Using spontaneous speech collections and a standardized test investigating expressive and receptive language, Nicholas and Geers (2007) found that children implanted between the age of 12 and 16 months were more likely to achieve spoken languages skills comparable to hearing age-peers. Children who receive a cochlear implant at the age of three may experience great difficulties in obtaining results comparable to normal hearing age-peers. Manrique et al. (2004) investigated lexical and general grammar skills and observed that children implanted before 2 years developed language more easily than those implanted after that age. Using a standardized comprehension test, Nikopoulos et al. (2004) found that children with hearing impairment showed levels of performance comparable to hearing peers if they received a cochlear implant before the age of 4, as opposed to those who underwent cochlear implantation later.

As for Italian, Caselli et al. (2012) investigated lexical-phonological and morpho-syntactic skills in children ranging in age from 3;9 to 5;5. They showed that cochlear implant activation has positive consequences for the lexical domain as it can promote the rapid ini-

tial acquisition and development of vocabulary. They found that children whose cochlear implant was activated in the second year of life showed very good language skills, even though comprehension abilities were not comparable to same-age peers, and some difficulties in the phonological and morphosyntactic areas can still be observed. Guasti et al. (2014) tested a group of children (age range: 4;2-6;10) who received their cochlear implants between the age of 1;0 and 4;8 years and found a correlation between age of implantation and accuracy scores in the production of clitic pronouns.

Other studies (Hodges et al. 1999; Connor et al. 2000; Tobey et al. 2000; Geers 2002; Geers et al. 2002; Osberger, Zimmerman-Phillips, Koch 2002; Geers, Brenner, Davidson 2003; Tobey et al. 2003) have shown that other factors (e.g., duration of cochlear implant use, amount of rehabilitation, device technology, educational setting) explained the variability in children with cochlear implants in different speech and language measures.

In the research carried out during my PhD, in addition to investigate whether and to what extent children with cochlear implants differed from normal hearing children in relative clause comprehension and production, it was verified whether the clinical variables investigated in previous studies (duration of cochlear implant use, age of hearing aid fitting, age of implantation) are predictors of performance in these tasks. The analysis of results is presented in chapters 3 and 4.

1.4 Language development in individuals with hearing impairment

Cross-linguistic research demonstrated that individuals with hearing impairment might show deficits in different domains of language acquisition (phonology, lexicon, semantics, morphosyntax and pragmatics) in comparison to hearing controls. Differences between children with hearing impairment and children with normal hearing may be already observed during the babbling stage.

Babbling represents the first form of linguistic production, which appears in the first months of life in children with normal hearing. At approximately 6 to 10 months of age, they start producing simple combinations of vowel and consonant sounds in well-formed syllables (papapa, dadada). Children with hearing impairment also babble, although they begin to babble with some delay compared to normal hearing children (Oller, Eilers 1988; Eilers, Oller 1994; Moeller et al. 2007). The first babbles produced by these children seem to suggest that this behaviour occurs in all children, regardless of their hearing status. However, if early vocalizations observed in children with hearing impairment appear to sound like those of normal hearing chil-

dren, after few months, they tend to decrease, clearly differing from those of children with normal hearing (Marschark 2009). The characteristics of babbles in children with hearing impairment seem to depend on the degree of hearing loss. Indeed, children with mild levels of hearing loss were observed to develop babbling differently from children with severe or profound hearing loss (Rvachew et al. 1999; Moeller et al. 2007). This is probably due to better perception of the speech signal in the case of low levels of hearing loss. Moreover, in children who received their cochlear implant between the age of 5 and 20 months, babbling started few months after the device activation (Schauwers et al. 2004; Colletti et al. 2005; Schauwers, Gillis, Govaerts 2008). This proves that these children start babbling at an age comparable to normal hearing peers, and from a qualitative point of view, their vocalizations are also very similar to those of age peers.

As for the investigation of vocabulary skills in individuals with hearing impairment, results are very controversial. Much research carried out on populations with hearing impairment showed that vocabulary is reduced in these participants in comparison to normal hearing peers. Early exposure to the linguistic input (either signed or spoken) during infancy was found to be fundamental for individuals with hearing impairment to develop lexicon adequately and easily, and to develop language (Mayne, Yoshinaga-Itano, Sedey 2000). However, in most cases, vocabulary knowledge is low, vocabulary acquisition is delayed, receptive and productive vocabulary is poor, and new words are acquired at slower rates (Moeller, Osberger, Eccarius 1986; Schirmer 2000; Lederberg, Spencer 2001; Lederberg 2003; Paul 2009; Lund 2016). Moeller, Osberger, and Eccarius (1986) showed that children with hearing impairment aged 13 to 20 years were comparable to 9-year-old children with normal hearing in receptive vocabulary. Ledeberg (2003) found that English-speaking children with hearing impairment have a lower rate of acquisition of words than hearing children, even when they wear cochlear implants or have consistent amplification and high-quality programming. Some children learn new words very slowly, differently from normal hearing children, for whom the vocabulary size increases very rapidly. In some cases, the lexical skills of children with cochlear implants were found to be comparable to those of normal hearing children (Caselli et al. 2012; Young, Killen, 2002). Caselli et al. (2012) found that young Italian-speaking children with cochlear implants performed comparably to normal hearing age peers in lexical production. Lexical comprehension was instead more problematic. In a different study on Italian children with cochlear implants, Chilosi et al. (2013) showed different findings. In these participants, expressive vocabulary was delayed, when related to chronological age. However, when related to the length of exposure to the language, expressive vocabulary showed faster development than receptive vocabulary.

If compared to vocabulary learning, morpho-syntactic development is even more delayed. Overall, individuals with hearing impairment frequently show poor syntactic knowledge, especially in the morphosyntax domain and, particularly, in the use of complex syntactic structures. Adolescents with hearing impairment show difficulties with syntactic rules even after long exposure to the oral language. Normally, acquisition of syntax seems to depend on the input from 'face-to-face' interactions, but the grammatical elements that are necessary to learn functional categories are unstressed and carry minimal semantic information (De Villiers, De Villiers, Hoban 1994). Markers such as inflectional morphemes, determiners, and pronouns are less perceptually salient in the speech stream than content words.

Cross-linguistically, much research has found that individuals with hearing impairment avoid producing complex structures, preferring short and simple sentences, and experience difficulties in the comprehension of complex syntactic structures, in the use of derivational and inflectional markers, noun and verb agreement, and functional elements, such as prepositions, determiners, auxiliaries, and pronouns, the presence of which are crucial to correctly interpret a sentence (a.o., for Dutch, Hammer 2010; Verbist 2010; Hammer et al. 2014; for English, Quigley, Paul 1984; De Villiers, Pomerantz 1992; De Villiers, De Villiers, Hoban 1994; Berent 1996; Spencer, Barker, Tomblin 2003; Geers et al. 2009; for French, Tuller 2000; Tuller, Jakubowicz 2004; Delage, Tuller 2007; Delage 2008; for German, Szagun 2004; Ruigendijk, Friedmann 2017; for Hebrew, Tur-Kaspa, Dromi 1998, 2001; Friedmann, Sztermann 2006; 2011; for Italian, Caselli et al. 1994; Taeschner, Devescovi, Volterra 1988; Volterra, Bates 1989; Fabbretti, Volterra, Pontecorvo 1998; Fabbretti 2000; Ajello et al. 2001; Volterra, Capirci, Caselli 2001; Franchi 2004; Chesi 2006; Fabbretti, Tomasuolo 2006; Bertone, Volpato 2009; Caselli et al. 2012; Guasti et al. 2014).

In English, among the most frequent errors for individuals with hearing impairment are omissions of tense inflections (present, past, or present progressive) in obligatory contexts (De Villiers, Pomerantz 1992; Berent 1996). Hebrew-speaking children with hearing impairment made errors in number and gender agreement between verbs and nouns and between adjectives and nouns (Tur-Kaspa, Dromi 1998). In German, Szagun (2004) showed that the use of articles is problematic, as shown by the frequent omission of these functional elements, as well as by the recurrent gender mistakes. German children using cochlear implants also experienced difficulties with case and gender agreement between articles and nouns (Szagun 2004). Verbist (2010) observed that Dutch-speaking children with a cochlear implant show a deficit in the use of weak pronouns in comparison to normal hearing children.

1.5 Language development by Italian-speaking individuals with hearing impairment

Focusing on Italian, most studies were mainly concerned with the assessment of linguistic skills in individuals fitted with conventional hearing aids (a.o., Taeschner, Devescovi, Volterra 1988; Rampelli 1989; Volterra, Bates 1989; Caselli et al. 1994; Emiliani et al. 1994; Fabbretti 2000; Ajello et al. 2001; Volterra, Capirci, Caselli 2001; Bigoni et al. 2003; Chesi 2006; Franchi 2004; Volpato 2008; Rinaldi, Caselli 2009; Volpato 2010a). Basically, all the above-mentioned studies show that children with hearing impairment experience difficulties with receptive and productive vocabulary, and morphosyntactic properties of simple structures as well as with complex sentences including passive sentences and relative clauses. They omit and substitute determiners, prepositions, auxiliary verbs, and clitic pronouns, they incorrectly add determiners, and they omit copulas. They frequently make gender and number agreement errors, and they show difficulties with verbal inflections, thus producing agreement errors between the subject and the finite verb (Caselli et al. 1994; Maragna 2000).

Caselli et al. (1994) investigated lexical and morphosyntactic abilities of 25 children with hearing impairment with different degrees of hearing loss (mild, severe, and profound), ranging in age from 2;6 to 11 years and attending nursery and primary schools in Rome. Their linguistic abilities were assessed by using lexical tasks of picture naming and identification, and grammar tasks investigating morpho-syntactic properties of nouns and verbs. For the youngest participants, the percentage of correct determiner-noun agreement between the article and the noun was 42%, and the percentage of incorrect agreement was 19%. The percentage of omissions was 30%, and 9% was the percentage of substitution of the definite article with an indefinite one. As for instances of incorrect agreement, in most cases (50%), the errors regarded incorrect number agreement (singular is used instead of plural, mainly for feminine) and incorrect gender agreement (feminine is used instead of masculine 33% of times). In the task investigating the use of number morphology on nouns, children produced 60% of correct responses. The performance by the oldest children showed a higher percentage of accuracy. Correct responses ranged between 88% and 100% for singular nouns and between 85% and 100% for plural nouns. The percentage of correct selection of definite articles is between 74% and 98% for singular nouns and between 73% and 91% for plural nouns. Children experienced some difficulties mainly in the use of plural features on nouns, especially on those ending in *e*. Indeed, singular nouns ending in *e* were treated as plurals (for instance the word *fiore* was produced instead of *fiori*). The use of number (plural) morphology is al-

so often problematic on verbs, and the third person plural marker is substituted by the correspondent singular (for instance, the word *dorme* '(he) sleeps' for *dormono* '(they) sleep').

A sentence repetition task including sentences of variable length and syntactic difficulty (Devescovi et al. 1992) was administered to a group of participants with hearing impairment to investigate simple sentences (e.g. *il bimbo piange* 'the child cries'), sentences containing the lexical verbs *be* and *have* (*il nonno ha il cappello* 'the grandfather has the hat', *la macchina è rossa* 'the car is red'), sentences containing adjectival or adverbial modifiers (*il cane guida la macchina rossa* 'the dog drives the red car'), and sentences containing negation (*la bambina non mangia la pappa* 'the child does not eat the food'). In this task, the rate of correct responses for the youngest participants was 52%. Incorrect responses contained both omission (90%) and substitution (10%) errors in the use of determiners, nouns, verbs, auxiliaries, prepositions, and negation particles. Prepositions were the most omitted categories (33%), while the elements showing the lowest rate of omission were nouns (11%). The highest percentage of substitutions concerned verbs (80%). The percentage of correct repetitions for the group of older participants with hearing impairment was also quite low (67%), considering that younger normal hearing children repeat these items correctly when they are 3;6 years old (Devescovi et al. 1992). Both omissions (74%) and substitutions (26%) were found. Again, most errors concerned the use of 'free morphology', especially the production of determiners and prepositions.

For a more in-depth investigation of the use of prepositions, a comprehension and a production task were administered to the oldest children. As for the production task, 66% of sentences contained the correct preposition. In 9% of the sentences, the children omitted the preposition or substituted the correct one with an incorrect one. 25% of responses did not correspond to the target sentence and did not contain any preposition. In the comprehension task, the group with hearing impairment showed a rate of correct responses of 87%, whereas the percentage of accuracy in the normal hearing group is 99%. The most problematic preposition was *da* (from) (17% of errors), and the less problematic was *dentro* (in) (4% of errors). The performance of the children with hearing impairment was comparable, both from a qualitative and a quantitative point of view, to that of hearing children ranging in age from 2;6 to 4-5 years (Caselli et al. 1993, Caselli et al. 1994).

Chesi (2006) investigated the oral and written production of a group of 13 children with severe and profound hearing loss ranging in age from 6 to 17 years. He investigated the use of articles and accusative, dative, and reflexive clitic pronouns and found that the main tendency for all participants was to systematically omit these

elements. The rate of correct clitic forms was 48% in oral productions and 52% in written productions. Enclitic pronouns were omitted more than proclitic ones, confirming a tendency also found in Taeschner, Devescovi, Volterra (1988) and Fabbretti (2000). The best strategy in order to avoid the use of a clitic pronoun was to repeat the lexical object or to omit the clitic pronoun altogether. However, when the clitic pronoun was produced, correct agreement between the clitic pronoun and its antecedent, correct case assignment, and correct placement were observed. Although problematic, the use of clitic pronouns in proclitic and enclitic position made it possible to infer that children were nonetheless able to distinguish between finite and non-finite verb forms. As for articles, definite forms were more frequently produced than indefinite or partitive ones. The highest rate of omissions was in the postverbal position (95%) (*Tom scivola e rompe ø piatti* 'Tom slips and breaks *ø* dishes', instead of *Tom scivola e rompe* ***i*** *piatti* 'Tom slips and breaks *the* dishes'). The most problematic article form was masculine plural (41%), followed by masculine singular (35%), feminine singular (18%) and feminine plural (6%).[3] Although the productions showed a high percentage of errors and non-standard forms, interestingly, the different constituents of the determiner phrase followed the restrictions fixed by their hierarchical order, and consequently their linear order (e.g. *tre ragazze sorda* 'three girls deaf.FEM.SG' meaning 'three deaf girls', but never *ragazze tre sorda* 'girls three deaf.FEM.SG'). In the verbal domain, failed agreement between subject and verb was found. Errors mainly concerned person (the third person was the most used form – *Dove va tu?* 'Where is you going?') and number features (singular used instead of plural – *È mio carte* '(it) is mine.MASC.SG papers.FEM.PL). Compound tenses were only attested in a small number of productions. Auxiliary verbs were correctly used, although some substitutions of the verb *essere* 'to be' with *avere* 'to have' were attested. Optional infinitives were used instead of the finite forms, and tense and agreement verbal morphology were sometimes expressed by other elements, namely lexical subjects, pronominal subjects, adverbs (*poi dopo mettere così* 'then to put so', *dopo fare i compiti io* 'then to do homework I').

Some attempts to produce more complex sentences, namely relative clauses, were identified, although the complementizer *che* was often replaced by coordinating particles (as was noticed for English by Quigley, Paul 1984): e.g. *(il formaggio) lo butta verso un vetro del comodino e si rompe* '(He) throws it (the cheese) against a bedside table glass *and* it breakes' instead of: *(il formaggio) lo butta verso un*

3 That feminine plural is the most preserved form is also shown in Volpato (2008). In the elicited production of clitic pronouns by adults with hearing impairment, the feminine plural clitic pronoun *le* 'them' has the highest percentage of correct responses.

vetro del comodino che si rompe '(He) throws it (the cheese) against a bedside table glass, *which* breaks'.

Rinaldi and Caselli (2009) assessed language development in 20 pre-schoolers with hearing impairment fitted with conventional hearing aids (5 with moderate hearing loss, 5 with severe hearing loss and 10 with profound hearing loss), comparing their performance to that of 40 children with normal hearing, 20 matched on chronological age and 20 matched on time of formal exposure to the oral language. Early grammar skills and comprehension and production of spoken vocabulary were assessed by using a questionnaire to be filled in by the children's parents. The questionnaire included a "Vocabulary" and a "Sentences" section. The lexical section investigated the comprehension and production of both nominal and verbal content words (*cane* 'dog', *dormire* 'to sleep'), and function words (*perché* 'why', *ancora* 'more'). The section assessing morphosyntax investigated the child's ability to produce sentences and the level of completeness in sentence production. The results demonstrated that children with hearing impairment showed a significant delay in both vocabulary and grammar, if compared to same-age children. The group of children with hearing impairment produced fewer and shorter sentences, and in most cases, they omitted functional elements, thus showing a pattern of performance comparable to that of younger normal hearing children, namely those matched on duration of hearing experience.

Emiliani et al. (1994) found that in grammatical comprehension, most errors were identified in the comprehension of closed class words, while fewer errors were detected in the domain of inflectional morphology.

Beronesi and Volterra (1986), Rampelli (1989), and Volterra and Bates (1989) analysed the linguistic competence of adolescents and adults with hearing impairment. Beronesi and Volterra (1986) analysed the written and spoken production of five adolescents, and Volterra and Bates (1989) that of a congenitally deaf woman with profound hearing loss. The participants with hearing impairment had poor vocabulary and tended to use short and syntactically simple structures. They experienced difficulties in the use of free morphology, namely determiners, pronouns and prepositions, which were mostly omitted or replaced by other elements thus making the sentence ungrammatical. Similar results were reported by Rampelli (1989) on the comprehension skills of a group of adults with hearing impairment. These individuals proved to have poor receptive lexical abilities and, from a morphosyntactic point of view, difficulties in the interpretation of passive and reversible sentences. The lack of a normally developing phonetic-phonological system was claimed to be the reason for the difficulties the individuals with hearing impairment had in the comprehension and use of closed class words in oral languages (Volterra, Bates 1989).

As said above, the studies presented so far were mainly concerned with participants with conventional hearing aids. In addition, the participants involved in all these studies were assessed using standardized measures, or in some cases, questionnaires filled in by parents.

More recent linguistic research has focused on the assessment of language competence by children with cochlear implants. In addition to studies in which the overall lexical and grammatical abilities were assessed using standardized tasks (e.g. Volpato 2010b; Caselli et al. 2012; Chilosi et al. 2013), a number of studies have developed experimental tasks to investigate the competence of specific complex structures of Italian in children with cochlear implants (Volpato, Adani 2009; Volpato 2010b; Volpato 2011; Volpato 2012; Guasti et al. 2014; Volpato, Vernice 2014).

Volpato and Adani (2009) is the first study investigating the competence of specific syntactic properties of Italian in children with cochlear implants. As I show in detail in chapter 3, this study assessed the comprehension of subject and object right-branching relative clauses by 8 children with cochlear implant (age range: 6;9-9;3; mean age 7;9). Their performance was compared to that of younger children matched on morpho-syntactic abilities, younger children matched on receptive vocabulary, and age-matched children. Volpato (2012) used a similar task but different materials to investigate the role of number features in the comprehension of right-branching relative clauses in 13 children with cochlear implant, older than in the previous study (age range: 7;9-10;8), comparing their performance with a group of younger children of comparable linguistic age. In the same group of children with cochlear implants, Volpato (2011) and Volpato and Vernice (2014) also investigated the production of relative clauses. Guasti et al. (2014) used a non-standardized measure to test the production of sentences containing accusative clitic pronouns in a group of young children with cochlear implants (age range: 4;2-6;10). These children showed lower performance than age-matched peers. In most cases, they omitted the clitic pronouns or produced sentences in which the lexical object was used instead of the clitic pronouns.

For Italian, studies on the assessment of the linguistic competence of children with cochlear implants are still scarce, especially as far as the production and comprehension of complex syntax. This volume aims at presenting in detail the recent research that has been carried out on the acquisition of complex structures, in particular relative clauses, by children with cochlear implants, and by adolescent LIS signers.