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Research paper

SPEECH AND LANGUAGE SKILLS OF MALTESE CHILDREN WITH BILATERAL COCHLEAR IMPLANTS: THREE CASE STUDIES

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Abstract. The purpose of this study was to document the speech and language skills of three Maltese children with bilateral cochlear implants. One child was simultaneously implanted and had a hearing age (HA) of 2;10 years at the time of testing, another was sequentially implanted and had a HA of 3;06 years, while the third child was sequentially implanted and had a HA of 5;03 years. Maltese standardised speech and language assessments were used to gather information on the children's speech and language skills, with data being collected during their speech and language therapy sessions. Following data transcription and analysis, the participants' speech and language abilities were compared to those of their HA- and chronological age (CA)-matched peers using available norms for Maltese children. Additional information regarding the children's speech and language history prior to and post-implantation was also collected, providing a holistic overview of the participants' speech and language development. Results indicated that the children presented with speech and language delay when compared to their CA-matched peers. Variations across the participants were found in specific language skills. Similarities in language patterns were also noted, including expressive abilities in advance of receptive skills. These findings extend the limited data on the speech and language skills of Maltese children with cochlear implants, with comparison to norms for typically-developing children being a novel approach to research in this area.

Keywords speech, language, hearing loss, Maltese children, cochlear implants, bilingualism

1 Introduction

In order to receive language input, children mainly rely on their hearing abilities. If the latter are impaired, a temporary or permanent hearing difficulty may result. Sensorineural hearing loss (SNHL) is a permanent type of hearing impairment that has often led to fitting of hearing aids. However, depending on the severity of the hearing loss, the latter may not be ideal because they amplify but do not clarify incoming sound for the hearing-impaired individual (Welling, 2010). Thus, in cases where the individual is unable to comprehend spoken language through conventional hearing aids, cochlear implants (CIs) might be an alternative (Roland, 2000). Indeed, CIs are a major technological attainment to treat deafness (Niparko et al., 2010). They allow the development of auditory skills in naturalistic, albeit supported environments and are able to support the acquisition of speech, language and communication (Archbold, 2002).

Children with a unilateral CI are reported to have difficulty understanding speech in noise and localising sound (Scherf et al., 2009). Bilateral implantation can overcome these limitations. Various researchers (e.g. Battista & Highhouse, 2011; Dunn et al., 2008; Litovsky et al., 2006; Sammeth, 2007; Therres, 2012) assigned three effects to binaural listening as a result of bilateral implantation, namely the head shadow effect, the binaural summation effect and the binaural squelch effect. In the head shadow effect, both ears are active. The ear with the more favourable signal-to-noise ratio (SNR) is immediately accessible and the person can selectively attend to this ear (Therres, 2012). Binaural summation enables the individual to perceive the sounds presented to both ears louder. Specifically, an improvement of 3 dB is known to occur for binaural listeners, leading to better speech perception (Therres, 2012). Furthermore, when input is received from both ears, the brain and the auditory system will be able to combine inputted information from both ears and produce a better central representation, providing a clear separation of the speech and noise signals (Therres, 2012). This is referred to as the binaural squelch effect. With these reported benefits, the cochlear implant enhances the individual's hearing experience which, as a result, would help the acquisition of speech and language.

Individuals with bilateral implants are implanted either sequentially or simultaneously. Sharma et al. (2007) compared the P1 latency, an evoked potential which analyses the auditory cortical response to auditory stimuli, in 20 children who received a bilateral implantation during the first 3;06 years of life. Ten children had a simultaneous implantation while the rest received sequential bilateral implants. In both groups, the average P1 latency was measured on implant activation and at two-month intervals post-implantation up to 15 months. The P1 latency for both groups was within normal limits by 3.5 months post-implantation. This suggests that any bilateral implantation that occurs within the first 3;06 years takes place within a highly plastic central auditory nervous system.

Despite the sensitive time proposed by Sharma et al. (2007), several studies have shown that there should be no age limit for the second implantation. Scherf et al. (2009) observed the auditory abilities and speech performance of 35 children with sequen-

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tial bilateral CIs following three years of bilateral implant use. CIs offered improved auditory skills to all children, even those sequentially implanted after the age of 6;00 years, although it emerged that the latter took longer than those implanted before the age of 6;00 years to demonstrate bilateral benefit. The older children, that is, those implanted after the age of 6;00 years, obtained better speech recognition levels. Additionally, at two to three years post-bilateral implantation, almost all children benefited in noisy situations.

In another study, Kim, Kim and Jeong (2013) investigated the functional benefits of sequential bilateral cochlear implantation in 42 children having a mean inter-stage interval of 5;06 years between the two implants. Average ages were 4;02 years at the first implant and 9;07 years at the second implant. The participants were grouped according to the inter-stage intervals. The second and third group, those with an inter-stage interval of 5;00 and 6;09 years, and 7;00 and 9;09 years respectively, obtained comparable results in both quiet and noise tests to the first group, who had a shorter interval of 3;00 and 4;09 years, two years following bilateral use. Additionally, speech performance in noise improved even in the older children following prolonged use of bilateral CIs. These results show that the binaural hearing experience plays an important role in the speech outcome.

On the other hand, simultaneous implantation enhances children's speech and language acquisition and decreases their ability difference in comparison to their chronological age (CA)-matched peers. Wie (2010) investigated a group of 21 children with cochlear implants two years post-simultaneous implantation. The majority of these acquired receptive and expressive language skills at a faster pace than expected in comparison to their hearing age (HA)-matched peers.

Apart from the type of implant, language skills depend on the severity of the SNHL, the age of identification and implantation, as well as the child's cognitive abilities (Welling, 2010). For example, Niparko et al. (2010), who studied 188 children who underwent cochlear implantation before the age of five, reported greater rates of improvement in children with better residual hearing and higher socioeconomic status. Additionally, Geers, Nicholas and Sedey (2003), who studied 181 8;00- and 9;00-year-old children who also received a cochlear implant by the age of five, found that the child's learning ability contributed greatly to the linguistic outcome. Participants with average learning ability were reported to show language levels similar to those of their HA-matched peers. Similar findings were reported for two Maltese children with a cochlear implant (Tabone, 2004). However, Geers et al. (2003) further stated that children with average or above average intelligence performed similarly to their CA-matched peers. Together, these results show that the linguistic outcome is multifactorial.

Speech production is influenced by the child's age at onset of deafness, time of implantation as well as the mode of communication and rehabilitation (Robbins, 2000). CIs improve speech perception and intelligibility (Robbins, 2006), both of which eventually improve speech production. In the two Maltese children with CI studied by Tabone (2004), speech development was identified as delayed, implying typical developmental stages emerging with a time lag, rather than as deviant. Furthermore, the Maltese-speaking child observed by Xuereb (2004) at 4;06 years post-implantation experienced speech and language delay when compared to her CA-matched peers on tests of speech and language. However, the tests used in both case studies were not standardised on the Maltese-speaking population, so interpretations of results need to be considered as tentative.

Importantly, speech and language assessments standardised on the Maltese hearing population have recently become available, enabling comparative evaluation of the speech and language skills of children with CIs in relation to those of Maltese hearing children. Such a comparison was the purpose of the current study. The following research questions were addressed:

1. What speech and language skills are manifested by three Maltese children with bilateral CIs?
2. Are the speech and language skills of these three Maltese children comparable to those shown by HA- or CA-matched typically-developing children?

More specifically, the study documented the participants' phonetic inventory, phonological error patterns, inconsistency in word production, verbal comprehension and expression, aiming to identify their strengths and weaknesses. It also sought to determine whether their skills were the same as, similar to or different from the speech and language abilities documented in a normative sample of Maltese children. This information was needed to indicate whether the speech and language development of the three Maltese participants with CIs was age-appropriate, delayed or deviant in relation to hearing children, while acknowledging the limited generalisability of results to other Maltese children with CIs.

2 Methods

2.1 Participants

All speech-language pathologists working in the public health service were asked to distribute an information sheet among potential participants in their current or previous caseloads. Children considered as potential participants had bilateral cochlear implants, a HA ranging between 2;00 and 6;00 years and were Maltese-English bilinguals. Children reported to have other developmental disabilities were excluded. Three children having a HA in the range of 2;10-5;03 years were identified as participants. Table 1 lists background information on each child.

2.2 Research design

A multiple case study design was implemented. Since this design is known to enable researchers to investigate real-life events holistically (Yin, 2009), its implementation in this study allowed the chosen participants to be studied in depth. The status of their speech and language development was assessed through the use of standardised assessments and results were analysed quantitatively and qualitatively. Furthermore, previous audiology and speech and language progress reports were accessed for background information that could help in the interpretation of results.

2.3 Method

All data were collected by the first author. Background information was obtained by reviewing the participants' medical and audiology file. Details on their hearing assessment results and implantation were noted. Their HA was subsequently calculated. Speech and language data were then collected through the use of two standardised assessments, outlined below, which enabled each participant's scores to be compared with population norms.

The Maltese-English Speech Assessment (MESA) (Grech, Dodd & Franklin, 2011) assesses speech and taps into articulation, phonology, consistency, diadochokinesis, consonantal clusters and multisyllabic words, as well as single oral movements and sequenced movements. In the present study, only the articulation, phonology and consistency subtests were administered. The articulation and phonology subtests involved naming 42 coloured pictures eliciting all the English and Maltese vowels and consonants (Grech & Dodd, 2008). This enabled compilation of their phonetic inventory and the tabulation of phonemes. Percentage Consonants Correct (PCC) and Percentage Vowels Correct (PVC) scores were calculated and error patterns were described and analysed. In the consistency subtest, the participants were to name 17 pictures, three times on separate trials. An inconsistency score was then computed.

Table 1. Background information on the participants chosen for the study

	Child 1	Child 2	Child 3
Chronological age (CA) during time of assessment (years)	4;08	6;10	7;06
Hearing age (HA) during time of assessment (years)	2;10	3;06	5;03
Type of implantation	Simultaneous bilateral	Sequential bilateral	Sequential bilateral
Chronological age (CA) at first implant (years)	1;10	3;04	2;03
Chronological age (CA) at second implant (years)	1;10	5;10	3;01
Interval between both implants (years)	- -	2;06	0;10
Language acquisition*	Sequential bilingual	Sequential bilingual	Simultaneous bilingual
Primary language	Maltese	Maltese	English
Gender	Male	Male	Female

*Child 1 and Child 2 were referred to as sequential bilinguals since, in line with Iglesias and Rojas's description (2012), they were predominantly exposed to Maltese (L1) from an early age and then to English (L2) at school. Child 3 was referred to as simultaneous bilingual following Genesee's (1989, cited in Iglesias and Rojas, 2012) definition of concurrent acquisition of more than one language during the time of primary language development. In fact, she was consistently exposed to both Maltese and English at home, although English input was reported to be more predominant.

The Language Assessment for Maltese Children (LAMC) (Grech, Franklin & Dodd, 2011) examines language skills, tapping into verbal comprehension, narrative vocabulary and grammar, sentence imitation, phonological awareness and pragmatics. It also includes a voice and fluency checklist. Participants were administered the verbal comprehension, narrative vocabulary and grammar subtests. They were first asked questions related to the story previously narrated by the assessor using a picture stimulus book. They were subsequently encouraged to retell the story with the help of the stimulus book.

Child 1 and Child 2 were assessed at their Speech and Language Clinic. Child 3, who no longer needed speech and language therapy, was assessed at home. Child 1 and 3 completed both assessments in one session, which took approximately 1.5 hours. Since Child 2 was noted to be distracted following the first part of assessment, the test battery was spread over two sessions lasting an hour each. Assessment duration was typical as during the standardisation of MESA and LAMC, administration of each test lasted up to 60 minutes. Assessment sessions were audio-recorded. Information from the children's speech and language file about performance during previous speech and language therapy sessions was also recorded. These details provided a holistic background to the quantitative speech and language data collected. The participants were free to speak in their preferred language during assessment. The primary language was taken to be the language used spontaneously and predominantly by the child. The speech data were transcribed phonetically while the language data were transcribed orthographically.

2.4 Ethical considerations

Prior to commencing data collection, the study was approved by the University of Malta Research Ethics Committee, ensuring that the participants' rights were safeguarded. The legal guardians of the potential participants were given an information sheet through their speech-language pathologist, explaining the children's potential involvement in the study. For Child 3, the information sheet was passed on through the speech-language pathologist previously working with the child. Upon understanding the children's involvement in the study and agreeing to their participation, parents completed a consent form.

3 Results

Descriptive statistics, including raw scores, means, standard deviations, z-scores and percentiles for each participant on every speech and language subtest, were calculated. The children's individual performance was compared to that of typically-developing HA- and CA- matched peers involved in assessment standardisation. However, the available norms for both assessments cover the 3;00-6;00-year age group, with the exception of the verbal comprehension subtest, for which norms begin at 2;06 years. Grech, Franklin and Dodd (2011) explain that children aged 2;00-2;06 years carried out only a small part of the language assessment. The resulting data did not warrant further analysis. Consequently, given Child 1's actual HA of 2;10 years, he was compared to HA-matched peers aged 3;00 years. Analogously, Child 2 and Child 3, whose actual CAs were 6;10 and 7;05 years respectively, were both compared to CA-matched peers aged 6;00 years, as this was the ceiling age of both assessments.

When the MESA was standardised, children were divided into monolingual and bilingual groups. As defined by Grech, Dodd and Franklin (2011), the monolingual group consisted of children exposed to Maltese at home and to English at school, whilst children in the bilingual group had simultaneous exposure to both languages at home. Hence, the results of Child 1 and 2 were compared to the monolingual group norming data, whilst Child 3's data were compared to the bilingual group.

Each participant's phonetic inventory was determined first. According to Ingram (1981, cited in Grech, 2006), a criterion for a sound to become part of the child's inventory is its frequency, in that it has to occur at least once in a mixture of 25 words selected at random. The phonetic inventory was noted from the articulation subtest of the MESA by listing the sounds that the child produced. These sounds are hereafter referred to as phones. The number of phonemes was subsequently counted from performance on the phonology subtest. For a sound to be considered a phoneme it should be used regularly and contrastively and it should occur in minimal or near minimal pairs (Grech, 2006). The phonology subtest also enabled calculation of the PCC and PVC scores. Finally, the inconsistency score was derived from the participants' inconsistent production of words on the consistency subtest.

Table 2. Child 1's PCC, PVC and inconsistency scores (means and standard deviations (SD) quoted from the MESA manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
		PCC			
HA: 2;10 years	91.45	89.6	9.20	0.201	58
CA: 4;08 years	91.45	97.23	2.68	-2.157	2
		PVC			
HA: 2;10 years	98.99	99.18	3.29	-0.058	48
CA: 4;08 years	98.99	99.89	0.35	-2.609	0.5
		PVC without outlier			
HA: 2;10 years	100	99.18	3.29	0.250	60
CA: 4;08 years	100	99.89	0.345	0.320	63
		Inconsistency Score			
HA: 2;10 years	29.41	15.05	18.59	0.748	77
CA: 4;08 years	29.41	4.03	7.79	3.258	100

Table 3. Child 1's phonological error processes, frequency of occurrence and age at which they are expected, based on data by Grech, Dodd and Franklin (2011)

	Phonological Error Processes		
	Error Processes	Frequency	Typically expected
Systemic Error Processes	Voicing	2	3;00 - 3;05 years
	Backing	2	3;00 - 3;05 years
	Fronting	2	3;00 - 6;00 years
	Lateralisation of /r/	2	3;00 - 4;11 years
	Nasalisation	1	MEP*
Structural Error Processes	Weak syllable deletion	1	3;00 - 3;05 years
	Final consonant deletion	1	3;00 - 4;11 years
	Initial consonant deletion	1	3;00 - 3;11 years
	Compensatory vowel lengthening	1	MEP*
	Consonant harmony	1	MEP*
	Epenthesis	1	MEP*
	Gemination reduction	1	MEP*
	Cluster formation	1	MEP*

*Minimally used error pattern (MEP): an error pattern used by less than 10% of children between 3;00 and 6;00 years

3.1 Child 1

Child 1 produced a complete phone repertoire, 22 phones, which included all the Maltese consonants documented by Azzopardi (1981) (cited in Borg & Azzopardi-Alexander, 1997). Given the child's CA (4;08 years) and Grech and Dodd's (2008) MESA results indicating that both sequential and simultaneous Maltese-English bilingual children produce all phones by 4;00 years, this was an expected finding. Therefore, Table 2 shows Child 1's raw scores on the MESA speech subtests in comparison to his HA- and CA-matched peers and Table 3 lists his phonological error processes. In the light of his CA, Child 1 should have mastered the majority of the adult phonemes (Grech, Dodd & Franklin, 2011). The child did show a complete phonemic inventory by producing 22 phonemes. Yet, his phonological system was still developing, with his performance similar to that of his HA-matched peers. On PCC, he scored close to the average of his HA-matched peers yet well below average in comparison to his CA-matched peers. A similar performance was noted on PVC. Although Child 1 performed below average in PVC when compared to both groups, there was a slight difference between his raw score and the mean score for both age-matched groups. This was due to an omitted vowel. Without this outlier, the child would have obtained a full score. Also, the possibility of an inconsistent phonological disorder was eliminated as the child obtained an inconsistency score lower than 40% (see Grech, Dodd & Franklin, 2011). However, the discrepancy between the child's score and the mean score for both age groups seems to suggest that he was still learning the Maltese and English phonological systems. As discussed by Grech and Dodd (2008), inconsistent production increases with initial exposure to two languages.

Child 1 produced five systemic and eight structural error processes. None were considered frequently-used error patterns. Yet, they are potential error patterns. When compared to his HA-matched group, seven error processes used by the child were all typically used at 3;00 years. Alternatively, when compared to his CA peers, voicing, backing, weak syllable deletion and initial consonant deletion should have been eradicated by the age of 4;08 years. Furthermore, half the error processes used by Child 1 (see minimally used error patterns

Table 4. Child 1's scores on verbal comprehension and narrative ideas (means and standard deviations (SD) quoted from the LAMC manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
Verbal Comprehension Score					
HA: 2;10 years	11.50	10.61	3.38	0.263	60
CA: 4;08 years	11.50	16.80	1.87	-2.834	0.2
Narrative Ideas Score					
HA: 2;10 years	14	0.92	1.44	9.083	100
CA: 4;08 years	14	9	6.14	0.814	79

Table 5. Child 2's PCC, PVC and inconsistency scores (means and standard deviations quoted from the MESA manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
PCC					
HA: 3;06 years	96.32	93.35	6.47	0.456	68
CA: 6;10 years	96.32	95.53	5.58	0.135	55
PVC					
HA: 3;06 years	98.85	99.99	0.02	-57	0
CA: 6;10 years	98.85	100	0*	-	-
PVC without outlier					
HA: 3;06 years	100	99.99	0.02	0.5	69
CA: 6;10 years	100	100	0*	-	-
Inconsistency Score					
HA: 3;06 years	35.29	10.60	14.96	1.65	95
CA: 6;10 years	35.29	3.19	6.65	4.827	100

*A standard deviation of 0 indicates no variation around the mean score, so that the z-score and percentile could not be computed.

(MEP) in Table 3) were typical between 2;00 and 3;00 years, as documented in Grech's (1998) study. This further suggested delayed phonological development in comparison to the child's CA. Child 1's verbal comprehension and narrative ideas scores are shown in Table 4.

Child 1 understood simple commands and 'why' questions. However, comprehension of 'who' and 'what' was difficult. Therefore, his understanding of wh-questions was still emerging. As documented by Sax and Weston (2007), typically-developing children between 2;00 and 3;00 years comprehend and produce simple wh-questions. However, Friedmann and Szterman (2011) reported that the understanding and production of wh-questions of 11 Hebrew-speaking children, some of whom were fitted with binaural hearing aids and others with a CI, was weaker compared to typically-developing children. Child 1 also understood basic colour terms, but knowledge of numbers and counting was still emerging.

Child 1's expression was mainly in Maltese. He used proper names and target lexical nouns appropriately with correct singular and plural forms. Various lexical target verbs and the definite and assimilated article were also employed appropriately. There was evidence of the use of the Maltese negative form *mhux* (not), the English lexeme 'no' and spatial and pronominal use of deictic expressions. On 90% of occasions, he produced correct person and number agreement and adequate sentence structures. On the other hand, Child 1 made limited use of adjectives and adverbs, conjunctions, prepositions, direct and indirect pronouns. He did not use possessives and showed gender agreement difficulties. The masculine form was used for 90% of the time. Infrequent and incorrect use of feminine forms possibly indicated their emergence at the time. A similar trend was documented by Coppini (2002), who investigated gender agreement between nouns and adjectives in Maltese children.

3.2 Child 2

Child 2 produced 22 phones, which made up a complete phone repertoire in view of his HA (3;06 years) and CA (7;10 years). Table 5 shows his raw scores on the MESA speech subtests in comparison to his HA- and CA-matched peers. Table 6 lists the phonological error processes.

Child 2 produced 22 phonemes, thus he had also developed a complete phonemic inventory. However, his phonological development was still emerging. On PCC, Child 2 performed moderately and slightly above average compared to his HA- and CA-matched peers respectively. Furthermore, on PVC, the slight difference between the child's score and that of the normative population was mainly due to the incorrect production of /mɛrɐ/ (mirror), for which he said /mɐrɐ/ (woman). Without this outlier, Child 2 obtained a full score, further indicating no vowel difficulty. His inconsistency score indicated a higher possibility of an inconsistent disorder.

Child 2 exhibited a chronological mismatch in the phonological processes observed. He produced five systemic error processes and no structural error processes. When compared to his HA-matched group, Child 2 produced developmental phonological processes typical of children younger than his HA. Alternatively, when compared to his CA-matched peers, backing, voicing and stopping should have been eliminated by 3;11 years. Therefore, a phonological delay was observed. Conversely, as expected by his CA, Child 2 did not exhibit structural error processes. Thus, he followed some patterns expected at 6;10 years.

Child 2's verbal comprehension and narrative ideas scores are shown in Table 7.

Child 2 understood simple commands and 'why' questions. Comprehension of 'where' and 'what' questions, as well as knowledge of numbers and counting was emerging. He made appropriate regular lexical choices of nouns and produced the Maltese negative form *ma* (verb)*x*. He made regular and adequate use of articles and conjunctions. On 90% of occasions, he also made correct verb choices and used adequate pronouns. The direct object was used appropriately but infrequently, on less than 30% of occasions. Child 2 showed correct gender, number and person agreement. On the other hand, he replaced proper names with nouns and made adequate use of prepositions while omitting others. His use of adjectives and adverbs amounted to less than 30% of their required usage. He rarely employed spatial deictic expressions and sentence structure was occasionally disrupted. The indirect object was incorrectly used due to person and number disagreement and possessive terms did not emerge.

Table 6. Child 2's phonological error processes, frequency of occurrence and age at which they are expected based on data by Grech, Dodd and Franklin (2011)

	Phonological Error Processes		
	Error Processes	Frequency	Typically expected
Systemic Error Processes	Backing	3	3;00 - 3;05 years
	Devoicing	1	3;00 - 3;05 years
	Stopping	1	3;00 - 3;11 years
	Delteralisation of /l/	1	MEP*
	Frictation	1	MEP*

*Minimally used error pattern (MEP): an error pattern used by less than 10% of children between 3;00 and 6;00 years

Table 7. Child 2's scores on verbal comprehension and narrative ideas (means and standard deviations (SD) quoted from the LAMC manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
Verbal Comprehension Score					
HA: 3;06 years	10.5	14.87	2.50	-1.748	4
CA: 6;10 years	10.5	17.21	2.43	-2.761	0.2
Narrative Ideas Score					
HA: 3;06 years	16	2.88	3.19	4.113	100
CA: 6;10 years	16	16.86	6.30	-0.137	45

Table 8.Child 3's PCC, PVC and inconsistency scores (means and standard deviations quoted from the MESA manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
PCC					
HA: 5;03 years	100	99.34	2.21	0.299	62
CA: 7;06 years	100	99.18	1.24	0.661	75
PVC					
HA: 5;03 years	100	99.94	0.21	0.280	61
CA: 7;06 years	100	99.74	0.83	0.313	62
Inconsistency Score					
HA: 5;03 years	5.88	0.45	1.63	3.331	100
CA: 7;06 years	5.88	1.32	2.62	1.740	96

Table 9. Child 3's verbal comprehension and narrative ideas scores (means and standard deviations (SD) quoted from the LAMC manual) with the equivalent z-scores and percentiles derived for HA- and CA-matched peers

	Raw Score	Quoted Mean	Quoted SD	Derived z-score	Derived Percentile
		Verbal Comprehension Score			
HA: 5;03 years	18.5	19	1	-0.500	31
CA: 7;06 years	18.5	18	1.41	0.355	64
		Narrative Ideas Score			
HA: 5;03 years	35	29.33	4.04	1.403	92
CA: 7;06 years	35	23	7.07	1.697	96

3.3 Child 3

Child 3 produced 23 phones. As expected for her HA (5;03 years) and CA (7;05 years), Child 3 produced all phones reported by Azzopardi (1981) (cited in Borg & Azzopardi-Alexander, 1997) including the voiced velar nasal [ŋ] which pertains to English phonology. Table 8 shows her raw scores on the MESA speech subtests in comparison to her HA- and CA-matched peers.

Child 3 produced 23 phonemes, thus showing availability of a complete phonemic inventory. She obtained full score in PCC and PVC. When compared to her age-matched groups, she performed above average. Additionally, Child 3 exhibited no phonological error patterns.

Table 9 shows Child 3's verbal comprehension and narrative scores. Just like typically-developing children, Child 3 was able to attend to the story while replying correctly to the questions asked. She understood simple commands, basic colour terms and why-questions. She had mastered the knowledge of numbers and counting. Her responses to questions during the comprehension subtest showed evidence of verbal reasoning. Yet, she did not understand the spatial term 'on'. Child 3 made good lexical choices of nouns, verbs, adjectives and adverbs. She produced the negative 'not', together with lengthy and informative sentences. Conjunctions, prepositions, pronouns, articles, possessive determiners, as well as gender, person and number agreement, were adequately used. Conversely, no deictic terms were employed by the child.

4 Discussion

The aim of this study was to describe and evaluate the speech and language skills of three children with bilateral CIs, to derive information on their strengths and weaknesses in relation to their HA- and CA- matched peers. The participants were assessed using three speech and two language subtests of the MESA and LAMC respectively, all of which were standardised on the Maltese population. Discussion of results follows and acknowledges the potential influence of each child's internal characteristics, learning environment and speech and language therapy on their speech and language performance.

Child 1 followed typical speech development. Yet, his scores indicated that he was on a par with his HA group whilst delayed when compared to his CA-matched peers. This was consistent with Tabone's (2004) and Xuereb's (2004) conclusions on the speech development of Maltese children with CI. On the verbal comprehension subtest, Child 1 performed within the average range compared to his HA-matched peers. Caselli et al. (2012) reported similar trends in lexical comprehension for 17 Italian children who received a CI at 2;00 years of age.

The child's generation of expressive ideas on narrative was excellent when compared to his HA-matched peers. Performance was above average when compared to his CA-matched peers. Therefore, at 2;10 years post-simultaneous bilateral implantation, the child's expressive skills were progressing well. This concurred with Wie's (2010) findings that the majority of children simultaneously implanted acquire both receptive and expressive language skills at a faster pace than expected in comparison to their HA. As observed from the reviewed files, the family members provided good support to the child. This was well reflected in his expressive language, which was developing at a steady pace. Additionally, it was reported by his speech-language pathologist that co-operation, motivation and carryover of therapy in the natural environment contributed to the child's positive prognosis. Furthermore, the fact that the child was given a shared learning support assistant (LSA) from kindergarten years enhanced and supported his educational needs. The speech-language pathologist liaised with the child's LSA to consolidate the child's learning in both the school and clinical contexts.

Child 2's speech development followed the pattern of typically-developing children. Nevertheless, his scores were similar to his HA-matched peers and sometimes even slightly delayed in comparison. He exhibited typical phonological error processes with a chronological mismatch, since he used error processes from different age groups with inconsistent production of words. The latter might be indicative of incomplete knowledge of two phonological systems. It seems reasonable to associate high variability in speech production with children having the least hearing experience. However, this was still evident at the HA of 3;06 years, reflecting instability in adult-like word production.

Child 2's performance on verbal comprehension was considerably poor when compared to both age groups. His difficulty understanding wh-questions was possibly due to the delayed auditory stimulation of 3;04 years. In fact, his audiology file reported that his left ear, being the worse one, was implanted at 3;04 years while he was wearing the right hearing aid on a full-time basis. Yet, as documented in his audiology file, Child 2 seldom made use of this hearing aid. He received his second implant at 5;10 years. Scherf et al. (2009) observed improved auditory skills even in children receiving their second CI after the age of 6;00 years. Yet, older children obtained comparable results two years following bilateral use. In the case of Child 2, bilateral use had been in effect for one year. This suggests that further bilateral experience was required.

In contrast, Child 2's narrative ideas were excellent when compared to his HA-matched group and slightly below average when compared to his CA-matched peers. This discrepancy between his receptive and expressive skills is not what is normally experienced by a typically- developing child. The wh-questions were likely to have impeded his performance on the comprehension subtest. From the assessments carried out by his speech-language pathologist, the child showed understanding of commands with two to three information carrying words. Therefore, rewording of the comprehension assessment questions and substitution of words like *'bniet'* (girls) with simpler ones might have possibly enhanced his performance. However, since both assessments used are standardised, this was not possible.

Additionally, Child 2 had few instances of unintelligibility which might have been due to the manifestation of systemic error processes. Allen, Nikolopoulos and O'Donoghue (1998) concluded that children with CI continue to develop intelligibility even after five years of implantation. Also, during the speech and language therapy sessions following implantation, emphasis was placed on the production of Ling sounds (/ɐ/, /ʊ/, /i/, /m/, /ʃ/, /s/) and thus, not all the speech sounds were targeted. This might have also possibly contributed to unintelligibility in the production of words. As in the case of Child 3, speech and language therapy targeted all the speech sounds in all the different word positions and also within sentences.

Child 3 showed typical speech skills. Her performance was similar to her CA-matched peers. Yet, unexpectedly, Child 3 obtained a higher percentile when compared to her CA than when compared to her HA-matched group. However, Grech and Dodd (2007) noted a dip in the phonological developmental profile of 5;00-5;05-year-old typically-developing bilingual children (Child 3's HA-matched group). Thus, the child's performance was typical for her HA. Moreover, she showed adequate phonological proficiency in both Maltese and English. This could have been due to her early exposure to both languages.

The language subtests also showed Child 3 to perform better in comparison to her CA- than to her HA-matched group. This led to the reliability of the derived equivalent z-scores and percentiles being queried. As discussed in the LAMC manual, z-score accuracy may be low when used for smaller samples (Grech, Franklin & Dodd, 2011). The English norming group to whom Child 3 was compared was small ($N = 30$) compared to the Maltese group ($N = 205$).

Child 3 performed well above average compared to both groups of age-matched peers. She had outgrown her HA peers and performed closely to her CA-matched peers. Her hearing experience of 5;03 years might have influenced her skills, given that she had the longest exposure to language when compared to the other participants in this study. In fact, Schramm, Bohnert and Keilmann (2010) concluded that children with CIs increase their linguistic abilities with their HA, that is, the longer the child is fitted with cochlear implants, the better the linguistic outcome. Furthermore, Child 3 was the only female participant in the study. Schramm et al. (2010) observed that better language competence was developed by females, possibly indicating that this factor might have played a role in her linguistic performance.

Interestingly, and unlike the other two participants, it was revealed by Child 3's file that following the diagnosis of hearing loss, she attended sessions with a teacher of the hearing-impaired, during which she was taught baby signs. It was reported that the child immediately picked up the signs and used them communicatively. Having the means to communicate from an early age might have therefore limited the gap in relation to her CA-matched peers. Also, following the implantations, Child 3 attended speech and language therapy sessions on a weekly basis. At the time of testing, the child did not attend therapy as speech and language difficulties were no longer reported. Furthermore, although Child 3 performed similarly to her CA-matched peers (6;00 years), her actual CA was 7;06 years. Thus, one needs to be cautious when interpreting her results, as a fair and accurate comparison would have ideally involved her actual CA.

It is acknowledged that this study presented with shortcomings which could not be controlled. These called for cautious interpretation of results. Data on Maltese children with bilateral CIs were not available. Thus, reference was made to sparse data on Maltese children with unilateral CI and comparison was then made to results of foreign research studies. However, exact comparisons could not be carried out due to the different languages and methodologies used. Data on Maltese typically-developing children were also limited. Moreover, generalisation of the results was not possible due to the case study design and the individual variability across the participants, which might have contributed to the differences in scores. Therefore, each participant was analysed and discussed separately.

5 Conclusion

The results of the current study shed light on the speech and language performance of three Maltese children with bilateral CIs. These findings are preliminary and cannot be generalised. However, with respect to the three participants, it appears that cochlear implantation provides relevant auditory information that helps develop oral communication. It was concluded that two of the participants presented with delayed but typical speech development, whilst the third child performed on a par with her CA-matched peers. With increased CI experience, phonetic accuracy improved. Additionally, the expressive language score was higher than verbal comprehension for all participants. It emerged that the earlier the cochlear implantation, the shorter was the gap in sequential implants. Moreover, better speech and language outcomes were observed with increased experience with CIs. Results showed that early cochlear implantation enabled the participants to engage in a typical school environment with their HA-matched peers.

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8 Conflicts of Interest

The authors report no conflicts of interest.

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