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# From 1-word to 2-words with cochlear implant and cued speech: A case study

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**Abstract**
This paper describes early language development in a deaf Spanish child fitted with a cochlear implant (CI) when she was 1;6 years old. The girl had been exposed to Cued Speech (CS) since that age. The main aim of the research was to identify potential areas of slow language development as well as the potential benefit of CI and CS. At the beginning of this research the child was 2;6 years (she had been using the CI for 12 months). Adult–child 30-minute sessions were videotaped every week for 1 year (13–24 months of CI use), and transcribed according to CHAT norms. Measures of phonemic inventory, intelligibility, lexicon, and grammar development were obtained. Part of the data were compared with data from two normally hearing (NH) children with the same mean length of utterance (MLU). In order to confirm trends observed during these 12 months of observation, an extra set of data was obtained in the next 3 months (25–27 months of CI use). Results in the initial 12 month period (13–24 months of CI use) showed irregular language development in the deaf child. The development of her phonemic inventory and lexicon progressed at a rate that was similar to, or faster than, that of NH children. However, the slow acquisition of articles and also the slow development of MLU suggested that the child might have problems with grammar. Data from the next 3 months (25–27 months of CI use) confirmed this trend. Results are discussed in relation to similar studies in other languages. Potential benefits of CS are also discussed.

**Keywords:** *Cochlear implant, Cued Speech, Spanish language acquisition, grammar, phonology*

## Introduction

Until 10 or 15 years ago, linguistic development in deaf children was often late, slow, and incomplete (Santana, Torres, & García, 2003). The main reason for such atypical developmental behaviour was the poor linguistic input that these children received in their first years of life. The increase in the use of cochlear implants (CI) by very young children has notably changed the scenario in which deaf children acquire language. The CI considerably increases the auditory input received by the child, and, thereby, provides important benefits for perception (e.g. Blamey, Sarant, Paatsch, Barry, Bow, Wales, Wright, Psarros, & Rattigan, 2001; Geers, Brenner & Davidson, 2003), production (e.g. Blamey, Barry, Bow, Sarant, Paatsch, & Wales, 2001; Horga & Liker, 2006), linguistic

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development (e.g. Ertmer & Mellon, 2001; McDonald Connor, 2006) and intelligibility (Descourtiex, Groh, Rusterholtz, Simoulin, & Busquet, 1999).

However, there is some variation in the reported benefits offered by CIs. While some children seem to catch up quickly with NH peers, other children might not benefit as much from CI use. Benefit seems to be more evident for some domains (i.e. lexicon) than others (i.e. grammar). Thus, there is considerable variability between subjects, and between linguistic domains.

### *Variability between CI subjects*

Several researchers have investigated the factors that might explain variability between CI children. These factors include, but are not limited to, age at implantation (e.g. Kirk, Miyamoto, Lento, Ying, O'Neill, & Fears, 2002; Osberger, Zimmerman-Phillips, & Koch, 2002; Nicholas & Geers, 2006), pre-implant experience with audition (e.g. Spencer, 2004; Nicholas & Geers, 2006), communication mode (e.g. Geers, Brenner, Nicholas, Uchanski, Tye-Murray, & Tobey, 2002; Kirk et al., 2002), and family characteristics (Spencer, 2004). In general, the likelihood of success is greater when implantation takes place before 2 or 3 years of age, if the child had some audition experience, and if in the post-operative period the family and education setting favours oral input. However, it has been suggested (Pisoni & Cleary, 2003) that these demographic variables account only for ~45–60% of the existing variance in outcome measures. Pisoni and Cleary (2003) show that cognitive factors, such as differences in working memory capacity and efficiency, also influence language outcomes.

### *Variability within linguistic domains*

Benefits of CI are not the same for all linguistic domains (Spencer, 2004). Generally, data about acquisition of phonetic inventories are very positive, even in children implanted over the ages of 3 or 4. For instance, Serry and Blamey (1999) studied the phonetic inventories of nine English-speaking children before implantation and during the first 4 years of implant use. All children were 5 years old or younger at the time of implant. The authors found the trend in phone acquisition was the same as that of NH children, though the process occurred at a slower rate. Barry, Blamey, and Fletcher (2006) obtained similar results with Cantonese children implanted at a mean age of 4;5 years.

Lexical development is another area where CI users might have important advantages (Spencer, 2004), especially when the implant is fitted before the age of 2 (see Nicholas & Geers, 2005). Using the PPVT-III to test receptive vocabulary plus analysis of a spontaneous language sample, Nicholas and Geers (2005) found that children implanted before 19 months of age acquired lexical items at a rate near that expected of hearing children. Children receiving implants between 19–24 months showed somewhat slower vocabulary acquisition. Those receiving implants after 24 months of age showed even more delay. In this study, all children were assessed at the age of 3;5 years, so duration of cochlear implant use differed.

Contrary to what has been observed in phonetic inventory and lexicon development, data about grammar acquisition are not so positive (Szagun, 2000; 2001; Svirsky, Lynne, Ying, Lento, & Leonard, 2002; Le Normand, 2004; Spencer, 2004). In a longitudinal study with German children, Szagun (2000, 2001) found that mean length of utterance (MLU) increase was significantly slower in deaf children, compared with NH children. In-depth examination of the grammar of a subgroup of children whose lexicon was rich showed differential progress in some areas of morphology. Children with CI did nearly as well as NH children in acquiring noun plurals and verb inflectional morphology on the main verb. However, they acquired substantially fewer forms of the definite and indefinite articles, particularly case inflected forms, and of the copular and modal verbs. Results in this subgroup are striking because they do not show a relation between lexicon and grammar acquisition. Szagun suggests that the deficit might be due to a processing deficit stemming from pre-implant auditory deprivation.

Le Normand (2004) studied language development in a group of French-speaking CI children. She compared lexical and grammatical development in children implanted between the ages of 2 and 4. Results showed the rate of lexical development to be considerably quicker than that of grammar acquisition.

Svirsky et al. (2002) studied grammar competence in a group of English-speaking deaf children. They examined three morphemes: noun plural, the uncontractible copula, and the regular past tense. NH children acquire noun plurals first, and the use of the uncontractible copula and regular past tense follow. Scores for eight out of nine of the deaf children in the study were higher for the copula than for the noun plural. The authors explain these results as a consequence of poor perception. The CI children might be missing acoustically non-salient particles.

The studies described above provide us with a general picture of language development in CI children. They have shown that the outcome in CI children may be affected by conditions prior to CI fitting (e.g. individual cognitive factors, auditory experience), by age at surgery, and also by post-CI environment (e.g. oral input and parental involvement). They have also shown that, when a delay is observed, it might be more important in morphosyntax than in other areas. However, data is very scarce, both in terms of the number of languages studied, and in terms of the linguistic aspects that have been examined. For instance, current research in English, French, and German does not provide a clear pattern of the error types that one might encounter. Note also that different explanations have been proposed (e.g. perceptual deficit, working memory deficit), and each explanation would predict different grammatical deficits. More data are needed to be able to test theoretical hypotheses. Furthermore, such data would also be most helpful for language therapists.

## Critical variables for the present case study

This case study focuses on the linguistic development in a Spanish CI child. The period that is examined starts when the first two-word utterances are produced. Two variables of this child's context require special attention, as they will guide the observation. The first is the oral language (Spanish). The next subsection will summarize some of the phenomena observed in NH children in this period of linguistic development. The second variable is the augmentative communication system (Cued Speech).

### *From 1-word to 2-words in NH Spanish children*

NH children produce their first two-word combinations between 18–24 months approximately. At the beginning of this period, and before they start to combine two words, they must have basic linguistic (phonology, lexicon) and communicative skills. In this period these skills will improve considerably, and the acquisition of other skills (morphology, syntax) will start. The phonetic inventory of the 18-month old Spanish child typically includes all vowels, most occlusive, and some nasal consonants (Serra, Serrat, Solé, Bel, & Aparici, 2000). In the following months the child acquires most of the remaining consonants.

When the NH child is 18 months old, his/her lexicon typically has 50 or more words. In the following months the vocabulary size increases considerably (Serra et al., 2000; Owens, 2001). Despite individual differences, first two-word combinations are already present in most children when they are 24 months old. In many languages, one of the first productive combinations is an article plus something else (Nelson, Hampston, & Shaw, 1993). In Spanish, as in other Romance languages, article+noun combinations occur very early, at least earlier than in German or Dutch (Lleó & Demuth, 1999; Guasti, de Lange, Gavarró, & Caprin, 2003). These facts motivate interest in articles as early indicators of grammar acquisition. Spanish has a relatively complex article system. There are distinctive forms for masculine and feminine of both singular and plural definite and indefinite articles (see Table I).

The development of articles is preceded in the child by the use of filler syllables or protoarticles (Peters & Menn, 1993). Protoarticles are phonologically imprecise and unstable syllables that appear in the position that should be occupied by an article, i.e. [u] or [o] in the place of the English article 'the'. Protoarticles are more frequent in Spanish and other Romance languages than in English, German, or Dutch (Lleó & Demuth, 1999; Guasti et al., 2003). In Spanish protoarticles are typically a sound near to [a] (Albalá, 2000). Albalá (2000) notes that a similar sound is used in the place of other particles such as prepositions or clitic pronouns. Protoarticles are soon replaced by proper articles. However, in an intermediate period (Rosado Villegas, 2000) the child tends to produce a phonetically simplified version of the adult articles (i.e. [a] for [la], [e] for [el], [u] for [un]). Such forms, which one may expect to find more frequently in deaf children, should not be confused with protoarticles, since they do correspond to basic grammatical distinctions. It is important to note that the distinction between singular and plural feminine article disappears in some dialects due to omission of the final /s/. This is the case of the deaf girl in this case study.

Researchers who have examined the sequence of acquisition of Spanish definite articles have reported that NH children tend to over-generalize to the feminine form 'la' (Clark, 1985; López Ornat, 1997). Clark (1985) suggested that the feminine form 'la' (the) is more salient than the masculine form 'el' (the). Additionally, López Ornat (1997) suggested that children's overuse of the feminine form may relate to its relatively higher form-function transparency. She noted that feminine cues have greater reliability because all feminine articles and most feminine nouns end in –a. On the other hand, while most common masculine nouns end in –o, masculine articles do not (*el, un*). Figure 1 shows the ratio of

Table I. Spanish articles.

| Article | Features | English |
|---|---|---|
| el | definite masculine singular | the |
| la | definite feminine singular | the |
| los | definite masculine plural | the |
| las | definite feminine plural | the |
| un | indefinite masculine singular | a |
| una | indefinite feminine singular | a |

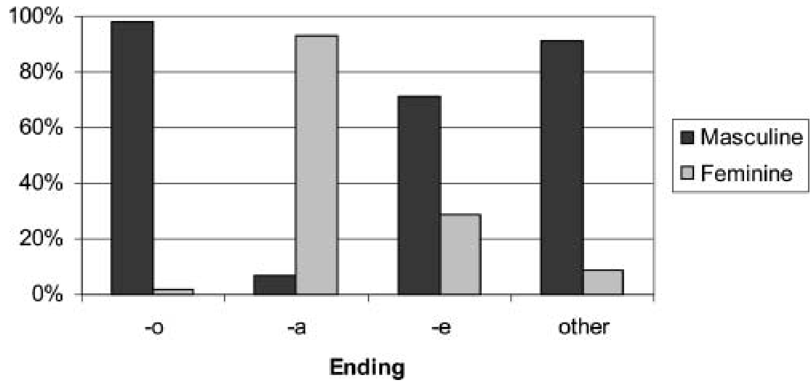


Figure 1. Predictability of gender of Spanish nouns.

masculine and feminine nouns for most common noun endings (Moreno-Torres, Adrián, González, & Buiza, 2004).

However, other researchers have not found this tendency to generalize to the feminine. Rosado Villegas (2000) examined López Ornat's and other CHILDES data. She found very few errors with definite and indefinite articles (*el, la, los, las*: the; *un, una*: a). She found relatively frequent errors with other determiners such as 'otro' (another) and 'este' (this), and an important number of protoarticles. Discrepancies in the calculation of protoarticles and agreement errors with 'la' might be caused by the difficulty to interpret [a] forms. Article omission is another feature of this period (Lleó & Demuth, 1999). Omissions may be due to processing limitations, or to a poor command of grammar. Note that article use and omission depend on relatively complex pragmatic and semantic information (Laca, 1999).

Even though typically developing children acquire all these linguistic skills, there is important variation in the order and rate of acquisition (Shore, 1995). One of the most influential descriptions of variation in acquisition is the analytic-holistic dimension proposed by Bates, Bretherton, and Snyder (1998). These authors suggested that some children tend to produce initially isolated words, and, later, they combine words into phrases (analytic). Other children tend to produce initially full phrases (holistic), which later are split into words. It is accepted that all children use both methods, but there can be some preference for one of them. Preference for analytic or holistic methods has some linguistic consequences. For instance, as regards the lexicon, analytic preference is associated with a high proportion of nouns in the first 50 words, or rapid vocabulary growth. As regards grammar, analytic preference is associated with a tendency to use morphological over-generalization, consistent application of rules, or a stronger tendency to be spontaneous. The fact that a child is more analytic or holistic has also an impact on the growth in MLU (Shore, 1995). More analytic children may have a low MLU initially, but show rapid gains in MLU as soon as they start to combine morphemes.

### *Cued speech*

Cued Speech (CS) was developed by Cornett (1967) to help deaf children to understand speech by eliminating the ambiguity of lip-reading (see Figure 2). The speaker holds one hand near his or her mouth while speaking so that the listener can see both the lips and the hands. In the Spanish version of CS (Torres & Ruiz, 1996), the hand can adopt eight

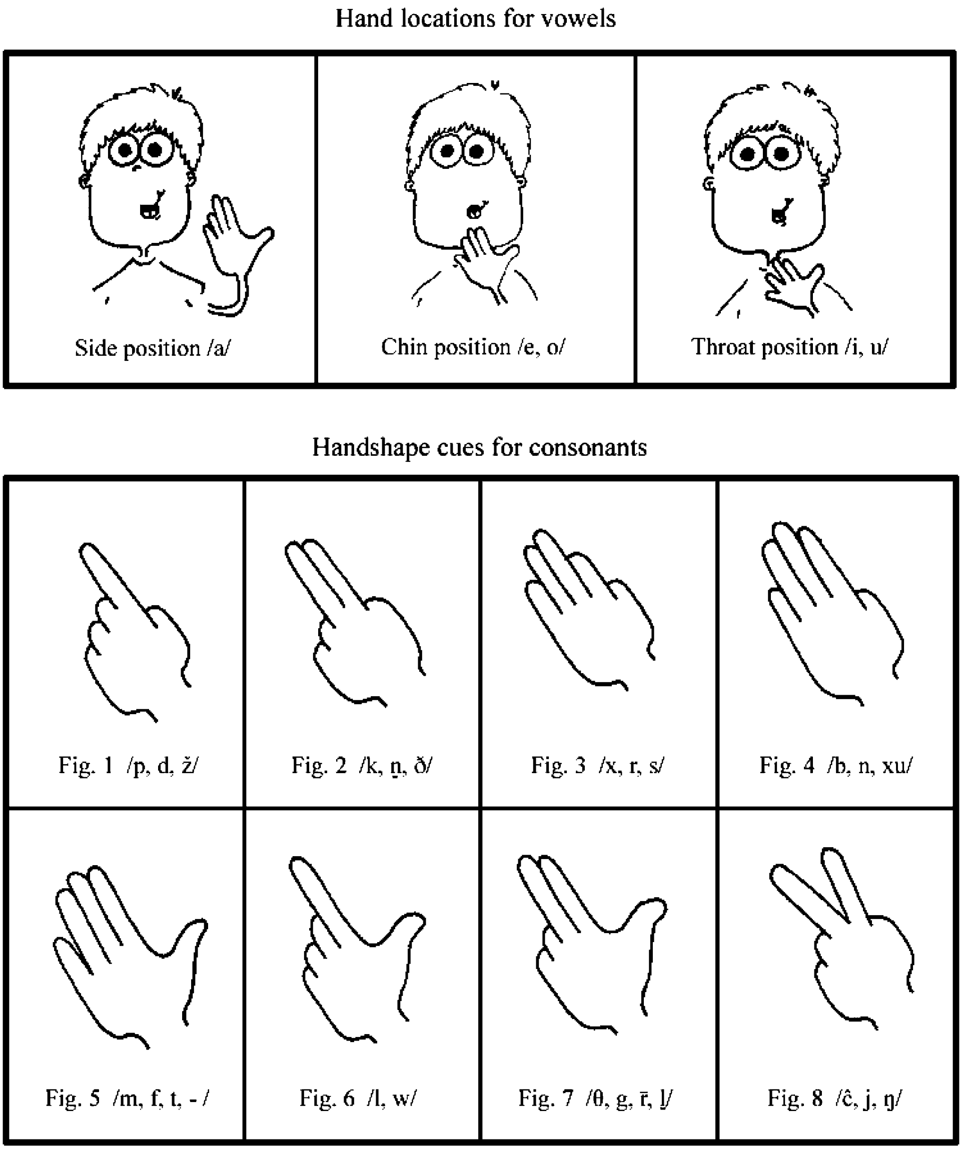


Figure 2. Spanish version of Cued Speech (Torres & Ruiz, 1996).

shapes in three different positions. Hand shapes disambiguate consonants, while hand positions disambiguate vowels. Each time the speaker produces a cue (a hand shape at a specific position), while pronouncing a consonant-vowel (CV) syllable, she is giving unambiguous phonological information about this syllable. Syllables with a single vowel (V) are also produced with a single cue. Other types of syllables are produced with two (VC, CVC, etc.) or more cues (CCVC, etc.). For details, see Torres and Ruiz (1996), and Alegría, Charlier, and Mattys (1999).

CS was initially meant to be used with children with no audition. However, it can also be used in combination with auditory input. In this case, the child receives visually the same phonological input as s/he receives through audition. It has often been noted (see Hage &

Leybaert, 2006) that CS might be particularly helpful to perceive non-salient sounds or syllables, such as unstressed articles and word endings. As long as this is true, CS might help to optimize the benefits of the CI.

### *Goals of the present study*

The main goal of this longitudinal study is to obtain data about linguistic development in a Spanish CI child. The study starts when the first 2-word utterances are produced. If the child progresses as NH children do, important changes should be observed in the following months in all linguistic domains.

A secondary goal is to analyse the progression of the CI child in comparison with NH children. Specifically, one wants to check if the child progresses more quickly than NH children (i.e. is she compensating for previous delay?); and if compensation is parallel in different linguistic domains (phonology, lexicon and grammar). A final goal is to examine the impact of CS.

## Method

### *Participant*

The main participant in this study is Blanca, a Spanish girl who was neurosensorial bilateral prelingually profoundly deaf, according to BIAP (Bureau International d'AudioPhonologie) Audiometric Classification of Hearing Impairments (see details at www.biap.org/biapanglais.html). Mean loss in the better ear was equal to 100 dB at 500, 1000, 2000, and 4000 Hz. There was no associated impairment. There were no antecedents of deafness in her family, which may explain the delay in detecting the impairment until the girl was 13 months old. She had a hearing brother 18 months older than herself. She used binaural hearing aids from 14–17 months. When the girl was 14.5 months old, she started the language rehabilitation programme, Oral Cued Model (MOC; see www.uma.es/moc). When she was 17 months old, she was fitted with a cochlear implant (CI). The CI was programmed 1 month later. According to the report from the CI centre, the auditive function of the girl improved in the months after the fitting of the CI. Just after CI programming, the aided threshold was ~50 dB. Seven months after programming, the aided threshold was ~35 dB.

During the 12 months between CI fitting and the start of this research, Blanca had progressed notably. Just before CI fitting, she was unable to produce adult-like sounds (see Nathani, Ertmer, and Stark (2006) for a description of sound development in children). Twelve months later, she could use all vowels and most occlusive and nasal consonants. Furthermore she had spontaneously produced more than 50 different words. More than 50% of her words at this point were nouns and onomatopoeias, though some phrases were also present. Compared with other deaf children implanted at the same age, Blanca might be considered somewhat slow. The ratio of canonical vocalizations (Oller, 2006) did not reach 20% until 6 months of implant use, and remained in that percentage for 3 more months. Other studies have found canonical vocalization rates of 20% after 1–4 months of implant use (Ertmer & Mellon, 2001; Schauwers, Gillis, Daemers, De Beukelaer, & Govaerts, 2004), and much higher rates of canonical vocalizations (Ertmer & Mellon, 2001; Moore, Scott Prath, & Arrieta, 2007). As regards consonant variation (place of articulation), until 11 months of implant use, over 90% of her consonants were labial. In

Ertmer and Mellon's (2001) case study, this happened in 7 months. Note also that compared with NH children, at this point Blanca had little articulatory experience, but her progression seemed to be quicker. Despite this apparently slow start, it seemed that Blanca had achieved in 12 months of auditory experience what NH children achieve in 18 months.

Data from Blanca has been compared to data from two normally hearing (NH) children, a girl (NH1) and a boy (NH2). For both children a 12-month period corpus was selected, starting when each child was 19 months old. Data for these NH children is available from the CHILDES database. NH1 is the child in Ornat corpus. NH2 is the child in the Aguirre corpus. These corpora have already been analysed by the authors (López Ornat, Fernández, Gallo, & Mariscal, 1994; Aguirre, 1995) and other researchers (i.e. Rosado Villegas, 2000; Clahsen, Aveledo, & Roca, 2002) and fulfil the basic requirement to yield reliable data for the aspects that we were interested in.

### *Material*

The core of the results of this research is based on 52 samples of spontaneous speech from Blanca. Each sample corresponds to a 30-minute weekly session. Sessions took place alternatively at home (with the mother) and in the lab (with the therapist). All samples were transcribed according to the CHAT scheme (MacWhinney, 2000). Transcriptions include all the words produced by the girl as well as her vocalizations. Coders were the two authors and Rafael Santana (Torres, Moreno-Torres, & Santana, 2006). These 52 files are part of the MOC corpus. A section of the MOC corpus can be downloaded from the CHILDES Project Database (http://childes.psy.cmu.edu/).

As this study examines very different research questions, for each question we have analysed either the whole corpus, or only specific sections. In order to study the phonemic inventory, it was sufficient to examine the first half of the corpus. To study intelligibility and grammar, the full corpus was examined. To study expressive lexicon and imitative/ spontaneous utterances, only the home sessions in which the child interacted with her mother were selected.

In order to obtain further data that might help to interpret results from the first year of observation (13–24 months of CI use), some extra data was obtained about her lexicon and grammar 3 months later (25–27 months of CI use). Five more speech samples were analysed. Receptive lexicon was evaluated with the Spanish version of PPVT-III (Dunn, Dunn, & Arribas, 2006). In order to examine agreement errors, a task was developed to elicit definite articles. In this task the child had to describe a card in which an object had a specific colour. For instance, if the card showed a red chair, the girl was expected to say 'la silla roja' (the-fem. chair red-feminine). If the card showed a red pencil, the girl was expected to say 'el lápiz rojo' (the-masc. pencil red-masculine). The objective of the task was to evaluate gender agreement in articles. Agreement errors in adjectives, and lexical errors were ignored.

### *Linguistic coding*

Every sample was encoded by the second author or another researcher, and revised by the first author. The second coder (i.e. the first author) always adopted the most conservative decisions. For instance, if the first coder considered an expression to be unintelligible, and the second coder considered it correct, the expression would be encoded as unintelligible.

*Phonemic inventory and intelligibility.* For those words that the girl mispronounced, a broad phonetic transcription was added. Any production that was completely unintelligible was encoded as a vocalization. A phoneme was considered to be acquired if the child produced the corresponding sound correctly at least on three occasions in two different words. This condition is stricter than the targetless condition of Serry and Blamey (1999), as sounds produced out of context are not counted. For instance if a child produces a sound [t] while trying to produce a phoneme /k/, the sound [t] would meet the targetless condition, but not the phonemic condition. In linguistic terms, Serry and Blamey measure phonetic development, while this study examines phonemic development. In order to measure intelligibility, all oral productions (correct words, incorrect words, and vocalizations) in the 26 home sessions were computed. Words that were part of repetitions or fixed phrases were also computed.

*Lexicon.* In order to examine the progression in Blanca's expressive lexicon, the mean number of tokens and types per session were computed. CLAN software (MacWhinney, 2000) was used to obtain these values. To compare Blanca's lexicon with that of the two NH children, 4000 words were selected, produced by Blanca in 13 home sessions (MLU in the range 1;5:1;7). Another 4000 words were selected for each NH child in that MLU range. Words that were part of songs, repetitions, or fixed phrases were omitted.

*Grammar.* MLU were calculated in words, excluding auto repetitions, imitations, fixed phrases, songs, and interjections. MLU values were computed with CLAN corpus software (MacWhinney, 2000) based on the whole corpus, and not on a fixed set of utterances. In order to obtain comparable data, it was necessary to recode the corpus for NH1, as criteria for segmenting productions into utterances was not as strict as ours. NH2 corpus utterance criteria were very similar to ours.

This study encoded as articles both proper Spanish articles (*el, la,* etc.), and also all instances of [a], [e], and [u] occurring in article position. It used the same criteria for the NH children. Then the agreement errors in each child were examined. Article omission was studied only in contexts in which it was clear that the article was obligatory, i.e. most singular noun phrases governed by a verb or preposition. When the article was optional, that case was not considered, e.g. plural noun phrases in direct object position.

*Imitation.* In order to compute the ratio of imitative utterances, all the productions in which: (1) the child repeated all or part of the words of the previous adult utterance; and (2) the child did not add any word to the adult's (i.e. we would not count as repetition if the child says 'dog nice' after the father says 'dog') were annotated. These criteria exclude auto repetitions, which were common in the final part of the deaf child corpus.

### *Reliability*

Consonant and vowel types were included in the inventory only when independent listener transcriptions agreed that a given consonant or vowel occurred at least three times in the same month. Thus, data for phonemic inventory represent 100% agreement between transcribers that a consonant or vowel type was produced in a month.

Articles were coded as such only if both coders agreed. Thus, for the set of articles analysed in this study agreement was 100%. However, 10% of the corpus were recoded to determine agreement between coders. Then, all instances of articles and protoarticles encoded by one or both coders were selected. Cohen's Kappa between coders was .93 for 'la', 'el' and 'un' articles and protoarticles.

Given the criteria used to identify mispronunciations and vocalizations, data for intelligibility represents agreement on a minimum level of intelligibility. We recoded 10% of the corpus to determine agreement between coders. Cohen's Kappa was .73. Examination of discrepancies showed that one of the coders tended to accept as correct, or as merely mispronounced, what the second coder would annotate as mispronounced or as unintelligible, respectively.

## Results

### *Mean length of utterance*

Between the age of 30–42 months (13–24 months of CI use), Blanca's MLU rises from 1.2 to 1.7. As Figure 3 shows, her MLU grows very slowly when compared with both NH children.

### *Phonemic inventory and intelligibility*

In Table II, white cells indicate the phonemes acquired in the first month of this study or before. Light grey cells indicate phonemes acquired in the following 2 months. Dark cells indicate phonemes acquired after 3 or more months. The number indicates the number of months. At the beginning of the research period, the inventories of all three children had almost exactly the same phonemes (see Table II): all five vowels, most occlusive consonants (except /d/, /g/, which appear later) and the nasals /m/, /n/. Most remaining consonants appear in all three children in the next 2 months. Thus, order of acquisition is similar in Blanca and the NH children, but the rate of acquisition is slightly slower in Blanca. These results are similar to those described by other reseachers (see Serry & Blamey, 1999; Barry, Blamey, & Fletcher, 2006).

Figure 4 shows the ratio of correct words, mispronounced words, and non-intelligible words. Data is grouped in four consecutive terms. Progression was evident throughout the year, especially in the ratio of words judged as correct, and in the ratio of non-intelligible productions.

### *Lexicon*

Table III shows the mean number of types and tokens that Blanca produced per session. Data is grouped in four consecutive terms. Number of types per session increases notably. Note in particular the increase in the number of types in the last term, while the standard

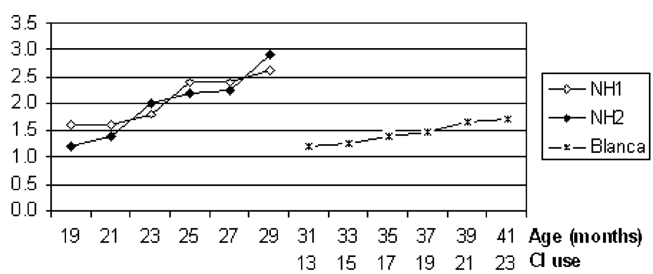


Figure 3. Mean length of utterance (MLU).

Table II. Phonemic inventory.

| | Phonemes | Blanca | NH1 | NH2 |
|---|---|---|---|---|
| Vowels | /a, e, i, o, u/ | | | |
| Occlusive | /b, p, t, k/ | | | |
| | /d/ | | 2 | 2 |
| | /g/ | 2 | | 3 |
| Fricative & approximant | /s/ | 3 | | 1 |
| | /θ/ | 2 | 2 | 1 |
| | /f/ | 2 | 2 | 1 |
| | /x/ | 6 | 3 | 1 |
| | /j/ | 1 | | 1 |
| Affricate | /tʃ/ | 2 | | |
| Liquid | /l/ | 1 | 1 | 1 |
| | /ɾ/ | 2 | 2 | 1 |
| | /r/ | 6 | 2 | 1 |
| Nasal | /m, n/ | | | |
| | /ɲ/ | 8 | 3 | 3 |

White cells indicate the phonemes acquired in the first month of this study or before. Light grey cells indicate phonemes acquired in the following 2 months. Dark cells indicate phonemes acquired after 3 or more months. The number indicates the number of months.

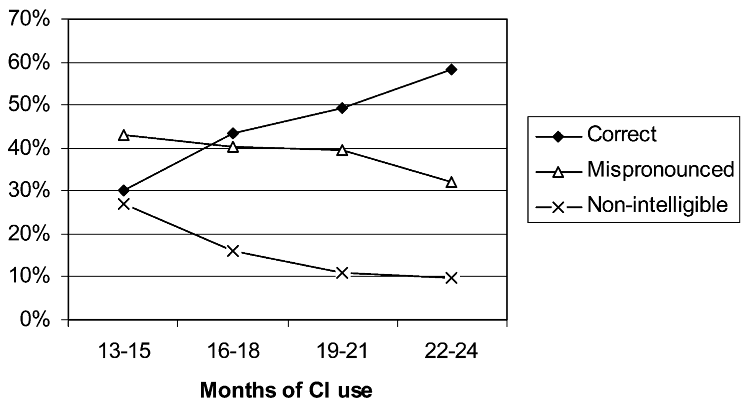


Figure 4. Blanca's correct, mispronounced, and non-intelligible productions.

deviation decreases. This suggests that progression is very stable. A similar change is observed in the number of tokens.

Comparison of the lexical variety between the three children (samples of 4000 words in the MLU range 1.5–1.7) showed that Blanca produced more lexemes than the NH

Table III. Mean number of types and token per session.

| | | Types | | Token | |
|---|---|---|---|---|---|
| Months of CI use | *n* | *M* | SD | *M* | SD |
| 13–15 | 6 | 36 | 13.8 | 77 | 31.8 |
| 16–18 | 7 | 62 | 16.9 | 166 | 51.1 |
| 19–21 | 6 | 77 | 30.5 | 186 | 58.7 |
| 22–24 | 7 | 99 | 17.2 | 292 | 62.4 |

Table IV. Article acquisition.

| MLU | Blanca | NH1 | NH2 |
|---|---|---|---|
| 1.2 | El | | La |
| 1.3 | Un | | El |
| | | | Los |
| 1.4 | La | La | |
| | Los | El | |
| 1.5 | | | |
| 1.6 | | Un | |
| | | Los | |
| 1.7 | | | Un |

children. The three children produced almost the same number of verbs (Blanca: 57; NH1: 57; NH2: 55). However, Blanca produced notably more nouns (Blanca: 168; NH1: 118; NH2: 119).

### *Grammar*

In this 12-month period (13–24 months of CI use), Blanca started to use all forms of the definite article (*el, la/las, los*: the) and the singular masculine form of the indefinite article (*un*: a). The more frequent forms were 'el' ($n$=248), 'la' ($n$=139) and 'un' ($n$=257). The feminine indefinite article (una: a) was used very occasionally, and mostly as part of songs or fixed phrases. A similar pattern was observed in the two NH children in the same MLU range (see Table IV).

There were some differences in terms of the use of definite and indefinite articles. Both NH children seemed to acquire first the masculine/feminine opposition, while in the deaf child the first opposition was definite/indefinite. As well as appearing earlier, the article 'un' is more frequent in Blanca (38%) than in NH children (13% in NH1 and 16% in NH2).

This study examined agreement errors in definite articles, as the children were already using both the masculine and feminine forms. Ratio of errors in Blanca was 8% ($n$=30), below that of the NH Children (NH1: 22%, $n$=68; NH2: 15%, $n$=55). Close examination of the error types showed that Blanca had a marked preference for masculine forms (see Table V). She often used a masculine article with a feminine noun. In both NH children the opposite pattern was found. They tended to use a feminine article with masculine nouns, but they very rarely used a masculine article with feminine nouns. As noted in the introduction, this pattern might be considered typical in Spanish children. These results suggest that Blanca was not using protoarticles. On the contrary, her errors seem to be grammatical: she was choosing the wrong form.

Figure 5 shows the ratio of feminine nouns used by Blanca with the wrong article, in five different periods. As Figure 5 shows, the error pattern of the definite article (*el*: the) and the

Table V. Distribution of agreement errors in definite singular articles.

| | El | | La | |
|---|---|---|---|---|
| Child | $n$ | $p$ | $n$ | $p$ |
| Blanca | 26 | .87 | 4 | .13 |
| NH1 | 6 | .9 | 62 | .91 |
| NH2 | 0 | .0 | 55 | 1.0 |

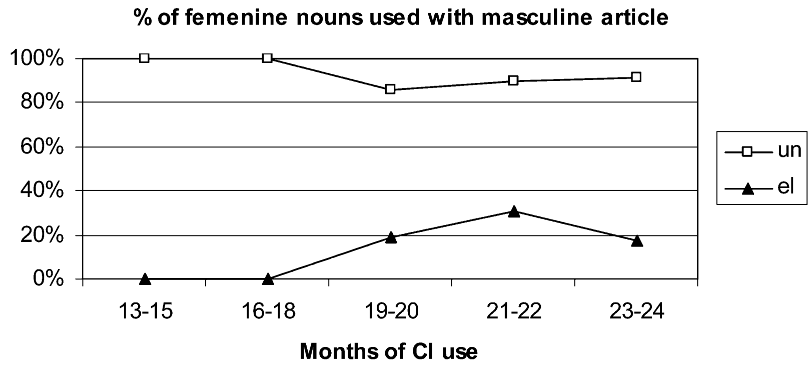


Figure 5. Feminine nouns used with masculine articles 'el' (the), 'un' (a).

indefinite (*un*: a) is notably different. In the first half of the year, Blanca made no error with the article 'el'. In the second half, she made 26 errors (21% of the feminine nouns were used with masculine article). All errors with the article 'el' involved using a noun ending in –a (camiseta, casita, conejita, cuchara, luna, pelota, piña, rana, silla, tarta, vaca). Curiously, in the few feminine words ending in –o (moto, mano), she chose the right feminine article. As these errors appear in the second half of the corpus, they suggest that by that time she might not have detected a rule of article selection for the definite article (*el/la*). The reason why she did not make errors in the first half of the year might have been that she was memorizing the article with the noun.

Errors with 'un' were constant all through the year. The girl used this form even when repeating the productions of the adults. For instance, on one occasion the adult said 'una niña' (a-fem girl), and Blanca repeated 'un niña' (a-masc girl). The same happened with four more nouns (cebra, zebra; tarta, cake; patada, kick; casa, house). It is possible that Blanca did not perceive the difference between masculine (un) and feminine (una) indefinite article forms. This might be due to perceptual similarity between these forms (both acoustically and in CS).

The ratio of omitted articles was 32% in Blanca ($n$=120), 51% in NH1 ($n$=79), and 56% in NH2 ($n$=95). To determine possible causes of article omission, the effect of utterance length measured in syllables, and the ratio of errors in two syntactic positions, subject and direct object, were examined. In Blanca the errors increased with the number of syllables of the utterance. In both NH children error rate remained stable. Examination of syntactic positions suggested that children were not using syntactic information to insert articles, as errors were more frequent (NH) or similar (Blanca) in subject position. However, with such limited data, it is not possible to know if results about article omission are representative.

### *Imitative and spontaneous utterances*

As Table VI shows, throughout these 12 months, the percentage of imitation decreased notably. In the final term reduction is noted both in means and standard deviations between sessions. This shows that the reduction is stable.

### *Follow-up*

Initial data about Blanca (first 12 months of CI use) suggested that the child was making important progress. In 12 months of auditory experience, her development seemed to be

Table VI. Ratio of imitated utterances per session.

| Months of CI use | $n$ | $M$ | SD |
|---|---|---|---|
| 13–15 | 6 | .35 | .17 |
| 16–18 | 7 | .19 | .19 |
| 19–21 | 6 | .18 | .7 |
| 22–24 | 7 | .8 | .8 |

similar to that of 18-month old NH children. Results over the next year (13–24 months of CI use) suggest that lexicon and phonetic progress was again good. However, grammatical development might be slow, as noted by MLU and article production. In order to confirm this trend, data were obtained about lexicon and grammar (MLU and article agreement) for 3 more months (25–27 months of CI use).

The mean number of lexical types that Blanca produced per session in this new period (25–27 months of CI use) was 137 ($n$=5; Std=24.6), i.e. an increase of 38% with respect to the previous 3 months (see Table III). The mean number of tokens was 410 ($n$=5; Std=59.1), i.e. an increase of 40%. Thus, both the number of types and tokens per session continued to grow. When Blanca was 45 months old (27 months of CI use), her score in the PPVT test for receptive lexicon was 104 (standard score), which corresponds to a chronological age range of 35–39 months. MLU in these 3 months was 1.95, i.e. an increase of 10%. In the test to elicit articles ($n$=36), Blanca made five agreement errors (16%) with the masculine article. Agreement was correct in all instances of the feminine article 'la', i.e. the same pattern as observed previously.

These results confirm the basic trends observed in the previous months. Lexicon seems to progress at a fast rate. MLU progresses constantly, but slowly. Finally, the same pattern of agreement errors is still present.

## Discussion

The aim of this study was to obtain data about early language acquisition in a deaf Spanish child fitted with a cochlear implant when she was 18 months old. From which time, as part of her post-operative habilitation programme, her parents used Cued Speech to communicate with her. In the first year of implant use her communicative skills developed considerably, suggesting she was ready to enter the two-word period by the end of this time.

During her second year of implant use, Blanca showed important progress. In this period, Blanca started to acquire the phonemes that she had not acquired earlier. After 24 months of implant use, her phonemic inventory was complete. As regards intelligibility, Blanca showed a slow but constant progression throughout the year. In the first month of this period (13 months of CI use) over 30% of her productions were completely unintelligible to expert listeners. Twelve months later, less than 10% of her productions remained completely unintelligible. Future evaluation of this child should provide more data about her achievements. Her lexicon also progressed notably in these 12 months. After 12 months of CI use, the mean number of word types that Blanca produced per session was 36. Twelve months later it was almost 100. The mean number of word tokens per session also increased dramatically. Data obtained after 27 months of CI use confirmed progress in the development of her expressive and receptive lexicons. Types in speech samples increased by 38% in just 3 months. Evaluation of receptive lexicon showed that her lexicon was richer than that of children with the same auditory experience (27 months old), i.e. she was compensating for previous delay.

Results in grammar suggested that Blanca was following the same steps as NH children. Her MLU progressed rather slowly in the second year of implant use, but article acquisition was similar to what has been observed in NH children. She quickly started to produce articles, and the most common articles were 'el', 'la', 'un'. The main difference is that her error pattern was different from that of NH children. Below, we analyse possible causes of this difference. Finally, the percentage of imitated utterances decreased considerably in this year, which suggests that she might be progressively adopting an analytic communicative style. In sum, Blanca's language and even her communicative style improved enormously in these 12 months.

This study also aimed to see if Blanca's development was quicker than that of NH children, i.e. if she was compensating for previous delay. Bear in mind that in the first 12 months of CI use, Blanca seemed to compensate phonologically and lexically. In the 12 months analysed in this study, progress in her phonemic inventory followed very closely the steps observed in NH children. In order to interpret results for lexicon and grammar, it is important to determine if she showed a preference for analytic or holistic methods. Several characteristics of Blanca's language suggest that she had a preference for analytic methods. As regards her lexicon, more than 50% of her first 50 words were nouns; and her vocabulary increased notably in the following 15 months (as confirmed by PPVT-III test, and speech samples). As regards grammar, initial MLU was very low (i.e. she produced few phrases), she over-used masculine articles, and the ratio of imitated utterances decreased notably. However, her grammatical development was not quick, as might be expected of an analytic child (note the slow development of MLU and the slow acquisition of articles). In sum, the quick progress observed in the first year of CI use was also apparent in the second year as regards phonemic inventory acquisition and lexical development, but the data regarding development of grammar was not so promising.

These results closely resemble what other researchers have observed (Le Normand, 2004; Szagun, 2004). Both Szagun and Le Normand found that progress in lexical development was notably quicker than acquisition of grammar rules. Thus, as regards lexicon and grammar, Blanca's development seems to be representative of at least some type of CI children. More research is needed to explain why development of grammar is so slow for children using cochlear implants.

Another objective of this research was to determine if Cued Speech might shape her linguistic development in some way. Several of Blanca's characteristics suggest that CS might have played an important role. As regards the use of protoarticles, Szagun (2004) had found that CI children (non-CS) used them for a longer period than NH children. Blanca, on the other hand, seemed to use few protoarticles. This fact might be a consequence of CS. Note that the articles that Blanca used more often (*el, la, un*) are each produced with a different hand position in CS (see Figure 2), which might have facilitated early perception. The second aspect on which CS might have had an impact is on the type of agreement error. As noted above, NH children tend to over-generalize to the feminine due to the feminine form being more salient. In Cued Speech, the opposite is true. Article 'el' is produced with two cues, while article 'la' is produced with one single cue. Thus, if perceptual saliency plays an important role in error pattern, one might expect that a child exposed to Cued Speech would tend to over-generalize to the masculine form. This is precisely what happened to Blanca. Finally, another aspect that might be related to perception is article omission. Note that if a child does not perceive articles, s/he will tend to omit them more often. Blanca omits articles, though less frequently than the NH children, which might indicate that she is perceiving articles clearly. However, even though results of this case clearly suggest that CS has facilitated perception of non-salient words, it is not possible to generalize these results. More research is needed regarding the language development of CI+CS children as compared with CI-only children.

## Conclusion

Based on the findings from this study, the authors would like to make some points regarding the role of language habilitation for CI children. In the last 15 years, many researchers and professionals have correctly emphasized the important benefits of CI. Such emphasis may make some parents and even language therapists complacent regarding the role of language training in the post-operative habilitation programme of their child. That is, they may assume that the CI will do all the hard work, particularly since the use of the implant has such a positive impact on things such as child attention, phonology, intelligibility, or vocabulary acquisition—areas of development which are most apparent for parents of pre-school children. However, problems such as agreement errors or slow development of MLU might not attract the parents' or even the therapists' attention until it is too late for them to ever develop normally. Further research in this area is thus required to provide language therapists and parents with realistic descriptions of the problems faced by the new deaf population. Furthermore, professionals should provide parents with advice based on realistic descriptions of the advantages and limitations of CI.

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