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Syntagmatic and paradigmatic development of cochlear implanted children in comparison with normally hearing peers up to age 7

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ABSTRACT

Objective: Grammatical development is shown to be delayed in CI children. However, the literature has focussed mainly on one aspect of grammatical development, either morphology or syntax, and on standard tests instead of spontaneous speech. The aim of the present study was to compare grammatical development in the spontaneous speech of Dutch-speaking children with cochlear implants and normally hearing peers. Both syntagmatic and paradigmatic development will be assessed and compared with each other.

Method: Nine children with cochlear implants were followed yearly between ages 2 and 7. There was a cross-sectional control group of 10 normally hearing peers at each age. Syntactic development is measured by means of Mean Length of Utterance (MLU), morphological development by means of Mean Size of Paradigm (MSP). This last measure is relatively new in child language research.

Results: MLU and MSP of children with cochlear implants lag behind that of their normally hearing peers up to age 4 and up to age 6 respectively. By age 5, CI children catch up on MSP and by age 7 they caught up on MLU.

Conclusion: Children with cochlear implants catch up with their normally hearing peers for both measures of syntax and morphology. However, it is shown that inflection is earlier age-appropriate than sentence length in CI children. Possible explanations for this difference in developmental pace are discussed.

1. Introduction

The current paper examines the development of grammatical language skills of Dutch-speaking congenitally deaf children who underwent cochlear implantation (CI) at an early age in comparison with normally hearing peers (NH) up to age 7. Early cochlear implantation has been shown to considerably foster language development in congenitally deaf children [1,2]. Some CI children are found to manifest age-appropriate language skills after 1–4 years of device use, while others still lag behind on their NH peers even after more than 4 years of device use [3,4]. Language development in CI children is thus subject to a large amount of interindividual variation as only some CI children seem to catch up with their NH peers. However progress and acquisition rates are also dependent on the particular linguistic field studied. For instance receptive language skills of CI children are faster age-appropriate than their expressive language skills [3,5]. In addition, CI children are found to have particular difficulties with syntax and morphology, in contrast to lexical development [5]. In other words, most CI children are found to catch up with their NH peers on vocabulary measures, but not on measures of productive morphology and syntax (grammatical aspects of language use).

Language development can be studied in different ways: standard tests can be used to assess children's grammatical competence or language measures based on spontaneous speech. A frequently used standard test for grammatical development is the Reynell Developmental Language Scale (RDLS). For instance Duchesne, Sutton and Bergeron [5] used the RDLS and showed that after 6 years of implant use, more than half of the CI children had receptive and expressive age-appropriate language skills at the word level, while less than 50% of the same group of children had receptive and expressive age-appropriate language skills at the sentence level. Even though other standardised tests were used,

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similar outcomes were found in for instance Young and Killen [6], Schorr, Roth and Fox [7], Geers, Nicholas and Sedey [8] and Caselli, Rinaldi, Varuzza, Giuliani and Burdo [9]. In studies of spontaneous speech, a similar relative developmental pace of lexicon and grammar is found: the delay of CI children comprises a shorter period for lexical development as compared to grammatical development, measured by, for instance, Mean Length of Utterance (MLU) [10] and adjectival inflection [11]. Contrastingly from outcomes on standard tests, early implanted CI children are found to catch up with their NH peers by approximately age 5 when studying their spontaneous speech [1,11]. Like in standard tests, most literature on spontaneous speech studied only one aspect of grammatical development. In contrast, the present paper focuses not only on spontaneous speech, but also on two specific aspects of grammatical development, viz. syntagmatic and paradigmatic complexity. Furthermore, the development of those two aspects in CI children is compared with each other.

CI children seem to have particular difficulties with grammatical development. Even in NH children, grammatical development is a slow and gradual process [12,13]. Grammatical development is generally considered to involve syntactic development, i.e. combining words into sentences, and morphological development, i.e. combining morphemes into larger units as in, e.g. inflection, compounding and derivation. Hence grammatical development exhibits a syntagmatic dimension, i.e. how words are ordered in sentences, and a paradigmatic dimension, e.g. the different forms of a particular root or stem. Both dimensions interact as can be seen in congruence: in languages such as English and Dutch a singular subject requires a singular form of the (finite) verb (e.g. the man is working), and a plural subject requires a plural form of the verb (e.g. four men are working). In the present paper, grammatical skills are analysed in both NH and early implanted CI children. More specifically, the present paper focuses on syntagmatic and paradigmatic development, operationalised by implementing Mean Length of Utterance (MLU) and Mean Size of Paradigm (MSP) respectively.

1.1. Mean Length of Utterance (MLU)

MLU is a widely used measure of general language development linked to morphology and syntax and thus grammar in general. Even though MLU, as presented by Brown (1973), is not a direct measure of syntactic development – for instance, it does not take correctness of word order into account – it provides an indication of the degree of sentence complexity [14]. Recently, Mimeau, Plourde, Ouellet and Dionne [15] showed that MLU is a valid and reliable measure of morphosyntactic complexity up to school ages. When children are combing more words into longer sentences, MLU becomes higher, which indicates at least the knowledge of some syntagms. Therefore, MLU is considered as a measure of syntagmatic development.

MLU can be calculated in several ways: Brown [16] suggested to divide the number of morphemes, i.e. the smallest meaningful units, words or word parts, by the number of utterances (MLU in morphemes). However, strong correlations of MLU in morphemes with MLU in words [17–20] and in syllables [17] are found. More detailed information about MLU calculation is given in Section 2.

MLU increases with age [20,21] between approximately 1;06 (years;months) and 5;00. MLU is useful in detecting language problems in children [22]. For instance in children with specific language impairment (SLI), MLU is lower in comparison to typically developing peers [20,23]. With respect to CI children, Tobey and Hasenstab [24] found no increase in MLU after 1 year of implantation. Note however that the mean age at implantation was 6;00 (SD = unknown). In contrast, for instance Blamey, Barry, Bow, Sarant, Paatsch and Wales [2], Moreno-Torres and Torres [10] and Schauwers [25] found an increase of MLU with longer implant use. Participants in these studies were implanted at younger ages: mean ages at implantation are 3;09 (SD = 1;00), 1;04 (case study) and 1;00 (SD = 0;05) respectively.

Comparisons of NH and CI children can reveal delays in syntagmatic development of CI children. In Table 1, the outcomes of some recent studies in various languages are shown. Even though the study design (longitudinal or cross-sectional, number of CI participants) and mean ages at implantation differed across studies, Table 1 shows that MLU of CI children is mainly found to lag behind that of NH peers up to approximately age 8;00. But, Nicholas and Geers [1] and Hammer [14] concluded that early implanted CI children catch up with their NH peers by age 4;06 and 8;00 respectively.

In the literature, the reported delays of CI children with respect to MLU have been explained by deficits of the short-term phonological working memory of those children [30–32]. For instance Willis and Gathercole [33] showed that an effect of phonological working memory capacities on sentence repetition accuracy. Working memory involves short-term storage, rehearsal and handling of information [34]. In longer and more complex sentences, more phonological information must be stored and handled. Furthermore, the cognitive load will be higher in longer sentences, which reduces the efficiency of the phonological short-term working memory [32]. As CI children have lower short-term phonological working memory capacities [30–32], their sentence length and complexity will be affected negatively. For instance Charest, Johnston and Small [35] showed a decrease in MLU with increasing load of the working memory in NH children. Similarly, Willis and Gathercole [33] showed a decrease in sentence repetition accuracy with increasing sentence length and thus an increase in cognitive load. A similar process is assumed to be present in CI children.

The present paper examines MLU development in 9 early implanted Dutch-speaking CI children up to age 7 and compares those children to age-matched NH children.

Table 1
Literature overview MLU in CI and NH children.

Authors	Language	# CI children	Design[a]	Mean age at implantation (SD)	Outcome: MLU CI < NH at age[b]	Do CI children catch up?
Ouellet, Le Normand and Cohen [26]	French	5	L	3;09 (1;02)	5;02	Not reported
Szagun [27] and Szagun [4]	German	22	L	2;05 (0;08)	5;06	Not reported
Schauwers [25]	Dutch	9	L	1;00 (0;05)	2;06	Not reported
Nicholas and Geers [1]	English	76	L	1;11 (unknown)	3;04	Catch up at 4;06
Hammer [14]	Dutch	48	C	1;04 (0;09)	6;00	Catch up at 7;00
Nittrouer, Caldwell-Tarr, Sansom, Twersky and Lowensthein [28]	English	55	PL	1;09 (1;02)	8;04	Not reported
Nittrouer, Sansom, Low, Rice and Caldwell-Tarr [29]	English	55	PL	1;09 (1;02)	7;08	Not reported

[a] L = longitudinal, C = cross-sectional, PL = one data point as part of a longitudinal design.
[b] Ages are represented in years;months.