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# Adequate formal language performance in unilateral cochlear implanted children: Is it indicative of complete recovery in all linguistic domains? Insights from referential communication

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ABSTRACT

*Objectives:* Referential communication (RC) is a key element in achieving a successful communication. This case series aimed to evaluate RC in children with unilateral cochlear implants (CIs) with formal language skills within the normal range.
*Methods and materials:* A total of 31 children with CIs, with language development within the normal range, were assessed using the Pragmatic Language Skills test (MEDEA).
*Results:* Of the children with CIs, 83.9% reached performance levels appropriate for their chronological ages. The results confirmed a positive effect of cochlear implantation on RC development, although difficulties remained in some CI users.
*Conclusions:* The outcomes emphasize the need to pay greater attention to the pragmatic aspects of language, assessing them with adequate testing in the early phase after cochlear implantation. Clear knowledge of children's communicative competence is the key in optimizing their communicative environments in order to create the basis for future successful interpersonal exchanges and social integration.



## 1. Introduction

Cochlear implantation has proved to be an efficient treatment for deficits in functional hearing and spoken language acquisition in many congenitally deaf children [1], and an increasing number of children with cochlear implants (CIs) have appeared to catch up with their normal hearing (NH) peers [2–4].

Traditionally, in this population, the assessment of oral-verbal skills has been undertaken using standardized tests, such as the Preschool Language Scale [5], the Clinical Evaluation of Language Fundamentals [6], the Reynell Developmental Language Scales [7], and the Peabody Picture Vocabulary Test [8], which measure the structural aspects of language, such as phonologic, lexical, semantic and morphosyntactic competence, omitting other aspects of the communication domain, such as pragmatic factors, on which attention has been placed only recently [9–11].

As children with CIs grow and participate in complex social environments, in addition to formal language knowledge, they require a deeper understanding of how language is used for social and functional purposes, to achieve age-appropriate communication and pragmatic competence during everyday social interactions [12,13]

A key element for achieving successful interaction is referential communication (RC), which is an area of pragmatics that concerns the manner in which speakers and listeners exchange information with each other [14]. The speaker must have the ability to consider the listener's perspective and to adjust the content and the form of the message in order to convey the information required for comprehension. In contrast, the listener must continuously monitor and comprehend what the speaker is saying, signaling problems with the message and for asking clarification when necessary.

RC tasks are useful for examining a child's potential for the successful exchange of information and for assessing how individuals bring together different pieces of information, keep this information in memory, inhibit conflicting information and

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subsequently generate communicative behavior to achieve successful exchanges [12,15–17]. Situations similar to RC tasks are frequent in everyday life both at home and at school, where children are continuously asked to carry and process decontextualized messages during interaction with their relatives, as well as teachers' explanations and pupils' oral or written interrogations [16].

Because the ability to select and transmit only information that is relevant for comprehension is strictly linked to the sensitivity of the speaker toward the point of view of the listener (previous knowledge, wishes, beliefs, emotions), RC tasks also offer the opportunity to investigate the Theory of Mind (ToM) from a linguistic point of view [18]. While progressing in their ability to establish relationships between their mental representations and those of others, children also become able to understand conversational exchanges as "meetings of minds", in which being aware of one's interlocutor's intentions and informational needs is crucial [19].

Children with the highest ToM have greater skills in adapting their language to their interlocutors' needs to the purpose of the communication and to the context of interaction. The greater their ability is for mental representation of other people's beliefs, which anticipate behavior, the greater their ability is to regulate communication adequately [19].

RC skills have been studied in a wide range of disorders, e.g., autism, specific language impairment, Down syndrome, Williams syndrome, fragile X syndrome, and schizophrenia [14], but they have received little attention in deaf populations [16,20–22]. The few studies of deaf children have reported poorer performance compared with age-matched NH populations both in listener [16,22] and in speaker conditions [16,20,21], and two main reasons have been offered for the recorded differences. The first was the impact on RC of the developmental lag in the speaking and listening skills of deaf children [16,22], as confirmed by the similarity of their performances with those of NH children at younger chronological ages [16]. The second hypothesis could be reconnected to the ToM. In a study by MacKay-Soroka et al. [21], difficulty in applying the procedural rules of RC observed in deaf children was explained by the impaired ability of deaf subjects to evaluate the informative needs of the listener, which was judged by the author as being independent of the children's linguistic competence.

The results of these studies were influenced by subject selection because they included heterogeneous groups of children, with different levels of formal language skills and variegated educational settings (oral, total communication, bimodal education). Moreover, the conclusions only concerned deaf children with different degrees of hearing loss who were using hearing aids, while no clear data have been reported from CI users.

Although it is well known that language skills alone cannot fully explain differences in RC performance [23], the effect of the language delay recovery on RC should receive greater attention, as has been placed on other aspects of pragmatics by Most et al. [9] using the Prutting Checklist for video analysis of conversation samples and by Nicastri et al. [13] using a standardized tool focusing on linguistic inferences and metaphoric comprehension.

Currently, no studies have been conducted to assess a homogeneous group of deaf children with CIs and to observe the effects of the linguistic gap recovery on their RC skills, attempting to answer the question of whether the implanted children we consider "normal" through our routine language testing are really comparable to their NH peers in all other language domains.

In this context, the present case series aimed to investigate RC skills using a standardized tool in unilaterally implanted children with normal scores on formal language tests in order to assess their abilities to deliver fully informative messages when they assumed the "speaker" role.

The study tested the following two hypotheses:

- In contrast to what was suggested by MacKay-Soroka et al. [21] and Lloyd et al. [16], RC skills are not completely independent of the linguistic competence reached by profoundly deaf children. In particular, the improved listening skills provided by cochlear implantation, if associated with a linguistic gap recovery, can offer a greater opportunity to gain RC skills similar to those of NH peers. According to this hypothesis, remarkable effects of lexical and morphosyntactic skills on RC scores were expected.
- Age at implantation has proved to have significant effects on linguistic outcomes [8]; therefore, it might be assumed that a younger age at implantation would have a more positive effect on RC performance. According to this hypothesis, some late-implanted children would show less mature RC skills, and the gap would increase in parallel with an increase in age at implantation.

## 2. Methods

### 2.1. Study design

This protocol was approved by the local ethics committee; informed consent was provided freely by the parents of each patient. The eligibility criteria for the study group were as follows:

- congenital severe/profound deafness (Pure Tone Average in the better ear $\geq$70 dB HL for 500–4000 Hz);
- age between 6.1 and 15 years old at test administration;
- good speech perception abilities, defined as bisyllabic word recognition and sentence comprehension >90% in a silent room;
- aural–oral rehabilitation mode;
- absence of associated disorders or socio-economic difficulties;
- mainstreamed school attendance; and
- formal Italian Language Test score within −1 SD.

All of the study participants attended mainstreamed classes. The absence of associated disorders was verified by clinical history. Normal socio-economic status was defined as $\geq$13 years of mother/father schooling (high school level) and annual family economic income $\geq$29.956 euros [24].

### 2.2. Study procedures

Language abilities, to include unilaterally CI-implanted children with adequate competences, were assessed using three Italian Standardized Language tests. Lexical comprehension was assessed using the Italian version of Peabody Picture Vocabulary Test, on which normal standardized scores range between 85 and 115 [25]. Lexical production was measured using the Italian version of the Boston Naming Test [26], adapted for school children and normal adults by Riva et al. [27]. The authors provided mean scores and standard deviations for a sample of 160 school children, so $z$ scores were calculated, and $z > -1$ was considered normal. Morphosyntactic comprehension assessment was undertaken using an Italian version of the Test for Reception of Grammar (TROG)-2 [28].

The assessment of RC skills was undertaken using the "Color Game" subtest of the Italian Standardized Battery of "Pragmatic Language Skills MEDEA" implemented by Lorusso [29] to provide a quantitative evaluation of pragmatic skills during comprehension and of the use of oral language.

Compared to the tests traditionally used, the Pragmatic Language Skills MEDEA assesses children's' RC skills only in the "speaker" condition, but it has different strengths, consisting of its simplicity and rapidity of administration, a population of