The acquisition of verbal morphology in coclear-implanted and specific language impaired children

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CHAPTER 1

General introduction

Already in 1800, Alessandro Volta experienced that hearing could be stimulated with electrical current. He connected batteries to two metal rods, which he inserted in his ear. Volta described the sensation as 'une recousse dans la tête', followed by a sound similar to that of boiling thick soup. This rather uncomfortable experiment was not repeated too often.

Some 157 years later, the battery-supplied electrical current was first used to stimulate the auditory nerve in deafness. In the 1960s and 70s, great advances were made in the clinical applications of the electrical stimulation of the auditory nerve. This resulted in a device with multiple electrodes driven by an implantable receiver and speech processor, the Cochlear Implant (henceforth CI). In 2009, 188,000 severely to profoundly deaf individuals worldwide received auditory input by means of a CI.

The technological advances of the CI and the effectiveness of this prosthetic device in speech perception has placed the emphasis on lowering the age criteria for implantation from adults to infants. In the Netherlands, severely to profoundly deaf children receive their implant generally between 18 and 24 months of age with a trend towards implanting between 12 and 18 months (Ministerie van Volksgezondheid, Welzijn en Sport, 2004). This trend has continued; in August 2009, for instance, breaking news reported the bilateral implantation of a 4-month-old boy in the Netherlands (VU medisch centrum, 2009).

In Belgium, cochlear implantation within the first year of life has been implemented since the year 2000 (Schauwers, 2006). Already in 2000, the University of Antwerp, in close collaboration with The Eargroup (Antwerp-Deurne), started to collect longitudinal speech samples of very early implanted CI children (between 0;6 to 1;9 years). The purpose of this data collection was to investigate the effect of a CI on the development of oral language. The present dissertation pursues this investigation. For the present study, the existing corpus has been enlarged with speech samples from CI children as well as from hearing impaired children wearing classical hearing aids, and children with specific language impairments. The present research is the result of a collaborative project carried out at Leiden University, the University of Antwerp and the Eargroup, and is funded by the Dutch Organisation for Scientific Research (NWO) VIDI project: *The morphosyntactic development of children with cochlear implants. A comparison with children using hearing aids, normally hearing children and children with SLI.*

Aim of this dissertation

Before the advent of the CI, language delays were particularly prevalent in the severely to profoundly deaf children who did not have sufficient gain from conventional Hearing Aids (henceforth HA) (Cooper, 1967; Gilbertson & Kamhi, 1995; Svirsky, Robbins, Kirk, Pisoni & Miyamoto, 2000; Norbury, Bishop & Briscoe, 2001; Hansson, Sahlén & Mäki-Torkko, 2007). For these children, the efficacy of the CI in the development of oral language has been shown systematically. Nowadays, for some of the CI children the expectation is that they will achieve language skills comparable to their Typically Developing (henceforth TD) peers (Nicholas & Geers, 2007; Coene, Schauwers, Gillis, Rooryck & Govaerts, to appear).

However, further analysis of the language data reveals that the development is not uniform across language domains. This means that some language domains are more difficult to master than others: CI children tend to reach age-appropriate lexical skills more easily compared to syntactic and grammatical skills (Geers, Moog, Biedenstein, Brenner & Hayes, 2009; Duchesne, Sutton & Bergeron, 2009).

Therefore, the aim of the present study is to enhance our knowledge of whether a CI provides sufficient access to auditory speech input to acquire grammatical morphemes. In this dissertation we concentrate on the acquisition of verbal morphology in CI children aged between 4 and 7 years.

Stages in Language Development

Language development starts from birth and continues to the tenth year of life (Gillis & Schaerlaekens, 2000). Language development occurs in four phases. The **first phase** (0 – 12 months) is the prelingual phase, in which the infant produces vocal sounds that lead to babbling. The first words occur in the **second stage** (>12 months). In this stage, words are put together to form ‘telegraphic-like’ utterances. Children also use *formulaic* utterances. Formulaic utterances are holistic phrases, that are not analyzed on grammar. In this stage, children are not aware that words consist of different elements such as morphemes. In phase 2 they collect utterances which are subjected to analysis in the **third stage** (>20 months). The stored utterances are decomposed and analyzed on structure. The analysis locates recurring elements within and across utterances, which enables a child to learn the rules of the language. The integration of systemic rules in the acquisitive systems allows for a rapid increase in lexical capacity and syntactic processing. This elaboration and integration of rules appears in **stage four** (>3 years) (Locke, 1997).

Figure 1. The four developmental stages as outlined by Locke (1997 p:268) (reprinted with permission from Elsevier, Oxford).

Phases and Processing Systems, and Neural and Cognitive Mechanisms, Associated with the Development of Linguistic Capacity, along with the Corresponding Areas of Language

Age of onset	Developmental phases and systems	Neurocognitive mechanisms	Linguistic domains
Prenatal	Vocal learning	Specialization in social cognition	Prosody and sound segments
5–7 months	Utterance acquisition	Specialization in social cognition	Stereotyped utterances
20–37 months	Analysis and computation	Grammatical analysis mechanism	Morphology Syntax Phonology
3+ years	Integration and elaboration	Social cognition and grammatical analysis	Expanded lexicon, automatized operations

Sensitive phases in language development

In 1967, Lenneberg related the acquisition of language to the plasticity of the brain. He proposed that between the age of 3 and early teens, children are especially sensitive to acquiring language. He labeled this the critical period. After the age of 10, primary language acquisition comes to be inhibited as the brain has reached its mature state. Lenneberg argued that *'the language skills not acquired by that time, except for articulation, remain deficient for life'* (1967 p:158). The developmental constraints on language learning are somewhat smoothened in the view of the sensitive period. The period for optimal language acquisition may never close completely; it is rather a case of sensitivity being diminished (Tomblin, Barker & Hubbs, 2007).

Locke (1997) argues that each phase in language development has its own critical/sensitive period, and that these periods occur in a fixed and overlapping sequence. The four phases in language development each have their own commitment of neural resources. An essential element in the neural organization of the brain and subsequent language development is early perceptual experience (Locke, 1997). Early exposure to auditory input changes future learning abilities, resulting in long-term language learning effects (Ruben, 1997; Kuhl, 2004; Kuhl, Conboy, Padden, Nelson & Pruitt, 2005; Zhang, Kuhl, Imada, Kotani & Tohkura, 2005).

The notion of the critical/sensitive period has motivated the decrease in age at implantation. Early auditory exposure allows the child to optimally use the critical/sensitive period for language learning. The beneficial effect of early implantation on language acquisition has been reported frequently in the literature (e.g. Kirk, Miyamoto, Ying, Perdew & Zuganelis, 2000; Kirk, Miyamoto, Lento, O'Neill & Fears, 2002; Svirsky, Teoh & Neuburger, 2004; Tomblin, Barker, Spencer, Zhang & Gantz, 2005; Dettman, Pinder, Briggs, Dowell & Leigh, 2007; Hay-McCutcheon, Kirk, Henning & Gao Rong Qi, 2008; Geers et al., 2009). On that account, our aim is to analyze the verbal morphology production of CI children as a function of their age at implantation.

Delayed language development

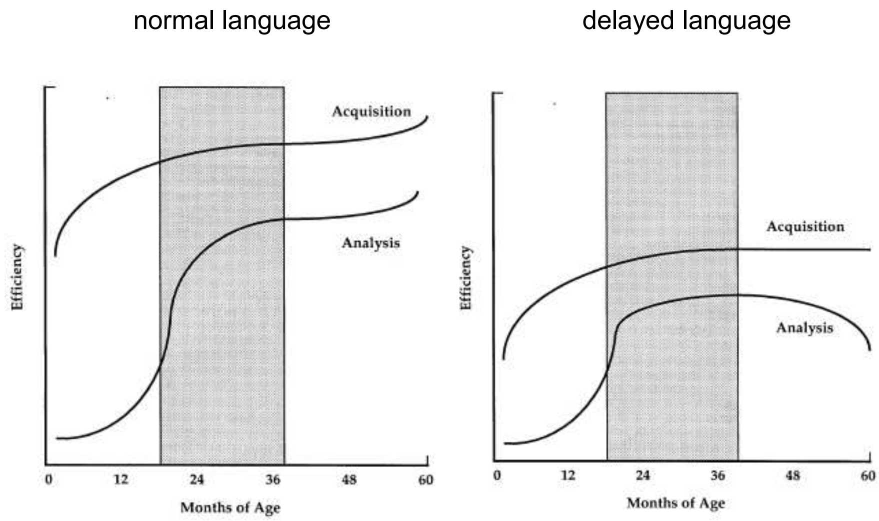
An important aspect of the language developmental theory of Locke (1997) is that the developmental phases are interdependent. This means that the storage of utterances (phase 2) triggers or reinforces the activation of the analytical stage (phase 3). This is presented in Figure 2. Delayed language occurs when the shortage of lexical items prevents the use of analytical mechanisms to acquire grammar. The shortage of lexical items can be due to reduced input. Reduced input may relate to a reduced *effective* exposure to linguistic behavior, as in the case of Specific Language Impairment (henceforth SLI), or to the reduced *auditory* exposure to speech input, as in the case of a hearing impairment (p:282). On that account, the language difficulties of children with SLI and hearing impairments should be comparable, regardless of any different underlying problem (cognitive versus auditory).

Therefore, the present dissertation includes children with SLI and children who wear classical HAs. The purpose of including these clinical groups is to compare the language scores of the CI children with those obtained by the HA and SLI children. These comparisons have the potential to contribute to our knowledge of the prerequisite for language development.

Delayed acquisition of morphology

It has been argued in the literature that the perceptual salience of morphemes partially predicts the order of morpheme acquisition (Goldschneider & Dekeyser, 2001). Perceptual salience refers to the phonetic substance, syllabicity and sonority of the morpheme. The rationale is that morphemes that are more perceptually salient are acquired before morphemes that are less perceptually salient. Besides the physical properties of morphemes, perceptual salience is defined in the acoustical terms of stress, fundamental frequency and amplitude (Leonard, Eyer, Bedore & Grela, 1997; Montgomery & Leonard, 2006).

Figure 2. Phases and systems in which linguistic capacity develops. The stippled area is a critical period in which utterance acquisition must reach a certain level of demonstrated efficiency in order to fully activate and stabilize an utterance-analytic mechanism that, for its part, is intrinsically 'ready' to respond to experience (reprinted with permission from Elsevier, Oxford).



Morphemes are usually unstressed syllables, are lower in fundamental frequency and amplitude and are therefore more difficult to acquire than lexical items.

For SLI children, it has been shown that the production of grammatical morphology in particular is difficult (e.g. Conti-Ramsden & Jones, 1997; Bedore & Leonard, 1998; Conti-Ramsden, 2003, Marchman, Wulfeck & Ellis-Weismer 1999). Leonard and colleagues (1992, 1997, 2003) attribute the deficit in grammatical morphology of SLI children to the combined effect of perceiving the grammatical morpheme and hypothesizing its function. This is called the Surface Account.

For CI children it has been demonstrated that they produce the uncontractable copula more often in an elicitation task as compared to the plural morpheme and past tense morpheme (Svirsky, Stallings, Lento, Ying & Leonard, 2002; Ruder, 2004). This developmental pattern is different from the pattern observed for TD and SLI children, who acquire the plural morpheme before the copula. As such, Svirsky et al. (2002) proposed the Perceptual Prominence Hypothesis, which states that the developmental pattern of morphemes for CI children is predicted by the perceptual salience of these morphemes.

As both accounts stress the importance of perceptual salience, our purpose is to analyze the production of verbal grammatical morphemes in the light of the perceptual salience of these morphemes. This type of analysis aims at enhancing our knowledge of the role of perceptual salience in the acquisition of grammatical morphemes.

Research questions

Based on the aforementioned observations, this dissertation concentrates on the following research questions:

- How do CI children aged between 4 and 7 years compare to their *a)* TD peers, *b)* HA peers and *c)* SLI peers in their verbal morphological development?
- Is there an effect of early implantation in the development of verbal morphology?
- Is there an effect of perceptual salience of grammatical morphemes in the acquisition of these morphemes?

Outline of this dissertation

Chapter 2 gives an overview of the three clinical groups included in this dissertation, which are the CI, HA and SLI children. The hearing-impaired children included in this dissertation have a sensorineural hearing loss. As such, this chapter starts with a short overview of speech perception in the normally functioning cochlea and dysfunctioning cochlea, after which both prosthetic devices (i.e. the cochlear implant and hearing aid) are discussed. This chapter ends with an overview of the literature on language acquisition of the CI, HA, and SLI children.

Chapter 3 presents an overview of the literature on the acquisition of tense and agreement in TD children. A puzzling phenomenon in the acquisition of agreement is that children aged between 2 and 3;6 use infinitive verbs in contexts where a finite verbs is appropriate in the adult speech. However, at the same time, they also produce finite verbs. The co-occurrence of infinite and finite verbs is fairly well documented and several accounts are available to explain this phenomenon. These accounts are summarized in this chapter. In this chapter, we also outline the temporal reference system and how children acquire this system. Special attention is given to the models related to the acquisition of regular and irregular past tense as this underlies the experimental task in chapter 6. We point out that the acquisition of the temporal reference system is related to cognitive maturation.

In **chapter 4**, we examine the STAP test on psychometric criteria. In this dissertation, we analyze spontaneous speech samples using a standardized language test, the STAP test. Prior to the implementation of this test, we conducted a small-scale study to investigate the validity and reliability of the language measures included in this test.

Chapter 5 consists of two sections. In ***section 5.1***, we compare the CI children with their HA peers on their production of verbal morphology in spontaneous speech. The scores of the CI children are analyzed as a function of their age at implantation. The scores of the CI and HA children are analyzed in the light of the Perceptual Prominence Hypothesis. In ***section 5.2***, we compare the CI children with their SLI peers on their production of verbal morphology in spontaneous speech. In this section, the scores of the CI and SLI children are analyzed in the light of the Surface Account.

In **chapter 6**, we examine the production of past tense morphology by CI and SLI children in spontaneous speech and on an experimental task. The experimental task included TD children, which allows for a comparison between both clinical groups with their TD peers. For CI children, further analysis investigates the effect of age at implantation in the production of past tense. This chapter starts with an overview of the acquisition of productive past tense morphology by TD and SLI children.

In **chapter 7,** general conclusions, directions for future research and clinical implications are reported.