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

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SECTION 5.2

CI children in comparison to SLI children

1. Introduction

The purpose of this section of chapter 5 is to compare CI and SLI children in their general language development and verbal morphology development by analyzing spontaneous speech samples. The rationale for such a comparison was outlined briefly in chapter 1, where the language developmental theory of Locke (1997) was described. This theory suggests that delays in the acquisition of language occur when there is a shortage of lexical items. This shortage prevents the analytical mechanism from activating. The shortage of lexical items can be due either to the reduced effective exposure to linguistic behavior, as in the case of SLI (see also Conti-Ramsden et al., 1997), or to the reduced exposure to auditory speech input, as in the case of a hearing impairment (Locke, 1997 p:282). In section 2, we elaborate on the influence of auditory speech processing and cognitive processing in the development of oral language.

The second purpose of this section is to determine the role of perceptual salience in the acquisition of verbal morphology. Problems in the use of grammatical morphology are characteristic of SLI children and serve as a clinical marker (Conti-Ramsden & Jones, 1997; Bedore & Leonard, 1998; Marchman et al., 1999; Conti-Ramsden, 2003). These problems have been linked to the perceptual salience of these morphemes and named the Surface Account (Leonard et al., 1997). The Surface Account is explained in section 3 and is subsequently related to hearing impairments.

Hypotheses relating to both research objectives are outlined in section 4. Section 5 contains an outline of the research method, followed by the results in section 6. The research objectives and hypotheses are discussed in section 7, and the chapter closes with section 8, the conclusion.

2. Language processing

2.1 Low-level auditory processing

The ability to discriminate and process auditory stimuli is a critical skill for successful language development. General auditory processing allows infants to identify phonetic units that differ on subtle acoustic cues, such as the spectral and temporal structural cues of speech. Infants learn to perceptually categorize sounds, which they hear as distinct. Strong phonetic perception facilitates the detection of phonotactic patterns, which play an important role in segmentation (e.g. word learning and grammatical morphology). It has been shown that infants with strong skills in native language phonetic perception have better language outcomes at 18 and 24 months of age than infants with less developed perception skills (Kuhl et al., 2004, 2005).

Spoken language requires the processing of rapidly presented, successive auditory stimuli occurring within tens of milliseconds. Acoustic information is carried by formants, which represent the frequency modulation of the speech signal across time. The accurate discrimination of consonants relies on the detection of formant transitions that are relatively short (~40 ms).

These rapidly changing acoustic cues seem to disrupt discrimination abilities of SLI children. Therefore, language difficulties of SLI children have been related to a lower-level processing deficit or auditory processing deficit (Tallal et al., 1974, 1975, 1981; Benasich & Tallal, 2002; Benasich et al., 2002). Using the results of several series of studies as evidence, Tallal and colleagues conclude that SLI children are impaired in their perception of verbal stimuli that are characterized by brief or rapidly changing temporal cues. For instance, they showed that SLI children needed more trials than their TD peers to correctly discriminate between the two syllable pairs [ba-da] and [da-ta]. The first syllable pair, [ba-da], is characterized by an initial brief transitional period in which the formants move towards the steady-state portion of the vowel. The second syllable pair, [da-ta], differs in voice onset time, that is the interval between the release of the burst and the onset of voicing. Importantly, the discrimination difficulties disappeared when duration of the verbal stimuli was decreased or protracted.

The cochlear implant provides limited spectral information due to the small number of electrodes and the mismapping between the allocation of the frequency bands to electrodes (for example a frequency band centered at 1000Hz is used to drive an electrode at the 2000Hz place within the cochlea) (Moore, 2003). Therefore, the CI users rely also on temporal information to derive pitch and formant cues from the speech input. However, the temporal information offered by the implant is not optimal with respect to formant frequencies (Moore, 2003). This, and the loss of spectral information, makes auditory speech material difficult to process. As such, the degraded speech input interferes with the discrimination and processing of auditory speech material, which could potentially lead to deficits comparable to the auditory processing deficit observed in SLI children (cf. Benasich & Tallal, 2002). It has been shown that CI users differ in their ability to discriminate between phonemes. The variability is only partially explained by the duration of auditory speech experience (Fryauf-Bertschy, 1997; Svirsky et al. 2001; Fu, 2002). Therefore, other factors appear to underlie discrimination abilities, such as lower-level processing abilities (see e.g. Fu 2002 on adult CI users).

2.2 High-level cognitive processing

Adequate processing of speech plays an essential role in higher order cognitive processing (Locke, 1997; Watson et al., 2007). Higher order cognitive processing refers to a temporary storage for information obtained from perception and retrieved from long-term memory. Mental operations are performed on the content of this store, hence this storage is called working memory (Gazzaniga, Ivry & Mangun, 2002). Working memory is limited in capacity and information is subject to fast deterioration. Therefore, to retain information, Baddeley (2003) proposed a subvocal rehearsal loop that crucially depends on acoustic and phonological representations of the input material - the 'phonological loop'. Thus, as the auditory speech stream is processed, phonological representations are fed into the working memory and the rehearsal loop. The data of CI children show positive correlations between the scores on working memory tasks and word recognition, sentence recognition and perception of grammatical morphemes. This points to the importance of auditory processing and working memory in the development of language (Pisoni & Geers, 2002; Pisoni & Cleary 2003; Willstedt-Svensson et al., 2004).

The effects of auditory processing and working memory on the perception of grammatical morphemes have also been reported for TD children. Hayiou-Thomas et al. (2004) have shown that TD children were less accurate in their grammaticality judgments when past tense morphemes, 3rd person singular morphemes and plural morphemes were presented at a faster than normal rate. Accuracy further decreased when these morphemes were embedded in longer utterances in addition to faster presentation rates.

With respect to the close links between perceptual abilities, auditory processing and working memory in the acquisition of morphology, it is reasonable to expect that the language performance of CI and SLI children is not only influenced by what they are able to process on an auditory level, but also by what they are able to do with this information in working memory. Regarding the acquisition of grammatical morphemes, a child not only has to perceive a grammatical morpheme but must also place it in the proper cell of the paradigm (Pinker, 1984).

Leonard et al. (1997) point out that the joint operation of perceiving an acoustically low-salient grammatical morpheme and hypothesizing its grammatical function seems challenging for SLI children. According to Leonard and colleagues, the incomplete processing of the auditory speech input is due to a higher-order cognitive deficit. The morpheme might be lost before morphological analysis is complete or morphological analysis does not occur at all, because processing is focused on previous material in the speech stream or abandoned prior to the inflection in favor of the next word appearing in the utterance. In the following section, we will elaborate on the hypothesis proposed by Leonard and colleagues.

3. Perceptual salience

We have already pointed out in section 5.1 of this chapter, that the perceptual salience of morphemes plays an important role in the acquisition process of TD children: highly salient elements typically emerge earlier in the child's grammar than non-salient ones, because highly salient elements are easier to process (Zobl & Liceras, 1994; Goldschneider & De Keyser, 2001).

With respect to acoustic features, Goldschneider & Dekeyser (2001) argue that perceptual salience of grammatical morphemes is composed of three factors, namely phonetic substance, syllabicity and relative sonority. Phonetic substance refers to the number of phones in a morpheme. The assumption is that the more phones in a morpheme, the more perceptually salient the morpheme is. For example, the Dutch past tense allomorphs /*-de*/ and /*-te*/ contain in total 4 phones. When divided by the number of allomorphs, this yields a mean of 2 for phonetic substance. The Dutch 3rd person singular morpheme (*-t*) contains only 1 phone. When divided by the number of allomorphs, this yields a mean of 1 for phonetic substance. As such, the regular past tense is perceptually more salient compared to the 3rd person singular morpheme. Syllabicity refers to the presence/absence of a vowel in the surface form of the morpheme. The presence of a vowel is perceptually more salient compared to morphemes without a vowel. In the above-mentioned example, the regular past tense is more salient compared to the 3rd person singular morpheme, because the former morpheme contains a vowel. Regarding relative sonority, the assumption is that the more sonorous the phones in the morpheme, the more perceptually salient the morpheme is. The 3rd person singular morpheme (*-t*) is a stop consonant, which is less sonorous compared to the vowel in the regular past tense morpheme.

3.1 The Surface Account

Under the so-called Surface Account as proposed by Leonard and colleagues, the acquisition of (English) morphemes is dependent on their physical and acoustic properties (Leonard et al., 1997). Crucially, this account assumes that SLI children can perceive low phonetic substance morphemes in isolation (Leonard et al., 2003) but that *'the difficulty seems to rest in the combined effects of perceiving the form and treating it as a morpheme'* (Leonard et al., 1992 p:1077). The additional operation of hypothesizing the grammatical function of the morpheme together with the low perceptual salience of morpheme can result in incomplete processing of the morpheme.

To take account of this, Montgomery & Leonard (1998) employed a grammaticality judgment task to assess the child's knowledge of the low perceptual salient past tense morpheme (*-ed*) and the high perceptual salient progressive morpheme (*-ing*). Results indicated that SLI children compared in performance to their TD peers in detecting the omission of the progressive morpheme in an obligatory context. However, the SLI children were less accurate in their grammaticality judgment when the past tense morpheme was omitted in an obligatory context.

In the study by Leonard et al. (2003), the reseachers examined the role of perceptual salience from another perspective. In this study they judged the effect of perceptual salience against the grammatical function of the morpheme. In this study, past tense forms [*the girl pushed the boy*] and passive participles [*the boy got pushed by the girl*] were elicited in an experimental task. The past tense morpheme and the passive participle have the same phonological form (i.e. *–ed*), but differ on grammatical function. The SLI children in this study were significantly less accurate in the use of the past tense morpheme as compared to the passive participles. Based on this finding, Leonard et al. concluded that the weak performance on the production of past tense morphemes could not be solely attributed to the acoustic characteristics of this morpheme. Rather, the function of the grammatical morpheme also plays a role.

3.2 Perceptual salience and hearing impairment

Under Leonard's Surface Account*,* that stresses the role of the perceptual salience of morphemes, the type of processing limitation observed in SLI children is not different from a perceptual deficit, as in the case of hearing impaired children (Locke, 1997; Norbury et al., 2001). Norbury et al. (2001) compared 14 SLI children aged between 7 and 10 years with 19 hearing impaired children, aged between 5 and 10 years. The hearing impaired children in this study wore conventional hearing aids and had a mild to moderate hearing loss (20-70dB). Two elicitation tasks were given which tested the child's knowledge of the 3rd person singular morpheme and the past tense morpheme. To elicit the 3rd person singular morpheme, the children had to describe what they themselves or their family members do every day, such as, '*every day Mark watches telly*'. They had to use at least 15 different verbs. Past tenses were elicited using the Ullman & Gopnik task (1999). In this task, the child was asked to complete sentences like: *'every day I rob a bank. Just like every day, yesterday I …….a bank'* (example from Ullman & Gopnik p:61).

On both tasks, group analysis showed that SLI children performed more poorly than the HA children. However, individual analysis indicated that 6 HA children showed impaired performance on inflectional morphology. This group of HA children was significantly younger compared to the unimpaired HA children (see also Hansson et al., 2007).

The results of Norbury et al. (2001) suggest that the problems in the target-like production of bound verb morphemes are not prevalent among all HA children, whereas they seem to be so for the SLI children. They argue that if perceptual salience plays a role in grammatical morpheme acquisition, the persisting problems in verb morphology for the SLI children are caused by other factors as well, such as cognitive disorders (e.g. Ellis Weismer et al., 2000), an auditory processing disorder (Tallal et al., 1981) or a phonological processing disorder (Briscoe et al. 2001, Baddeley, 2003). The combination of factors leads to a more severe language impairment, as observed for the HA children (Hansson et al., 2007).

4. Hypotheses

Based on the fact that adequate processing skills at an auditory and cognitive level have a pivotal role in language acquisition, we expect that disrupted processing skills can lead to delayed language acquisition. As outlined in section 2, a number of researchers have argued that SLI is the result of processing limitations (see also chapter 2, section 4). Therefore, we hypothesize that CI children compare to their SLI peers in this respect. It is therefore expected that both clinical groups will show similar outcomes on MLU and their production of unbound/bound verb morphology.

Alternatively, CI children may be seen not to compare to their SLI peers with respect to processing. This implies that the effect of reduced auditory input offered by the cochlear implant does not compare to reduced effective exposure in SLI children. This places more weight on external factors such as the role of input, peripheral hearing and education.

With respect to perceptual salience, we formulated the following hypothesis in section 5.1 regarding verb morphemes: items containing a lexical stem (whether or not in combination with a bound morpheme (e.g. *works*) are perceptually more salient than the inflection by itself (e.g. *-s*). Therefore, we expected to find a higher error rate for bound verb morphemes as compared to omissions of inflected verbs, i.e. the complex morpheme consisting of a lexical stem followed by a bound morpheme. However, the results of section 5.1 show that this hypothesis was not borne out for the CI and HA children.

As an alternative, we hypothesized that the children would omit an equal number of inflected verbs and bound verb morphemes due to the underspecification of inflection in their grammar (Hyams, 1996). According to the latter hypothesis, once inflection is acquired, the child should be able to produce any type of verbal agreement marking, regardless of its perceptual prominence status. For SLI children, it has been shown that they have more difficulty in the acquisition of verb morphemes pertaining to agreement as compared to other grammatical morphemes, such as plural *–s,* possessive *–s* or progressive *-ing* (Bedore & Leonard, 1998; Leonard et al., 2003). Therefore, to disentangle the effect of perceptual salience and underspecification from the acquisition of verbal morphology, we need to include an analysis of a [-AGR/+TNS] morpheme.

In Dutch, the circumfix of the past participle is an instantiation of such a morpheme. In this section, we will elaborate on perceptual salience and its role in circumfix omission of past participles. Past participles of weak verbs are formed by means of a prefix *ge-* and a suffix *–D*, in which *–D* stands for the allomorphs /*-t* /and /*-d*/ (Booij & Van Santen, 1998). In this circumfix, the prefix (*ge-*) is perceptually more salient than the suffix (*-D*). The first, but not the latter, contains a vowel (*schwa*) and is thus syllabified (Goldschneider & Dekeyser, 2001). If perceptual salience does not play a role in the acquisition of morphology, it is expected that *–D* will be omitted at an equal rate as compared to the prefix (*ge-).* With respect to verbal morphology, this would indicate an underspecification rather than a perceptual salience hypothesis. However, this would also imply that SLI children not only omit the bound verb morpheme more often, but that they also produce fewer finite verbs than their TD peers.

5. Research Method

Participants

A total number of 48 CI children and 38 SLI children participated in this study. The CI children were selected from special schools for deaf children in Flanders (Belgium) and from The Eargroup, an audiology centre in Antwerp-Deurne (Belgium). The CI children were aged between 47 and 93 months and had received their implant between 5 and 43 months of age. All CI children had a minimum of 2 years of exposure to speech with a maximum of 6;7 years. Their mean unaided hearing loss was 110 dB (SD 11dB) (i.e. hearing thresholds averaged over 500, 1000 and 2000Hz for the best ear) (For more details regarding the unaided and aided hearing thresholds, see Table 2 of the Appendix and for individual data, see Table 3 of the Appendix).

Data from two groups of SLI children were analyzed. The first group included spontaneous speech data of 15 children with orthographic transcriptions readily available from the Bol & Kuiken corpus (Bol & Kuiken, 1988), through the

Child Data Exchange System (MacWhinney, 2000). The 19 transcripts involve four 4-year-olds, five 5-year-olds, seven 6-year-olds and three 7-year-old SLI children. The children included in the Bol & Kuiken corpus all attended special education schools in the Netherlands (Amsterdam, Haarlem, Amersfoort and Leiden).

The second group consisted of 19 SLI children who were selected for the present study. These children were selected from schools for special education in Flanders, Belgium.

For both SLI groups, all children were previously diagnosed as being language impaired by a certified speech-language pathologist. They received interventions at their schools for special education. None of the children had hearing losses, neurological/cognitive disorders or social/emotional problems. They were all of normal intelligence. An overview of the group characteristics is given in Table 1 (for individual data see Table 5 of the Appendix).

For all CI and SLI children selected for the present study, informed consent was obtained from the parents before participation.

Table 1. Overview of the CI and SLI children participating in this study.

	group	*N*	*age (SD)*
4 yrs	CI	15	50.9 (*4.8*)
	SLI	5	54.3 (*3.2*)
5 yrs	CI	14	63.2 (*4.1*)
	SLI	9	65.2 (*3.8*)
6 yrs	CI	10	73.5 (*2.5*)
	SLI	15	76.5 (*3.8*)
7 yrs	CI	9	85.8 (*2.7*)
	SLI	9	87.6 (*3.0*)

Language assessment

The CI and SLI children selected for the present study were recorded for 15 – 30 minutes using a Panasonic NV-GS180 digital video camera. To elicit speech, the same procedure was employed as in Bol & Kuiken (1988), which resembles the procedure of the STAP protocol, as explained in chapter 4, section 3. During the interactions, CI and SLI children spoke about daily activities. The topics of conversation varied from one sample to another, as the adults encouraged the children to discuss their own interests in an effort to reduce the number of possible silent periods during the registration session. Toys and books were not incorporated into the procedure eliciting speech. The child's personal school books or picture books were occasionally used as a method to familiarize the child with the situation and/or experimenter. Interactions with the CI and SLI children were carried out by either one of the parents, a speech therapist or by a member of the research group. All recordings were made in quiet rooms at the schools the children were attending or at the audiology centre.

The CI samples were transcribed by an experienced speech therapist familiar with listening to the speech of deaf children. The experienced speech therapist trained a second transcriber, who transcribed the speech samples of the SLI children. Transcriptions were made according to the CHAT conventions, available through the Child Data Exchange System (MacWhinney, 2000).

Following the test procedure, the first 50 child utterances were analyzed. Repeated and unintelligible utterances, idioms (e.g. 'weet ik niet' *I don't know*) as well as elliptical answers i.e. answers to preceding questions without a finite verb and/or other utterance parts that can be inferred from the preceding question (e.g. adult: 'does it hurt' child: 'a little bit') were excluded from the analysis.

The use of standardized language testing allows us to compare the scores of the CI and SLI children with normative data of 240 TD children. This study included the same measures as in section 5.1. These are Mean Length of Utterance (MLU) in words, finite verb production (that counted the number of produced finite verbs in the 50-utterance sample) and a qualitative measure for verbal morphology. For the latter measure, we counted the number of finite verbs omitted in obligatory contexts and the number of non-target-like usages of bound verb morphemes (see section 5.1 of chapter 5 section 4, for examples).

Non-target-like production of verbal agreement

The non-target-like productions of verbal agreement were further analyzed and subdivided into five categories (for the Dutch verbal paradigm see section 5.1 of chapter 5, Table 4).

No.	*Description*
1	Omission of the 3rd p/sg morpheme (i.e. –*t*) Die slaap*(t) in een klein bedje That sleep*(s) in a little bed *'That one sleeps in a little bed'*
2	Bare verb stem in plural contexts [Er] *mag/mogen geen leeuwen in hoor [There] *may no lions in (interjection) *'Lions cannot go in there'*
3	No deletion of the 2nd/3rd p/sg morph. in inversion context (see ex.) *or* use of 2nd/3rd p/sg morpheme with first person singular context Dan *weent jij Than *cries you *'Than you cry'*
4	Plural verb morpheme in singular contexts Hier *waren/was het podium There *were/was the stage *'There was the stage'*
5	Other non-target-like production of bound verb morphemes [De] lepel kanne inne [in de] vrachtwagen [The] spoon can in [in the] truck *'The spoon can be put in the truck'*

Circumfix omission of past participles

The past participle production and errors in the use of weak verbs were also analyzed for both clinical populations. In Dutch, all weak verbs have a circumfix (see (1)). For the strong verbs, the past participle is formed by a prefix, a vowel change in the stem or the use of a bare stem combined with a suffix –*t*/–*en* (see (2) and (3)). All past participles for which the target form requires a circumfix (i.e. the weak verbs) were taken into account and analyzed with respect to the omission of both prefix and suffix.

(1) ge-stem-D	De auto is tegen de boom gebotst *'The car has bumped into the tree'*
(2) ge-past tense form	Ik heb koekjes gekocht *'I have bought cookies'*
(3) ge-stem/past tense form –en	Ik ben naar huis gelopen *'I have walked home"*

Reliability

The language assessment of the STAP test is based on paraphrasing ungrammatical utterances. Although a clear protocol is provided, the paraphrasing guidelines leave room for interpretation. This is demonstrated in the following paraphrased utterances (4b-d) of the original utterance in (4a) (examples taken from Schultz, 2008) (inserted elements in brackets).

(4) a. Alleen met papa kunnen wel lezen bij mij
Only with daddy can-INF indeed read at me

b. Alleen met papa kunnen [we] wel lezen bij mij
Only with daddy can-INF [we] indeed read at me

c. Alleen papa kan wel lezen bij mij
Only daddy can indeed read at me

d. Pappa kan wel [voor] mij alleen lezen
Daddy can indeed [to] me only read
'However, daddy can read to me only'

The options in paraphrasing, as exemplified *supra*, are reflected in the counts on various variables. This places emphasis on determining the coding reliability, particularly when more than one coder is involved. In the present study, STAP analyses were performed by three coders.

To examine the between-coder reliability, 10% of the transcripts were reanalyzed by one of the coders. Correlations were calculated to determine the degree of correspondence between the first and second coding. The correlations were as high as .99 for MLU and finite verb production and .89 for verbal agreement errors/omissions.

The application of standardized language testing allows language development to be identified as being deviant or not. Deviance is represented by language outcomes that correspond to P2.5 or less in TD children. In order to determine the degree of correspondence between the two coding sessions in this deviant/non-deviant categorization, the percentage agreement was calculated. In this analysis, we found 100% agreement for MLU and finite verb production and 89% agreement for verbal agreement errors/omission.

Data analysis

In order to compare the results of the CI and SLI children with their TD peers on MLU, finite verb production and errors/omission of verbal agreement, all raw scores were standardized according to the norms of the TD children. According to this standardization, each individual raw score was transformed into a z-score (for an explanation of the z-scores, see section 5.1 of this chapter, section 4 data analysis). Statistical testing between CI and SLI children at each age was done with a one-way ANOVA when the assumption of equal variances was met. When this was not the case, the non-parametric Mann-Whitney U-test was opted for. We lowered alpha to .01 to adjust alpha for multiple testing.

In chapter 2, section 4, we pointed out that problems in the use of grammatical morphology are characteristic of SLI children and serve as a clinical marker. We have shown that finite verb morphology, measured by means of an equation containing outcomes for the production of regular past tense, 3rd person singular present inflections, copulas and the auxiliary *be* together with MLU (Bedore & Leonard, 1998) is able to successfully discriminate between TD and SLI children. In this section of chapter 5, we intend to use the same measure to assess the morphological development of CI children.

To analyze the effect of perceptual salience on the acquisition of verb morphology, we will analyze the type of subject-verb agreement errors according to the 5 categories outlined above. The weak past participles will be analyzed on circumfix omission.

6. Results

6.1 General language and verbal morphological production

MLU

The first analysis compared the CI and SLI children on their MLU. The mean raw scores and standard deviations for MLU are presented in Figure 1 and Table 3. This Table includes the ranges in MLU scores and the statistical results for the group comparisons.

As already pointed out in section 5.1, CI children show a steady increase in MLU over the years. From Figure 1, it can be observed that no such linear growth in MLU is present for the SLI children. The mean MLU scores of the SLI children fall below the P2.5 at the age of 4, 5 and 6. At the age of 7, the mean lies within the lower boundary of the 95% confidence interval.

Statistical results reveal no significant differences between CI and SLI children at any age. However, at the age of 6, group comparisons begin to reach significance. At this age, there is a strong trend for CI children to produce longer utterances as compared to their SLI peers.

Figure 1. Mean raw MLU scores and SD per age group for the CI and SLI children. Reference scores are plotted in each graph, with the dotted line indicating the lower boundary of the 95% confidence-interval in TD children (i.e. P2.5).

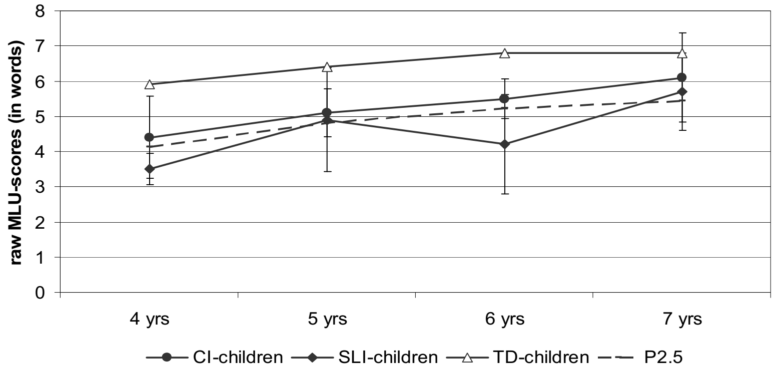


Table 3. Mean MLU scores, standard deviations and range per age group for the CI and SLI children. Statistical results for the group comparisons are also presented.

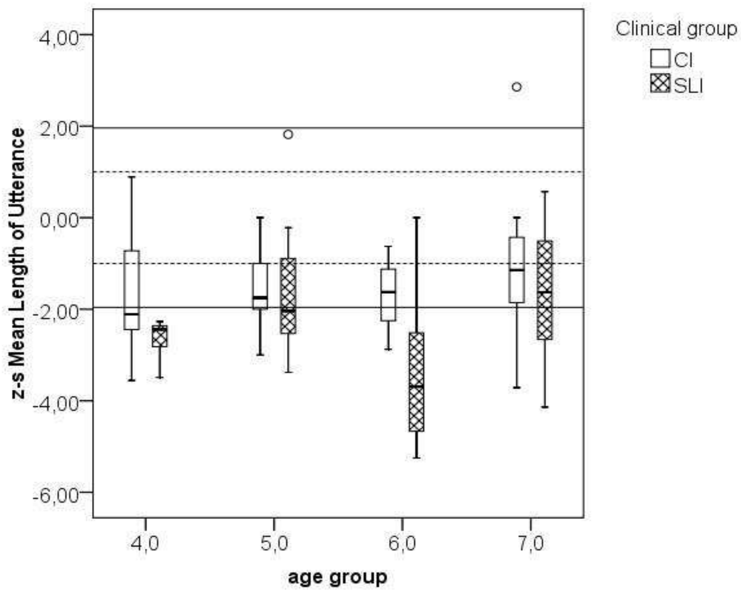
	CI children			*SLI children*			*statistical results*
	M	SD	range	M	SD	range	
4 yrs	4.4	1.2	2.7 – 7.7	3.5	0.5	2.8 – 3.9	U=18, p=.10
5 yrs	5.1	0.7	4.0 – 6.4	4.9	1.5	3.4 – 8.0	F(1,21)=.000, p=.99
6 yrs	5.5	0.6	4.5 – 6.3	4.2	1.4	2.6 – 6.8	U=33, p=.02
7 yrs	6.1	1.3	4.2 – 8.8	5.7	1.1	3.9 – 7.2	F(1,16)=.433, p=.52

The raw scores of the CI and SLI children have been standardized by transforming them into z-scores. These z-scores are plotted in Figure 2. The results are presented in box plots as this presentation type gives information about the intra-group variation. The horizontal lines in the Figure indicate the upper and lower boundary of the 95% confidence interval (P2.5 and P97.5) in TD children. A z-score outside the 95% confidence interval shows significant deviance from the performance of the TD children. The dotted horizontal lines indicate the boundaries of the 68% confidence interval (P31 and P68) in TD children.

At the age of 4, 46.7% of the CI children perform well within the 95% confidence interval. This indicates that approximately 50% of the CI children produce utterances at a comparable length to their TD peers. With increasing age, CI children show a higher level of correlation to their TD peers.

For the SLI children, no consistent increasing pattern correlating with increasing age is observed. All 4-year-old SLI children perform significantly below their TD peers. At the age of 5, 50% of the SLI children perform within the 95% confidence interval. However, at the age of 6, the number of SLI children performing within the 95% confidence interval decreases. At this age, 75% of the SLI children produce significantly shorter utterances as compared to their TD peers. The percentage SLI children performing within the 95% confidence interval increases at the age of 7. At this age, more than 50% of the SLI children perform within the 95% confidence interval.

Figure 2. Box plots represent the standardized MLU scores for the CI and SLI children per age group. Reference values from TD children are depicted by dotted lines representing the area within one SD from the mean (z-scores -1 – 1) and by solid lines marking the 95% confidence-interval (z-scores -1.96 – 1.96).



Finite verb production

The mean number of finite verbs per age group as well as standard deviations are presented in Figure 3 for CI and SLI children. Table 4 presents the mean, standard deviations and range in raw finite verb production scores per age group for both clinical groups. The CI and SLI children were statistically compared on their finite verb production and the results are given in Table 4.

The results in Figure 3 show that whereas CI children show a steep increase in finite verb production between the age 4 and 7, SLI children remain well below the P2.5 of their TD peers. This means that the gap between the SLI children and their CI and TD peers increases over the years. Statistical analysis shows that CI and SLI children compare in their finite verb production at the ages of 4 and 5. However, the SLI children produce significantly fewer finite verbs compared to their CI peers at the ages of 6 and 7 (see Table 4).

Figure 3. Mean raw finite verb production scores and SD per age group for the CI and SLI children. Reference scores are plotted in each graph, with the dotted line indicating the lower boundary of the 95% confidence-interval in TD children (i.e. P2.5).

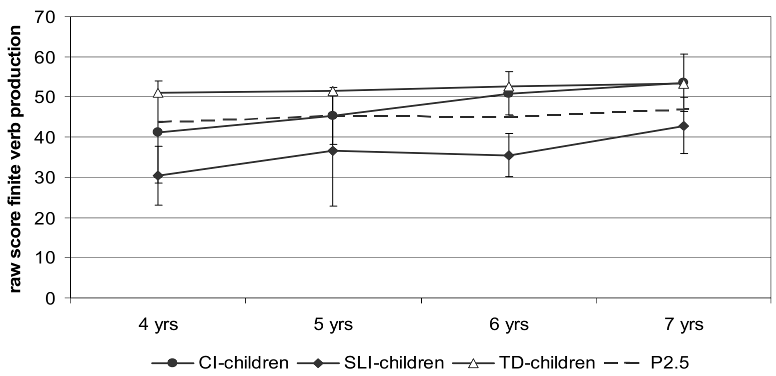
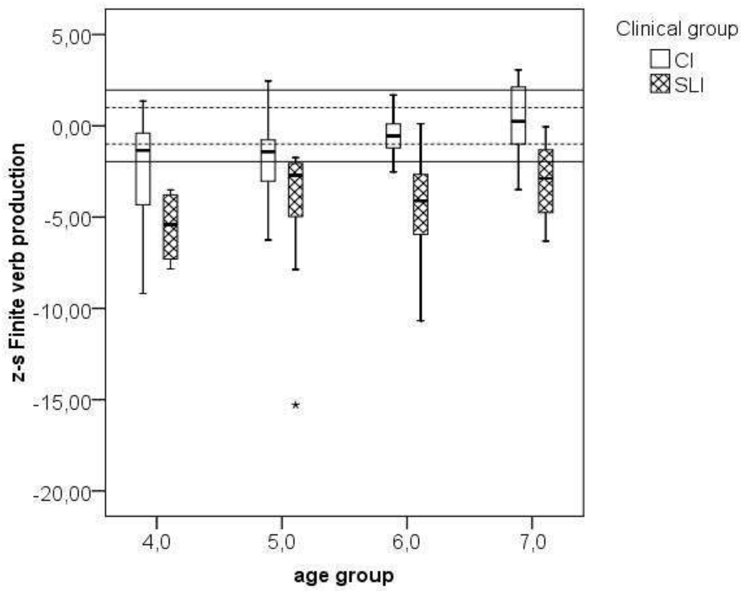


Table 4. Mean raw scores, standard deviations and range for finite verb production per age group for the CI and SLI children. Statistical results for the group comparisons are also presented.

	CI children			*SLI children*			*statistical results*
	M	SD	range	M	SD	range	
4 yrs	41.3	12.8	17 – 56	30.4	7.3	22 – 38	F(1,18)=3.198, p=.09
5 yrs	45.3	7.2	32 – 59	36.7	13.8	4 – 46	F(1,21)=3.910, p=.06
6 yrs	50.8	5.4	43 – 59	35.5	12.7	12 – 53	U=22, p=.002*
7 yrs	53.6	7.1	42 – 63	42.9	6.9	33 – 53	F(1,16)=10.376, p=.005*

For the CI and SLI children, raw scores on finite verb production are adapted to the age norms by transforming them into z-scores. The z-scores of the CI and SLI peers are plotted in Figure 4. The z-scores are presented in box plots as these types of plots give information about the intra-group variation. The horizontal lines in the box plot indicate the upper and lower boundary of the 95% confidence interval (i.e. P97.5 and P2.5).

Figure 4. Box plots represent the standardized finite verb production scores for the CI and SLI children per age group. Reference values from TD children are depicted by dotted lines representing the area within one SD from the mean (z-scores -1 – 1) and by solid lines marking the 95% confidence interval (z-scores -1.96 – 1.96).



The increasing gap between the CI and SLI children on finite verb production becomes evident from Figure 4. Between the ages of 4 and 7, the CI children move towards the mean of the TD children. In contrast, no such improvement is observed for the SLI children. At all ages, more than 50% of the SLI children remain below the P2.5.

The intra-group variation decreases for the CI children from age 4 to 7. At the age of 4 and 5, some weak-scoring CI children are observed. These CI children perform more poorly as compared to their CI peers on finite verb production. The group of weak-scoring CI children decreases at the ages 6 and 7. In contrast, the SLI children do not show such a decrease in intra-group variation.

Errors/omission of verbal agreement

The mean and standard deviations for the CI and SLI children are depicted in Figure 5 and represented in Table 5 for the errors/omissions in the production of verb morphology (i.e. bound and unbound verb morphology in obligatory contexts). The mean scores for the production of errors/omissions in verb morphology are considerably higher for the CI and SLI children as compared to the mean of the TD children. In addition, the means of both clinical populations are well beyond the P97.5 (i.e. the upper limit of the 95% confidence interval, indicating the maximum number of errors/omissions a child can make to be within normal range).

Figure 5. Mean raw scores and SD for omissions/errors of verb morphology for the CI and SLI children. Reference scores are plotted in each graph, with the dotted line indicating the upper boundary of the 95% confidence interval in TD children (i.e. P97.5).

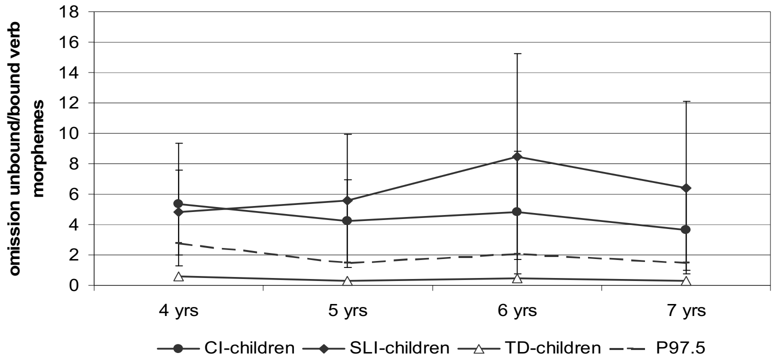


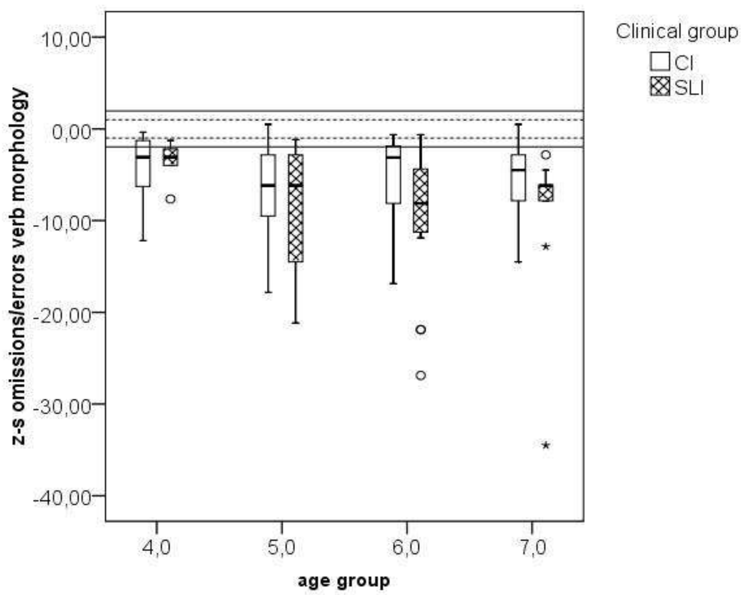
Table 5. Mean raw scores, SD and range for omissions/errors of verb morphology per age group for the CI and SLI children. Statistical results for the group comparisons are also presented as well.

	CI children			*SLI children*			*statistical results*
	M	SD	range	M	SD	range	
4 yrs	5.3	4.0	1 – 14	4.8	2.8	2 – 9	F(1,18)=.142, p=.71
5 yrs	4.2	2.7	0 – 11	5.6	4.4	1 – 13	F(1,21)=.832, p=.37
6 yrs	4.8	2.8	2 – 9	8.5	6.8	1 – 25	F(1,23)=2.294, p=.14
7 yrs	5.6	4.4	1 – 13	6.4	5.7	2 – 21	F(1,16)=1.444, p=.25

Figure 5 shows that a gap starts to emerge between CI and SLI children. The latter groups tend to produce more errors/omissions in verb morphology as compared to their CI peers. However, at no age does the difference between CI and SLI children become significant (see Table 5). This could be due to the large intra-group variation.

All raw scores are transformed into z-scores. These scores are depicted in Figure 6. This figure shows that more than 75% of the CI children produce significantly more agreement errors than their TD peers and this percentage does not decrease over the years. For the SLI children, it is observed that the median z-score decreases with increasing age. This indicates that the gap between the SLI children and their TD peers increases with increasing age.

Figure 6. Box plots represent the standardized agreement error scores for the CI and SLI children per age group. The reference data from hearing children are depicted by horizontal lines. The area within one SD from the mean is indicated by a dotted line (z-scores -1 – 1). The 95% confidence interval is indicated by a solid line (z-scores -1.96 – 1.96).



With respect to the intra-group variation, Figure 6 shows that the variation within the group of CI children is consistent with age. This contrasts with the SLI children, for whom it is observed that the intra-group variation increases with increasing age. At the age of 7, some SLI children produce more agreement errors compared to their SLI peers.

6.2 Combining scores on MLU and verbal morphology

Correlation between language measures

According to Wexler's Optional Infinitive account (Wexler et al., 1994), the transition from non-finite to finite utterances involves an increase in syntactic and grammatical complexity. It is generally assumed that this increase in syntactic complexity cannot be measured in MLU (Miller & Chapman 1981; Klee & Fitzgerald, 1985; Rondal et al. 1987). For example, the production of a finite verb as in (6) is not different in MLU as compared to the utterance in (5). Moreover, an increase in MLU can be observed in purely nominal contexts, i.e. in utterances where there is no finite verb, compare (7) and (8). This leads to the expectation that there is no one-to-one relation between MLU and the production of finite verb morphology.

(5) Die papegaai zo vliegen (MLU in words: 4)
That parrot so fly-INF

(6) Die papegaai vliegt zo (MLU in words: 4)
That parrot flies so
'That parrot flies like this'

(7) Jan in de tuin (MLU in words: 4)
Jan in the garden

Jan werkt in de tuin (MLU in words: 5)
Jan works in the garden

(8) Marie mee naar school (MLU in words: 4)
Marie with to school
'Marie with us to school'

Marie niet mee naar school (MLU in words: 5)
Marie not with to school
'Marie not with us to school'

When controlled for age, strong significant correlations are found between MLU and finite verb production for the CI children (r=.664, p=.000) and the SLI children (r=.802, p=.000). This indicates that the increase in sentence length as measured by the MLU in words is mainly due to an increase in finite verb production.

When controlled for age, no significant correlations are found between the production of finite verbs and the errors in bound verb morphology for the CI children and the SLI children (respectively, r=-.089, p=.551 and r=.078, p=.646). This suggests that a higher finite verb production is not necessarily associated with more errors in the production of bound verb morphology, indicating that there is a qualitative improvement over time.

MLU and verb morphology

The fact that MLU measures to some extent complexity, the scores on MLU and finite verb production were combined to compare the CI and SLI children individually. When multiple variables are combined, the alpha will decrease and, as a consequence, the risk of a type II error increases (considering a child non-deviant, when in fact the child is deviant). To prevent this, an alpha of .05 should be applied to the composite of variables (MLU, finite verb production and errors in bound verb morphology), rather than to one variable only. When applying an alpha of .05 to the composite of MLU, finite verb production and subject-verb agreement errors, the estimated cut-off lies between the P5 and P37[5]. A cut-off of P20 has been substantiated and used by several researchers who also use multiple variables in their diagnosis (Tomblin et al., 1997; Dunn et al., 1996). Therefore, the P20 that corresponds with a z-value of -1.28 will be used to discriminate between impaired and non-impaired language proficiency.

The MLU z-scores are plotted as a function of the z-scores on finite verb production. (See Figure 7, panel A for the CI children and Figure 7, panel B, for the SLI children). The vertical line in Figure 7 A and B indicate the P20 of the finite verb production. The horizontal line in Figure panel A and B indicates the P20 of the MLU. This means that the upper right quartile represents the CI and SLI children who compare to their TD peers in MLU and finite verb production.

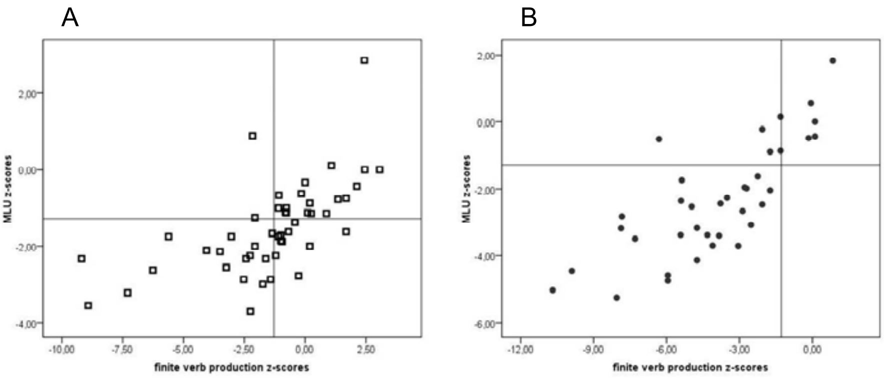
From Figure 7, panel B, it is observed that the majority of the SLI children perform below the age expectations on finite verb production and MLU (72.9%) (lower-left quadrant). 8.1% of the SLI children compare to their TD peers in MLU, but produce fewer finite verbs than their TD peers (upper-left quadrant). Another small group of SLI children (18.9%) compare to their TD peers on MLU and finite verb production (upper-right quadrant). None of the SLI children produce significantly shorter utterances than their TD peers, and produce an equal number of finite verbs as their TD-peers.

For the CI children, it is observed that 35.4% perform below age expectations on MLU and finite verb production (lower-left quadrant). 6.3% of the CI children compare to their TD peers in MLU, but produce fewer finite

[5]When combining MLU, finite verb production and bound verb morphology errors, the cut-off point lies at P37 (two-sided) ((37/100)x(37/100)x(37/100)=5/100^3). However, this would be true if all language measures were independent of each other. As this is not the case with the language measures used here, the estimated cut-off point lies between the P5 and P37.

verbs (upper-left quadrant). Of the CI children, 29.2% compare to their TD peers on MLU and finite verb production (upper-right quadrant). 29.2% of the CI children compare to their TD peers in finite verb production, and fall behind their TD peers on MLU. This contrasts with the SLI children.

Figure 7. Individual MLU z-scores plotted as a function of the z-scores on finite verb production, in panel A for the CI children and in panel B for the SLI children. The vertical line in the graphs indicates the P20 of the finite verb production. Scores that fall on the left side of the line are deviant from the TD children. The scores on the right are non-deviant. The horizontal line in the graphs indicates the P20 of MLU. Scores below the horizontal line are deviant from the TD children; scores above the horizontal line are non-deviant. Clockwise: the upper-right quartile represents the children who compare to their TD peers in finite verb production and MLU. The lower-right quartile represents the children who are deviant on MLU, but not on finite verb production. The lower-left quartile represents the children that score deviant on finite verb production and MLU, and the upper-right quartile represents the children that score non-deviant on MLU and deviant on finite verb production.

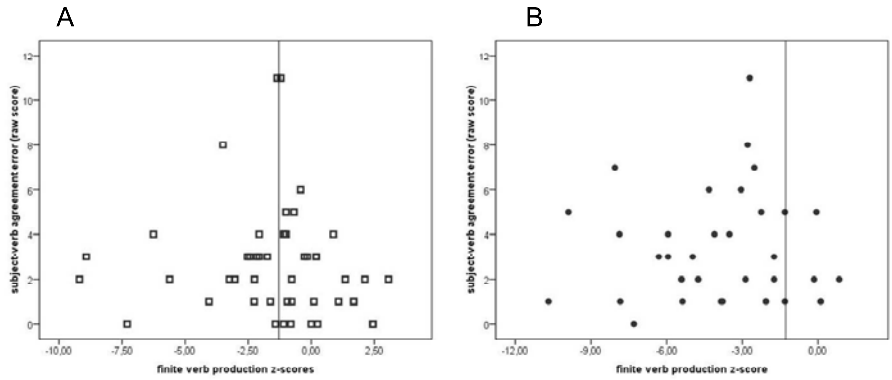


Analysis on age group level indicates that the majority of the CI children who perform deviantly on MLU and finite verb production belong to the age groups 4 and 5, rather than the age groups 6 and 7. Twenty-seven per cent of the 4 and 5-year-old CI children perform poorly on MLU and finite verb production as opposed to 8.3% in the group of 6 and 7-year-olds. No such pattern is observed for the SLI children. Of the 4 and 5-year-old SLI children, 29.7% perform deviantly on MLU and finite verb production as compared to 43.2% of the 6 and 7-year-old SLI children.

In Figure 8, subject-verb agreement errors (e.g. *she *sleep/sleeps*, excluding finite verb omissions in obligatory contexts) for each child are plotted against the finite verb production z-scores. This can be seen in panel A for the CI children and in panel B for the SLI children. The vertical line indicates the P20 for the finite verb production. All finite verb scores below the P20 (falling on the left side of the vertical line) are considered deviant from the TD population. No norms are available for the subject-verb agreement errors, therefore no cut-off line is depicted for this measure.

The plots in panel A and B confirm the lack of correlation between the production of finite verbs and the subject-verb agreement errors for the CI and SLI children. This indicates that the increase in finite verbs is not related to the production of more agreement errors. These findings indicate an improvement.

Figure 8. Individual subject-verb agreement errors (raw scores) are plotted against the finite verb production z-scores, in panel A for the CI children and in panel B for the SLI children. The vertical line in the graphs indicates the P20 of the finite verb production. Scores on the left side of the line are deviant from the TD children.



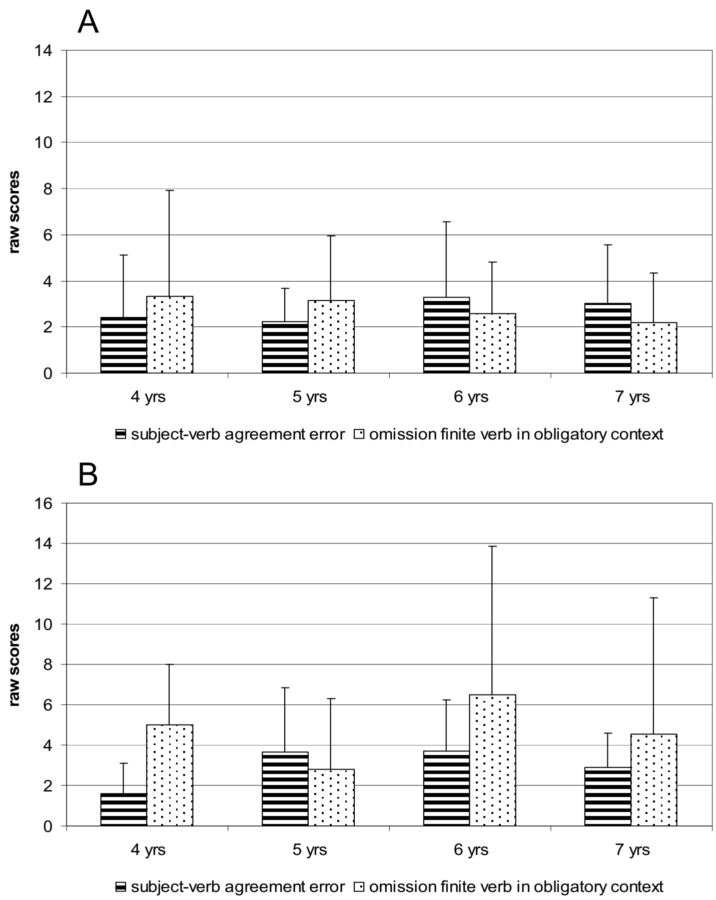
6.3 Analysis of agreement errors

Finite verb omission and subject-verb agreement errors

The finite verb omissions in obligatory contexts and subject-verb agreement errors are presented separately in Figure 9 for the CI and SLI children. The total number of finite verb omissions and subject-verb agreement errors is divided by the number of children in the age group to obtain the mean and standard deviations of both measures.

At the ages of 4 and 5, CI children tend to omit the finite verb more often compared to the production of subject-verb agreement errors. This pattern changes at the ages of 6 and 7, when CI children tend to produce more subject-verb agreement errors as compared to the omission of finite verbs. The difference between finite verb omissions and subject-verb agreement errors is not significant at any age (see Table 6 p:116).

Figure 9. The raw number of finite verb omissions in obligatory contexts and subject-verb agreement errors is presented separately for each age group and clinical group. The results for the CI children are presented in panel A, and for the SLI children in panel B.



No such shift is observed for the SLI children. These children omit the finite verb more often than they produce subject-verb agreement errors at the ages of 4, 6 and 7. At the age of 5, this pattern is reversed. At this age, the SLI children produce more subject-verb agreement errors as compared to the omission of finite verbs in obligatory contexts. The difference between finite verb omission and subject-verb agreement errors begins to reach significance at the age of 4 (see Table 6). No significant difference is observed in subsequent years.

Table 6. Statistical results for the comparison between finite verb omission in obligatory contexts and subject-verb agreement errors.

	CI children	*SLI children*
4 yrs	U=107.0, p=.838	U=3.0, p=.056
5 yrs	U=90.0, p=.734	U=29.5, p=.340
6 yrs	U=47.0, p=.853	U=87.5, p=.635
7 yrs	U=33.5, p=.546	U=39.0, p=.931

No significant difference is found between the CI and SLI children in terms of their omission of finite verbs and their production of subject-verb agreement errors at any age. However, for the SLI children, it is observed from Figure 6 that the variation between these children is higher when compared to their CI peers on the omission of finite verbs (cf. CI and SLI children at age 6). These results point towards a more severe problem in the acquisition of finiteness among SLI children as compared to their CI peers.

Table 7. Statistical results for the comparison between CI and SLI children on finite verb omission in obligatory context and number of subject-verb agreement errors.

	finite verb omissions	*subject-verb agreement*
4 yrs	U=21.5, p=.168	U=31.5, p=.612
5 yrs	U=54.5, p=.600	U=49.5, p=.403
6 yrs	U=49.5, p=.235	U=57.5, p=472
7 yrs	U=33.0, p=.546	U=39.0, p=.931

Subject-verb agreement errors

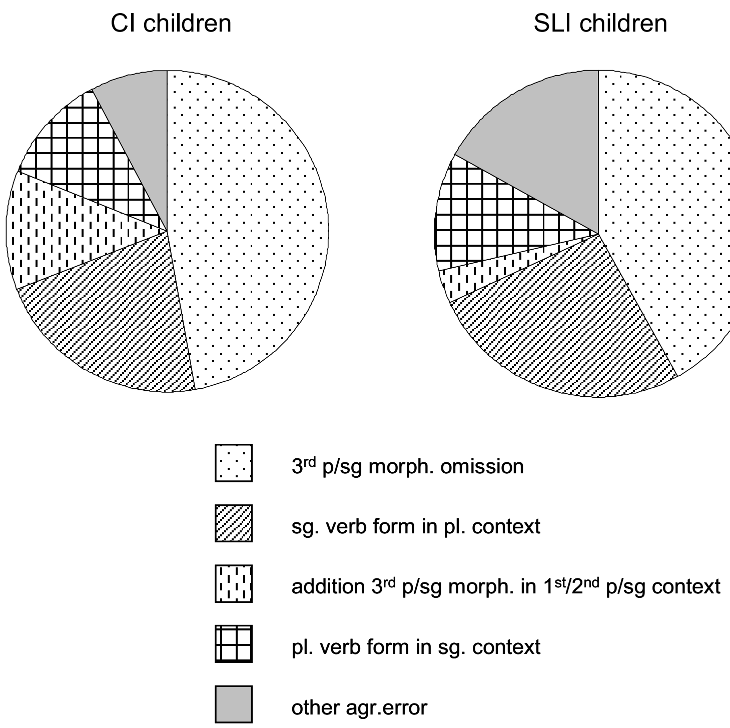
The CI children produced 2250 finite verbs between the ages of 4 and 7. A total of 127 subject-verb agreement errors were counted. This indicates that 5.6% of the finite verbs produced were incorrect. For the SLI children, a total of 1418 finite verbs were counted, of which 119 were produced incorrectly. This indicates that 8.4% of the finite verbs were incorrectly marked for finiteness.

The pie charts in Figure 10 depict the distribution of subject-verb agreement errors across the five categories (outlined in section 5 of this chapter) for the CI and SLI children. From the pie charts, it is observed that the distribution is comparable between the CI and SLI children. The majority of the subject-verb agreement errors involve the omission of the 3rd person singular morpheme. The production of bare verb stems is also a common subject-verb agreement error for the CI and SLI children. This type of error may include the omission of the plural morpheme (*-en*), or the use of a 1st person singular morpheme instead of a plural one, as illustrated in (9):

(9) De wespen is [zijn] in de appel
The wasps is [are] in the apple
'The wasps are in the apple'

Although the majority of subject-verb agreement errors involve the omission of the agreement morpheme, some substitutions may occur. This implies that some CI and SLI children use a third person singular form when the subject is first or second person or they may insert a plural verb form in a singular context (see examples under category 3 and 4, section 5, language assessment).

Figure 10. Percentage of subject-verb agreement types from total number of subject-verb agreement errors for the CI and SLI children.



Past participle errors

The CI children produced a total of 216 past participles between the ages of 4 and 7. Fifty-eight of these past participles were formed with circumfix. From these 58 past participles, 41% were produced incorrectly. The difference between the omission of the prefix and the suffix is 7%, with more omissions of the prefix occurring than the suffix (see Table 8).

The SLI children produced 177 past participles between the ages of 4 and 7. Fifty-five of these past participles were formed with circumfix. Of these 55 past participles, 27% were produced incorrectly. The difference between the omission of the prefix and suffix is 9% (see Table 8). The SLI children omitted the suffix more often than the prefix.

Table 8. Number of past participles with circumfix that were analyzed; raw number of omissions of the prefix and omissions of the suffix. Percentages in parentheses were calculated by dividing the raw number of omissions by the total number of past participles that were analyzed.

	number of past participles analyzed	*omission of the prefix*	*omission of the suffix*
CI children	58	14 (24%)	10 (17%)
SLI children	55	5 (9%)	10 (18%)

7. Discussion

Do CI children out-perform their SLI peers?

In this section of chapter 5, we compared CI and SLI children aged between 4 and 7 years on their MLU, finite verb production and errors/omission of verbal agreement. Based on the literature indicating difficulties in the acquisition of grammatical morphology for both populations, we concentrated on the question: To what extent does the vulnerability of morphology in language acquisition by CI children resemble the behavioral language pattern observed in SLI children?

The results indicate that for the CI children, a steady growth in MLU is found between the ages of 4 and 7, although shorter utterances were found for the SLI children that almost reached significance at the age of 6. The CI children demonstrated a sharp increase in the production of finite verbs, whereas the SLI children remained below the lower boundary of the 95% confidence interval. At the ages of 6 and 7, the SLI children produced significantly fewer finite verbs as compared to their TD peers. From the age of 6, the gap between the CI and SLI children continued to increase. Nevertheless, no significant differences were found between both clinical groups in their production of subject-verb agreement errors at any age.

Also, positive correlations were found between MLU and finite verb production for the CI and SLI children. Between 44 and 64% of the increase in MLU was due to the increased production of finite verbs. This is a remarkable result, as it has been argued that longer MLUs lose their indicative value for syntactic growth as the development of syntactic complexity does not necessarily result in longer utterances after the age of 3 (Miller & Chapman 1981; Klee & Fitzgerald, 1985; Rondal et al. 1987). The positive correlation found in this study suggests that the growth in verbal syntactic complexity can be measured to some extent with MLU for the CI and SLI children up to the age of 7.

Taken together, MLU and finite verb production have been used to identify children who show a deviance in language development. Of the SLI children, 73% performed below age-expectations on this combined measure of language production. By contrast, only 38% of the CI children had outcomes that are below age-expectations. Therefore, only a subgroup of the CI children compare to their SLI peers. Roughly speaking, only 1 out of 3 early implanted CI children demonstrated a deviant developmental pattern. Importantly, this proportion falls within the SLI prevalence estimate of hearing impaired children presented in other studies, which is between 22% and 50% (Gilbertson & Kamhi, 1995; Norbury et al. 2001; Hansson et al. 2007).

A close inspection of this subgroup of CI children with deviant language development indicates that the majority belong to the youngest age groups (4 and 5-year-olds). This suggests that the atypical language development identified does not persist into the older age groups (6 and 7-year-olds). Similar observations have been made for children with classical hearing aids. Younger HA children have been said to have more language difficulties than older HA children (Norbury et al. 2001; Hansson et al., 2007), indicating that they somehow outgrow their language development problems.

Interestingly, 21% of the CI children compare in their finite verb production to their TD peers, but fall significantly behind on MLU. This indicates that both populations are comparable in verbal complexity. This profile is not observed for the SLI children, indicating more severe problems in the acquisition of finiteness in comparison with their CI peers. The findings observed thus question the fact that processing limitations and sensory deprivation may yield similar language outcomes (Locke, 1997). The effect of the reduced auditory input of CI children and of the processing limitations found in SLI children are therefore not directly comparable.

What is the role of perceptual salience in verb morphology development?

The second objective consisted of comparing CI and SLI children on subject-verb agreement errors in relation to perceptual salience. According to the Surface Account proposed by Leonard and colleagues (1997), the joint operation of perceiving an acoustically low-salient grammatical morpheme and identifying its grammatical function is challenging for SLI children.

CI and SLI children have been found to be comparable in the distribution of subject-verb agreement error types. In most cases, both populations omit the 3rd person singular morpheme. Less frequently, they use a singular form in a plural context. The latter type of agreement error includes the omission of the plural verb morpheme. As the plural morpheme in Dutch contains a vowel, it may be taken to be perceptually more salient as compared to the 3rd person singular morpheme (*-t*). The results show that both CI and SLI children are more likely to omit the 3rd person singular morpheme as compared to the plural verb morpheme. This is in accordance with the Surface Account.

Since SLI children are especially impaired in their acquisition of finiteness, we also included an analysis of past participles. Weak past participles in Dutch require a circumfix, in which the prefix is relatively more salient than the suffix. The result of this analysis indicates that SLI children omit the suffix slightly more frequently compared to the omission of the prefix. This is also expected under the Surface Account. This underlines the effect of perceptual salience in the acquisition of morphology for SLI children.

No effect of perceptual salience was found for the CI children in the omission of the circumfix of past participles. Remarkably, these children tend to omit the prefix slightly more often than the suffix. In contrast to SLI children, their results are therefore not predicted by the Surface Account.

This finding contrasts with that of subject-verb agreement omissions, where results were explained by the Surface Account. However, taken together with the results obtained in section 5.1 (where no effect of perceptual salience was found for the acquisition of unbound versus bound verb morphology), we argue that the delay in target-like subject-verb agreement marking is not primarily related to perceptual salience. Rather, the delay results from speech perception difficulties in noisy day-to-day environments. This is proposed in the newly formulated *Morpheme-in-Noise Perception Deficit Hypothesis* in chapter 6, subsection 8.2.

Implications and future research

In this study, 85 CI and SLI subjects were tested in 4 different age groups. Consequently, the number of tested subjects per age group for each population is relatively small. The question that rises therefore concerns the generalizability of the results to the population of CI and SLI children. For both populations, heterogeneity and variability between subjects was reported (De Jong, 1999; Geers et al., 2004; Tomblin et al., 2005; Hay-McCutcheon et al., 2008; Duchesne et al., 2009). For the CI children, a large body of research was dedicated to accounting for the variability between CI children. Research was directed to factors such as age at implantation, hearing age, oral or total communication mode and perception abilities (Nicholas & Geers, 2007, Bo Wie, Falkenberg, Tvete & Tomblin., 2007). Research was conducted for the SLI children to reveal the mechanisms behind the slow intake of language, such as processing speed and working memory capacities. Much of the research was focused on one of the clinical groups, rather than both clinical groups together. The present study has taken a new perspective on CI and SLI children by comparing them directly. This type of study suggests avenues for future research as it enhances our understanding of determinants of successful language development.

The present study is also limited with respect to the time span in which the CI and HA children were tested. The upper limit for testing was 7 years of age, mainly due to the availability of standardized testing material up to this age. Nevertheless, it would be interesting to see whether the CI and SLI children are able to catch up with their TD hearing peers with respect to verbal morphology production after the age of 7. If so, this would indicate that in both populations, verbal morphology production is delayed rather than impaired.

Finally, the influence of perceptual salience on the acquisition of morphology can be investigated only to a limited extent in Dutch. Given that Dutch is a language which lacks rich verbal morphology, there is rather limited variation with respect to perceptual salience in verbal morphemes. A cross-linguistic comparison of the results with those from CI and SLI children in morphologically rich languages would yield interesting insights with respect to the presumed role of perceptual salience in the acquisition of verbal morphology in both populations.

8. Conclusion

The objectives of the present study were to compare 4 to 7-year-old CI and SLI children on their general language production, finite verb production and agreement errors. This study provided an in-depth analysis of the type of subject-agreement errors produced by these CI and SLI children. The errors identified were related to the perceptual salience of the verbal morphemes.

The results show that 73% of the SLI children performed below age-expectations on general language production and finite verb production. Only a subgroup of the CI children (38%) showed a similar pattern. The majority of this subgroup of CI children were younger CI children (4 and 5 years of age). This indicates that the delay in MLU and finite verb production does not persist into the older ages (6 and 7 years) for all CI children.

The CI children were compared to the SLI children on the number and type of subject-verb agreement errors. Most errors involved the omission of the 3rd person singular morpheme and the plural morpheme. The delay observed in the acquisition of low salient grammatical morphemes is predicted by the so-called Surface Account.

In terms of the acquisition of past participle morphology, SLI children tended to omit the low salient suffix (*-t* e.g. *gewerkt*) more often than the relatively more salient prefix (*ge-* e.g. *gewerkt*). This is, once again, in line with the Surface Account and underlines the effect of perceptual salience in the acquisition of morphology for these children. By contrast, in CI children, the acoustically less salient suffix was not omitted more frequently than the more salient prefix. The results of the acquisition of past participle morphology indicates that perceptual salience of morphemes alone cannot account for the high error rate in verb morphology, and that the results of the prefix and suffix omission is therefore difficult to explain under a Surface Account.

Based on data from the errors/omission of verbal agreement as discussed in section 5.1, we propose that the findings observed are best explained under the newly formulated *Morpheme-in-Noise Perception Deficit Hypothesis*. Àccording to this hypothesis, the deficits in verbal morphology production in CI children are the result of perceptual deficits in noisy day-to-day environments regardless of the morphemes' acoustic salience.