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The production of Dutch finite verb morphology: A comparison between hearing-impaired CI children and specific language impaired children

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Abstract

Background: This study compares 4- to 7-year-old cochlear implanted (CI) and specific language impaired (SLI) children in the production of finite verb morphology and mean length of utterance (MLU). It has been hypothesized that, due to reduced exposure to grammatical elements in the ambient language, both groups are delayed in their acquisition of morphosyntax.
Method: Spontaneous language samples were analyzed for Dutch monolingual CI (N = 48) and SLI children (N = 38) on MLU, number of finite verbs, and number of errors in the target-like production of verbal agreement. CI and SLI children were compared on their linguistic profiles, including MLU and finite verb production, using the norms of typically developing (TD) children.
Results: Statistical differences between CI and SLI children were found only for finite verb production at ages 5 and 6, in the direction of better outcomes for CI children. Both groups produced significant numbers of verbal agreement errors. Weak linguistic profiles were found for 75% of the SLI children and 35% of the CI children.
Conclusion: CI and SLI children show both weak performances on the target-like production of verbal agreement. Nevertheless, CI children produce more finite verbs and have stronger linguistic profiles as compared to SLI children.

Keywords: Cochlear implantation; Specific language impairment; Finite verb morphology; Morphosyntax; Perceptual salience

1. Introduction

In the neurolinguistic theory of language development proposed by Locke (1997), it is argued that the acquisition of language can be broken down into four interdependent developmental stages. The acquisition of morphology and syntax crucially depends on the storage of lexical items and unanalyzed utterances and the subsequent analysis of this linguistic material. During the so-called analytical stage, the stored utterances are decomposed into smaller lexical and functional units, leading to morphological and syntactical acquisition. Importantly, this particular stage of language development is claimed to be triggered or reinforced by the pressure of the expanding vocabulary as well as by maturational advances.

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Under such a view, failure to store sufficient lexical items and utterances will delay analytical mechanisms from turning on and, consequently, morphological and syntactic acquisition will be delayed. Morphosyntactic delays are typically observed in specific language impaired children (henceforth SLI) (e.g. Hansson and Leonard, 2003; Leonard et al., 1992; Wexler et al., 1998). In general, such language delay cannot be explained by hearing loss, neurological damage, or mental retardation. Instead, their language delay has been attributed to limited processing abilities, such as reduced speed of auditory information processing (Benasich and Tallal, 2002; Tallal and Piercy, 1974, 1975) or limited working memory capacity (Baddeley et al., 1998; Ellis-Weismer, 1996; Ellis-Weismer et al., 2000). The underlying idea of these accounts is that there is a limited amount of resources available for human information processing. If task demands exceed this amount of resources, it will have a negative effect on the processing and storage of linguistic material (Ellis-Weismer, 1996:34). As such, lexical and grammatical information conveyed in the auditory speech input needs to be encountered numerous times in order for SLI children to adequately store it in their linguistic system (Leonard et al., 2007; Locke, 1997). This results in reduced effective exposure to linguistic material, which, at its turn, will eventually lead to protracted language development.

Although different in nature, reduced effective exposure to linguistic material in the speech stream also arises in the case of hearing loss. The majority of children diagnosed with profound hearing loss receive auditory speech input via the cochlear implant (henceforth CI) that electrically stimulates the auditory nerve through electrodes placed in the cochlea. In comparison with classical hearing aids, CIs provide qualitatively improved auditory speech input that gives profound hearing-impaired children better opportunities to develop oral language skills (Svirsky et al., 2000). Nevertheless, CI children are not normal hearing listeners, the CI signal yields a temporally and spectrally reduced auditory signal as compared to the signal provided by the normal functioning cochlea (Moore, 2003). As such, CI children can be taken to develop morphosyntax with reduced auditory speech input.

Although the underlying cause of the reduced exposure to auditory speech input is clearly distinct between SLI and CI children (cognitive vs. auditory respectively), it is hypothesized that this reduced input will have similar effects on the acquisition of morphosyntax, i.e. it will result in a morphosyntactic delay in both groups of children (Locke, 1997:282). Therefore, similar outcomes in morphosyntactic development are expected for both CI and SLI children. To test this hypothesis, we compare the production of finite verb morphology by age-matched Dutch-speaking CI and SLI children. By taking this perspective we are able to increase our understanding of the role of auditory speech input and processing in the development of morphosyntax.

The remainder of the paper is organized as follows: in section 2 we give a concise state-of-the-art on morphological development in CI and SLI children. In section 3 we will outline our research aims and hypotheses. The research method is given in section 4, followed by the results in section 5. The results are discussed in section 6 and conclusions are drawn in section 7.

2. Grammatical development in CI and SLI children

2.1. CI children

Currently practice is that most children who are diagnosed with a profound bilateral hearing loss (i.e. a hearing loss > 90 dB HL in the best ear) receive a CI. Research has shown that approximately 40–50% of the children with CIs implanted at or before the age of 2 are able to achieve age-appropriate scores on expressive and receptive language (Geers, 2004; Geers et al., 2003, 2009). In addition, regression analysis has shown that children who received their implant before the age of 2 are more likely to enter preschool in mainstream education (Nicholas and Geers, 2007). The improvements in oral language development can be directly related to the type of hearing device itself. It has been established that CI children develop language at a faster rate as compared to children with similar hearing losses who use classical hearing aids (Svirsky et al., 2000; Tomblin et al., 1999). Secondly, thanks to neonatal hearing screening programmes, hearing losses in newborns can be diagnosed right after birth, which enables early intervention. It has been shown that early intervention has beneficial effects on later language development in the hearing-impaired (Yoshinaga-Itano et al., 1998). Also in the CI literature it has been frequently shown that earlier ages of implantation lead to better language outcomes (e.g. Coene et al., 2011; Hay-McCutcheon et al., 2008; Kirk et al., 2000; Tomblin et al., 2005).

However, fewer than 50% of the CI children reach age appropriate scores on the production of bound morphology. This can be due to the suboptimal acoustic input offered by the CI, which is likely to affect the acquisition of low salient linguistic elements, such as grammatical morphemes (Svirsky et al., 2002). A close inspection of the CI literature reveals that they produce fewer bound morphemes (Geers, 2004; Nicholas and Geers, 2007; Young and Killen, 2002) and omit free morphology (e.g. articles, verbs) more often as compared to typically developing hearing peers (henceforth TD) (Caselli et al., 2012) In addition, CI children perform poorly on tests assessing their receptive knowledge of grammatical morphemes (Duchesne et al., 2009; Hawker et al., 2008; Nikolopoulos et al., 2004). To our knowledge, no studies have yet conducted an in-depth analysis on the accuracy of morpheme production in CI children.

2.2. SLI children

The language production of SLI children as measured by mean length of utterance (MLU) is consistently lower as compared to their TD peers (Rice et al., 2006). Moreover, cross-linguistic evidence suggests that the core deficit of these children lies in the domain of morphology, particularly at the level of the verb. More precisely, low accuracy scores are found in the production of third person singular (e.g. *he works*) and regular past tense inflections (e.g. *he worked*) as well as infrequent use of auxiliaries (e.g. *he is working*) (e.g. Italian: Leonard et al., 1992; English: Conti-Ramsden and Jones, 1997; Bedore and Leonard, 1998; German: Clahsen, 1989; Swedish: Hansson and Leonard, 2003; Dutch: De Jong, 1999). Several studies have indicated that measures pertaining to the production of morphology combined with MLU have high sensitivity and specificity in the diagnosis of SLI (Bedore and Leonard, 1998; Dunn et al., 1996; Rice et al., 2006).

The underlying cause of the grammatical deficit observed in SLI children has raised considerable debate among linguists. For instance, it has been argued that the grammatical deficit is domain-specific and can be attributed to a primary deficit of the computational grammatical system (Van der Lely, 1997, 2005; Van der Lely and Ullman, 2001). Other accounts dispute the modularity of the disorder and relate the grammatical deficit to perceptual and cognitive deficits (see references in section 1). According to the so-called ''Surface Account'' (Leonard et al., 2003) the observed morphological deficits in SLI children are caused by the low perceptual salience of the morphemes themselves. The surface account states that although SLI children are able to perceive low-salient morphemes, their limited processing abilities are taxed when these morphemes have to be perceived and their grammatical function has to be identified. Not only must both operations be performed within a limited amount of time, also the child has to process the rest of the sentence. Contrary to TD children, SLI children are often not able to complete this complex processing operation resulting in delays of the storage of the morphemes in the proper cell of the morphological paradigm.

3. The present research

The purpose of this study is to compare Dutch-speaking CI and SLI children, aged between 4 and 7, in their target-like production of finite verb morphology, including age-matched TD children as controls. This comparison allows for testing the hypothesis put forth by Locke (1997) that reduced exposure to auditory speech input will delay the acquisition of grammatical morphology. Based on the literature, we assume that perceptually non-salient morphemes are difficult to perceive by hearing-impaired children with CIs and difficult to process by SLI children. As such, we expect that CI and SLI children will show similar outcomes with respect to the production of target-like finite verb morphology.

The second purpose of this study is to relate the outcomes on the production of finite verb morphology obtained by the SLI and CI children to those on MLU measuring general language development. The rationale behind this approach must be sought in the fact that the combination of both measures presents a characteristic profile of SLI children (Bedore and Leonard, 1998; Dunn et al., 1996; Rice et al., 2006). The literature has revealed that 50% of CI children are able to achieve general language levels that are age-appropriate, for example as measured by MLU (see Geers, 2004). Therefore, we hypothesize that this profile is not shared by the majority of CI peers and that language delays are only found in the domain of morphology. In the case of shared profiles, this could imply that a hearing loss place children at a higher risk of general language impairments as has been suggested by Young and Killen (2002). In the analysis of individual results we take into account that for the CI children important age related factors in language development other than chronological age alone have been reported. These are the age at which the child received his implant and the number of years the child has received acoustic speech input via the implant (i.e. hearing age) (Coene et al., 2011; Kirk et al., 2000; Tomblin et al., 2005). As such, the language measures under study are analyzed according to these factors.

4. Research method

4.1. Participants

A total number of 48 CI children and 38 SLI children participated in the study. The CI children were selected from special schools for deaf children in Flanders (Belgium) and from the Eargroup, a CI centre in Antwerp-Deurne (Belgium). The CI children in the study have been selected in such a way to provide maximal correspondence between children within the different age groups, i.e. all children were monolingual speakers of Dutch and their medical file did not report any additional disorders (e.g. Autistic Spectrum Syndrome) besides their hearing impairment. The CI children were aged

Table 1
Overview of participants, including number of children per age group, chronological age (in months) and for the CI children age at implantation (in months), unaided hearing loss (HL) and the percentage of children who attended special education at the time of testing (UNK = unknown).

	CI children					SLI children	
	N	Age *M* (SD)	Age at implantation *M* (SD)	Unaided HL *M* (SD)	Special education	*N*	Age M (SD)
4 yrs	15	50.9 (4.8)	14.8 (7.3)	109 (13)	43% (1 UNK)	5	54.3 (3.2)
5 yrs	14	63.2 (4.1)	17.7 (10.2)	108 (12)	43%	9	65.2 (3.8)
6 yrs	10	73.5 (2.5)	15.5 (10.8)	114 (9)	11% (1 UNK)	15	76.5 (3.8)
7 yrs	9	85.8 (2.7)	15.6 (6.7)	113 (10)	25% (1 UNK)	9	87.6 (3.0)

between 3;9 and 7;7 years and had received their CI between 5 and 43 months of age. The CI children had a minimum of 2 years of exposure to auditory speech with a maximum of 6;7 years.

Data of two groups of SLI children were analyzed. The first group included spontaneous speech data of 19 children with orthographic transcriptions readily available from the Bol and Kuiken corpus (Bol and Kuiken, 1988) from the Child Data Exchange System (MacWhinney, 2000). The 19 transcripts involve 4 4-year-olds, 5 5-year-olds, 7 6-year-olds and 3 7-year-olds. The SLI children from the Bol and Kuiken corpus attended schools for special education in the Netherlands (area Amsterdam, Haarlem, Amersfoort and Leiden). The second group of SLI children was recruited for the purpose of the present study. These children were attending schools for special education in Flanders (Belgium) (area Hasselt and Antwerp).

All SLI children included in the study were diagnosed as being language impaired by a certified speech-language pathologist. In the Netherlands, children receive the diagnosis of SLI if they score 1.5 SD below average on at least two language tests, intervention for at least 6 months did not lead to improvements and their limited language abilities reduces engagement in learning and communication activities. For the present study, children with SLI with speech problems were excluded. The children received interventions at their schools for special education. None of the children had hearing losses, neurological disorders or social, emotional problems and were all of normal intelligence. All children were monolingual speakers of Dutch.

In agreement with the standards of ethical requirements, informed consent was obtained from their parents prior to participation. An overview of the group characteristics is presented in Table 1, for CI children mean age at implantation are also given in Table 1.

4.2. Language assessment

The CI and SLI children selected for the present study, were recorded for 15–30 min using a Panasonic NV-GS180 digital video camera. The same procedure was used as in Bol and Kuiken (1988) to elicit speech. Conversations were held between the child and either one of the parents, the speech language pathologist, or the first or second author of this paper. The children spoke about different topics. The adults encouraged the children to talk about their own interests. This reduced the number of possible silent periods during the conversation. No toys or books were incorporated in the conversations, however, in some cases a child's personal school book or picture books were used to familiarize the child with the situation. All recordings were made in quiet rooms at the schools the children were attending or at the CI centre.

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

All transcripts, including the SLI transcripts available from the Bol and Kuiken corpus (1988), were analyzed using a standardized procedure, the STAP procedure (Spontane Taalanalyse Procedure [Spontaneous Language Analysis Procedure] Verbeek et al., 1999). This procedure assesses the morphosyntactic abilities of the participants and provides norms for children aged 4–7 ($N = 240$). The spontaneous language samples that are required by the STAP procedure compares to the procedure of Bol and Kuiken (1988) as outlined earlier. Following the STAP procedure, the first 50 child utterances were analyzed. Excluded from the 50-utterance sample were repeated and unintelligible utterances, idiomatic and collocational utterances (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').

Table 2
Overview of the Dutch inflectional verbal paradigm exemplified for the verb *lopen* ‘to walk’.

Person	Singular		Plural	
1st	stem + ø	ik loop	stem + en	wij lop*en*
2nd	stem + t#	jij loop*t*/ loop jij	stem + en	zij lop*en*
3rd	stem + t	hij loop*t*	stem + en	zij lop*en*

4.3. Language measures

The following measures of language development have been taken into consideration:

1. MLU: Mean length of utterance measured in words.
2. Finite verb production: This is a quantitative measure for finite verb morphology consisting of the total number of finite verbs produced in a 50-utterance sample. As fifty finite verbs are expected in a 50-utterance sample, the omission of a finite verb in one or more utterances is reflected in a $50 - n$ score, where n is the number of omitted verbs. However, in case of an additional finite verb (for example in subordinate clause production) these scores were added to 50 ($50 + n$ score).
3. Errors/omission of verbal agreement: This is a qualitative measure for finite verb production building on (i) the omission of unbound verbal agreement in a obligatory context, see (a) and (b). An obligatory context is defined as a context in which the unbound morpheme needs to be present in order for the utterance to be grammatical. The qualitative measure further builds on (ii) the non-target like use of bound verb morphemes, for instance the omission of the 3rd person singular (see (c)) or plural morpheme, or the mismatch between bound finite verb morpheme and the subject (see (d)). The Dutch inflectional paradigm is given in Table 2.

(a) Ikke *(ben) naar de film geweest
I *(am) to the movie been
‘I have been to the movie’ — omission auxiliary

(b) Hij *(is) ziek
He *(is) ill — omission copula

(c) Die slaap*(t) in een bedje
That sleep*(s) in a little bed
‘That one sleeps in a little bed’ — omission 3rd person singular morpheme

(d) Hier *waren/was het podium
There *were/was the stage
‘There was the stage’ — plural morpheme in singular context

For these three measures, we have investigated the internal consistency of reliability for the analyzed 50-utterance sample by means of a split-half method (Spearman-Brown formula, Drenth and Sijtsma, 2006). The internal consistency reliability coefficients were found to be high to very high (.87–.95, Hammer, 2010).

4.4. Reliability

For the purpose of transcription reliability, 10% of the language samples were transcribed in their entirety by independent transcribers. The transcripts were compared word-for-word yielding a transcription agreement of 79%. Accordingly, the videotaped conversations were watched and the initial transcript was changed where necessary. The second word-for-word comparison yielded an agreement percentage of 93%.

According to the STAP procedure, the analysis of the ungrammatical utterances is based on paraphrasing. Although a clear protocol is provided, there is still some room for interpretation. This places emphasis on determining the coding reliability, particularly as for the present research multiple coders were involved. To examine the between-coder reliability, 10% of the transcripts were reanalyzed by one of the coders. Correlations were calculated between the results of the recoder and the original coder. The correlations were as high as .99 for MLU and finite verb production and .89 for verbal agreement errors/omissions.

4.5. Data analysis

To compare the results of the CI and SLI children with their TD peers, results on MLU, finite verb production and verbal agreement errors/omissions are standardized according to the norms provided by the STAP procedure. The group comparisons were controlled for age with the norms of the test. Standardization involves the transformation of the raw score into a *z*-score. A *z*-score denotes the distance to the mean of the TD population. The mean of the TD population is indicated by a *z*-score of 0. The 95% confidence interval lies within *z*-scores −1.96 to 1.96 (corresponding to P2.5 and P97.5 respectively). If a child obtains a *z*-score below −1.96, it has performed significantly below age expectations. Statistical testing between CI and SLI children at each age was done using a one-way ANOVA in case of equal variances. If the assumption of equal variances was not met, the non-parametric Mann–Whitney *U*-test was used. We lowered alpha to .01 to adjust for multiple group testing.

The scores on MLU and finite verb morphology were plotted in a correlation matrix. However, when measures are combined, a cut-off point at P2.5 (or *z*-score −1.96) can no longer be used to assess age-appropriateness. Combining variables will lead to a decreased alpha and, as a consequence, this increases the risk of a type II error (i.e. considering a child to have a non-deviant language development, when in fact it should be considered to show a deviant development). To prevent this, an alpha of .05 should be applied to the composite of variables (including the measures under consideration in this study), rather than on one variable only. This results in a cut-off point of P20 (i.e. *z*-score −1.28) and as such will be used in the correlation matrix to assess age-appropriateness on the measures included in the matrix.

On the data of the CI children, we performed a regression analysis including the predictor factors age at implantation and hearing age on MLU, finite verb production and verbal agreement errors/omissions. We used an alpha level of .05.

5. Results

As two data sets are included for the SLI children, it is important to verify if these children compare to one another and as such can be taken to belong to the same population. Statistical comparisons were performed at age groups with approximately equal distributions of SLI children included from the different data sets. Equal distributions were found at the age of 5 and 6. Mann–Whitney tests revealed no statistical differences between both SLI data sets at the age of 5 on MLU ($U = 4$, $p = .142$), finite verb production ($U = 8$, $p = .621$) and verbal agreement errors/omissions ($U = 7.5$, $p = .539$). No statistical differences were found between the data sets for the 6-year-old SLI children on MLU ($U = 16.5$, $p = .183$), finite verb production ($U = 23$, $p = .562$) and verbal agreement errors/omissions ($U = 23$, $p = .561$). The non-significant findings indicate that the SLI children from different data sets can be considered to be from the same population. As such, for subsequent analysis the data sets were grouped together to form one group of SLI children.

5.1. Finite verb production and verbal agreement errors/omissions

Table 3 presents the mean raw scores, standard deviations and ranges for the production of finite verbs and verbal agreement errors/omissions obtained by the CI and SLI children per age group. Table 3 includes the statistical results comparing both clinical groups on mean finite verb production and mean verbal agreement errors/omissions.

Table 3
Mean raw scores, standard deviations and ranges for finite verb production and verbal agreement errors/omissions obtained by CI and SLI children per age group. The statistical results indicate the difference in mean scores between CI and SLI children. * indicates significant at alpha .01.

	CI children			SLI children			
	M	SD	Ranges	*M*	SD	Ranges	Statistical results
Finite verb production							
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	$U = 22$, $p < .01$*
7 yrs	53.6	7.1	42–63	42.9	6.9	33–53	$F(1, 16) = 10.376$, $p < .01$*
Verbal agreement errors/omissions							
4 yrs	5.3	4.0	1–14	4.8	2.8	2–9	$F(1, 18) = .074$, $p = .79$
5 yrs	4.2	2.7	0–11	5.6	4.4	1–13	$F(1, 21) = .833$, $p = .37$
6 yrs	4.8	4.1	1–14	8.5	6.8	1–25	$F(1, 23) = 2.345$, $p = .14$
7 yrs	3.7	2.7	0–9	6.4	5.7	2–21	$F(1, 16) = 1.757$, $p = .20$

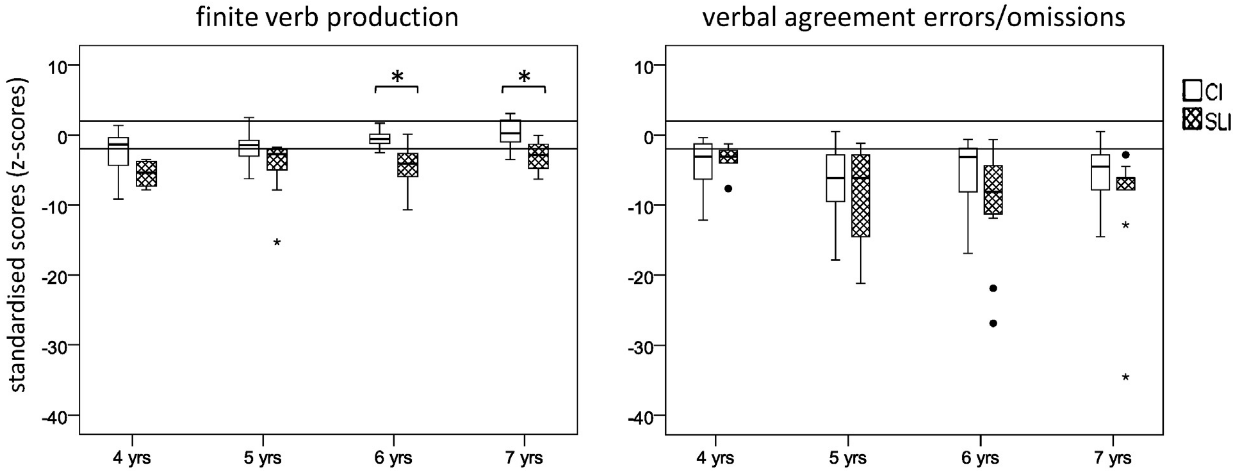

Fig. 1. Boxplots represent the standardized finite verb production scores and the standardized verbal agreement errors/omissions scores for the CI and SLI children per age group. The horizontal lines represent the 95% confidence interval (i.e. between P2.5 and P97.5).

The norms of the TD children indicate that approximately 50 finite verbs are produced in a 50 utterance sample from age 4 onwards. CI children achieve an average of 50 finite verbs at the age of 6, whereas SLI children are not able to achieve this average by the age of 7. At the age of 6, significant differences emerge between CI and SLI children on finite verb production in the direction of better outcomes for the CI children. Large standard deviations and ranges are found for both clinical groups at all ages, indicating large within-group variability.

The norms of the TD children reveal that verbal agreement errors and omissions are rare from age 4 onwards (raw mean is .50). This implies that already at this age TD children use (bound and unbound) verbal morphemes in a target-like manner. The results of the CI and SLI children show relatively high numbers of verbal agreement errors and omissions at all ages, pointing in the direction of persistent problems in the target-like production of finite verb morphology. At none of the ages significant differences were found between CI and SLI children. This could be due to the large ranges that were observed.

The standardized results are presented in Fig. 1. The boxplots in this figure show first of all the large within-group variation observed for the CI and SLI children and secondly the distance of their scores towards the mean of their TD peers. The solid horizontal lines indicate the lower bound and upper bound of the 95% confidence interval, respectively P2.5 and P97.5. The percentages of CI and SLI children who compare to their TD peers are presented in Table 4.

From Fig. 1 it becomes clear that the finite verb production of the CI children moves within the normal range of TD children (i.e. the 95% confidence interval) over the years. The rapid improvement of CI children is also evident from the increasing percentages of CI children who compare to their TD peers on finite verb production (see Table 4). The boxplots for the SLI children remain below the cut-off point of P2.5. This means that most of the SLI children produce significantly less finite verbs as compared to their TD peers in a 50-utterance sample. The lack of improvement is also supported by the percentages in Table 4, which show that the number of SLI children who perform age-appropriately remains more or less stable over the years. The gap between the CI and SLI children that starts to emerge around the age of 6 is clearly visualized in the boxplots. For verbal agreement errors and omissions, it is observed that CI and SLI children perform below age-expectations without an improvement over the years. This is also demonstrated by the stable and small percentages of CI and SLI children (0–33%) who compare to their TD peers (see Table 4).

5.2. Language profiles in CI and SLI children

As expected, we found a strong correlation between finite verb production and MLU ($r = .737$, $p < .001$) for the SLI children, when controlled for age and one outlier (see Fig. 2, black square). The correlation indicates that weak MLU

Table 4
Percentage of CI and SLI children performing within the 95% confidence-interval and therefore compare to TD children.

	CI children				SLI children			
	4 yrs	5 yrs	6 yrs	7 yrs	4 yrs	5 yrs	6 yrs	7 yrs
Finite verb production	60%	57%	80%	78%	0%	22%	38%	22%
Verbal agreement errors/omissions	33%	14%	30%	22%	20%	22%	32%	0%

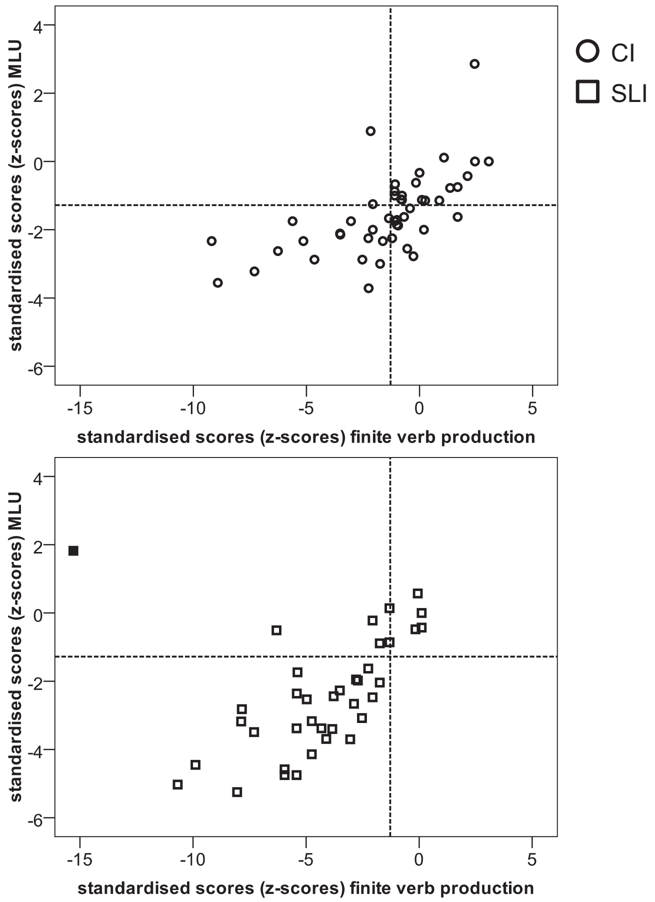

Fig. 2. Individual standardized MLU scores plotted as function of the standardized scores on finite verb production for CI children (upper matrix) and SLI children (matrix below). The vertical dotted line in the matrices indicates the P20 (i.e. *z*-score −1.28) for finite verb production in the TD population. Scores that fall on the right side of the vertical line are age-appropriate, scores on the left side can be considered to be below age-expectations. The horizontal line in the matrices indicates the P20 for MLU in the TD population. Scores that fall beyond the horizontal line can be considered to be age-appropriate, scores below the horizontal line are below age-expectations.

scores are related to weak scores on the production of finite verb morphology, i.e. shorter utterances are those in which the finite verb is lacking. For CI children, we found a similar correlation between MLU and finite verb production ($r = .621$, $p < .001$). This correlation implies that MLU is not only a measure of general language development but also provides some information with respect to grammatical complexity in the spontaneous speech production of SLI and CI children.

In Fig. 2 we plotted the children's outcomes on MLU and finite verb production in a correlation matrix. The dotted vertical line in both matrices represents the cut-off (i.e. *z*-score −1.28) for finite verb production. The scores that fall on the left side of the line are below age-expectations, whereas the scores on the right side are age-appropriate. The horizontal dotted lines represent the cut-off for MLU. Scores that fall below the horizontal line can be taken to be below age-expectations, whereas the scores beyond the horizontal line are age-appropriate. Clockwise these matrices can be read as follows: the upper right quadrant represents CI and SLI children who score age-appropriately on MLU and finite verb production; the lower right quadrant represent CI and SLI children who score age-appropriately on finite verb production, but below age-expectations on MLU; the left lower quadrant represent the children who score below age-expectations on MLU and finite verb production; the left upper quadrant represents the children who score age-appropriately on MLU, but below age-expectations on finite verb production.

From Fig. 2, it is observed that the majority of SLI children (75%) perform significantly below age-expectations on MLU and finite verb production (lower left quadrant). Two smaller groups with different profiles are observed for SLI children: one subgroup of SLI children (10.8%) performs age-appropriately on finite verb production and MLU, the other one (13.5%) performs age-appropriately on MLU, but lays behind on finite verb production. None of the SLI children can be found in the lower right quadrant, showing that none of the SLI children has MLU scores below age-expectations, but nevertheless achieve age-appropriate scores on finite verb production.

This contrasts with the CI children, for which a subgroup (22.9%) can be found in the lower right quadrant. This implies that these children produce significantly shorter utterances as compared to their TD peers, but nevertheless these are grammatical, i.e. they include a finite verb. The number of CI children that compares to their TD peers on MLU and finite verb production is almost equal to the number of children that perform below age-expectations on both measures, respectively 37.5% and 35.4%. Close inspection of the data reveals that 27.1% of the CI children in the latter group (i.e. performing below age-expectations on MLU and finite verb production) belong to the age groups 4 and 5 as compared to only 8.3% in the age groups 6 and 7. Only two CI children (i.e. 4.2%) perform below age-expectations on finite verb production, but are age-appropriate with respect to MLU.

In the group of CI children, language measures can be influenced by the age at which the child has received the implant and the amount of time the child has had access to auditory speech input. Regression analysis, including the factor age at implantation and hearing age, revealed non-significant results for MLU ($F(2, 45) = 1.995$, $p = .148$) and significant results for finite verb production ($F(2, 45) = 8.323$, $p < .001$, $R^2 = .270$) and verbal agreement errors/omissions ($F(2, 45) = 3.369$, $p = .043$, $R^2 = .130$). For finite verb production, a significant effect was found for hearing age ($t(45) = -2.928$, $p = .005$) but not for age at implantation ($t(45) = -1.149$, $p = .256$). The effect of hearing age indicates that CI children with longer exposure to auditory speech input will produce more finite verbs as compared to CI children with shorter exposure to speech input. For verbal agreement errors/omissions, age at implantation was a significant predictor ($t(45) = -2.528$, $p = .015$) rather than hearing age ($t(45) = -.655$, $p = .516$). Children who received their implant at younger ages were likely to produce less error as compared to children who received their implant later in life.

6. Discussion

6.1. How do CI children compare to SLI children in their production of finite verb morphology?

The first purpose of this study was to compare the production of finite verb morphology by 4–7 year-old Dutch CI and SLI children. This study included a quantitative measure of finite verb morphology consisting of the number of finite verbs produced in a 50-utterance sample and a qualitative measure of finite verb morphology consisting of an analysis on the target-like use of finite verb morphology. We expected to find similarities between CI and SLI children on both measures of finite verb morphology. This hypothesis was grounded on Locke's theoretical work on language acquisition, claiming that reduced exposure to language input will delay morphosyntactic development. This reduced exposure can arise either due to hearing loss, as in the case of CI children, or due to processing limitations, as has been suggested for SLI children.

The results of this study partially support our expectation: it was found that both CI and SLI children show persistent difficulties in the target-like production of finite verb morphemes (bound and unbound). Both clinical groups made significantly more verbal agreement errors (e.g. **she sleep* instead of *she sleeps*) or omitted the auxiliary, modal or copula (e.g. **he ill* instead of *he is ill*) as compared to their TD peers. For both clinical groups, no improvement was observed between the ages 4–7. These findings add to the existing body of cross-linguistic evidence showing that SLI children have persistent delays in the target-like production of finite verb morphology (e.g. Conti-Ramsden and Jones, 1997; De Jong, 1999; Leonard et al., 1992). This study also confirms previous findings indicating that CI children experience difficulties in the acquisition of bound morphology (e.g. Duchesne et al., 2009; Geers, 2004).

However, our expectation was not borne out with respect to the quantitative measure of finite verb morphology development. CI children aged 6–7 produced significantly more finite verbs as compared to their SLI peers. These results question our initial hypothesis that processing limitations and sensory deprivation yield similar language outcomes. CI children seem to be aware of the fact that most target-like utterances need an overtly expressed finite verb but perform poorly on perceptually low-salient morphemes, their SLI peers struggle with both the obligatoriness of finite verbs as well as particular low-salient verb morphemes.

The fact that we found a mixed picture regarding the acquisition of finite verb morphology in CI and SLI children opens up the discussion on the nature of the language deficit the latter group of children. Our results do not rule out the possibility that the language impairment in SLI children is caused by limited processing abilities. Limited processing can have a more disruptive effect on the acquisition of morphosyntax as compared to hearing loss (see also Norbury et al., 2001; Hansson et al., 2007). However, the nature of the language impairment can also be grammar-specific, caused by a deficit in the computational grammatical system (Van der Lely, 1997, 2005; Van der Lely and Ullman, 2001). This means that SLI children use grammatical–structural rules optionally rather than obligatory as in target adult-like speech.

For CI children, the difficulties in the target-like production of finite verb morphemes, forces an explanation relating these difficulties to their reduced auditory speech input. Previous findings indicate that the morphological development of CI children is determined by the perceptual salience of morphemes (Svirsky et al., 2002). If CI children frequently miss perceptually low-salient morphemes (e.g. 3rd person singular /t/ in *hij slaapt* – he sleeps) in the auditory speech input, they will have fewer opportunities to set up hypotheses regarding the grammatical functions of these morphemes. Building a successful paradigm for morphological development will only succeed when CI children encounter the morphemes a sufficient number of times.

6.2. Do CI children show the same grammatical profile as SLI children?

The second purpose of this study sought to determine to what extent CI children showed the same grammatical profile as their SLI peers. We combined the outcomes on finite verb production and general language production, as measured by MLU, in a correlation matrix.

Our results showed that 75% of the SLI children scored below age-expectations on MLU and finite verb production as opposed to 35.4% in the group of CI children. This is in line with our previous observation, i.e. the linguistic deficit of SLI children is more pervasive as compared to the deficit observed in CI children. In addition, we also found that approximately 20% of the CI children produced shorter utterances as compared to their TD peers, but nevertheless produced grammatically complex utterances including a finite verb. This profile is not observed in the group of SLI children. This again is in support of our conclusion that the language deficit of SLI children is more severe as compared to CI children. Interestingly, the CI children who compared to their SLI peers in their grammatical profile where generally younger (i.e. 4–5 years).

There are several explanations for these results. First of all the result can be due to a bias in participant selection. It has to be noted that for both clinical groups under study, selection of homogeneous groups is difficult or almost impossible as both groups are known for their variation (e.g. Geers et al., 2009; Van Weerdenburg et al., 2006). In our study for instance, some children with CI attended regular schools whereas others attended schools for special education. The percentage of children with CI attending special education was higher in the youngest groups (4 and 5 years) as compared to the older groups (6 and 7 years). This corresponds with the sudden increase in age-appropriate finite verb production at the older age groups (see Table 4).

A second explanation is that longer exposure to auditory speech input (i.e. hearing age) positively correlated with the production of finite verbs. This indicates that gaining more experience with acoustic speech input, regardless the age at which children received their implant, enables children to make a fast progress in their development of finite verb morphology. As the mean ages of implantation are comparable between age groups, children in the older age groups had more acoustic experience as compared to the younger age groups.

When taken together, future research on individual linguistic trajectories has the potential to shed light on these explanations. In our study, we found that approximately 27% of the 4 and 5 year-old CI children and 8% of the 6 and 7 year-old CI children compared to their SLI peers in MLU and finite verb production. The estimated prevalence of language impairment in the population of TD children is approximately 7.4% (Tomblin et al., 1997). It has been suggested that the prevalence of SLI in the population of CI children is the same as in the population of TD children (Hawker et al., 2008). However, our results suggests that the prevalence of SLI is higher in the group of pre-school CI children as compared to their TD peers and it is uncertain if these children are able to catch up with their peers at a later age. Longitudinal research should be able to provide the necessary data to dissentangle the effects of hearing loss in the language development of CI-children and long-term specific language impairments in this group of children.

7. Conclusion

The objectives of this study were to compare 4–7 year-old Dutch CI and SLI children in their production of finite verb morphology and to compare both clinical groups in grammatical profile. The rationale for this comparison was found in the literature showing that SLI children have difficulties to process low-salient morphemes, whereas CI children have difficulties to perceive them. As such, it has been argued that both clinical group have reduced exposure to oral language morphology and are therefore delayed in their acquisition of this language component.

The results of this study indeed showed that CI and SLI children had persistent difficulties in the target-like production of verbal agreement. However, CI children achieved rather unexpected age-appropriate outcomes on finite verb production whereas SLI children did not. In addition, we found that 75% of the SLI children performed below age-expectations on general language production and finite verb production. This profile was only found in 35% of the CI children and was also restricted to the younger age groups. Therefore, we conclude that the morphosyntactic deficit of SLI children should be considered to be more severe as compared to the one observed in CI children.

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