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

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CHAPTER 6

The acquisition of past tense

1. Introduction

It is well known that SLI children are severely delayed in their acquisition of the regular past tense as compared to their TD peers. This delay has been attributed to incomplete processing of the low salient regular past tense morpheme, which protracts the time needed for analysis before the grammatical morpheme can be placed in the verbal paradigm. This has been named the Surface Account (Leonard et al., 1997, see chapter 5, section 5.2). Under such a view, which stresses the role of perceptual input on language learning, the type of processing limitation observed in SLI children is similar to a perceptual deficit, as in the case of CI children (Locke, 1997; Norbury et al., 2001).

Therefore, the first purpose of this chapter is to compare 5 to 7-year-old CI and SLI children in their production of regular and irregular past tense in spontaneous speech and on a past tense elicitation task. The elicitation task allows us to compare the results of both clinical populations with their TD peers. A norm-referenced approach to past tense production using spontaneous speech is not viable, because the variable past tense cannot be reliably assessed (see chapter 4, section 4). This chapter will start with an overview of the regular and irregular past tense acquisition in TD children (section 2) and in SLI children (section 3).

The second purpose of this chapter is to relate the production of regular and irregular past tense to the frequency with which past tense forms occur in the adult target speech. The rationale behind the inclusion of frequency lies in the two models of past tense acquisition, which have been outlined in chapter 3 (subsection 3.3). In short, according to the dual-route model, regular past tense inflection involves the symbol-manipulating rule of *add –ed* (e.g. *work-worked*)

which operates as a default, whereas irregular forms are memorized pairs of words (e.g. *ring-rang*). Alternatively, according to the single-route model, regular and irregular verb forms arise from an associative memory system. As such, a rule for regular past tense does not exist in the language system. The two models make different predictions regarding the role of frequency in regular past tense acquisition. This will be explained in more detail in section 4.

The hypotheses will be outlined in section 5. The past tense analysis in spontaneous speech and the results are given in section 6. The results of the past tense elicitation task are presented in section 7. The results of both analyses are discussed in section 8, followed by a conclusion in section 9.

2. The acquisition of past tense in TD children

2.1 First past tense forms

The analyses of (English) longitudinal child language data have provided valuable insights into the development of past tense. Brown (1973) conducted an extensive analysis of spontaneous language data of Adam, Eve and Sarah to determine the order of grammatical morpheme acquisition. In his analysis he adopts a criterion for acquisition in which the morpheme of interest appears in its obligatory context 90% of the time in three successive samples (i.e. correct productions of irregulars in 90% of the situations in which irregulars are required is considered to evidence a child's acquisition of the irregular past tense form). Brown observes that Adam and Sarah acquire irregular past tense prior to the regular past tense. The irregular past tenses are numerous and varied, such as came, went, did, made, saw, ate.

However, it has been argued that the children's early productions of past tenses are restricted to high-frequency forms occurring in the linguistic input of the child. Most high-frequency verbs belong to the class of the irregulars, rather than the regulars (Rumelhart & McClelland, 1986). Kuczaj (1977) argues that these early past tense forms are semantically appropriate but syntactically unanalyzed. As such, these irregular forms have not been acquired yet. The children learn when these high-frequency past tense forms may be used and thus occasionally use them appropriately.

Based on the longitudinal study of the boy Abe, Kuczaj concludes that, in the course of past tense development, the irregular past tense is more difficult to acquire than the regular past tense. In his longitudinal analysis of Abe, compared with data from 14 children cross-sectionally, he observes that all children reached the 90% criterion for regular past tense from MLU 3.00 onwards. In contrast, a stable 90% success rate for the irregular past tense was only achieved for three children with an MLU above 4.50, who were included in the cross-sectional sample. Abe reached the 90% criterion for irregulars 20 months later as compared to the regulars.

It is important to note, however, that the study by Kuczaj (1977) is biased regarding regular past tense as it also includes overgeneralizations. Overgeneralizations refer to the application of the regular suffix (*-ed*) to irregular verbs, e.g. eat – eated. Kuczaj scored overgeneralizations as instances of regular past tense usage, as these overgeneralizations are correct instances of the regular past tense suffix in the appropriate context. This increased the number of regular past tense inflections and consequently influenced the attainment of the 90% criterion.

2.2 Overgeneralizations

The phenomenon of overgeneralizations provides valuable cues as to the processes that underlie past tense acquisition. On this account, the analysis of overgeneralizations has received a great deal of attention in the literature. In the analysis of the Adam, Eve and Sarah transcripts, both Cazden (1968) and Brown (1973) report the occurrence of overgeneralizations. Adam, Eve and Sarah all use forms like 'comed', 'goed', 'falled' and 'maked'. The analysis of overgeneralizations is elaborated by Marcus et al. (1992). Marcus et al. distinguished two types of overgeneralizations, in which the first type attaches the regular suffix *–ed* to the verb stem (e.g. eat – eated) and the second type to the past tense form of the irregular (e.g. ate – ated*)*. The latter occurs in approximately 1-2% of all past tense forms produced.

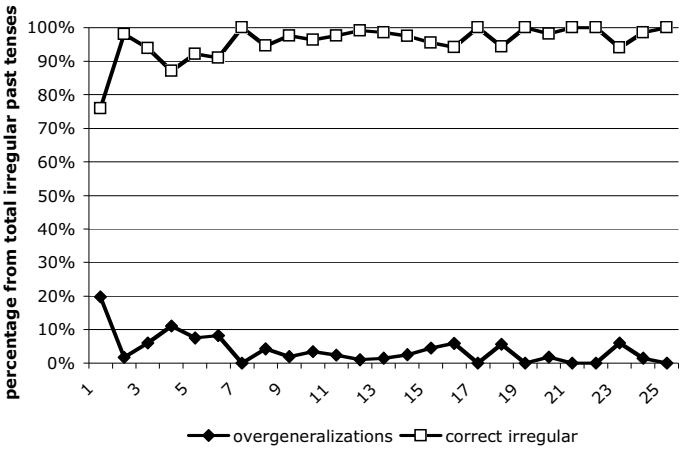
In the present analysis, a more stringent definition of overgeneralization is adopted by referring only to the first type of overgeneralization, i.e. verb stem + suffix *–ed* or the 'eat –eated' type. This decision is motivated by the fact that overgeneralizations of the 'ate – ated' type are not target-like past tense forms according to regular past tense process (i.e. verb stem +- *ed*), whereas the 'eat – eated' type is. The 'ate – ated' type involves the feeding of the irregular past into the regular past tense process. These forms compare to errors like 'wenting' and 'ating', which are occasionally produced by children. The progressive is fully regular, so these forms could only be produced by inserting the irregular past into the morphological process (Hoeffner, 1992). Fortunately, Marcus et al. (1992) presented individual overgeneralization data of the 25 children included in their study. This allows recalculation of overgeneralization rates of the 'eat – eated' type solely.

Figure 1 presents the percentages of target-like irregular forms and overgeneralization of the 'eat - eated' type from the total number of past tense forms belonging to the irregular verb class. Percentages are given per child (N=25). These percentages are recalculated versions from Marcus et al. (1992 p: 36) which exclude the 'ate-ated' type of overgeneralization. This means that the percentages of correct irregular forms and overgeneralizations in Figure 1 do not add up to 100% for all children. For example in the case of child 1, 20% of the irregular verbs received regular past tense marking and 75% target-like

irregular marking. This means that 5% of the irregular verbs received regular past tense marking on the irregular verb ('ate- ated' type).

The average rate of overgeneralization (only 'eat-eated'-type) across the 25 children is 3.88%, which indicates that overgeneralizations are extremely rare in spontaneous speech. Across the board, children produce more correct irregulars as compared to overgeneralizations.

Figure 1. Recalculated percentages of target-like irregular past tense productions and overgeneralizations from the total number of past tense forms produced. Overgeneralizations include present tense irregular+suffix and exclude past tense form irregular+suffix. Percentages are given per child. Data from Marcus et al. (1992 p:36).



2.3 U-shaped development of irregular past tense

In the development of irregular past tense, Cazden (1968) observed that 11 out of the 32 overgeneralized past tense forms appeared earlier in the transcripts with the correct irregular form. She reports that Eve said 'comed' three times between 25 and 27 months when she previously used came 11 times between 20 to 22 months. This has led to the claim that children follow a U-shaped developmental pattern in acquiring irregular past tense inflection. The U-shaped development, as proposed by Cazden (1968), Rumelhart & McClelland (1986), Marcus et al. (1992) and refers to a transition from a period in which irregular past tense forms are marked correctly to a period in which overgeneralizations coexist with target-like irregular past tenses. This definition is based on the fact that the regular past tense inflection does not completely replace all irregular past tenses. Rather, overgeneralizations and irregular past tenses temporarily coexist (Cazden, 1968; Kuczaj, 1977).

In their extended longitudinal analysis of 9 children, Marcus et al. (1992) have shown that 7 of these 9 children used target-like irregulars before the appearance of their overgeneralized forms. This indicates that there is evidence for an U-shaped development. The coexistence of overgeneralizations and target-like irregulars in spontaneous speech is fairly steady from the age of three to at least into the sixth year. It has even been reported that overgeneralizations persist into the tenth and eleventh year of life (Kuczaj, 1977). The overgeneralization rate decreases extremely gradually. As irregulars need to be learned from the input, the decrease depends on the frequency with which a irregular occurs in the input. It has been shown that irregular verbs that are used less often in the past tense are more likely to be overgeneralized (Marcus et al., 1992). We will return to the frequency effect in section 4.

2.4 Past tense marking of nonce verbs

To test a child's knowledge of morphological generalizations, Berko (1958) elicited past tense forms of nonce verbs. The underlying idea is quite straightforward. The nonce verbs are not available in the input; therefore past tense forms of these verbs could not be learned and stored. The nonce verbs can only receive past tense inflection if the child has (implicit) knowledge of morphological generalizations.

The elicitation task included 6 nonce verbs, which were made up following the rules for phonological sequences in English, and 2 existing verbs. All verbs were accompanied by drawings on a card, for example, a man standing on the ceiling (see Figure 2, next page). Then the experimenter would say *'This is a man who knows how to bing. He is binging. He did the same thing yesterday. Yesterday he….'*. The child was requested to provide the past tense form. 47 girls and 33 boys, aged between 4 to 7 years, participated in the study.

In the experiment by Berko, the adult responses on the nonce verbs were considered as target-like responses. This made it possible to rate each child's answer as target-like or not. The first analysis revealed that younger children, aged between 4 and 5 years, scored slightly less target-like past tense forms as compared to the older children, 5;6 to 7 years. The percentages of target-like responses per verb for both groups of children are presented in Figure 3, adapted from Berko (1958 p:160).

Berko's results provide evidence that children as young as 4 years have knowledge of the process of regular past tense formation. All children have a high percentage of target-like use of both regular past morphemes /*-t*/ and /*-d*/ (e.g. *ricked, spowed*). The regular pattern is extended even in nonce verbs ending in –ing, such as *bing* and *gling*, for which the irregular would yield *bang* and glang (cf. *ring-rang*). 50 to 75% of the adults opted for these irregular responses. However, the children did not have control over the irregular form yet, as indicated by the low scores on the past tense form rang. Consequently, children

did not form new past tenses according to this form. The regular productions of *bing* and *gling* can be considered as overgeneralizations. Children did not seem to be able to extend the use of the past tense allomorph */-id/* as in *melt-melted* to nonce verbs of the type *mot-motted*. Instead, for the forms ending in -t or -d, the children added nothing to form the past tense.

Figure 2. Picture to elicit the past tense form of 'bing', as presented in the experiment by Berko (1958). Picture retrieved from http://childes.psy.cmu.edu/topics/.

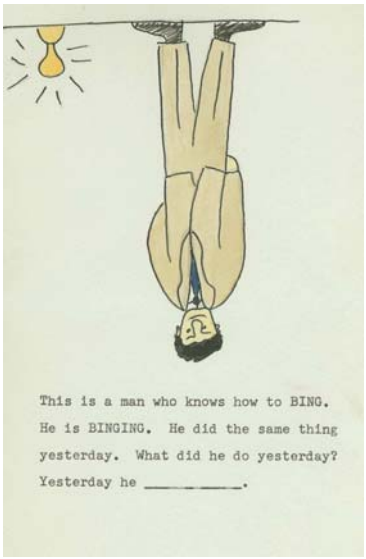
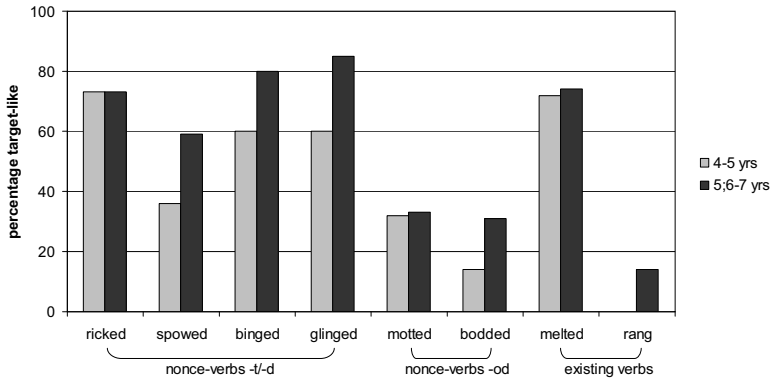


Figure 3. Percentage of target-like productions on nonce verbs for young children (4-5 years) and older children (5;6-7 years). Percentages are taken from Berko (1958 p:160).



3. The acquisition of past tense in SLI children

3.1 Regular past tense

With respect to the development of regular past tense in SLI children, longitudinal analysis has been carried out by Rice, Wexler & Hershberger (1998). In their study they compared SLI and TD children in their target-like use of past tense morphemes in obligatory contexts, both in spontaneous speech samples and elicitation data. The SLI children in their study were aged between 4;5 to 8;9 years and the TD children between 2;6 to 8;9 years. All children were tested at 6-month intervals. The results from the spontaneous speech and elicitation data indicated that the 6-year-old SLI children compare to their 3;6-year-old TD peers in the production of target-like regular past tense. This indicates a delay of approximately 2.5 years in the development of regular past tense for the SLI children.

The production scores of the 6-year-old SLI children of Rice et al. (1998) compare to the results of Oetting & Horohov (1997). On their elicitation task, they found that 6-year-old SLI children marked 15 out of 30 regular verbs target-like for past tense. This score was significantly lower when compared to their language-matched (LM) peers, who were approximately 2 years younger. The LM children marked 22 verbs target-like out of 30. Oetting & Horohov also analyzed spontaneous speech samples on target-like use of regular past tense in obligatory contexts. The SLI children produced 87% target-like regulars in obligatory contexts as compared to 92% by the LM children.

For the TD and SLI children a similar development pattern in past tense production has been observed. For the spontaneous data, a sudden increase is observed in percentage target-like regular past tense use. Between the ages of 5 and 6, the SLI children increase from 0% target-like regulars to 90%. For the TD children, this sharp development of target-like regulars starts before data collection (i.e. <3 years) and moves between the ages 3 to 3;6 from 50 to 90%. In the elicitation task, the development of target-like regulars is more gradual. At the age of 3, when data collection starts, the TD children perform at chance level. They reach ceiling performance one and a half year later. This means that at 4;6 years, they produce all regulars target-like. In contrast, the SLI children have not yet reached ceiling performance at the age of 8. Between the ages of 5 to 8 their production of target-like regulars increases from 30 to 88% (Rice et al., 1998).

It is questionable whether SLI children are able to catch up with their TD peers after the age of 8. Van der Lely & Ullman (2001) show that their 11-year-old SLI children are still significantly worse on target-like regular past tense production than the 6-year-old TD children, as indicated by an elicitation task. Interestingly, Van der Lely & Ullman found frequency effects in the production of regulars for the SLI children, but not for the TD children. Their 11-year-old

SLI children produced significantly more target-like past tenses for the high frequency regular verbs as compared to the low frequency verbs. However, conclusions must be drawn cautiously, as the SLI children in this study were selected on having extreme difficulties with morphology. This poses problems for generalization of the findings across the population of SLI children.

3.2 Overgeneralizations

The delay in the acquisition of the regular inflectional process is reflected in the lower numbers of overgeneralizations for the SLI children as compared to TD children, as observed in the elicitation tasks. Oetting & Horohov (1997) calculated percentages of overgeneralizations by dividing the number of overgeneralizations by the number of irregulars included in the elicitation task minus the target-like irregulars. The results indicated that the percentage of irregular forms receiving regular marking was significantly lower for the 6-year-old SLI children as compared to their chronological age-matched (CA) peers and LM peers (4 years of age), respectively 34%, 81% and 61%. For the CA peers, higher percentages of overgeneralizations can be attributed to a higher number of correct irregulars (6 out of 10), thereby decreasing the denominator. For the LM children, the difference from the SLI children is striking. As the number of target-like irregulars is almost comparable with the SLI children (2/3 out of 10), results indicate that the LM children produce twice as many overgeneralizations as compared to the SLI children.

These results are in accordance with the results of Rice, Wexler, Marquis & Hershberger (2000). They analyzed the percentage of overgeneralizations from the total number of inflected irregulars minus the correct irregulars. Their 6-year-old SLI children produced almost 35% of the irregulars with regular inflection. Up to the age of 8, the percentage of overgeneralizations for the SLI children remained between 35 and 40%, whereas their CA peers showed a clear decrease in the overgeneralization rate within the same period.

Marchman, Wulfeck & Ellis Weismer (1999) indicate that if SLI children produce overgeneralizations it is more likely that they overregularized low frequency irregulars than high frequency irregulars. The influence of frequency on overgeneralization rates is also observed for the TD children (cf. Marcus et al., 1992, see subsection 2.3 from this chapter).

3.3 Irregular past tense

When only target-like irregular past tenses are considered, Rice et al. (2000) observed a steady growth in percentage target-like for the SLI children on their elicitation task. At the age of 4;6, the SLI children scored 13% target-like irregulars and slowly increased to 48% at the age of 8. This developmental

pattern was similar to that observed for the younger LM children. They started with 24% target-like irregulars at the age of 3 and reached 48% target-like at the age of 6. Significant differences were found between the SLI children and their TD peers at every test instance on a 6-month interval base. The latter group reached a score of 86% target-like irregulars at the age of 8, whereas the 8-year-old SLI children produced target-like irregulars at chance level (i.e. 50%).

Similar to the development of regulars, it is questionable whether SLI children catch up with their TD peers. In the study by Van der Lely & Ullman (2001), the 11-year-old SLI children produce significantly less correct irregulars when compared to the 7 and 8-year-old TD children. Again, Van der Lely & Ullman found frequency effects for the SLI children. The SLI children are more likely to produce a target-like irregular for high frequency verbs than for verbs that occur less often in the input. The same pattern was observed for all TD children included in their study.

3.4 Cross-linguistic differences

By and large, the literature on past tense acquisition has focused on TD and SLI children acquiring English. For the SLI children, cross-linguistic studies with respect to past tense acquisition are increasing. As the language of interest in this dissertation is Dutch, I will present some data on past tense development in SLI children for Germanic languages.

Hansson et al. (2000, 2003) investigated the past tense production of Swedish SLI children aged between 4;3 and 5;7. Production scores of the SLI children were compared with CA peers and LM peers, aged between 2;1 and 3;7. The Swedish past tense system compares to the Dutch system (which is outlined in section 3 of this chapter). In short, the regular past tense morphemes in Swedish are */–de/* and */–te/*, their distribution being phonologically conditioned. The former morpheme attaches to a stem ending in a voiced consonant, the latter to an unvoiced consonant. The irregulars involve a vowel change, sometimes a consonant is added to the stem in addition to a vowel change.

The analysis of spontaneous samples by Hansson et al. (2000) indicate that the SLI children produce significantly less target-like regulars in obligatory contexts as compared to the CA, and LM children. Although, percentages of regular production in the samples were high for the SLI children (i.e. 86%), The difference between SLI children and LM and CA children becomes more pronounced when regulars are elicited. Hansson et al. (2003) found that SLI children produced 37% of the regulars target-like, whereas the LM and CA children score between 87% and 99% target-like. This leads to a significant difference between the SLI children and their TD peers. These results indicate

that the Swedish SLI children are more than 2 to 3 years delayed on their acquisition of the regular inflectional process.

On irregular past tense use, differences are found in production scores when spontaneous speech samples and elicitation data are compared. In Hansson et al. (2000), the speech samples of SLI children show a production of 94% target-like irregulars in obligatory contexts. For the LM and CA children this percentage is around 99%. No statistical difference between groups is observed. In contrast, the elicitation data show a percentage of 45% for the SLI children and 66% for the LM children in their target-like production of irregulars. The production score of the SLI children is significantly lower when compared to their CA peers and is comparable to TD children who are 2 to 3 years younger.

De Jong (1999) analyzed past tense productions in a narrative task of 28 Dutch SLI children, with a mean age of 7;8 years. Results are compared to those of LM children (mean age 5 years) and CA peers. Results showed that the SLI and LM children produced 10% regular past tense inflections out of the total number of produced past tenses. This percentage was significantly lower when compared to the production of regular past for the CA peers (22%). For the production of irregular past, no significant differences were observed between the SLI, LM and CA children. Between 49 and 55% of all past tenses produced were target-like irregulars. An interesting observation is that the SLI and LM children produced significantly more constructions with the verb 'to go' + infinitive (ging(en) + infinitive) as compared to the CA children. The SLI and LM children used this construction between 33 and 38% out of all past tenses produced as opposed to 21% for the CA children. De Jong (1999) argues that the use of 'to go' can be seen as an alternative strategy for expressing tense; the auxiliary carries the tense marker, but has no semantic load that adds to the main predicate.

4. Frequency effects in past tense acquisition

According to the dual-route model, the trigger for overgeneralization is the acquisition of the process responsible for regular past tense marking. This means that the onset of overgeneralizations is predicted by the mastery of the regular 'rule'. Marcus et al. (1992) have shown that overgeneralizations are not predicted by an increase in regulars from the input. About one-quarter of the parental verb tokens from Adam, Eve and Sarah were regular, and this proportion did not change before and after overgeneralizations began. The correlations between the rate of monthly change in proportion adult regular verb tokens and the child's overgeneralizations were negative or close to zero. This implies that the input does not interfere with the onset of overgeneralizations (Marcus et al., 1992). Therefore, the dual-route model does not expect to find frequency effects for regular past tenses. Marcus et al. (1992)

observed that the onset of overgeneralizations is followed by a rapid increase in regular past tense forms.

The dual-route model expects to find frequency effects in the acquisition of irregular past tense. If children fail to retrieve the irregular form to mark the verb for past tense, they inflect the stem productively. Retrieval of irregular forms fails because the memory trace is still weak. Hearing the irregular more often strengthens the memory trace. This is supported by frequency effects observed in irregular past tense: the more often a child hears an irregular form, the less likely it is that the child will overgeneralize it (Marcus et al., 1992; Pinker, 1998; Marchman et al., 1999).

The expectations drawn from the dual-route model partially contrasts with those from the single-route model. The single-route model expects frequency effects for irregular and regular past tenses. Rumelhart & McClelland (1986) hypothesize that as the child learns more and more verbs, the proportion of regular verbs increases more strongly relative to the irregulars (see also Ragnarsdottir et al., 1999). This new experience alters the connections within the network. The network learns the regular pattern, because of the predominance of regulars in the input. This leads to temporary overgeneralization of the newly learned pattern to the irregulars, which were already stored in the network. In their computer simulation of past tense acquisition, Rumelhart & McClelland (1986) show that their model overgeneralizes irregulars when it is exposed to high numbers of regulars.

Nevertheless, the influence of a verb's frequency of past tense occurrences in the input remains open to question. As demonstrated by Marcus et al. (1992), the production of regular verbs remains fairly stable in child-directed speech and regular verbs never dominate. Therefore, the training of the computer-based past tense acquisition model of Rumelhart & McClelland (1986) does not seem to correspond with the child's linguistic environment.

Despite this, subtle frequency effects have been reported for regular and irregular verbs. In the study by Ragnardottir et al. (1999), it is shown that Norwegian and Icelandic children produced more correct regular and irregular past tenses for verbs that occurred frequently in the input as compared to verbs that are lower in input frequency. In Norwegian and Icelandic, three classes of verbs occur, two regular classes and one irregular class. In their elicitation task, they included, for each verb class, verbs that occur often in the input (i.e. high frequency) and verbs that occur less often in the input (i.e. low frequency). For the Norwegian children, the percentage of target-like past tense marking on high frequency verbs was 10% higher as compared to the low frequency verbs. The same result was found for one regular verb class. On all verb classes, the Icelandic children showed better performance on high frequency verbs as compared to low frequency verbs. Moreover, the frequency effect was stronger

for the regular verb classes as compared to the irregular verb class, respectively 11-14% and 5%.

5. Hypotheses

The aim of the current study is to compare 5 to 7-year-old CI and SLI children in their production of regular and irregular past tense forms. Spontaneous language samples of CI and SLI children are analyzed on number of past tense productions and types of past tense used. The production of past tense is also assessed using an elicitation task with regular, irregular and nonce verbs. In this task, TD children are included as controls.

We hypothesize that CI children compare to their SLI peers in the production of past tense. In chapter 5, section 5.2, we have already pointed out that adequate processing skills on an auditory and cognitive level have a pivotal role in language acquisition. For SLI children it has been hypothesized that their language delay is due to processing limitations (see also chapter 2, section 4). Hearing impairment disrupts processing skills on an auditory level, which could lead to similar language outcomes.

The regular past tense morphemes in Dutch are /*–de*/ and /*–te*/. The distribution of the morphemes is phonologically conditioned. The former morpheme attaches to a stem ending in a voiced consonant, the latter to an unvoiced consonant. The irregulars involve a vowel change (Booij & Van Santen, 1998). Examples for all forms are given in (1).

(1) spelen '*to play*'	– speelde '*played*'	regular /*-de*/
werken '*to work*'	– werkte '*worked*'	regular /*-te*/
komen '*to come*'	– kwam '*came*'	irregular

The regular past tense morphemes are weak syllables and therefore low in perceptual salience. In contrast, the irregular past tense is monosyllabic, carrying stress, and hence is perceptually salient in the speech input. The hypothesis is that the low salient regular past tense morpheme is more difficult to process than the irregular past tense for CI and SLI children (following the Surface Account outlined in chapter 5, section 5.2). Therefore we expect that CI and SLI children have more difficulties in the production of the regular past tense as compared to the irregular past tense.

Alternatively, one may assume that CI children do not compare to their SLI peers with respect to past tense production. 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 or education.

The acquisition of the regular past tense involves the generalization of regularities observed in the speech input. Most of the literature on past tense acquisition is concerned with the question of how children develop these generalizations. According to the dual-route model, past tense acquisition involves mainly top-down processes driven by innate language mechanisms. In contrast, the single-route model states that the frequency with which a past tense occurs is of vital importance as regularities are only discovered when enough speech material is present.

Therefore, the elicitation task used in this study include past tense verbs that occur relatively frequently in the adult target speech and past tense forms that occur less often in the adult target speech. If frequency effects are found on regular and irregular verbs for the CI and SLI children, as hypothesized by the single-route model, this would underline the importance of speech input in the acquisition of grammatical morphology.

6. Past tense production in spontaneous speech

6.1 Research method

Participants

This study includes spontaneous language samples of 30 CI children and 31 SLI children. The CI children were drawn from schools for special education (Antwerp and Hasselt) and an audiology centre (Antwerp), all located in Flanders. At the time of the study, the CI children were aged between 60 to 93 months and received their implant at between 5 and 34 months of age. They had a mean hearing loss of 111dB (i.e. hearing thresholds averaged over 500, 1000 and 2000 Hz for the *best* ear). None of the CI children had additional disorders, besides their hearing impairment. (For individual data of the CI children see Table 3 of the Appendix to chapter 5)

The SLI children consisted of 2 subgroups. The first SLI subgroup included 15 transcripts from the Bol & Kuiken corpus (Bol & Kuiken, 1981), available through the Child Data Exchange System (MacWhinney, 2000). The 15 transcripts included 5 for the 5-year-old SLI children, 7 for the 6-year-olds and 3 for the 7-year-old SLI children. The SLI children of the Bol & Kuiken corpus attended special education in the Netherlands (Amsterdam, Haarlem, Amersfoort and Leiden).

The second SLI subgroup (N=18) was selected for the present study. These SLI children were drawn from schools for special education in Flanders, Belgium.

The SLI children in both subgroups were diagnosed as language- impaired by a certified speech-language pathologist. The children received intervention at the schools for special education they were attending. None of the SLI children presented hearing losses, neurological and cognitive disorders or social-

emotional problems. For individual data see Table 5 of the Appendix to chapter 5).

For the CI and SLI children, who were selected for the present study, informed consent was obtained from the parents to participate in the study. An overview of the group characteristics is presented in Table 1.

Table 1. Overview of the number of participants per group and corpus (Bol & Kuiken corpus = B&K corpus). For the SLI and CI group age (in months) means and standard deviation in parentheses are given. For the CI children, additionally, means and standard deviations for Hearing Loss without devices (HL) and Age At Implantation (AAI, in months) are given.

		5 yrs		*6 yrs*		*7 yrs*	
			B & K corpus		B & K corpus		B& K corpus
SLI	N	4	5	8	7	6	3
	Age	66	64	79	74	89	86
		(*3.0*)	(*2.8*)	(*2.8*)	(*2.6*)	(*3.2*)	(*2.1*)
CI	N	13		8		9	
	Age	64		74		86	
		(*4.2*)		(*2.8*)		(*2.7*)	
	HL	108.3		113.8		112.7	
	(dB)	(*10.2*)		(*8.7*)		(*6.7*)	
	AAI	17.7		15.5		15.6	
		(*10.2*)		(*10.8*)		(*6.7*)	

Data collection and procedure

The CI and SLI children (selected for the present study) were recorded for 15 to 30 minutes using a Panasonic NV-GS180 digital video camera. To elicit speech, the same procedure was followed as in Bol & Kuiken (1988). During interactions, the CI and SLI children talked about daily activities and events outside the here and now. Toys and books were not incorporated in the procedure to elicit speech. The child's personal school book or picture books were sometimes used to familiarize the child with the situation and/or experimenter. Interactions with the CI and SLI children were carried out by either a caregiver, a speech therapist or by a member of the research group. All video recordings were made in a quiet room at the audiology centre or at the schools the children attended.

All video recordings from the CI children were transcribed by an experienced speech therapist. The experienced speech therapist trained a second transcriber, who transcribed the video recordings of the SLI children.

All transcriptions were made according to the CHAT conventions, available through the Child Data Exchange System (MacWhinney, 2000).

Data analysis

In previous studies, spontaneous language samples have been analyzed according to past tense use in obligatory contexts (see Brown, 1973; Kuczaj, 1977; Oetting & Horohov, 1997; De Jong, 1999; Hansson et al., 2003). However, it is difficult to define an obligatory context for the simple past. First of all, the use of past participles is preferred to refer to past events in Dutch as compared to the use of the simple past (De Houwer, 1997). Secondly, children go through a developmental stage in which they refer to past events with present tense forms (Kuczaj, 1977). Therefore, in this study past tense productions were studied when children grammatically encode past tense.

From each transcript, 50 utterances were selected for analysis. Elliptical answers, repeated and unintelligible utterances are not included in this 50-utterance sample. For the selection of utterances, the STAP protocol (Verbeek et al., 1999) was followed. On each 50-utterance sample, the number of past tense productions were counted and categorized as regular or irregular. The aim of this analysis was to obtain an inventory of past tense productions per verb class (i.e. regular or irregular) and variation in verb type and tokens for the CI and SLI children. Differences between the CI and SLI children on past tense productions were tested with a Mann Whitney U-test (alpha .05). This non-parametric was used because of the group outliers.

For every past tense type, frequency of occurrence (i.e. tokens) in adult conversational speech was calculated to obtain an indication for adult target speech. The analysis is based on the Corpus Gesproken Nederlands (CGN) database, 'spontaneous conversation' component. The 'spontaneous conversation' component involves conversational face-to-face speech only. This component of the corpus consists of 3 million words, subdivided into a Flemish corpus of 1 million words and a Dutch corpus of 2 million words. The number of occurrences per verb type was combined for the Dutch and Flemish corpus.

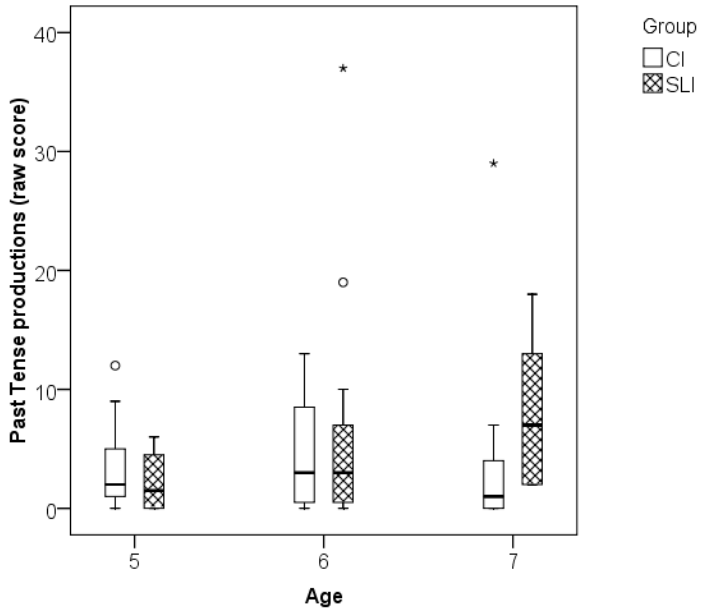
Spearman correlations were carried out between the past tense tokens (i.e. the number of past tense occurrences of a verb type) of the CI and SLI children and the adults (alpha .05). A non-parametric test was used because the distribution of past tense tokens across verb types was not normally distributed. This type of analysis reflects the relation between past tense forms used in adult target speech and past tense production of the CI and SLI children.

6.2 Results

Past tense productions

The number of past tense productions was counted per age group for the CI and SLI children. This number of past tense productions was based on a 50-utterance sample. The median raw past tense production scores and the variation within each age group is presented in Figure 4. The median past tense productions for the 5-, 6- and 7-year-old CI children is respectively 2.00, 3.00 and 1.00. The SLI children produced 1.50 past tense forms at the age of 5, 3.00 at 6 years and 7.00 at 7 years. For the CI and SLI children, large within-group variation was observed in past tense productions. No significant differences were observed between the CI and SLI children at any age (5 years: U=44.00, p=.595, 6 years: U=59.00, p=.975, 7 years: U=19.00, p=.063).

Figure 4. Box plots present the variation in raw past tense productions as measured in spontaneous speech samples for CI and SLI children. Results are presented per age group.



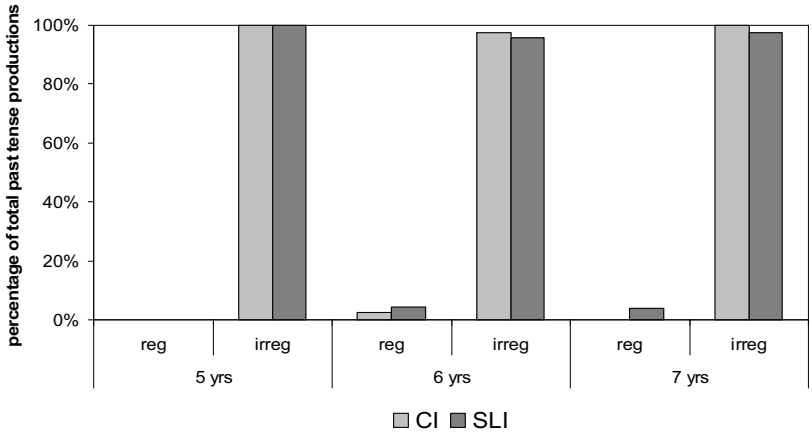
Regular versus irregular

All past tense productions were categorized in regular and irregular past tense productions. Accordingly, the total number of regulars and irregulars was divided by the total number of past tense productions to obtain a percentage of

regular and irregular past tense productions. Calculations were carried out per age group. The percentages are presented in Figure 5.

The percentages in Figure 5 indicate that most past tense productions were irregular past tense productions rather than regular past tense productions. This pattern is equal between the CI and SLI children and persists across ages.

Figure 5. The bars present the percentage of regular and irregular past tense verbs from the total number of past tenses produced per age group.



Types and adult target speech

All past tense productions are classified by type for the CI and SLI children. The number of occurrences of each type is also counted (i.e. tokens). The results of this analysis are presented in Table 2. For each past tense type, frequency of occurrence in adult target speech is presented as well.

The past tense types that occurred most often in the spontaneous speech of CI and SLI children are forms of the auxiliaries 'zijn' *(to be)* and 'hebben' *(to have)*. These past tense types are also highly frequent in the adult target speech. The CI and SLI children produced ≥10 tokens of the past tense types 'gaan' *(to go)* and 'moeten' *(moesten)*. The past tense 'gaan' *(to go)* occurred most often in a construction of 'gingen' *(went)* + infinitive (see examples in (2)). For the CI children this construction occurred 16 times out of 16 past tense tokens of the verb 'gaan', and for the SLI children 10 times out of 14. The past tense of 'gaan' *(to go)* and 'moeten' *(must)* do not occur relatively more often in spontaneous speech of adults when compared to other past tense types (cf. 'zullen' *(shall)* and 'vinden' *(to find)*).

(2) a. En toen ging de kapitein zijn hoed aan Berend geven
and then went the captain his hat to Berend give
'And then the captain gave his hat to Berend'

b. En dan ging de uil verder vliegen
And then went the owl afar fly
'And the owl flew afar'

Across the board, the number of past tense tokens for the irregular verbs is higher when compared to the regulars in the adult target speech (see Table 2). This pattern is reflected in the spontaneous speech of CI and SLI children; the CI and SLI children produce more past tenses for the irregular verbs as compared to the regular verbs. Significant positive correlations are found in past tense tokens between the spontaneous speech of CI and SLI children and adults, respectively rs= .534, p=.018 and rs=.517, p=.028.

Table 2. Overview of the number of past tense occurrences of each verb type. The number of occurrences per verb type was measured for the CI children, SLI children and adults (CGN).

		CI children	*SLI children*	*CGN*
verb type	regular/ irregular	Occurrence child spontaneous speech	Occurrence child spontaneous speech	Occurrence adult spontaneous speech
zijn *(to be)*	irregular	**62**	**85**	**21549**
gaan *(to go)*	irregular	**16**	**14**	**2987**
hebben *(to have)*	irregular	**13**	**34**	**11263**
moeten *(must)*	irregular	**10**	**12**	**2720**
komen *(to come)*	irregular	3	4	1916
willen *(to want)*	irreg(reg)	3	3	1691
mogen *(to may)*	irregular	2	5	540
denken *(to think)*	irregular	2	0	2171
vliegen *(to fly)*	irregular	2	0	38
vinden *(to find)*	irregular	1	1	2211
slapen *(to sleep)*	irregular	1	2	44
staan *(to stand)*	irregular	1	0	1405
weten *(to know)*	irregular	1	1	1029
doen *(to do)*	irregular	1	1	906
kunnen *(can)*	irregular	1	2	1753
worden *(to become)*	irregular	1	5	1010
krijgen *(to get)*	irregular	1	1	680
zullen *(shall)*	irregular	1	0	5446
vallen *(to fall)*	irregular	1	0	234
hangen *(to hang)*	irregular	1	0	111

zitten *(to sit)*	irregular	0	5	2018
zien *(to see)*	irregular	0	5	827
jeuken *(to itch)*	regular	1	0	0
maken *(to make)*	regular	0	1	153
botsen *(to bump)*	regular	0	1	0
spugen *(to spit)*	regular	0	1	0
bedoelen*(to mean)*	regular	0	1	55

6.3 Summary

In this study, spontaneous speech samples have been analyzed on past tense production for 5 to 7-year-old CI and SLI children. Results show that CI and SLI children produce equal numbers of past tenses in their spontaneous speech. Moreover, the CI and SLI children produce more irregular past tenses in their spontaneous speech as compared to regulars. This pattern persists up to the age of 7. The most frequently occurring irregulars are forms of the auxiliaries 'zijn' *(to be)* and 'hebben' *(to have)*. The type of past tense occurrence in CI and SLI child speech is partially explained by the number of occurrences of the past tense type in target adults speech, as positive correlations have been found between past tense tokens (per verb type) for children and adults

7. Past tense elicitation task

7.1 Research method

Participants

For this task, three groups of children are included, aged between 5 to 7 years. The first group included 74 TD children who were drawn from mainstream schools in Flanders (Westmalle) and the east of The Netherlands (Hengelo). Numbers of TD children from Flanders and the Netherlands are specified in Table 3 as well as mean ages and standard deviations (individual data of the TD children is presented in Table 2 of the Appendix). All TD children were monolingual speakers of Dutch and did not present any disorders, such as hearing losses, language impairments, social-emotional problems or cognitive delays. The group of TD children served as controls for the CI and SLI children.

The second group included 14 CI children between the ages 5 to 7. The CI children were drawn from schools for special education in Flanders (Antwerp and Hasselt) and an audiology centre (Antwerp). Five of these CI children also participated in the study of past tense analysis based on spontaneous speech samples. These samples were been recorded 1 or 2 years prior to the present

elicitation task. The CI children had a mean unaided hearing loss of 104dB (SD 13.8dB) (i.e. hearing thresholds averaged over 500, 1000 and 2000 Hz for the *best* ear). They received their implant at between 7 and 59 months, with a mean of approximately 26 months for age at implantation. All CI children were monolingual speakers of Dutch. None of the CI children had additional disorders, such as cognitive disorders or social-emotional disorders. Mean age, hearing loss and age at implantation per age group are presented in Table 3 (for individual data see Table 3 of the Appendix).

Table 3. Overview of the number of participants per group and age is presented. The TD children were subdivided in a group tested in the Netherlands and Flanders. Mean age and standard deviations are given for the TD, SLI and CI children. For the SLI children mean Hearing Loss (HL) for the worst ear is given. For the CI children mean Hearing Loss for the best ear is given as well as the mean age of receiving an implant (AAI).

		5 yrs		*6 yrs*		*7 yrs*	
		NL	VL	NL	VL	NL	VL
TD	N	10	14	6	18	12	11
	Age	66.8	66.6	80.0	79.2	88.4	87.3
		(*4.5*)	(*2.6*)	(*2.9*)	(*3.4*)	(*3.7*)	(*2.8*)
SLI	N		8		9		8
	Age		65.7		77.1		88.4
			(*4.3*)		(*3.7*)		(*3.6*)
	HL (dB)		14.2		15.0		12.7
			(*4.0*)		(*11.2*)		(*3.3*)
CI	N		6		5		3
	Age		67.0		77.0		91.6
			(*2.4*)		(*3.9*)		(*4.2*)
	HL (dB)		105.8 (		102.8		103.4
			(*16.6*)		(*13.0*)		(*16.5*)
	AAI		28.6		26.6		17.9
			(*19.9*)		(*13.0*)		(*9.9*)

The third group included 25 SLI children, who were selected from schools for special education in Flanders (Antwerp and Hasselt). The SLI children were all diagnosed as language-impaired by a certified speech-language pathologist and received therapy at the schools they were attending. None of the SLI children presented hearing losses, as indicated by the most recent audiograms (mean hearing loss 14dB (7.2dB) (i.e. hearing thresholds averaged over 500, 1000 and 2000Hz for the *worst* ear). No additional disorders, besides their language impairment, were reported for the SLI children. The SLI children were all

monolingual speakers of Dutch (for individual data see Table 4 of the Appendix).

The parents of the TD, CI and SLI children were informed about the present research and permission was asked for their child to participate. For all participating children, the relevant permission was obtained.

Tasks

Pretest: Discrimination task

To evaluate the discrimination abilities of the CI and SLI children we used the Auditory Speech Sounds Evaluation test (A§E®, ©PJ Govaerts, Antwerp, Belgium). This test is language-independent and gives information about the auditory function with as little cognitive bias as possible (Govaerts, 2006). The test uses an oddity procedure in which two speech stimuli are presented and the child is conditioned to react to the odd speech sound. The stimuli selected for this test were pairs of verbs. The pairs consisted of the present tense form and the past tense form of the same verb. The pairs are the regular werk-werkte (*to work - worked*) and the irregulars breek-brak,(*to break - broke*) and kijk-keek (*to look- looked*). The children listened to the repetition of the present tense form of the verb and were asked to raise their hand if they heard another word, which was the past tense form of the verb pair. Children passed the discrimination task if they discriminated three past tense forms (of the same verb) in succession.

The discrimination task served as a pretest, if a child failed to discriminate between the stimuli, no past tense elicitation task was given. This assures that children who were participating in the elicitation task were able to discriminate between present and past tense on phonological form when presented in isolation.

The auditory stimuli were played on a laptop with loudspeakers. The children were placed at a distance of one meter from the loudspeakers. Stimuli were presented at 60-65dB as measured by an audiometer on one meter distance from the speakers. The discrimination task was video recorded for all children.

Elicitation task

Berko's experiment from 1958 was used to guide the current analysis. The elicitation task consisted of a short movie in which two characters, Bob and Boris, are building a sandcastle. The movie is composed of an oral story supported by pictures in which the two characters acted out the story (for the full script see Appendix). The pictures served as a visual reminder of the actions of Bob and Boris. The target verbs are interwoven in the story together

with the filler verbs. The target verbs are introduced in their present tense form, see example (3a/4a), followed by the test sentence in (3b/4b). All test sentences were recorded in full form, i.e. containing the past tense form of the target verb, to obtain the correct intonation pattern of the sentence. Accordingly, the target verb was replaced by a beep. By leaving only one gap in the test sentence, children were forced to use the simple past (for more information about the task construction see Schultz, 2009). This way of constructing the test sentence avoids the use of past participles or the past tense of the verb 'gaan' *(to go)* combined with an infinitive, which are constructions frequently used by children in Dutch to mark past tense (De Jong, 1999).

Part of the script:

Dit is Bob
'This is Bob'

En dit is Boris
'And this is Boris'

(3) a. 'Hallo' zegt Bob
'Hello' says Bob'
b. Gisteren, toen _____ Bob hallo (zei)
'Yesterday, Bob _____ hello' *(said)*

Boris zegt hallo terug
'Boris says also hello'

Bob en Boris zijn elkaars beste vrienden
'Bob and Boris are each other best friends'

(4) a. Vandaag spelen zij in de speeltuin
'Today they play on the play ground'
b. Gisteren, toen _____ zij in de speeltuin (speelden)
'*Yesterday, they _____ on the playground'* *(played)*

Stimuli

The elicitation task included 6 regular and 6 irregular verbs. To make sure that the children in our study were familiar with the regular and irregular verbs, we performed frequency counts on the verbs listed in the Dutch version of the MacArthur Communicative Development Inventory (Zink & Lejaegere, 2002), a standardized parent-reporting system used to assess monolingual children's

lexical growth. The frequency counts present the number of occurrences of the present and past tense form (singular and plural) of each CDI verb in two child corpora. These counts indicate the degree of familiarity with the verb type in child speech.

The child corpora that were analyzed consist of spontaneous speech samples of CI children and TD children. The procedure for the collection of spontaneous speech samples is outlined in 6.1 of this chapter. For the frequency counts, corpora were analyzed including 48 CI children and 52 TD children aged between 4 and 7 years. All children were monolingual speakers of Dutch and lived in Flanders, Belgium. The frequency counts for each CDI verb are summarized in Table 1 of the Appendix.

The frequency counts of the CDI verbs, based on the child corpora, were compared to the number of past tense tokens per verb type in the adult corpus. The latter frequency measure was used to approach the frequency of occurrence in the adult target speech of the past tense form of each CDI verb. The number of past tense tokens per verb type were calculated using the database from the Corpus Gesproken Nederlands. Frequency counts are based on the 'spontaneous conversation' component of the CGN database, that only involves conversational face-to-face speech. This component of the corpus consists of 3 million words, subdivided into a Flemish corpus of 1 million words and a Dutch corpus of 2 million words. For the present analysis, frequency counts of the Dutch and Flemish corpora were added together.

Results of the frequency counts per CDI verb are presented in Table 1 of the Appendix. From the list of regular and irregular verbs, three high frequency verbs and three low frequency verbs were selected (see Table 4 in this chapter). High frequency indicates that adults produce the past tense form relatively often in their spontaneous speech, hence the past tense form is highly frequent in the adult target speech. Low frequency indicates that adults produce the past tense form less often in their spontaneous speech as compared to the high frequency verbs. To put it in other words, the low frequency verbs occur less often in the adult target speech.

Across the board, the high frequency regular verbs occurred less often as compared to the high frequency irregular verbs (cf. spelen *(to play)* with zeggen (*to say)* in the Table 4). Frequency counts in the adult spontaneous speech coincide with the frequency counts in the child corpora (see Table 4). This indicates that the children were relatively more familiar with the high frequency verbs than the low frequency verbs. However, this does not imply that the children were familiar with the past tense form of the verb, as the frequency counts are mainly based on present tense forms.

Table 4. Overview of the stimuli included in the elicitation task, categorized in high frequency and low frequency. Frequency counts for the children indicate familiarity with the verb. Frequency counts are based on number of past and present tense occurrences of the verb in child corpora. Frequency counts for the adult corpora (CGN) are based on past tense occurrences in adult spontaneous speech. This measure indicates input frequency.

	regular	*child corpora*	*adult corpora*
High frequency	spelen *(to play)*	110	103
	stoppen *(to stop)*	26	23
	leggen *(to lay down)*	34	18
Low frequency	botsen *(to bump)*	4	0
	schoppen *(to kick)*	1	1
	schommelen *(to swing)*	5	2
	irregular		
High frequency	zeggen *(to say)*	91	3676
	vallen *(to fall)*	87	234
	kijken *(to look)*	362	160
Low frequency	schrijven *(to write)*	4	41
	brengen *(to bring)*	5	29
	breken *(to break)*	2	5

Four nonce verbs (see data analysis) were created for each verb selected by replacing the onset for the first syllable and maintaining the rhyme (e.g. [b]otsen – [w]otsen). According to Prasada & Pinker (1993), the maintenance of the rhyme is the most salient factor for a nonce verb to be considered a prototypical verb. Prototypical verbs are phonologically acceptable. For adults it has been shown that they are more likely to produce a past tense form for a phonologically acceptable nonce verb as compared to less phonological acceptable nonce verbs (Albright & Hayes 2003).

Procedure

The elicitation task was played on a laptop (Dell latitude D600) with external loudspeakers (Trust, portable sound station SP2986Bi). The elicitation task was presented at 65 – 70dB as measured by an audiometer at one meter distance from the speakers. Children were seated approximately one meter in front of the laptop and loudspeakers. They were given the following instruction: *'You are going to watch a movie of Bob and Boris. They are each other's best friends. Today they are playing in the playground. They do a lot of things. Some things are familiar; probably you have done them, too. But they also do a lot of crazy things. Then we have to pay attention of what they are doing. But, the movie has some beeps. Can you tell me what Bob and Boris did?*

The elicitation task is preceded by two practice items (lopen '*to walk*' and gooien '*to throw*'). If the children did not respond to the first practice item the procedure of the task was explained to them again and, if necessary, the past tense of the first practice item was given by the experimenter. Movie fragments were repeated if children were unable to remember a particular verb, or if they produced the wrong stem for a target verb. Two versions of the elicitation task were made, one with a Dutch female narrator and one with a Flemish female narrator. The Dutch children were given the Dutch version of the movie, the Flemish children were given the Flemish version of the movie.

Data analysis

The past tense responses on the verbs in the elicitation task were judged target-like or non-target-like. Target-like responses conform to the past tense responses of adults. The first step to obtain target-like responses for the nonce verbs was to embed all nonce verbs (48 in total) in intransitive sentences. The sentences were given to 22 adults who placed all nonce verbs in its past tense form. A cut-off level of 75% agreement between adults on the past tense form of the nonce verb was a prerequisite for eligibility in the elicitation task. This prerequisite was met for 6 nonce verbs, which are listed in Table 5. Of those, only 'glijven' was deemed irregular ('gleven').

Table 5. Overview of the nonce verbs included in the elicitation task. Percentages of agreement among adults on the past tense form of the nonce verb are included.

nonce verb	*past tense form*	*percentage agreement*
joppen	jopten	95.8%
prommelen	prommelden	100%
wotsen	wotsten	100%
grallen	gralden	91.7%
teggen	tegden	79.2%
glijven	gleven	75%

After this reduction in nonce verbs, 28 adults performed the elicitation task (20 adults from The Netherlands, 8 adults from Flanders). These adults followed the same procedure as the children. The results of the adults are presented in Table 6. The nonce verbs 'glijven' and 'teggen' fell below the cut-off level of 75% agreement. Therefore, these two nonce verbs are discarded for further analysis.

Table 6. The target-like past tense forms of the verbs taken up in the elicitation task. Target-like responses are based on the responses given by 28 adults. The percentage of agreement for each past tense form is given.

regular	*agreement*	*irregular*	*agreement*	*nonce verbs*	*agreement*
speelden	100%	keek	100%	jopten	86%
legden	96%	viel	100%	prommelden	100%
stopten	100%	zei	96%	wotsten	100%
schopten	100%	brak	100%	gralden	89%
botsten	100%	schreef	100%	*tegden*	*68%*
schommelden	100%	bracht	100%	*gleef*	*50%*

The TD, CI and SLI children were compared in their production target-like past tense responses with a Mann-Whitney U-test (for a detailed analysis of target-like responses per verb for the TD, SLI and CI children see Willemsen (2008-2009). A non-parametric test was used because the assumption of equal variances was not met. The non-target-like responses were further categorized. Statistical analysis is performed on the largest non-target-like categories. These are present tense responses instead of past tense responses and null responses (i.e. no answer is given for the stimulus). Differences between TD, CI and SLI children are tested with a Mann-Whitney U-test. Again, a non-parametric test is used because of unequal variances between groups.

For the irregular verbs, a separate analysis involves overgeneralizations. As outlined in the introduction (see subsection 2.2), overgeneralizations in this study refer only to the feeding of the stem of the verb into the regular process. For example, the past tense form of the irregular verb 'kijken' *(to look)* becomes 'kijkte'. The feeding of the past tense form of the irregular verb into the regular process is excluded from the analysis of overgeneralizations (e.g. 'keken' *(looked)* → 'keekte'). The proportion of overgeneralizations and target-like irregulars was calculated for the TD, SLI and CI children per age group.

All target-like regular and irregular responses are divided into low and high frequency categories. The parametric ANOVA test was applied for statistical analysis in the case of equal variances in production of high versus low frequent verbs. If the assumption of equal variances was not met, Mann-Whitney U-tests were performed.

Pearson correlations were performed to test the relation between target-like production scores on regular, irregular and pseudoverbs. Correlations were performed across ages, with age included as a covariate in the correlation analysis. For the CI children we also correlated past tense production scores with age at implantation. The effects of frequency (i.e. high versus low frequent) on past tense production scores were also tested within each group. If the parametric assumptions were met, ANOVA analysis was performed, otherwise

a Mann-Whitney U-test was used. For all statistical testing we adopted an alpha of .01.

7.2 Results elicitation task

7.2.1 Regular past tense

Figure 6 presents the percentage target-like responses for the TD, SLI and CI children from age 5 to 7 as compared to the non-target-like responses. The grey-shaded area indicates the category of target-like regular responses. The non-target-like responses are categorized as follows:

1. no answer or null responses
   (i.e. no answer is given to the stimulus)
2. past tense forms with a different allomorph
   (e.g. 'legte' instead of 'legde')
3. present tense forms
4. attempts to form an irregular past tense form
   (e.g. 'leggen' – 'lag')
5. past participles
   (e.g. heeft gelegd)
6. the past tense form of 'gaan' *(to go)* combined with an infinitive
   (e.g. ging leggen)
7. a residual category
   (e.g. when another verb was used 'gooide' instead of 'legde')

Percentages were calculated by dividing the number of responses within a category (i.e. target-like responses and the 7 non-target-like responses) by the number of regular verbs included in the elicitation task (i.e. 6). The first analysis compared TD, CI and SLI children on non-target-like responses.

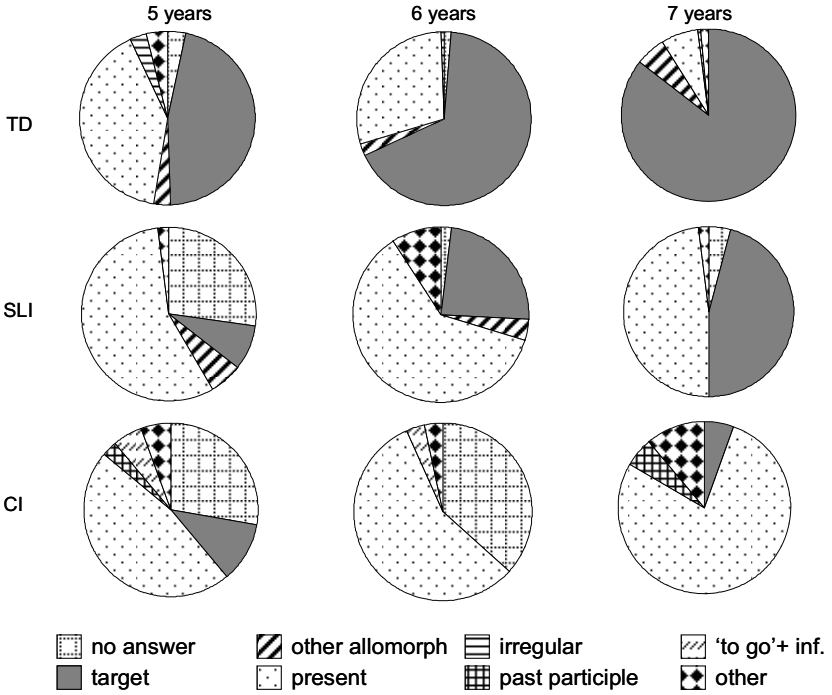
Non-target-like responses for regular verbs

Present tense forms

The pie charts in Figure 6 indicate that the TD, CI and SLI children often gave the present tense form of the verb instead of the past tense form. For the TD children, there is a strong decrease in the non-target present tense production across years. The percentage decreases from 40% at the age of 5 to 7% at the age of 7. Such a decrease is not observed for the SLI and CI children. For the SLI children, the production of the non-target present tense form remains fairly constant over the years. At the age of 6 and 7, an overall significant difference in present tense production is found between the SLI and TD children (respectively U=33.5, p=.002 and U=24.5, p=.001). CI children show an increase in the production of non-target present tense responses from 47% at 5

years to 78% at the age of 7. Only at the age of 7 is a significant difference found between the CI and TD children (U=0.0, p=.001). No significant difference on the production of non-target present tense forms is found between SLI and CI children at any age.

Figure 6. Proportion of target-like responses and non-target-like responses from the total number of regular verbs (i.e. 6). Results are presented for the TD, SLI and CI children separately and per age group.



Null responses

For the 5 to 7-year-old TD children, the percentage of non-target null responses is close to zero. This is in contrast with the younger SLI and CI children. At the age of 5, the percentage of non-target null responses is higher for the SLI and CI children as compared to their TD peers. This difference reaches significance (U=20.0, p=.003) only between the 5-year-old CI and TD children. At 6 years, the proportion of null responses has decreased for the SLI children, but remains high for the CI children. The higher proportion of null responses for the 6-year-old CI children as compared to the TD and SLI children is not significant. The percentage of non-target null responses is zero or close to zero for the 7-year-old TD, SLI and CI children.

Other non-target-like responses

The CI children produce two other categories of non-target-like responses, which do not occur for the TD and SLI children. The CI children use other constructions to mark past tense, such as the past participle and the past tense form of 'gaan' *(to go)* combined with the infinitive. Despite the constraint in the elicitation task (i.e. children were forced to use the simple past) some CI children produced other sentences to allow for alternative constructions to place the event in the past tense.

Regular target-like past tense responses

The variability between children in the production of target-like regular past tense is presented in Figure 7. This graph presents the mean percentages of target-like regular responses and standard deviations for the TD, SLI and CI children.

The results for the TD children show an increase in the production of target-like regular past tense over the years. At the age of 5, the TD children produce target-like regular past tense at chance level (50%). However, some TD children are able to produce 80% of all regular verbs target-like even at this early age. The mean performance of the TD children is near ceiling at the age of 7.

Similarly to the TD children, the SLI children show an increase in the production of target-like regular past tense between the ages of 5 to 7. However, at all ages their production of target-like regular past tense remains significantly below the production scores of their TD peers (see Table 7 for the statistical results). All 5 and 6-year-old SLI children perform below chance level in their production of target-like regular past tense. They reach chance level at the age of 7, with some SLI children reaching a score of 80% target-like regular past tense. This indicates that their production of target-like regular past tense compares to the 5-year-old TD children.

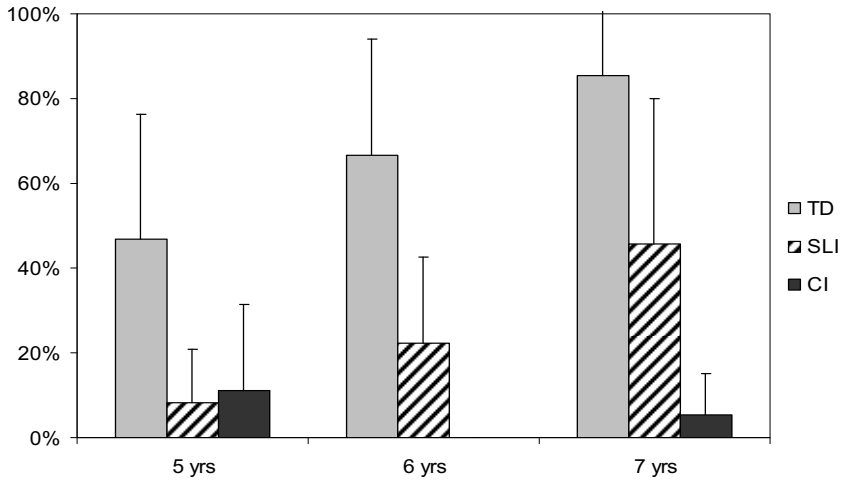
The production of target-like regular past tense for the CI children is below 20% at all ages. They do not show an increase in target-like regular past tense production, which is in contrast with their TD and SLI peers. When compared to their TD peers, CI children produce significantly lower percentages target-like responses at all ages (see Table 7). No significant differences in regular target-like responses are found between the CI and SLI children at any age (see Table 7). The lack of any significant identifiable difference between the CI and SLI children at the age of 7 could be attributed to the low number of CI children in this group (N=3).

Table 7. Results of the Mann Whitney U-test, comparing the TD, SLI and CI children on regular target-like past tense production.

	TD – SLI	*TD – CI*	*SLI – CI*
Age 5 yrs	U=23.5, p=.000**	U=23.5, p=.006*	U=24.0, p=1.0
6 yrs	U=22.5, p=.000**	U=2.5, p=.000**	U=7.5, p=.042
7 yrs	U=29.0, p=.002*	U=0.0, p=.001*	U=3.0, p=.085

* significant at alpha .01 ** significant at alpha .001

Figure 7. Mean percentage target-like regular past tenses and standard deviations for the TD, SLI and CI children. Results are presented per age group.



7.2.2 Irregular past tense

Figure 8 presents the percentages of target-like and non-target-like responses to stimuli that require an irregular past tense form for the TD, SLI and CI children. The grey-shaded area indicates the category of target-like irregular responses. The non-target-like responses are categorized as follows.

1. no answer or null responses
   (i.e. no answer is given to the stimulus)
2. target-like irregular responses with double marked past by concatenation of an irregular past verb stem with a regular past morpheme
   (e.g. 'viel' *(fell)* – 'viel-te' *(fell-ed)*)
3. target-like irregular response with a regular present tense agreement marker

(e.g. 'viel' *(fell)* – 'viel-t' (fell-s*)*)
4. overgeneralization in which the stem of the irregular verb is concatenated with the regular past tense allomorph
(e.g. 'vallen' *(to fall)* – 'valte' *(fall-ed)*
5. non-target-like irregular past tense, possibly based on the past participle stem
(e.g. 'brook' instead of 'brak' *(to break)*).
6. present tense forms
7. past participle is used to place the event in the past tense
(e.g. zijn gevallen)
8. construction with the past tense form of the verb 'gaan' *(to go)* and infinitive
(e.g. ging vallen)
9. residual category
(e.g. 'bruin' for the irregular 'bracht' (*brought*))

Percentages were calculated by dividing the number of responses within a category (i.e. target-like responses and the 9 non-target-like responses) by the number of irregular verbs included in the elicitation task (i.e. 6). The first analysis compared TD, CI and SLI children on non-target-like responses.

Non-target-like responses for irregular verbs

Present tense responses

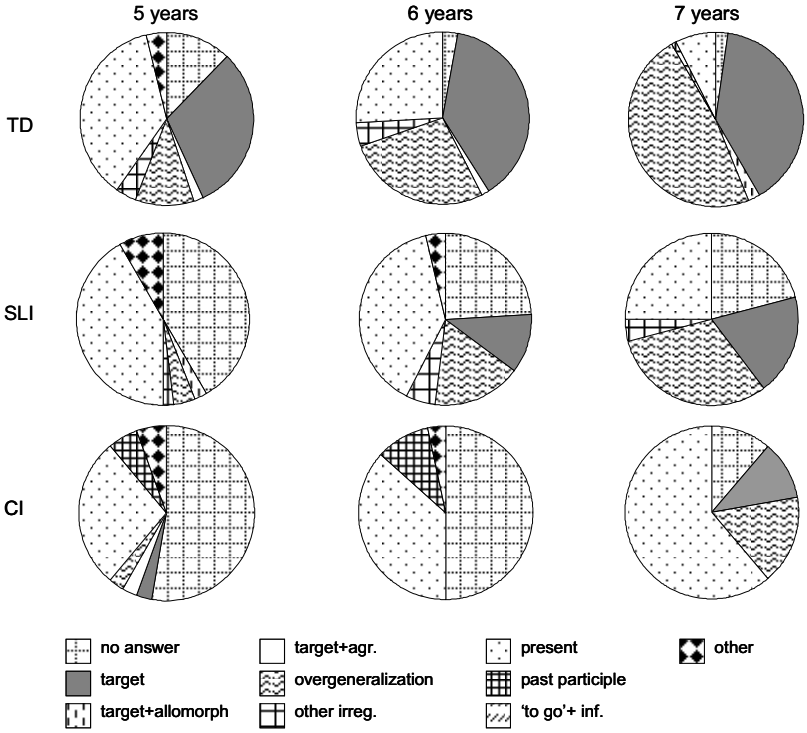
The pie charts in Figure 8 show that for the 5-year-old TD, SLI and CI children the production of the non-target present tense form is the most frequent non-target-like response. For the TD and SLI children, the production of non-target present tense forms decreases between the ages of 5 to 7. No significant differences are found between the TD and SLI children in the production of non-target present tense at any age. In contrast, the CI children increase in their production of non-target present tense forms across the years. A significant difference is found between the CI and TD children at the age of 7 ($U=1.5$, $p=.001$). No significant difference is found between the CI and SLI children at any age on the production of non-target present tense.

Null responses

The TD children have low percentages null responses at the age of 5 and this percentage decreases in subsequent years. The 5-year-old SLI children have significantly more null responses when compared to their TD peers ($U=36.0$, $p=.004$). The percentage of null responses remains high for the 6 and 7-year-old SLI children when compared to their TD peers, but the difference is not significant. For the CI children, it is observed that at the age of 5 and 6

approximately half the irregular stimuli do not elicit any answer. The 5 and 6-year-old CI children have significantly more null responses when compared to their TD peers (respectively U=21.5, p=.004 and U=4.0, p=.000). At the age of 7, the number of null responses is comparable between the TD and CI children. No significant differences are observed between the CI and SLI children at any age.

Figure 8. Proportion of target-like responses and non-target-like responses from the total number of irregular verbs (i.e. 6). Results are presented for the TD, SLI and CI children separately and per age group.



Overgeneralizations

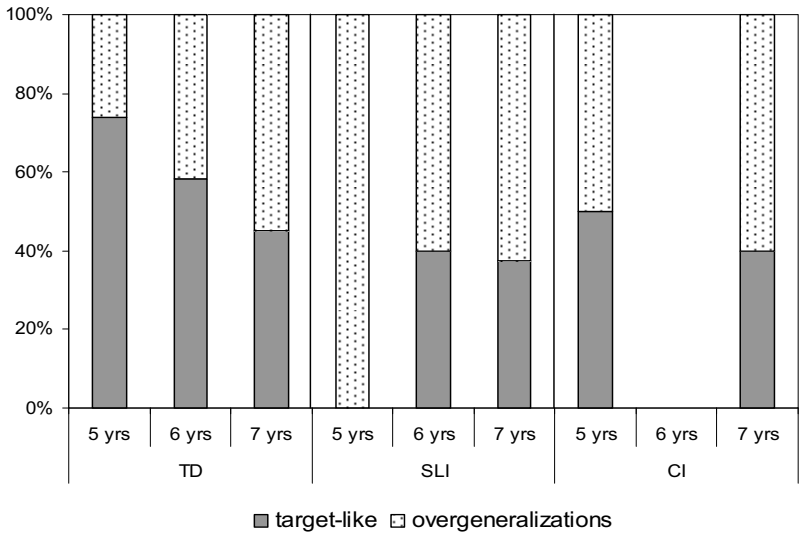
For the TD, SLI and CI children it is observed that the percentage of overgeneralizations increases between the ages of 5 to 7 (see Figure 8). The TD children produce more overgeneralizations across the board as compared to the SLI and CI children. A significant difference in the production of overgeneralizations is found only between the 6-year-old CI and TD children

(U=15.0, p=.007). No further significant differences between the TD, SLI and CI children were found at any age.

The production of overgeneralizations indicates that the TD, SLI and CI children are able to use the regular process to mark irregular verbs for past tense. From the pie charts in Figure 8, it becomes clear that the production of non-target-like overgeneralizations and target-like irregular past tense forms co-occur. The proportion of regularized past tense forms and target-like irregular past tense forms is presented in Figure 9.

For the TD children, the proportion of overgeneralizations increases between the ages 5 and 7. Consequently, the number of target-like irregular past tense responses decreases. At the age of 7, approximately 50% of the irregular verbs received either regular past tense marking or are target-like irregular past tenses.

Figure 9. Proportion of target-like irregular past tenses and overgeneralizations from the total number of past tenses formed via suffixation or via target-like (i.e. irregular) responses.



Interestingly, the 5-year-old SLI children used only regular past tense marking for the irregular verbs. The target-like irregulars appear in subsequent years, However, at the ages of 6 and 7, the SLI children predominantly mark irregular verbs via the regular past tense process. At the ages of 5 and 7, the CI children produce approximately 50% of the irregulars either target-like or with a regular suffix. None of the 6-year-old CI children produced either target-like irregulars or overgeneralizations. This probably explains the significant difference in the

percentage of overgeneralization between the 6-year-old CI and TD children, which was reported earlier.

Other non-target-like responses

Other constructions to express past tense, such as past participles and the past tense of the verb '*to go*' combined with an infinitive, are used by the CI children at the ages of 5 and 6. None of the TD and SLI children make use of these constructions to mark past tense at any age.

Target-like irregular past tense responses

The variability between children in the production of target-like irregular past tense is presented in Figure 10. This graph presents the mean percentages of target-like irregular responses and standard deviations for the TD, SLI and CI children.

The TD children show a small increase in target-like irregular past tense production between the ages 5 to 7. Their mean performance remains below chance level at all ages. Only some 6 and 7-year-old TD children produce between 60 to 70% target-like irregulars.

The first target-like irregulars are observed when the SLI children are 6 years of age. At this age they produce significantly fewer target-like irregulars when compared to their TD peers (see Table 8 for statistical results). The SLI children increase in their production of target-like irregulars from age 6 to 7. At the age of 7, their production of target-like irregulars compares to the production observed for their TD peers.

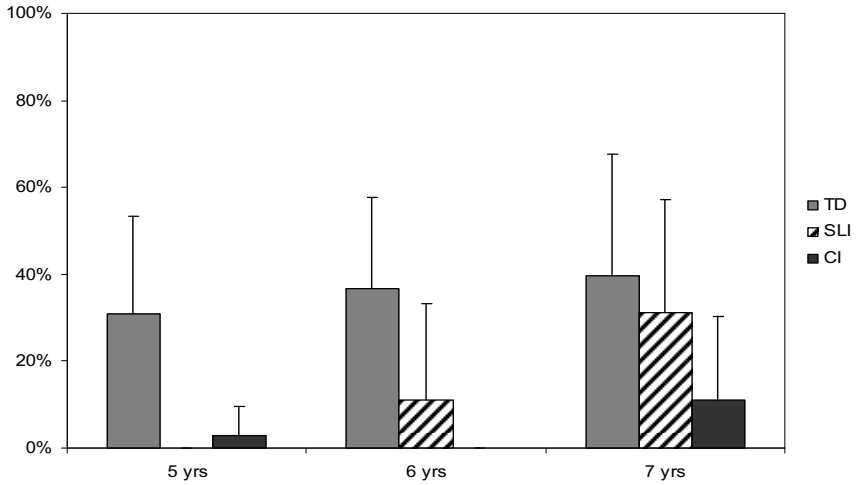
The CI children show poor performance on the production of target-like irregulars across all ages. At the age of 5, they produce significantly fewer target-like irregulars as compared to their TD peers. At 6 years, no target-like irregulars are produced at all. The 7-year-old CI children show lower percentages of target-like irregulars as compared to their TD peers. This difference is not significant, probably due to the low number of CI children in the group of 7-year-olds (N=3). Between the CI and SLI children, no significant differences were observed at any age. Although, at the age of 7, the CI children show lower percentages of target-like responses than the SLI children.

Table 8. Results of the Mann Whitney U-test, comparing the TD, SLI and CI children on irregular target-like past tense production.

	TD - SLI	*TD - CI*	*SLI – CI*
Age 5 yrs	U=16.0, p=.000**	U=18.0, p=.002*	U=20.0, p=.662
6 yrs	U=18.0, p=.003*	U=5.0, p=.000*	U=15.0, p=.364
7 yrs	U=79.5, p=.480	U=14.5, p=.101	U=6.0, p=.279

* significant at alpha .01 ** significant at alpha .001

Figure 10. Mean percentage of target-like irregular past tenses and standard deviations for the TD, SLI and CI children. Results are presented per age group.



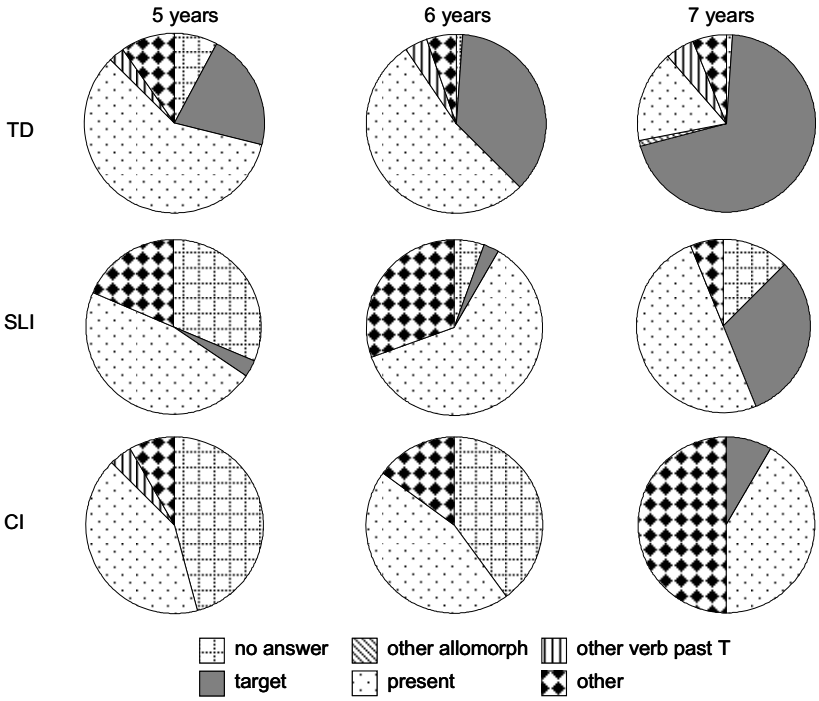
7.2.3 Past tense on nonce verbs

Figure 11 presents the percentages of target-like and non-target-like responses for the nonce verbs. Results are presented for the TD, SLI and CI children separately. The grey-shaded area indicates the category of target-like responses for the nonce verbs. All nonce verbs received regular past tense marking by the adults (see Table 6). The non-target-like responses for the nonce verbs are categorized as follows:

1. no answer or null response
2. another allomorph is attached to the stem
   (e.g. jop<u>de</u> instead of jop<u>te</u>),
3. present tense marking
4. a residual category
   (e.g. 'grammen' as a past tense of the nonce verb 'grallen')

Percentages were calculated by dividing the number of responses within a category (i.e. target-like responses and the 4 non-target-like responses) by the number of nonce verbs included in the elicitation task (i.e. 4). The first analysis compared TD, CI and SLI children on non-target-like responses.

Figure 11. Proportion of target-like responses and non-target-like responses from the total number of nonce verbs (i.e. 4). Results are presented for the TD, SLI and CI children separately and per age group.



Non-target-like responses of nonce verbs

Present tense responses

For the TD children, the number of non-target present tense forms decreases from age 6 to 7. The SLI and CI children produce approximately 50% of the nonce verbs in their non-target present tense form. The production of non-target present tense forms does not decrease over the years for the SLI and CI children. No significant differences between the TD, SLI and CI children are found at any age.

Null responses

The TD children show low percentages of null responses at all ages. The 5-year-old SLI children have more null responses as compared to their TD peers. In subsequent years, the percentage of null responses decreases for the SLI

children. No significant differences between the SLI and TD children are found at any age. The CI children have more null responses as compared to their TD peers at the ages of 5 and 6. At the age of 7, no null responses are observed for the CI children. No significant differences between the TD, SLI and CI children were found at any age on the number of null responses.

Other non-target-like responses

The production of other responses is high for the 5 and 6-year-old SLI children and 6 and 7-year-old CI children as compared to their TD peers. Further analysis shows that, in the majority of cases, the nonce verbs are repeated with a different stem without past tense suffix.

Target-like past tense for nonce verbs

The variability between children in the production of target-like past tense for nonce verbs is presented in Figure 12 (see p:160). This graph presents the mean percentages of target-like past tense responses and standard deviations for the TD, SLI and CI children on nonce verbs.

The TD children show an increase in target-like past tense production on nonce verbs between the ages 5 to 7. However, the mean production of target-like past tenses for the 5 and 6-year-old TD children remains below chance level. Only some 6-year-old TD children perform above chance level. At the age of 7, mean target-like past tense production on nonce- verbs is well above chance level (at 70%), and some TD children perform at ceiling.

The SLI children increase in their production of target-like past tense on nonce verbs between the ages 6 to 7. However, their production of target-like past tenses remains significantly below their TD peers at the ages of 6 and 7 (see Table 9 for statistical results). The 7-year-old SLI children compare to the 6-year-old TD children in their production of target-like past tense of nonce verbs. This means that the mean performance of the 7-year-old SLI children is approximately at chance level, with some SLI children performing above chance level.

The CI children do not produce target-like past tenses for any of the nonce verbs at the ages of 5 and 6. At the age of 7, approximately 10% of the nonce verbs received target-like past tense marking. The CI children produce significantly fewer target-like past tenses for nonce verbs as compared to their TD peers at the ages 6 and 7. No significant differences are observed between the CI and SLI children at any age, although the 7-year-old CI children produce fewer target-like past tenses for nonce verbs as compared to the 7-year-old SLI children.

Figure 12. Mean percentage of target-like past tenses for pseudo-verbs and standard deviations for the TD, SLI and CI children. Results are presented per age group.

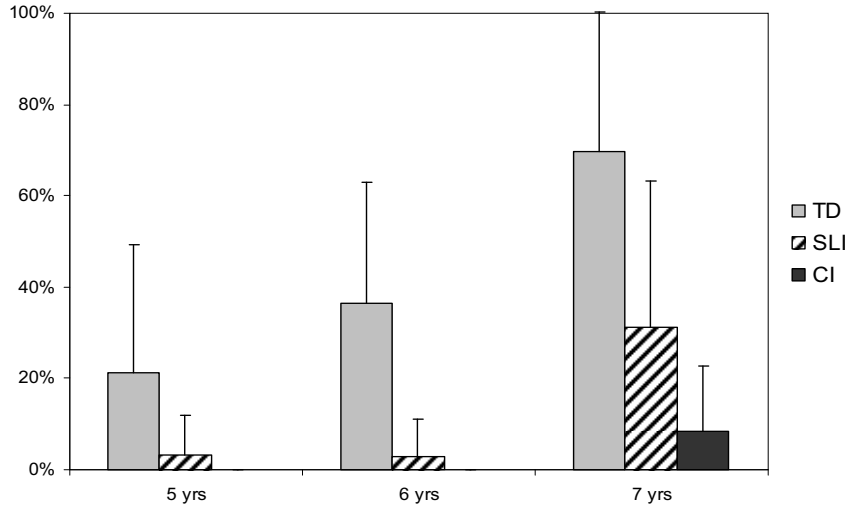


Table 9. Results of the Mann Whitney U-test, comparing the TD, SLI and CI children on target-like past tense production for pseudo-verbs.

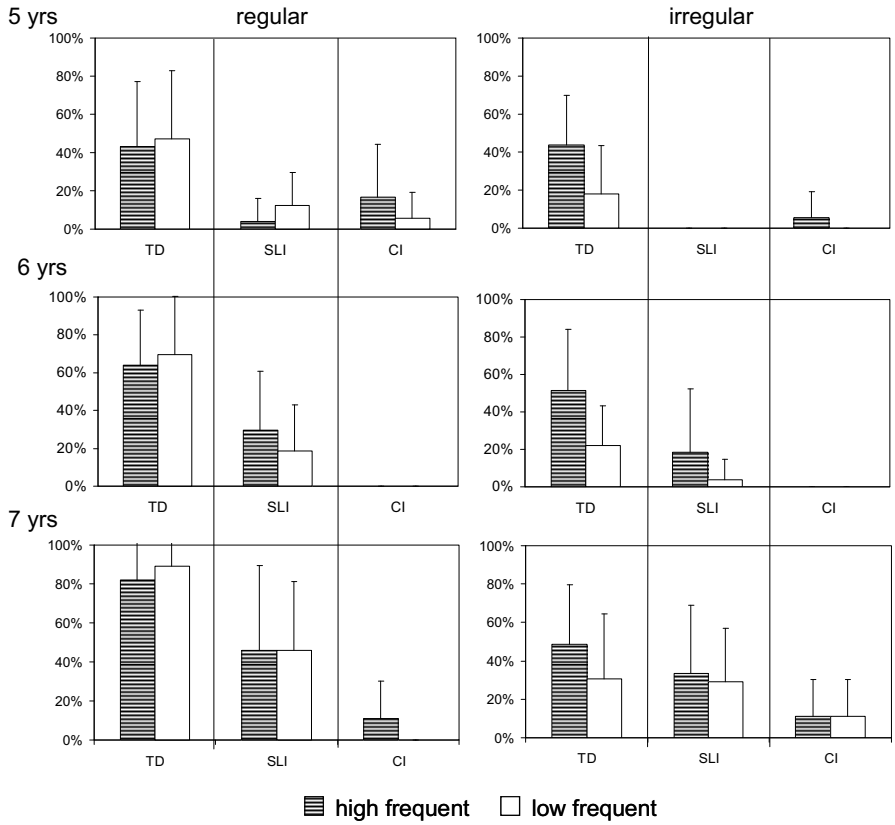
	TD - SLI	*TD - CI*	*SLI – CI*
Age 5 yrs	U=62.5, p=.092	U=39.0, p=.062	U=21.0, p=.755
6 yrs	U=32.5, p=.001*	U=15.0, p=.007*	U=20.0, p=.797
7 yrs	U=37.5, p=.009*	U=4.5, p=.008*	U=7.0, p=.376

* significant at alpha .01 ** significant at alpha .001

7.2.4 Frequency effects

The regular and irregular verbs are divided in high frequency (i.e. the past tense form occurs relatively frequently in the target adult speech) and low frequency (i.e. the past tense form occurs relatively infrequently in the target adult speech). The production of target-like past tenses for the regulars and irregulars is presented in Figure 13 for the TD, SLI and CI children separately. The percentages were calculated by dividing the number of target-like past tenses by the total number of past tenses within the category (i.e. 3 verbs). Categories are high-frequency regular and irregular and low-frequency regular and irregular. The statistical results for the comparison between high and low-frequency verbs are presented in Table 10.

Figure 13. Target-like production scores for the regular and irregular verbs divided by frequency of occurrence. Results are presented per age group for the TD, SLI and CI children separately.



For the TD children, no significant effects are observed for frequency in adult target speech in the production of target-like regular past tense at any age. In contrast, significant effects of frequency are observed in adult target speech for the irregulars. The 5 and 6-year-old TD children produce significantly more past tense productions for high-frequency irregulars as compared to low-frequency verbs. The difference between high and low frequency irregulars is lost at the age of 7.

For the SLI and CI children, no significant effects for input frequency are observed for either regular or irregular verbs.

Table 10. ANOVA and Mann Whitney U-results comparing target-like past tense production scores between high and low-frequency regular and irregular verbs. Statistical analysis was performed per age group for the TD, SLI and CI children separately.

		TD *HF - LF*	*SLI* *HF - LF*	*CI* *HF - LF*
Regular	5 yrs	F(1,51)=.071, p=.791	U=24.0, p=.442	U=14.5, p=.589
	6 yrs	F(1,47)=.407, p=.527	F(1,17)=.720, p=.409	
	7 yrs	F(1,47)=1.242, p=.271	F(1,15).000, p=1.000	U=3.0, p=0.700
Irregular	5 yrs	F(1,51)=12.821, p=.001*		U=15.0, p=.699
	6 yrs	U=143.0, p=.001*	U=31.0, p=.436	
	7 yrs	F(1,47)=3.698, p=.061	F(1,15)=.068, p=.798	U=4.5, p=1.000

* significant at alpha .01** significant at alpha .001

7.2.5 Correlation analysis of target-like past tense production

Development of target-like past tense production

For the TD, SLI and CI children, correlations are performed between age and target-like production of regular and irregular past tense, overgeneralizations and target-like past tense production of nonce verbs. It has been argued that the onset of overgeneralizations is followed by a rapid increase in regular past tense forms (Marcus et al., 1992). Moreover, the onset of past tense marking on nonce verbs indicates that the child has knowledge of morhphological regularizations (Berko, 1958). As such, it is expected that correlations exist between the regular past tense marking, overgeneralizations and past tense marking of nonce verbs. Pearson correlations are performed between age, measured in months, and the four past tense variables (see Table 11).

For the TD children, significant positive correlations are found between age and target-like regular past tense, overgeneralizations and target-like past tense production of nonce verbs. Firstly, this indicates that TD children produce more target-like past tenses for regular verbs and nonce verbs as they mature. Secondly, the significant increase in overgeneralizations across years prohibits a positive correlation between age and target-like irregulars, as the variables are interrelated (i.e. overgeneralization decreases the chance for a target-like irregular).

The SLI children show significant positive correlations between age and target-like regular and irregular production. This indicates that the SLI children produce more target-like regular and irregular past tenses with increasing age. The correlation between age and target-like past tense production of nonce verbs failed to reach significance. No significant correlation is found between age and overgeneralization for the SLI children.

In contrast to the TD and SLI children, the CI children do not show any positive correlation between age and target-like past tense production and overgeneralization. This means that the CI children do not produce more target-like past tenses between the ages of 5 to 7.

Table 11. Pearson correlation coefficients and p-values for age correlated with the production of target-like regulars, irregulars and nonce verbs, as well as overgeneralizations. Results are presented for the TD, SLI and CI children.

age	*target-like regular*	*target-like irregular*	*overgeneralization*	*target-like nonce verbs*
TD	.477	.111	.517	.465
	p=.000**	p=.537	p=.000**	p=.000**
SLI	.525	.536	.411	.494
	p=.007*	p=.006*	p=.041	p=.012
CI	-.190	.411	.421	.462
	p=.515	p=.144	p=.134	p=.096

* significant at alpha .01** significant at alpha .001

Correlation among target-like past tense productions

Partial correlations were performed between target-like regular and irregular past tense, overgeneralizations and target-like past tense of nonce verbs. Age was included as a covariate in all correlations. This analysis investigates whether a particular target-like past tense production (e.g. regular past tense) is affected by performance on another target-like past tense production (e.g. performance on nonce verbs). The results are presented separately for the TD, SLI and CI children (see Table 12).

For the TD children, the production of target-like regular past tense is positively correlated with target-like irregular and target-like past tense on nonce verbs. This indicates that TD children who score highly on target-like regular past tense production also tend to perform highly on target-like irregulars and past tense of nonce verbs. The correlation between target-like regular past tense and overgeneralizations failed to reach significance. A significant negative correlation is found between the production of target-like irregulars and overgeneralizations. This is expected as both variables are related.

The production of target-like past tense of nonce verbs is not correlated with the production of target-like irregulars or overgeneralizations.

Table 12. Results from the partial correlation, with age inserted as covariate, between the past tense variables.

TD children	*target-like regular*	*target-like irregular*	*overgeneralization*	*target-like nonce verbs*
Regular	-	.327 p=.006*	.302 p=.011	.537 p=.000**
Irregular		-	-.351 p=.003*	.197 p=.103
Overgeneralizations			-	.246 p=.040
SLI children	*target-like regular*	*target-like irregular*	*overgeneralization*	*target-like nonce verbs*
Regular	-	.118 p=.582	.749 p=.000**	.600 p=.002*
Irregular		-	-.258 p=.224	.130 p=.545
Overgeneralizations			-	.575 p=.003*
CI children	*target-like regular*	*target-like irregular*	*overgeneralization*	*target-like nonce verbs*
Regular	-	.075 p=.808	.690 p=.009*	-.039 p=.899
Irregular		-	.091 p=.767	-.367 p=.218
Overgeneralizations			-	-.409 p=.165

* significant at alpha .01** significant at alpha .001

The SLI children show a significant positive correlation between target-like regular past tense production and overgeneralizations. This indicates that SLI children who produce more target-like regular past tenses tend to produce more overgeneralizations as compared to SLI children with lower production of target-like regulars. The same relation is found between target-like regular past tense and the production of target-like past tense on nonce verbs. Moreover, a significant positive correlation is found between the production of target-like past tenses on nonce verbs and overgeneralizations. The production of target-like irregulars does not correlate significantly with any of the other past tense production variables.

For the CI children a positive correlation is found between the production of target-like regular past tense and overgeneralizations. This indicates that CI children with high scores on target-like regular past tense tend to produce more

overgeneralizations as compared to the CI children with lower production of regular past tense. No further correlations are found between past tense production variables.

Effect of age at implantation, hearing age and hearing loss

Additional correlations were carried out for the CI children. Pearson correlations were carried out between the past tense production variables and age at implantation, hearing age (i.e. the time (in months) the CI children had access to auditory speech input) and unaided hearing loss. This analysis investigates whether external variables influence scores on past tense production. Pearson correlation coefficients and p-values are presented in Table 13.

Table 13. Results of the correlation analysis between target-like past tense productions of regulars, irregulars and nonce verbs, as well as overgeneralizations and age at implantation, hearing age (chronological age – age at implantation) and unaided hearing loss.

	age at implantation	*hearing age*	*unaided hearing loss*
Regular	-.282	.119	.370
	p=.329	p=.684	p=.263
Irregular	-.115	.297	-.411
	p=.695	p=.302	p=.210
Overgeneralizations	-.149	.328	-.028
	p=.611	p=.252	p=.934
Nonce verbs	-.354	.506	.384
	p=.215	p=.065	p=.244

* significant at alpha .01 ** significant at alpha .001

No significant correlations are found between past tense production and the external variables. This is partially due to the low past tense production scores within the group of CI children.

7.3 Summary

The elicitation task in this study compared 5 to 7-year-old CI and SLI children in their past tense production, with TD children included as controls. The SLI children improve significantly in their production of regular past tense between the ages of 5 to 7. However, when compared to their TD peers, SLI children show a delay in regular past tense production of approximately 2 years.

The CI children do not show any significant improvement in regular past tense production between the ages of 5 to 7. When compared to their TD peers, significant lower production scores are found for the regular past tense at all ages. With respect to regular past tense production scores, the CI children cannot keep up with their SLI peers. Therefore, the CI children have lower production scores when compared to their SLI peers, but this does not lead to significant differences.

With respect to the production of irregular past tense, SLI children show a significant improvement in irregular past tense production across years. Also in irregular past tense marking a delay is observed for the SLI children, when their production scores are compared to their TD peers. However, this delay is less severe than in the case of regular past tense production. The SLI children catch up with their TD peers in irregular past tense production at the age of 7.

The CI children do not show a significant improvement in irregular past tense production across years. Their production of irregulars falls significantly below their TD peers at the age of 5 and 6. Nevertheless, the delay in irregular past tense production is less severe as in the case of regular past tense marking. The CI children compare to their TD peers at the age of 7 in terms of the production of irregulars. CI children compare to SLI children in their production of irregular past tense at all ages.

The CI and SLI children show lower production scores on target-like past tense of nonce verbs as compared to their TD peers. Only for the TD and SLI children is a positive correlation found between the production of regular verbs and nonce verbs. No such correlation is found for the CI children. The production of overgeneralizations is positively correlated with regular past tense production for the CI and SLI children. This shows that the CI and SLI children extend the regular suffix to irregular verbs.

The elicitation task found frequency effects only for the TD children in their production of irregular past tense. TD children produced more target-like irregulars for those irregulars that occur frequently in the input. No further frequency effects are found in the elicitation task.

8. Discussion

In section 6, the 50-utterance spontaneous speech samples of the CI and SLI children have been analyzed on past tense production. The results yielded extremely low numbers of past tense verb forms. Moreover, almost all of them were irregular verb forms. As such, no conclusions can be drawn with respect to the acquisition of past tense morphology. These findings were expected as in Dutch speakers replace the simple past tense by the present perfect. This implies that the input to Dutch children will contain more instances of the type 'Gisteren heb ik wat rondgefietst' lit. '*Yesterday I have a bit biked around*', than of the type 'Gisteren fietste ik wat rond' lit. '*Yesterday I biked around a bit*'. This is

not the case for languages such as English where the simple past is also frequently used in spontaneous speech.
The difference between these two languages with respect to the use of the simple past in spontaneous speech is reflected in the acquisition process. De Houwer (1997) has shown that the spontaneous speech of a bilingual 3-year-old Dutch-English child contains simple past forms in English but present perfect forms in Dutch.

Our analyses of spontaneous speech samples were therefore complemented by an elicitation task. The rationale behind this additional study design is that it allows us to investigate the acquisition of infrequently used morphology in the input.

The aim of the elicitation task was to compare the past tense production of 5 to 7-year-old CI children with their SLI and TD peers. The task included CI , SLI and TD children; the TD children were included as controls. The CI and SLI children were compared on their production of target-like past tenses of regular, irregular and nonce verbs.

It was hypothesized that the CI and SLI children perform similarly on past tense production. This hypothesis is based on literature regarding the joint operation of auditory perception, processing and working memory in the acquisition of grammatical morphology. For instance, the delay in the acquisition of the regular past tense morpheme reported for the SLI children has been attributed to the incomplete processing of the perceptually low salient morphemes (Leonard et al. 1992, 1997, 2003). Under such a view, which stresses the role of perceptual input on language learning, the type of processing limitation observed in SLI children is no different from a perceptual deficit, as in the case of CI children (Locke, 1997). Given this, we expected that the CI and SLI children show a delay in their acquisition of the regular past tense morpheme, due to the low perceptual salience of this morpheme.

The present study shows that CI children, at all ages, produce significantly fewer regular and nonce verb past tenses as compared to the TD children. No significant difference was identified between CI and SLI children when compared to their SLI peers, in the production of regular and nonce verb past tenses. However, the regular past tense production of the SLI children significantly improves between the ages of 5 to 7. In contrast, no such improvement in regular past tense production is observed for the CI children. This indicates that the gap between CI and SLI children is increasing over the years. As will be discussed in subsection 8.1, these results are difficult to place under the perceptual salience hypothesis. Therefore, we will propose an alternative hypothesis in subsection 8.2 in which the delay in grammatical morpheme acquisition is related to possible speech perception deficits in 'incidental' learning contexts.

In addition to the analysis on the effects of perceptual salience in grammatical morpheme acquisition, the present analysis sought to determine the effect of past tense usage in adult speech on the acquisition of past tense by CI children. According to the dual-route-model of past tense acquisition such an effect is expected to be found for irregular verbs, but not for the regular ones. The rationale behind this is that, according to the dual-route model, regulars are generated by a standard symbol-concatenation rule, whereas irregulars need to be stored in an associative memory. In contrast, the single-route-model suggests that regulars and irregulars need to be stored in an associative memory, hence effects of adult target speech are expected to be present in both regular and irregular verbs.

8.1 The effect of perceptual salience on past tense marking

It has been shown that SLI children are severely delayed in their acquisition of the regular past tense morpheme (Oetting & Horohov, 1997; Rice et al., 1998; Marchman et al., 1999; Hansson et al., 2000; Conti-Ramsden, 2003). The results of the elicitation task given in section 7 are in accordance with these findings. SLI children show a significant lower production of regular past tense as compared to their TD peers. This delay is approximately 2 years. Instead of producing the target-like past tense form, SLI children were more likely to use the non-target present tense form of the verb. The production of the non-target present tense in obligatory contexts for past tense has also been reported for the 6-year-old SLI children in the study of Marchman, Wulfeck & Ellis Weismer (1999).

The morphological difficulties of the SLI children have been attributed to the limited processing of perceptually low salient morphemes, i.e. the Surface Account (Leonard et al., 1997, 2003, 2007; Benasich & Tallal, 2002). In order to test the influence of perceptual salience on the acquisition of past tense morphology, one first needs to define the notion of perceptual salience. According to Goldschneider & Dekeyser (2001), perceptual salience 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. Syllabicity refers to the presence/absence of a vowel in the surface form of the morpheme. The presence of a vowel renders the morpheme perceptually more salient as compared to morphemes without a vowel. Regarding relative sonority, the assumption is that the more sonorous the phones in the morpheme, the more perceptually salient the morpheme is. Past tense morphemes have low scores on all three factors. As such, these morphemes are difficult to perceive and to process, and they can therefore easily be missed in incoming speech.

The results of this study challenge the role of perceptual salience in the acquisition of past tense morphology as all CI children in the present study were able to discriminate regular verbs inflected for past tense morphemes (e.g. werkte '*worked*') from present tense verb forms (e.g. werkt '*works*') tested in an oddity paradigm with the present tense form as background stimulus and the past tense verb form as the odd form to be discriminated. Clearly, the minimal pair (werkt - werkte) needs to be discriminated on a low salient phoneme (*schwa)*. This suggests that CI children are able to perceive stimuli that differ on perceptually low salient features. Previous research has shown that for CI children a close link exists between the perception and production of speech, which implies that improved perception skills contribute to better production skills (Blamey et al., 2001; Duchesne et al., 2009). Interestingly, the perception of the regular past tense morpheme by CI children is not reflected in their production of this morpheme on the elicitation task. In general, CI children show poorer performance on regular past tense production when compared to their SLI peers.

The low regular past tense production of the CI children in this study could not be attributed to other characteristics particular to the CI group, such as later access to auditory input or shorter durations of speech input. In the present study, neither age at implantation nor hearing age (i.e. the duration in months that a CI child has access to speech input) correlated significantly with the production of regulars. This is in accordance with the results from previous studies in which age at implantation did not predict scores on grammar (Willstedt-Svensson et al.; 2004; Duchesne et al.; 2009).

The overall low performance on regular past tense production of CI children cannot be attributed to the low perceptual salience of the morphemes per se. As these children by definition have a perceptive deficit, it seems reasonable to hypothesize that it is rather the qualitatively degraded speech input offered by the implant that makes auditory speech material difficult to perceive. As processing, and consequently acquisition, are dependent on perception, the qualitatively degraded speech input has an important impact on the development of grammar, in particular on those morphemes that are perceptually low salient. In the following paragraph we intend to outline why we consider the speech input to CI children to be qualitatively degraded and how this interferes with the acquisition of grammatical morphology.

8.2 Morpheme-in-Noise Perception Deficit Hypothesis (MIND)

It is common practice to assess the perception abilities of CI children in quiet environments, which is the optimal listening situation. This is precisely how the speech discrimination task in this study was administered. Based on these results, we assumed that the poor outcomes on past tense morpheme

production in CI children could not be related to a mere perceptual deficit. In everyday life, CI users are hardly ever confronted with speech in such ideal listening situations. Young CI children will encounter noisy backgrounds in all aspects of their lives, including classrooms, where there is a constant level of noise ranging from 34 to 73 dB (Knecht, Nelson, Whitelaw & Feth, 2002). This implies that the perception abilities demonstrated in clinical practice are not always representative of perception abilities in everyday life. To date, no research has been conducted on how noisy backgrounds affect the perception of grammatical morphemes, although, there is a considerable body of research indicating that particularly noisy backgrounds make the perceiving of speech difficult for CI users (Eisenberg, Kirk, Martinez, Ying & Miyamoto., 2004; Lorenzi et al., 2006).

When listening in noisy backgrounds, normal-hearing people perform better in fluctuating than in steady-state noise. Normal-hearing people have a capacity called 'dip listening': they are able to glimpse speech in background noise valleys and are able to decide whether a speech signal in the dips of the noise is part of the target speech (Moore, 2008). They are able to do this due to the information derived from fluctuations in the temporal fine structure (TFS) of speech sounds (Lorenzi et al., 2006).

Cochlear damage degrades the ability to code TFS (Lorenzi et al., 2006). This implies that the listeners with sensorineural hearing loss do not benefit from the dips in fluctuating noise to achieve better speech understanding. CIs are not able to restore the information obtained from TFS. CI users are, therefore, limited in perceiving speech when background sounds are present.

Given this, it can be hypothesized that the CI children do not adequately perceive grammatical morphemes in everyday speech, as this speech is embedded in a noisy background.

It has been shown that TD children are able to learn language when the linguistic input is in the background and the child is not directed to listen to the speech stream (Saffran, Aslin & Newport, 1997). As perception precedes auditory and cognitive processing, it seems reasonable to hypothesize that CI children will have a *Morpheme in Noise Perception Deficit* (MIND), i.e. a suboptimal perception of low salient grammatical morphemes that delays the acquisition of these morphemes.

If residual low-frequency hearing is present in profoundly deaf people, this can be acoustically stimulated. The benefit of acoustic stimulation is to provide low-frequency TFS that is not conveyed by a CI (Lorenzi et al., 2006). The TFS increases the spectral resolution, which is particularly helpful in perceiving speech in noise (Turner, Gantz, Vidal, Behrens & Henry, 2004; Gantz, Turner, Gfeller, Lowder, 2005). Research to date has indicated that acoustic stimulations of the residual low-frequency hearing of CI users improves speech recognition in noise. Better speech-in-noise recognition has been shown for CI

users who received electrical/acoustical stimulation (EAS) (Gantz et al., 2005) as well as for CI users who wear a Hearing Aid (HA) in the opposite ear (Dunn, Tyler & Witt, 2005; Ching et al., 2005; Coene. Daemers, Govaerts & Rooryck, to appear). Direct comparisons between CI and HA children have shown that the difference in speech recognition scores in a quiet and noisy environment is greater for CI children as compared to their HA peers, who have a moderate-to-severe hearing impairment (Eisenberg et al., 2004). This implies that the HA children had less difficulty perceiving speech-in-noise than the CI children.

It is therefore likely that HA children show better skills in perceiving morphemes-in-noise. This is confirmed indirectly, as it has been shown with respect to the acquisition of the regular past tense, that HA children tend to produce more target-like past tenses than their SLI peers, as measured on an elicitation task (Norbury et al., 2001; Hansson et al., 2007). This finding is interesting as it differs from our findings from comparisons of SLI children with CI children, who also have a perceptual deficit. The *Morpheme-in-Noise Perception Deficit* hypothesis therefore suggests avenues for future research.

To test this hypothesis, a perception task should be developed in which different types of perceptually low salient morphemes are to be discriminated. For Dutch, morphemes of interest would include e.g. regular past tense /*-te*/ /*-de*/, possessive *-s* (e.g. Jans boek – *John's book*), plural *-s* (e.g. tafel *table* – tafels *tables*) and 3th person singular agreement morpheme *-t* (e.g. werkt *works*). An inter-group comparison between CI and HA children could then reveal whether the perception of these grammatical morphemes in noisy and quiet conditions is different for both populations of hearing-impaired children. Obviously, the development of such a new discrimination task is beyond the scope of this dissertation but it is an interesting topic for future research.

8.3 Frequency effects

For the TD children in the present study, frequency effects are found for the irregular verbs, but not for the regular verbs. At the ages of 5 and 6, TD children produced significantly more target-like irregulars that occurred frequently in the adult target speech as compared to irregulars that occur less frequently in the adult target speech. No such effect is found for the production of regulars. This seems to correspond with the prediction made by the dual-route-model. This model predicts that regular past tense forms are generated by the symbol concatenation rule, whereas the irregular past tense forms need to be stored in memory. Hearing the irregular past more often strengthens the memory trace and is therefore dependent on frequency of occurrence in the target speech. As the aim of this study is to explore how frequency of past tense forms in the adult target speech affects the production

of past tense in CI and SLI children, we are less interested in distinguishing between the dual and single-route model.

The results of the present study indicate that frequency affects the production of past tense in CI and SLI children to an equal extent. In spontaneous speech, CI and SLI children produce more irregular past tenses as compared to regular past tenses. This corresponds with the adult target speech, as in this study it is found that token frequencies of irregular verb types are higher than token frequencies of regular verb types. These results are in accordance with the early past tense productions of young TD children, who produce more irregulars than regulars (Brown, 1973; Rumelhart & McClelland, 1986). Moreover, the frequencies of the past tense verb types in the speech of CI and SLI children correlated significantly with the frequencies of the past tense verb types in adult speech. This suggests that the frequency distribution of the production of past tense verb types is similar between CI and SLI children and the adults.

In the elicitation task, no significant effects are found for frequency on the production of target-like regulars and irregulars for either CI or SLI children. For the SLI children, this finding contrasts with other studies that have reported effects of input frequency for regular and irregular past tense (Ragnarsdottir et al., 1999; Norbury et al., 2001; Van der Lely & Ullman, 2001). It is likely that any frequency effects in the present study have gone unnoticed, because the number of occurrences of the high frequency verbs is actually not high enough. This implies that the difference between high and low frequency verbs is too small to detect an effect of input frequency. A point to remember is that the irregulars that occurred most often in the spontaneous speech of CI and SLI children occurred in the input between 2720 and 21549 times, whereas the high frequency irregulars included in the elicitation task occurred between 160 and 3676 times in the input.

8.4 L2 past tense acquisition

With respect to the effect of frequency in adult target speech on the target-like production of past tense, bilingual children (henceforth L2) have been studied as well. The general assumption is that L2- children perceive less of their L2 as compared to the monolinguals, hence learn their L2 with reduced adult target speech input (Pearson, Fernández, Lewedeg & Oller, 1997). This assumption particularly holds for children who acquire their L2 after the establishment of their L1 (sequential bilinguals). However, even for L2 children, who acquire both languages simultaneous, effects of exposure to the adult target speech input have been reported. Nicoladis, Palmer & Marentette (2007) have shown that their simultaneous L2 children are less accurate in their production of past tense morphology when compared to monolingual children. The authors

attribute the lower performance of the simultaneous L2 children to the less frequent L2 exposure of these children.

Leonard et al. (1997) have argued that the '*incomplete processing [of perceptually low salient morphemes] is the functional equivalent of reduced input frequency'* (p:744). Accordingly, SLI children need a greater number of exposures to a particular morpheme in order to adequately process and acquire that morpheme. As L2 children learn their language with a reduced exposure to their L2, it is expected that the L2 and SLI children have similarities in their past tense production.
Regarding this hypothesis, the results presented in the literature are not unequivocal. Paradis & Crago (2000) compared sequential L2 children with SLI children on their correct choice of tense in obligatory contexts, measured on spontaneous speech. The L2 children were exposed to their L2 from nursery school onwards. Results showed that L2 children were significantly less accurate in their choice of past tense as compared to SLI children. L2 children tended to produce present tense forms where the context required a past tense, although, when past tense measures were derived from elicitation tasks, no significant differences between sequential L2 and SLI children occurred in the production of past tense forms (Håkansson, 2001). The sequential L2-children in the study of Håkansson were mainly refugee children, with approximately four months of L1 exposure.

As such, a group of 10 12-year-old sequential L2 children were given the elicitation task used in this study (see Poche, 2009). The L1 of these children is French and their L2 is Dutch. All L2 children attended so-called 'immersion schools' in Brussels. At these schools, some courses are taught by native Dutch speaking teachers and some are taught in their L1. The exposure to the L2 is therefore quite limited.

The percentage of target-like responses of the L2 children is presented in Figure 14 (see p:175), together with the results of the 5 to 7-year-old TD, SLI and CI children. The L2 children produce fewer target-like regulars and irregulars as compared to their 5-year-old TD peers. However, only for the irregulars does this difference reach significance ($U=32.0$, $p=.000$). On nonce verbs, L2 children compare to the 5-year-old TD children.

With respect to the SLI children, statistical testing did not reveal any significant differences between the 12-year-old L2 children and the 5-year-old SLI children. However, from Figure 14, it is observed that the production of target-like regular and nonce verb past tenses by L2 children falls between the mean production scores of the 6 and 7-year-old SLI children. For the irregulars, the mean production of the L2 children is lower when compared to the 6-year-old SLI children. This indicates that the L2 children produce more target-like past tenses as compared to the 5-year-old SLI children.

Statistical testing did not reveal any significant differences between the L2 children and the 5-year-old CI children on the production of regular, irregular and nonce verb past tenses. However, the mean target-like responses for the L2

children are higher when compared to the 5 to 7-year-old CI children for the regular and nonce verbs (see Figure 14). This implies that in past tense formation involving regularization, L2 children outperform CI children.

The results of this study indicate that the 12-year-old L2 children compare to the SLI children who are 5 to 6 years younger in their regular and irregular past tense production. This finding suggests that reduced input frequency can have stronger effects on past tense acquisition compared to incomplete processing of perceptually low salient morphemes. The indication is, therefore, that incomplete processing cannot be regarded as the functional equivalent of reduced input, as argued by Leonard et al. (1997). Moreover, the better performance of the L2 children on past tenses requiring regularization as compared to the CI children underlines the importance of sufficient perception of low salient material. This supports our hypothesis that CI children are delayed in their grammatical morpheme acquisition due to their reduced perception of these morphemes.

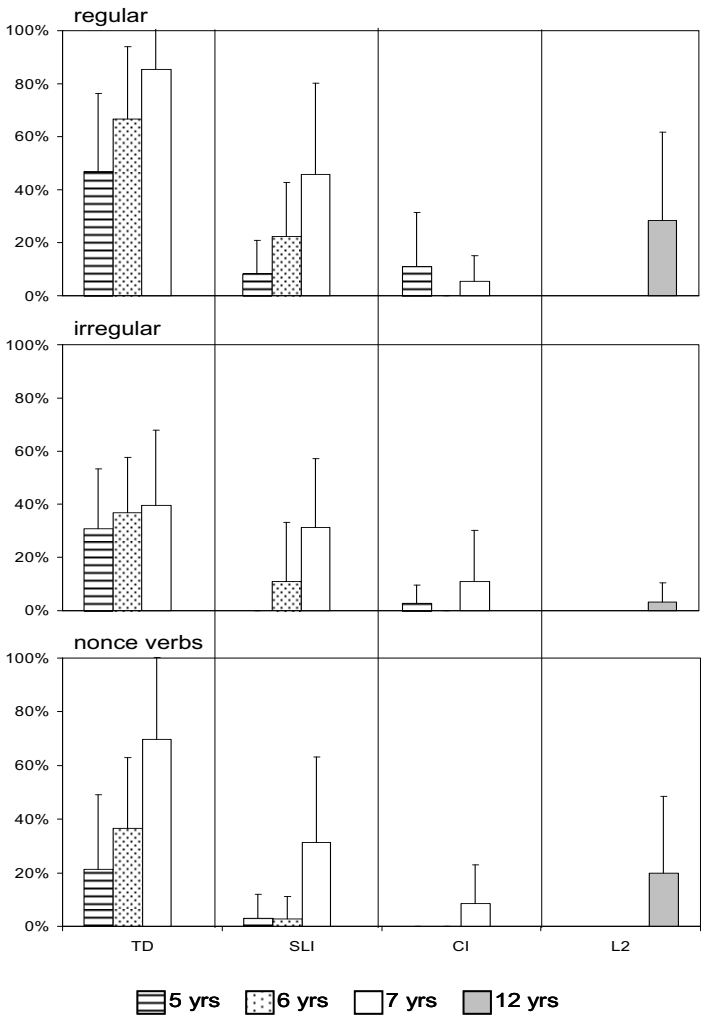
8.5 Morphological generalizations

Nonce verbs were included in the elicitation task in order to discover to what extent CI and SLI children are able to generalize past tense regularities to new verbs. This study has shown that the CI and SLI children had more difficulty than their TD peers in inflecting the nonce verbs for past tense, thus indicating that the CI and SLI children are delayed in their ability to use the regular process for marking past tense. This substantiates the delay observed in regular past tense marking.

The CI and SLI children in this study are more likely to apply the regular past tense suffix to known verbs. Despite the low past tense production of nonce verbs, the CI and SLI children did produce overgeneralization errors. Obviously, these past tense forms could not be rote-learned. In the traditional view it has been claimed that overgeneralizations are an indicator of the development of the regular past tense rule (Marcus et al., 1992; Pinker, 1998). For both groups, children with higher regular past tense production scores had higher overgeneralization scores. As such, these children may be taken to have developed a regular past tense rule.

In contrast to this traditional view, new forms are extrapolated from the lexicon either by similarity-based general analogical processes or by artificial neural networks in which rules and representations are merged (Ernestus & Baayen, 2004). In that case, overgeneralizations produced by the children can also be explained as resulting from analogy effects between existing lexical representations and the newly presented nonce verbs.

Figure 14. Target-like production scores for the regular, irregular and nonce verbs. Results are plotted for the TD, SLI and CI children aged between 5 and 7 and for the L2 children, aged 12.



8.6 Study limitations

The present study is limited in terms of the number of participants included in the group of CI children. It is therefore difficult to generalize the present findings across the population of CI children. To our knowledge, no past tense elicitation task has previously been conducted in this population. Future

research should therefore continue to examine the past tense development of CI children.

With respect to the production of past tenses in the elicitation task, it has to be commented that the results of our TD and SLI children are generally lower when compared to the results of the English TD and SLI children in the studies of Rice et al. (1998, 2000). The difference in past tense production could be due to task demands. The elicitation task in the study of Rice et al. used picture pairs, in which the first picture showed a child engaged in an activity and in the second picture the child had completed the activity. It is possible that the task used by Rice et al. provides a greater encouragement to use a past tense form, as children prefer to use past tense for closed events (Wagner, 2001; Shirai & Anderson, 1995; Weist et al., 2004, see also chapter 3 subsection 3.2). Another possibility is that the simple past occurs more often in the input of English children as compared to the speech input of Dutch children (see De Houwer, 1997). For French, it has been shown that the input of the English simple past corresponds to the input of the passé composé, in which an auxiliary verb is combined with a past participle (Nicoladis et al., 2007). The same could hold for Dutch, therewith decreasing input frequency and consequently delaying the past tense acquisition of Dutch children as compared to their peers acquiring English.

9. Conclusion

The first aim of this chapter was to compare 5 to 7-year-old CI children with their SLI and TD peers on past tense production. The results of the past tense elicitation task show that CI children, aged between 5 and 7 years, are delayed in their acquisition of the regular and irregular past tense. With respect to the production of the regular past tense, the gap between CI and their SLI peers tends to widen over the years, with SLI children producing more target-like regular past tenses. This indicates that the effect of the qualitatively degraded speech input offered by the implant has stronger implications for the acquisition of grammatical morphology than the perceptual salience of these morphemes per se. We argued that the qualitatively degraded speech input of the CI children interferes with the perception of speech in noisy backgrounds. The present study therefore hypothesizes that the low production of the regular past tense morpheme is due to the *Morpheme-in-Noise Perception Deficit* of the CI children. Future research should be directed towards the perception of morphemes in noise.

The second aim of this chapter was to relate the past tense production to the frequency with which past tense forms occur in the adult target speech. The CI children produce more irregular than regular verb forms in their spontaneous speech, which corresponds with adult target speech. However, the results of the elicitation task did not show an effect of frequency for the CI and

SLI children; high-frequency verbs are not inflected more often as compared to low-frequency verbs. Further investigation included sequential L2 children, as these children acquire their L2 with reduced input frequency. It is concluded that acquiring a language with reduced input has stronger negative effects on the acquisition of grammatical morphology than the perceptual low saliency of these morphemes. This points to the pivotal role of input in the acquisition of grammatical morphology. In addition, when regularization is involved, L2 children perform better than CI children. This underlines the importance of sufficient perception of grammatical morphemes in the speech input in order for these morphemes to be acquired.