

Empirical Article

Acquisition of Tense Marking in English-Speaking Children with Cochlear Implants: A Longitudinal Study

Ling-Yu Guo^{*1}, Linda J. Spencer², J. Bruce Tomblin³¹University at Buffalo²New Mexico State University³University of Iowa

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This study investigated the development of tense markers (e.g., past tense *-ed*) in children with cochlear implants (CIs) over a 3-year span. Nine children who received CIs before 30 months of age participated in this study at three, four, and five years postimplantation. Nine typical 3-, 4-, and 5-year-olds served as control groups. All children participated in a story-retell task. Percent correct of tense marking in the task was computed. Within the groups, percent correct of tense marking changed significantly in children with CIs and in typical children who had more hearing experience. Across the groups, children with CIs were significantly less accurate in tense marking than typical children at four and five years postimplantation. In addition, the performance of tense marking in children with CIs was correlated with their speech perception skills at earlier time points. Errors of tense marking tended to be omission rather than commission errors in typical children as well as in children with CIs. The findings suggested that despite the perceptual and processing constraints, children who received CIs may learn tense marking albeit with a delayed pattern.

Young, typically developing (TD) children who speak English tend to inconsistently use tense markers (Brown, 1973; Pine, Conti-Ramsden, Joseph, Lieven, & Serratrice, 2008). Tense markers (or tense and agreement morphemes) in English refer to the inflections (e.g., third person singular *-s* as in *He walks everyday*) or function words (copula BE as in *The dogs are happy*) that give information of person, number, and time in

sentences. Young English-speaking children sometimes produce and sometimes omit these morphemes in obligatory contexts (i.e., utterances that require the use of tense markers, e.g., *The dogs are running*) in spontaneous speech (Hadley & Rice, 1996). Current theories that account for the inconsistent use of tense markers include grammar-based accounts (e.g., Radford, 1990) and processing-based accounts (e.g., Montgomery, Magimairaj, & Finney, 2010). The surface hypothesis (Leonard, 1989; Montgomery & Leonard, 1998), one of the processing accounts, suggested that young children inconsistently produce tense markers, partly because these morphemes in English are acoustically insalient. English tense markers are either word-final consonants or unstressed syllables. Hence, these morphemes have relatively shorter duration and/or weaker energy as compared to the surrounding content words (e.g., *walk, dog, happy* in the examples above). In addition, processing tense markers requires multiple mental operations. Because tense markers are brief and there is little time before new materials appear, young children may not always be able to process tense markers completely in real-time speech. In order to fully acquire these morphemes, young children will need a number of exposures to speech materials with tense markers. Before full acquisition is achieved, they will inconsistently produce tense markers.

Acquisition of tense markers may be even more challenging for children with profound deafness who

*Correspondence should be sent to Ling-Yu Guo, Department of Communicative Disorders and Sciences, University at Buffalo, 118 Cary Hall, Buffalo, NY 14214 (e-mail: lingyugu@buffalo.edu)

receive cochlear implants (CIs) because of the constraints in their speech perception and information-processing abilities. The speech input that children with CIs perceive is a degraded, electrical signal instead of an acoustic signal (Wilson, 2006). In addition, these children do not receive significant auditory input of spoken language until they are implanted, which does not typically happen until they are at least 12 months of age. Due to the deprivation of auditory input in the early year(s), cortical development in the typical auditory cortex locations is compromised by the visual system that takes over the auditory cortex space (Buckley & Tobey, 2011). The perception of tense markers in children with CIs may therefore be negatively affected by the electrical input that they receive and the cortical compromise. Furthermore, recent studies have shown that children with CIs tended to have limited information processing skills because of the deprivation of auditory input in the early year(s) (Conway, Pisoni, Anaya, Karpicke, & Henning, 2011; Pisoni, Conway, Kronenberger, Horn, Karpicke, & Henning, 2007). Thus, tense markers are more likely to be processed incompletely in children with CIs than in typical children. Given the perceptual and processing constraints, children with CIs are likely to show delayed acquisition of tense markers.

Current studies that document spoken language development in children with CIs have typically evaluated their general language skills (e.g., Niparko et al., 2010) or skills in specific components of language, such as grammatical skills (e.g., Nikolopoulos, Dyar, Archbold, & O'Donoghue, 2004; Ramirez Inscoc, Odell, Archbold, & Nikolopoulos, 2009) and narrative skills (Crosson & Geers, 2001; Worsfold, Mahon, Yuen, & Kennedy, 2010). Although these studies consistently indicated that children with CIs, as a group, tended to acquire spoken language at a lower level than typical children, they did not indicate what grammatical structures children with CIs have particular difficulties learning, such as tense markers. Understanding how well children with CIs may acquire tense markers is important because these morphemes have significant impact on children's comprehension and production of grammatical sentences, which, in turn, affects their academic outcomes (Ramirez Inscoc et al., 2009). Based on the surface hypothesis, this current study examined

the extent to which children with CIs can produce tense markers over time via a story-retell task. In what follows, we first review the studies that examine general language skills, grammatical skills, and tense marking abilities in children with CIs and then lay out the scope of the current study.

Development of General Language Skills in Children with CIs

Several studies have used standardized tests to document the general language skills in children with CIs in order to evaluate the efficacy of cochlear implantation or the factors contributing to individual variability. Svirsky, Robbins, Kirk, Pisoni, and Miyamoto (2000) examined the language abilities of 70 deaf children about four months before the cochlear implantation and 6, 12, 18, 24, and 30 months after implantation using the Reynell Developmental Language Scale (RDLS; Reynell & Huntley, 1985). The RDLS evaluated children's receptive and expressive language skills, such as vocabulary, morphology, and syntax. The rate of language growth was computed from the language scores of each child at each data point. Overall, the rate of language development in children with CIs exceeded that in unimplanted deaf children and was similar to that in typical children, though children with CIs still fell behind typical children in language scores. Svirsky et al. (2000) therefore concluded that earlier implantation in deaf children would alleviate language delay.

Niparko et al. (2010) followed a group of children for three years who received cochlear implantation before 5 years of age and their typical peers of similar age. Each child with CIs was tested before implantation and 6, 12, 24, and 36 months after implantation using the RDLS. Typical children were also tested at the same time intervals. As a group, children with CIs showed greater improvement on the RDLS than would be predicted by their preimplantation baseline scores. However, children with CIs performed at a lower level on the RDLS than typical children after three years of CI experience. In addition, given that there were large variabilities among children with CIs, Niparko et al. (2010) further examined the factors associated with the variabilities. In general, younger age of implantation, greater residual hearing prior to

cochlear implantation, higher socio-economic status, and higher ratings of parent-child interaction led to better language outcomes.

Geers, Nicholas, & Sedey (2003) further examined language skills of 181 8- or 9-year-olds who received cochlear implantation by age 5 and the factors that accounted for their language skills. Children in this study had 4–7 years of experience of CI use. One part of the test protocol was *Test for Auditory Comprehension of Language-Revised* (TACL-R; Carrow, 1985), which examined children's receptive language skills, including lexical, morphological, and syntactic skills. As a group, children with CIs scored lower on the TACL-R than typical children. About 30% of children with CIs had age-appropriate TACL-R scores. Significant predictors of the performance on TACL-R as well as other spoken language measures included higher nonverbal intelligence, higher socioeconomic status, smaller family size, and female gender. However, age of implantation did not account for spoken language outcomes in children with CIs in this study. Geers et al. (2003) speculated that though age of implantation may be a strong predictor of language outcomes when children were younger, its effect may decrease with increasing chronological age and length of CI experience. The findings were similar in Geers (2002), which further indicated that implant demographics (e.g., number of electrodes, dynamic range) and intervention factors (e.g., communication mode) also played a role in the language outcomes in children with CIs.

Taken together, these studies showed that cochlear implantations allowed some children with severe to profound hearing loss to learn language at a rate similar to typical children. Though some children with CIs may learn language at a level comparable to typical children with similar chronological ages as measured by standardized tests, children with CIs, as a group, did not demonstrate age-appropriate language skills even after six years of CI experience. In addition, there were considerable variabilities in the language outcomes of children with CIs. The differences of language outcomes among children with CIs may be attributed to several demographic factors, such as gender, age of implantation, pre-implantation residual hearing, implant characteristics, and communication modes (Geers, 2002; Geers et al., 2003; Niparko et al., 2010;

Svirsky et al., 2000). Based on a series of preliminary studies, Pisoni et al. (2007) further suggested that the cognitive learning mechanisms (e.g., working memory, executive functions, and implicit sequence learning abilities) also accounted for the speech and language outcomes in children with CIs. Though these studies clearly indicated that children with CIs were likely to have difficulty learning spoken language due to a variety of factors, they did not inform us what language components (e.g., morphology, syntax) might be challenging to children with CIs because only composite language scores were reported in these studies. Below we focus on reviewing the studies that examined the grammatical development in children with CIs not only because it is most relevant to the goals of the current study but also because it has strong impact on the later acquisition of reading and writing (Nikolopoulos et al., 2004).

Development of Grammatical Skills in Children with CIs

Nikolopoulos et al. (2004) examined the development of spoken language grammar in 82 children who received cochlear implantation before 7 years of age longitudinally by using the Test for the Reception of Grammar (TROG; Bishop, 1989), which evaluated individuals' comprehension of sentences that involved a variety of morphological and syntactic forms. Before implantation, 2% of the children achieved scores above the first percentile. This percentage increased to 40% at three years postimplantation and 67% at five years postimplantation. In addition, children who received cochlear implantations at a younger age performed better on the TROG than those who received cochlear implantations at an older age. This study specifically indicated that children with CIs had difficulties learning morphological and/or syntactic forms, although their performance improved over time.

Ramirez Inscocoe et al. (2009) evaluated the development of expressive grammar in 45 children who received cochlear implantation before 3 years of age and had about three years of CI experience using the South Tyneside Assessment of Syntactic Structures (STASS, Armstrong & Aninley, 1983). The STASS used pictures and prompts to elicit utterances from children to assess whether they were producing age-appropriate

morphological and syntactic forms. After three years of CI use, 42% of the children with CIs did not produce the grammatical forms that were expected in typical children between the ages of 2 years 6 months and 3 years 0 months. This study suggested that children who received cochlear implantation before age 3 were still not able to learn the grammatical forms at a level comparable to their typical peers who had a similar length of hearing experience (i.e., hearing age) after three years of CI use.

Geers, et al (2003) investigated the development of expressive grammar as well as other areas of speech and language in 181 8- and 9-year-olds who underwent cochlear implantation by age 5. Children's skills of expressive grammar were evaluated by computing the mean length of utterances, the frequency of inflectional (e.g., plural *-s*, past tense *-ed*) and derivational (e.g., *-ly*, *-ment*) morphemes, and the productive use of grammatical structures in speech-only language samples. The Index of Productive Syntax (IPSyn; Scarborough, 1990) was adopted to score children's use of grammatical structures, such as noun phrases, verb phrases, and sentence structures. Overall, children with CIs produced shorter utterances, lower number of bound morphemes per word, and lower IPSyn scores than their typical peers who had matched chronological ages. This suggested that children with CIs tended to show lower morphological and syntactic skills compared to their typical peers at similar ages. These results were consistent with Geers (2004), which further indicated that only about 52% of children with CIs who were implanted by age 2 in their study had IPSyn scores within the typical range. The percentage dropped to 35% in those who were implanted by age 4.

In summary, the studies that specifically examined the development of receptive and expressive grammar in children with CIs consistently showed that children with CIs performed at a level below their age-matched peers and their hearing-matched peers. However, these studies did not explore what grammatical structures might be particularly challenging to children with CIs, such as tense markers. Though the study of Geers et al. (2002) explored bound morphemes in children with CIs, the measure covered the use of some tense markers as well as other morphemes (e.g., derivational morphemes). Thus, how well children with CIs can acquire tense markers remains unclear in these studies.

Development of Tense Marking Abilities in Children with CIs

To the best of our knowledge, only two published studies have examined the use of tense markers in English-speaking children with CIs. Spencer, Tye-Murray, and Tomblin (1998) investigated the production of noun- and verb-related inflectional morphology (e.g., plural *-s* as in *I have two books*; past tense *-ed* as in *He laughed*) in deaf children using CIs or hearing aids while they engaged in conversation. The CI group included 25 English-speaking children with CIs between the ages of 5 and 16 years. These children received their CIs between the ages of 2 years 7 months and 14 years 0 months and had a minimum of 2 years of CI experience at the time of testing. The findings most relevant to the present study are that the children with CIs produced third person singular (3SG) *-s* more accurately than they produced past tense *-ed*. The percent correct was 68% for 3SG *-s* and 49% for past tense *-ed*. In addition, children with CIs who had better word-recognition skills also produced more inflectional morphemes for nouns and verbs within conversation. Therefore, Spencer et al. (1998) suggested that the amount of input that children with CIs can perceive influences the acquisition of inflectional morphology, such as tense markers.

Svirsky, Stallings, Lento, Ying, and Leonard (2002) directly tested the surface hypothesis in children with CIs by examining the production of plural *-s*, uncontractible copula BE (e.g., *'is'* in *The horse is big*), and past tense *-ed* in nine children with CIs at the ages between 4 years 5 months and 8 years 11 months via an elicited production task. These children were implanted between the ages of 1 year 9 month and 6 years 11 months. It was predicted that children with CIs should produce uncontractible BE with higher accuracy than plural *-s*, followed by past *-ed* because of the durational differences among these morphemes. Children with CIs produced significantly lower accuracy for past tense *-ed* (28%) than for plural *-s* (63%) and uncontractible copula BE (71%), which did not differ significantly from each other. Overall, these findings are consistent with the prediction of the surface hypothesis.

Taken together, the studies of Spencer et al. (1998) and Svirsky et al. (2002) can be considered evidence for the surface hypothesis in that tense markers with

longer duration (e.g., 3SG *-s*, uncontractible copula BE) tended to be produced more accurately than those with shorter duration (e.g., past tense *-ed*) in children with CIs. However, there are some methodological limitations of these studies. First, these studies did not include TD children who had matched hearing experience. Thus, it is unclear whether the production of tense markers in children with CIs is comparable to their peers matched in hearing experience. Second, these studies included children with different length of CI experience and only tested children at one point of time. How tense marking develops over time in children with CIs was not clear in these studies. Third, children who were included in these studies had a wide range of age of implantation. It has been documented that age of implantation has a significant impact on the speech and language outcomes in children with CIs (Geers, 2004; Nicholas & Geers, 2007; Nikolopoulos et al., 2004; Niparko et al., 2010; Peterson, Pisoni, & Miyamoto, 2010). The wide range of age of implantation makes it difficult to generalize the results to the current pediatric CI recipients, who were typically implanted around 24 months of age.

The Present Study

To understand the acquisition of tense marking in children with CIs over time and to eliminate the confounds of age of implantation, we explored the production of tense markers in a group of children with CIs who were implanted before 30 months over a 3-year span (i.e., three, four, and five years postimplantation) via a story-retell task and compared their performance with typical children who had matched hearing experience. The data of the children with CIs were obtained from a longitudinal study (see below). We chose the story-retell task instead of conversational language samples because the story-retell task was administered longitudinally. In addition, the story-retell task was more likely to elicit the production of past tense *-ed* than conversational language samples given that the stories involved events that already happened. Furthermore, the story-retell task may eliminate the potential effect of content elaboration on the production of grammatical forms, such as tense markers. Children with language impairment were likely to experience difficulties in creating

a narrative that was both elaborate and grammatical (Colozzo, Gillam, Wood, Schnell, & Johnston, 2011). They tended to show trade-off between the elaboration of content and the accuracy of grammatical forms in narratives. Using a story-tell task allowed us to control the content of narratives across children and hence eliminate its impact on the production of tense markers. We also chose not to use the standardized tests for the current investigation because they did not include enough items of tense markers to allow legitimate analyses (McCauley, 1996).

In addition to exploring children's development of tense marking abilities over time, this study used lagged correlations to examine the relation between speech perception skills and tense marking abilities in children with CIs (Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). That is, we also evaluated the relation between the speech perception skill of children with CIs at three years postimplantation and their tense marking performance at four and five years postimplantation. Similarly, we also evaluated the relationship between speech perception skill at 4-year postimplantation and the tense marking performance at five years postimplantation. Lagged correlation allowed us to explore the enduring relations between speech perception and tense marking abilities and to examine how speech perception may affect the acquisition of tense marking over time (Huttenlocher et al., 2010).

The specific questions addressed were as follows: Did the percent correct of tense marking increase over time in children with CIs? Was the performance of tense marking in children with CIs comparable to that in typical children who had matched hearing experience over the 3-year span? Was the performance of tense marking in children with CIs associated with their speech perception skills at earlier time points? What type of tense marking errors did children with CIs tend to make? Based on the surface hypothesis, we predicted that the accuracy of tense marking should increase over time in children with CIs, because as time goes on, there are more instances of exposure to materials with tense markers. In addition, we predicted that children with CIs would mark tense with lower accuracy when compared to their typical peers over the 3-year span, given the degraded auditory input and limited processing abilities in children with CIs.

The performance of tense marking in children with CIs would correlate with their speech-perception skills. Finally, we predicted children with CIs would make more omission errors than commission errors in tense marking because the tense markers may not be properly perceived or processed in these children. Understanding how well children with CIs acquire tense markers overtime and to what extent speech perception is associated with the acquisition of tense makers will guide clinicians and educators in CI device tuning and/or goal selection for habilitation given the acoustic properties and processing demands of tense markers in English.

Method

The present investigation used archival data from a large, longitudinal study of children with prelingual deafness who received CIs. Approval for this longitudinal study was granted by the Institutional Review Board. In the protocol, the children were seen at least five times during the first year after implantation (i.e., typically 1, 3, 5, 7, and 10 months after implantation) and annually thereafter for device setting and follow-up and for data collection in the areas of speech and music perception, as well as speech and language development. One part of this protocol called for the children to retell stories, which was originally designed to explore children's development of speech-production skills (Tye-Murray, Spencer, & Woodworth, 1995). From the first use of the story-retell task to the year of 2006, 72 children with CIs participated in this task (Spencer & Oleson, 2008). To be included in the present study, children had to 1) receive cochlear implantation before 30 months of age and have used the Nucleus CI 24R or Nucleus CI 24M devices with the processing strategy of advanced combination encoder (ACE; Cochlear Ltd., 2010; excluding 39 children), 2) participate in the story-retell task in the annual evaluation three, four, and five years postimplantation (excluding 19 children), and 3) produce at least four obligatory contexts of tense marking (Lahey, Liebergott, Chesnick, Menyuk, & Adams, 1992; excluding two children). We included children who received cochlear implantation before 30 months in order to eliminate the effect of age of implantation. The current population of pediatric CI

users typically received cochlear implantations before 24 months of age, though according to Nicholas and Geers (2007) children who received cochlear implantations between 12 and 30 months showed similar growth rate in language skills as measured by a standardized language test, which supported the use of 30 months as the cut-off for age of implantation in the current study. We also limited participants to those who used the processing strategy of ACE because this is the default processing strategy of the current Nucleus CI devices (Cochlear Ltd., 2010; Wilson, 2006). Limiting the participants to those who received the 24-electrode CI device with the ACE strategy made the current findings more applicable to the current populations of children with CIs.

In addition, children had to produce at least 60% correct for word-final consonants of nouns, adjectives, and adverbs in the stories they retold three, four, and five years postimplantation (excluding three children). This last requirement was included because English tense markers tended to be realized as word-final consonants phonologically (e.g., *He walked*, *The dog's happy*). We wanted to reduce the possibility that children's ability to produce final consonants might confound the production of tense markers. A description of the children included in the study and the story-retell task follows.

Participants

Nine children (five girls; four boys) with CIs who met all the four selection criteria were included in the present study. They were unilaterally implanted between the years 1997 and 2001. The age of implantation ranged from 1 year 0 months to 2 years 2 months (mean = 1 year 4 months; SD = 0 years 3 months). Despite hearing impairment (HI), these children did not show frank signs of cognitive, motor, or psychological deficits as documented by parent report (i.e., Minnesota Child Development Inventory, Ireton & Thwing, 1974) and clinician observation. Table 1 presents the background information and language measures for each child. The mean chronological age of these children was 4 years 4 months, 5 years 4 months, and 6 years 4 months when the story-retell task was administered at the third, fourth, and fifth year of postimplantation follow-up, respectively. The mean length of CI experience of these

Table 1 Background information and language measures of the CI group by child

Child	Gender	Etiology ^a	Pre-CIHL level ^b	Year of CI Surgery	AoI (months) ^c	CI Ear	CI Internal Device ^d	Speech Processor	Processing Strategy ^e	SES ^f	Mode ^g	PPVT ^h	PLS-EC ⁱ	PBK-3 ^j (%)	PBK-4 ^k (%)
CI-1	M	unknown	>115	2000	12	R	NU1	SPrint	ACE	C	AO	97	105	—	97
CI-2	F	CNX	>115	2000	12	R	NU1	SPrint	ACE	E	AO	107	123	96	94
CI-3	M	CNX	85	2001	14	R	NU1	SPrint	ACE	E	AO	79	75	85	83
CI-4	M	Meningitis	>115	1998	16	R	NU2	SPrint	ACE	D	TC	96	92	100	96
CI-5	F	Mondini	>115	2001	17	L	NU1	SPrint	ACE	D	TC	51	84	62	52
CI-6	F	unknown	>115	1999	18	R	NU2	SPrint	ACE	D	TC	100	—	90	88
CI-7	F	Ushers	>115	1997	18	R	NU2	SPrint	ACE	E	TC	101	123	98	89
CI-8	M	unknown	>115	2000	19	L	NU1	SPrint	ACE	C	TC	79	62	78	71
CI-9	F	unknown	>115	1999	26	R	NU1	SPrint	ACE	E	TC	84	54	59	89

Note.

^aCNX = connexin gene

^bPre-CIHL Level = mean pure tone average across 500Hz, 1000Hz, and 2000Hz in dB HL for the better ear

^cAoI = Age of implantation

^dNU1 = Nucleus CI 24R device; NU2= Nucleus CI 24M

^eACE = advanced combination encoder

^fSES = socio-economic status; C=High School Diploma; D=Some College; E=Bachelor's Degree

^gTC=Total Communication; AO=Auditory Oral

^hPPVT = Peabody Picture Vocabulary Test-3 (Dunn and Dunn, 1997) in standard scores obtained at 4-year postimplantation

ⁱPLS-EC = The Expressive Communication subtest of Preschool Language Scale-3 (Zimmerman, Steiner, & Pond 1992) in standard scores obtained at 4-year postimplantation

^jPBK-3 = Percent of phoneme correct in the Phonetically Balanced Kindergarten Test that was obtained at 3-year postimplantation

^kPBK-4 = Percent of phoneme correct in the Phonetically Balanced Kindergarten Test that was obtained at 4-year postimplantation

children was 3 years 0 months (SD = 0 years 1 month), 4 years 0 month (SD = 0 years 1 month), and 5 years 0 months (SD = 0 years 1 month), respectively, at each data point. We chose to examine children with the range of length in CI experience because tense marking in typical development was still variable in 3-year-olds with typical development and reached a near-mastery level in 5-year-olds (Rice et al., 1995). All of the story-retell data that were included in this study were collected between the years 2000 and 2006.

All of the children with CIs were from Midwest states in the United States: six from Iowa, two from Wisconsin, and one from Missouri. They were all from families speaking standard American English. Three children (CI-1, CI-2, and CI-3) primarily used oral communication, and six children (CI-4 to CI-9) primarily used total communication. None of the children in this study used hearing aids for the unimplanted ear. All children received early intervention from their local school districts. The birth to three programs included weekly home visits by an early childhood specialist who provided a combination of sign language instruction, information on targeting speech and language development and child development in general. By age 3, all children were enrolled in half-day preschool programs sponsored by their local Area Educational Agency.

As part of the annual follow-up, the Phonetically Balanced Kindergarten Word List (PB-K test; Haskins, 1949) was used to evaluate speech perception skills of children with CIs. The PB-K test, an open-set spoken word recognition test, consisted of 50 monosyllabic words that were familiar to young children (e.g., *pants*, *ride*, *take*). The words were presented one at a time in a sound-only condition and required the child to repeat each word after it was presented. The child's responses on the PB-K test were reported in percent phoneme correct. Specific testing and scoring procedures were documented in Fryauf-Bertschy, Tyler, Kelsay, Gantz, and Woodworth (1997). All children with CIs, except participant CI-1, received the PB-K test at both three- and four-year postimplantation, which took place between the years 2000 and 2005 (see Table 1).

For the purpose of comparison, we also recruited 27 TD children whose chronological ages matched the length of CI experience of each child in the CI group by ± 3 months at each data point (i.e., the TD

and CI groups had matched length of hearing experience) from the neighborhoods in Iowa City through flyers, which was approved by the Institutional Review Board. All of the 27 typical children were TD as documented by parent report, performance above the 10th percentile in the Expressive Communication subtest of the *Preschool Language Scale-3* (PLS-3; Zimmerman, Steiner, & Pond 1992) or on the *Structured Photographic Expressive Language Test—Preschool* (SPELT-P; Werner & Kresheck, 1983), hearing within normal limits as per *American Speech-Language-Hearing Association standards* (1997), and no history of receiving intervention for cognitive, motor, or communication disorders. All of the typical children were monolingual native speakers of standard American English.

Thus, we had three groups of nine TD children: 3-year-olds (TD-3: 6 girls, 3 boys), 4-year-olds (TD-4: 5 girls, 4 boys), and 5-year-olds (TD-5: 3 girls, 6 boys). The mean chronological age was 3 years 1 month (SD = 0 years 2 months) for the TD-3 children, 4 years 0 months (SD = 0 years 3 months) for the TD-4 children, and 5 years 0 months (SD = 0 years 2 months) for the TD-5 children. Though the distribution of gender in the typical groups did not completely match that in CI children, Rice and Wexler (2001) did not indicate gender as a significant factor in accounting for the accuracy of tense markers in typical 3- to 8-year-olds.

Materials

Each child was asked to re-tell six short stories. The stimuli were six sets of four-picture sequences. The pictures, all black and white drawings, were colored and laminated by a research assistant. Each story involved a setting (e.g., A boy got a truck), a problem (e.g., The boy broke the truck), and a solution (e.g., The boy's father fixed the truck for the boy).

Procedure

Each child was tested individually by an examiner. The children with CIs were all seen by the second author, a certified speech-language pathologist with over 15 years of experience in using Signed English in the clinical and research settings. The typical children

were evaluated either by the second author or by two research assistants majoring in speech and hearing science. Each trial involved the examiner presenting one set of picture sequence on the table and describing each of the four pictures by reading the prewritten scripts. The examiner told the stories with spoken English and Signed English for children with CIs but with only spoken English for typical children. The examiner used spoken English and Signed English for all children with CIs, regardless of their communication mode, because we wanted to keep the procedure consistent for these children.

After each story presentation, the examiner collected all the pictures from the table and asked the child to retell the story by saying “Let’s look at the pictures again and you tell me the story.” The examiner then showed the child the pictures of each set one at a time and instructed the child to tell a story. If the child did not talk about the picture, the examiner used up to two prompts per picture to elicit the story (e.g., *Tell me about the picture* or *What’s happening in the picture*). All utterances from the CI and typical groups were audiorecorded for transcription and coding. In addition, we videotaped the sessions of the CI groups to observe if children with CIs used signs to mark tense in the task.

Transcription and Coding

The utterances of the children with CIs were first phonetically transcribed with broad transcription by the second author. The phonetic transcriptions were then used to generate the orthographic transcription of these utterances. The utterances of the typical children, however, were only orthographically transcribed by the second author and the research assistants. All of the orthographic transcriptions were then segmented and coded based on the conventions of *Systematic Analysis of Language Transcripts* (SALT, Miller & Iglesias, 2010).

The child’s utterances were segmented into C-units (Loban, 1976). A C-unit is an independent clause plus all of its dependent clauses. Side comments unrelated to the story (e.g., *Bring the pictures down lower*), incomplete utterances, or unintelligible utterances were excluded from analysis.

In this study, we explored children’s use of regular tense markers (i.e., 3SG *-s*, past tense *-ed*, copula BE, auxiliaries BE and DO) in obligatory contexts (Rice et al., 1995). We did not include auxiliary HAVE in our analysis because young children speaking American English did not use auxiliary HAVE frequently in spontaneous speech. This decision was further supported by our data in which no children produced obligatory contexts for auxiliary HAVE. We also did not include modal auxiliaries that marked future time (e.g., *will*, *shall*) because “there is no formal future tense in English” (Biber, Johansson, Leech, Conrad, & Finegan, 1999, p. 456), and it was difficult to define obligatory contexts for these modal auxiliaries. In addition, verbs that had an invariant past tense form (e.g., *put*, *hurt*) were excluded for analysis. This is because when a child produced an utterance like *He put on his shoes*, we were not able to determine whether it was an omission of 3SG *-s* or a correct use of irregular past tense. Furthermore, we excluded verbs with overgeneralization of 3SG *-s* (e.g., *He haves a truck*) or *-ed* (e.g., *The truck breaked*) from analysis because verbs in these contexts, by definition, did not require the use of regular 3SG *-s* or *-ed* and thus were not considered as obligatory contexts for these morphemes.

The correct usages and errors of tense markers in obligatory contexts were coded. An obligatory context was defined as an instance in which the tense marker was required for the utterance to be grammatical. For instance, the utterance *He walks everyday* has an obligatory context of 3SG *-s* and the tense marker is used correctly. In contrast, the utterance *He walk everyday* has an obligatory context of 3SG *-s*, but it is omitted by the speaker. There are instances where the structures of the utterance were ambiguous. For instance, the utterance *Wash the water off* does not have a subject. Though it could be an utterance in which the child omitted the subject and the tense marker, it could also be an imperative sentence. To be conservative, utterances that had bare verbs but not subjects were excluded for analysis. However, utterances that had inflected verbs but not subjects (e.g., *Fixed the truck*) were included for analysis to avoid underestimating children’s ability to mark tense. To be included for analysis, each child had to produce at least four obligatory contexts of tense markers.

For each obligatory context, the tense marker was coded as 1) correctly used (e.g., *He washes the dog*), 2) omitted (i.e., omission errors, like **He wash the dog*; where “*” denotes ungrammatical), or 3) incorrectly used (i.e., commission errors, like **The boy and the girl is playing*). Because the analysis was based on the child’s spoken utterances, it was possible that children with CIs might omit tense markers in their speech but mark tense in Signed English. Thus, we may be at risk of underestimating their tense marking ability. To explore this possibility, the second author checked the videos of each child with CIs at each data point. It was found that when children with CIs omitted tense markers in their speech, they did not produce these markers in signs either. We therefore focused our computation on the spoken utterances and did not consider signs in the following analysis. For each child, percent correct of tense marking was computed by dividing the total number of correct tense marking by the total number of obligatory contexts across stories at each data point.

Reliability of Transcription and Coding

Recall that the data of the CI group were selected from a longitudinal study and were transcribed phonetically. The reliability of broad transcription was computed and described in [Spencer and Oleson \(2008\)](#). The average point-to-point reliability of phoneme accuracy was 79.05% (SD = 8.87). This is considered to be within acceptable range of phonetic transcription (i.e., 60–90%, [Shriberg & Lof, 1991](#)). To check the transcription reliability of the typical groups, we randomly sampled the stories from 30% of the children in each group ($n = 9$). The first author retranscribed these language samples. Though previous studies typically sampled about 10% (e.g., [Rice et al., 1995](#)) or 20% (e.g., [Nicholas & Geers, 2007](#)) of the language transcripts for reliability checking, we sampled 30% of the language transcripts in order to be particularly cautious. The average agreement was 95.99% (SD = 3.85%) in transcribing lexical morphemes and 95.00% (SD = 4.29%) in transcribing grammatical morphemes.

We also checked the reliability of C-unit segmentation and coding of tense marking for both groups. To that end, we further randomly sampled stories

from 30% of children with CIs at each data point. All of these samples were re-segmented and re-coded by the first author. The average agreement of segmenting C-units was 99.57% (SD = 1.58%) for the CI group and 98.79% (SD = 1.28%) for the TD groups. In addition, the average agreement of coding tense marking was 99.35% (SD=1.96%) for the CI group and 94.85% (SD=3.28%) for the TD groups.

Results

Descriptive Measures of the Stories

[Table 2](#) summarizes the descriptive measures of stories retold by children with and without CIs in this study. It should be noted again that the CI group and the TD group were matched in the length of hearing experience but the CI group was older than the TD group. Within the CI group or the TD group, there were no significant effects of hearing experience on mean number of C-units or MLCU in words or morphemes, $F_s < 1.05$, $p_s > .36$, $\eta_p^2 < .07$. Across groups, children with CIs produced fewer C-units in the story-retell task as compared to the typical children matched in hearing experience at three, four, and five years postimplantation; $F_s > 11.93$, $p_s < .003$, $\eta_p^2 > .43$. However, the CI and the TD groups did not differ in mean length of C-units in words or morphemes across the 3-year span; $F_s < 3.16$, $p_s > .10$, $\eta_p^2 < .17$.

Accuracy of Tense Marking

[Table 3](#) presents the mean number of obligatory contexts and percent correct of tense marking by group

Table 2 Descriptive measures of stories by group and hearing experience

	Number of C-units	MLCU- Words	MLCU- Morphemes
CI			
3 Years	22.56 (7.07)	3.80 (1.49)	4.20 (1.58)
4 Years	23.22 (6.18)	4.84 (1.32)	5.20 (1.37)
5 Years	22.11 (5.88)	4.85 (0.97)	5.30 (1.14)
TD			
3 Years	32.11 (4.34)	4.75 (1.14)	5.39 (1.25)
4 Years	34.78 (3.38)	5.14 (0.45)	5.65 (0.57)
5 Years	34.56 (6.21)	5.27 (0.92)	5.79 (0.99)

Note. CI = children with cochlear implants; TD = typically developing children; MLCU = Mean length of C-units

Table 3 Mean number of obligatory contexts and percent correct of tense marking by group and hearing experience

	Number of Obligatory Contexts		Percent Correct	
	Mean (SD)	Range	Mean (SD)	Range
CI				
3 Years	10.33 (4.15)	4–17	64.52% (28.80%)	20.00–100%
4 Years	10.89 (3.02)	7–18	75.21% (21.62%)	45.45–100%
5 Years	10.33 (2.84)	7–14	84.54% (17.12%)	57.14–100%
TD				
3 Years	16.80 (6.46)	10–25	81.30% (16.68%)	60.00–100%
4 Years	16.78 (6.52)	8–24	91.45% (7.71%)	80.00–100%
5 Years	18.33 (6.75)	12–24	96.96% (4.88%)	88.89–100%

and hearing experience. Within the TD group, there were significant effects of hearing experience in percent correct of tense marking, $F(2, 24) = 7.80$, $p = .002$, $\eta_p^2 = .393$. Post hoc Tukey tests indicated that typical 4- and 5-year-olds produced higher percent correct of tense marking than 3-year-olds. There were no other significant effects of hearing experience between the TD subgroups. Within the CI group, the effect of hearing experience on percent correct of tense marking approached the significant level, $F(2, 16) = 3.53$, $p = .054$, $\eta_p^2 = .31$. Post hoc paired t-tests indicated that children with CIs produced tense markers more accurately at four or five years postimplantation than at three years postimplantation. There were no other significant effects of hearing experience within the CI group. That is, percent correct of tense marking increased significantly in children with and without CIs over the 3-year span though the differences between children with four and five years of hearing experience were not significant in either group.

Across groups, children with CIs produced lower percent correct of tense marking than typical children at four years [$F(1, 16) = 4.51$, $p = .05$, $\eta_p^2 = .22$] and five years postimplantation [$F(1, 16) = 5.23$, $p = .04$, $\eta_p^2 = .25$] but not at three years postimplantation [$F(1, 16) = 2.10$, $p = .17$, $\eta_p^2 = .12$].

It is possible that by analyzing data for the group, individual trends were obscured. Given that there is wide variability of speech and language outcomes in children with CIs (Conway et al., 2011), it is important to explore whether individual trends confirmed the group data. Figure 1 shows the percent correct of tense marking of each child in the CI group and of the typical children as a group (i.e., the star signs). Overall, the performance of tense marking in individual children

with CIs was quite variable, which was also evident in the range and standard deviation of percent correct of tense marking in Table 3. If we focus on children's performance at five years postimplantation, we can see that four children with CIs (CI-3, CI-5, CI-8, and CI-9) produced tense markers with lower accuracy compared to the typical children matched in hearing experience. In contrast, the other five children with CIs (CI-1, CI-2, CI-4, CI-6, and CI-7) produced tense markers close to the group mean of typical children. The finding suggests that at least some children with CIs can produce tense markers comparable to typical children at five years postimplantation. This was also observed in some children with CIs who had three or four years of hearing experience.

It should also be noted that though the performance of tense marking in individual children with CIs was variable, the variability decreased over time. At three years postimplantation, the SD was 28.80% (range: 20–100%). At five years postimplantation, the SD dropped to 17.12% (range: 57–100%). This indicated that even though some children with CIs progressed slowly (e.g., CI3 and CI9), their accuracy of tense marking still improved over time. One child (CI5), however, showed the pattern of backtracking. She produced tense makers with 92% correct at three years postimplantation, but the percent correct dropped to 57% at five years postimplantation. We will discuss this case below in more detail.

Relations between Speech Perception and Tense Marking

We then examined whether the performance of tense marking among children with CIs was associated with

their speech perception skills at earlier time points. Spearman ranked correlations showed that the PB-K scores of children with CIs at three years postimplantation were significantly correlated with the accuracy of tense marking at four ($\rho = .76, p = .02$) and five years ($\rho = .77, p = .01$) postimplantation. Similarly, the PB-K scores of children with CIs at four-years postimplantation were significantly correlated with the accuracy of tense marking at five years ($\rho = .64, p = .03$) postimplantation. These results suggest that children with CIs who had better speech perception skills at earlier time points tended to produce tense markers more accurately at later time points.

Error Analysis

Table 4 presents the frequency and percentage of tense marking errors by type and group. The percentage is computed by dividing the number of a specific type of errors (e.g., omission errors) by the total number of errors at a given age. For instance, typical 3-year olds produced 27 errors in total, among which were 26 omission errors. Thus, the percentage of omission errors in typical 3-year-olds was 96% (i.e., 26/27). McNemar tests indicated that the distribution of omission and commission errors was asymmetrical in children with three or four years of CI experience ($p < .003$), but not in those with five years of CI experience ($p = .63$). Inspection of the distribution reveals that, like the TD children, children with CIs were more likely to produce omission errors than commission errors in tense marking at three, four, and five years postimplantation. The distribution of errors in children with five years of CI experience did not reach a significant level, possibly because of the small number of errors.

Discussion

This study examined the acquisition of tense marking in children with prelingual deafness who received CIs before 30 months of age via a story-retell task over a 3-year span. The percent correct of tense marking increased significantly over time in children with CIs, as in their TD peers. As a group, children with CIs produced tense markers at a level comparable to TD children at three years postimplantation, but at a lower level than TD children at four and five years postimplantation. However, there was considerable variability in the accuracy of tense marking in children with CIs. Although some children with CIs produced tense markers at a level comparable to the hearing-matched peers, some did not. The variability of tense marking in children with CIs was associated with their speech perception skills at previous time points. In addition, the errors that children with CIs made in tense marking tended to be omission errors instead of commission errors.

Limitations of the Current Study

Before we discuss the results, we should consider three limitations of this study. First, we had a small number of children with CIs in the statistical analysis because we excluded 63 out of 72 children with CIs in the database in order to observe the development of tense marking over time and to eliminate the confounding factors. The primary concern with having too few participants in a study is that the study will lack power to detect the differences in question. Nevertheless, the within- and between-group differences in the accuracy of tense marking were detectable. In addition, the small number of participants also limits the generalizability of the current findings. Large-scale longitudinal studies are

Table 4 Frequency (percentage) of tense marking errors in obligatory contexts by type and group

	3 Years		4 Years		5 Years	
	Omission	Commission	Omission	Commission	Omission	Commission
CI ^a	28 (100%)	0 (0%)	26 (96%)	1 (4%)	11 (92%)	1 (8%)
TD ^b	26 (96%)	1 (4%)	12 (100%)	0 (0%)	3 (100%)	0 (0%)

Note.

^aThe total number of obligatory contexts across children with CIs was 94 at three years postimplantation, 98 at four years postimplantation, and 96 at five years postimplantation.

^bThe total number of obligatory contexts was 158 across typical 3-year-olds, 158 across typical 4-year-olds, and 170 across typical 5-year-olds.

thus needed to verify whether the current findings still hold in a larger group of children with CIs.

Second, all of children with CIs in this study received unilateral rather than bilateral implantation. A question that arises is to what extent the findings from this study were generalizable to the current young CI users who are implanted bilaterally. To the best of our knowledge, the advantages of bilateral implantation over unilateral implantation in children's audiological performance remain unclear in the literature. For instance, Lovett, Kitterick, Hewitt, and Summerfield (2010) found that bilaterally implanted children tended to perform better than unilaterally implanted children in sound localization and speech perception in noise after about four years of CI experience, whereas Galvin, Mok, and Dowell (2007) did not find such benefits in their study. Similarly, there is still no trustworthy evidence favoring bilateral over unilateral implantation in the outcomes of language development (Wie, 2011). Thus, it is possible that some children with bilateral CIs may have difficulties acquiring tense markers—like those with unilateral CIs in the current study. A related issue is whether children with more advanced CI devices would perform differently from children in the current study. Though the children in the current study were implanted between the years 1997 and 2001, all of them used the ACE processing strategy, which is still the default processing strategy of current Nucleus CI devices (Cochlear Ltd., 2010; Wilson, 2006). There is still no published evidence showing that different processors with the same processing strategy would lead to significant differences in speech and language outcomes. In addition, there is also no published evidence consistently indicating that different processing strategies from different makes at the same time period (e.g., ACE in Cochlear devices, High Resolution in Advanced Bionics devices) would result in significant differences in the outcome measures. Comparisons of acquisition of tense markers in children with bilateral and unilateral CIs, children with different processors but the same processing strategy, or children with different makes of CIs are worthy of future studies.

Third, though the mean age of implantation in the current study was 16 months (range: 12–26 months), we did not include those who received CIs before 12 months of age. One might ask whether the current

findings were applicable to those who were implanted before 12 months of age. It is worth noting that though age of implantation played a significant role in the speech and language outcomes in children with CIs, whether children implanted before 12 months of age and those implanted between 13 and 24 months of age would differ significantly in their speech and language outcomes remains an open question (Holt & Svirsky, 2008). Thus, although we are not able to suggest that the current findings can be generalized to those who were implanted before 12 months, it is possible that children implanted before 12 months of age and those implanted between 13 and 24 months of age would not differ significantly in tense marking at the group level.

The acquisition of tense marking in children with CIs: Group and Individual Trends

In the current study, children with CIs, as a group, produced tense markers with lower accuracy than typical children at four and five years postimplantation. However, children with CIs made more omission errors than commission errors like typical children. In addition, children with CIs who had better speech perception abilities at earlier time points tended to produce tense markers more accurately at later time points. These findings were consistent with the surface hypothesis, which states that the difficulties in the acquisition of tense markers in English may result from the interaction between the brevity and the processing demands associated with these markers (Leonard, 1989). Nevertheless, the current study is not a direct test for the surface hypothesis. Though we tested the speech perception skills of children with CIs by using the PB-K test, we did not test how well children with CIs can perceive tense markers, because the PB-K test only evaluated children's perception of single words. Nor did we have measures to explore information processing capacity in children with CIs due to the limitation of the archival data. Understanding the role of processing capacity is important because some children with high speech perception score did not produce tense markers at a level close to the mean of typical children (e.g., CI-9). This indicates that though speech-perception abilities are crucial in the acquisition of tense markers, some other abilities

(e.g., information-processing abilities) are also involved. Future studies that measure the perception of tense markers (e.g., Montgomery & Leonard, 1998) and information-processing capacity (e.g., Competing Language Process Test; Gaulin & Campbell, 1994) in children with CIs are needed to help researchers and clinicians determine how perception and processing constraints may account for children's acquisition of tense markers.

In addition to the child factors (e.g., speech perception skills), the task factors may also play a role in explaining the group difference in tense marking. Children with CIs tended to show less sophisticated narrative skills than their age-matched peers (Crosson & Geers, 2001; Worsfold, Mahon, Yuen, & Kennedy, 2010). In the current study, the CI group produced fewer C-units than their hearing-matched peers in the story-retell task. This seems to suggest that children with CIs may also fall behind their hearing-matched peers in the development of narrative skills. If this is the case, it is possible that children with CIs produced tense markers with lower accuracy than their hearing-matched peers, because the narrative task was relatively more challenging for the children with CIs than for their typical, hearing-matched peers. Although we are not able to rule out this possibility, it should be noted that the story-retell task does not require story formulation (Schneider & Dubé, 2005). Instead, this task taps children's auditory memory. Thus, the extent to which children's narrative skills and/or auditory memory account for their performance in the story-retell task, and hence the production of tense markers needs further investigation.

It should be noted that although children with CIs, as a group, produced tense markers less accurately than typical children who had matched hearing experience, some of the children with CIs (e.g., five out of nine children with CIs at five years postimplantation) produced tense markers at a level comparable to TD children who had matched hearing experience. The finding was similar to a study by Norbury, Bishop, and Briscoe (2001) that investigated the use of past tense *-ed* and third person singular *-s* in children with mild-to-moderate sensorineural HI. In that study, some children with HI ($n = 13$) used target tense markers at levels comparable to typical age-matched children, while the others

($n = 6$) performed at a lower level than typical children. These findings suggest that some children with CIs may develop sufficient speech-perception and/or information-processing skills that allow them to learn language components (e.g., tense markers) in ways that are comparable to typical children. This speculation was partially supported by the finding that children with CIs who had better speech perception abilities tended to produce tense markers more accurately.

Even though there was considerable individual variability among children with CIs, the variability decreased over time, possibly because those who acquired tense markers at a slower rate gradually catch up after three to five years postimplantation. The accuracy of tense marking in one child (CI-5), however, decreased over time. There are at least two possibilities to explain this trend of backtracking. The first possibility is that the CI device in CI-5 was not performing at the level that it should be. If we look at her speech perception scores (i.e., PB-K test in Table 1), we can see that her scores dropped from 62 to 52% from three to four year postimplantation. However, there are some other reasons that can cause the decrease of the test score, such as attention. In addition, the PB-K scores of CI-8 also dropped between the two time points, although her performance in tense marking did not decrease. Thus, although the functioning of the CI device may explain the backtracking pattern of tense marking in CI-5, it cannot be the whole story. The second possibility is that CI-5 produced more memorized chunks with tense markers (e.g., *he's*, *she's*) at three years postimplantation than at five years postimplantation, which may have led to overestimation of her knowledge of tense marking at three years postimplantation. Research has shown that young children may memorize Pronoun + contracted *be* verb combinations (e.g., *He's ___-ing*, *It's a ___*) as gestalt chunks or limited-scope formulae because these combinations are highly frequent in child-directed speech (e.g., Pine et al., 2008; Rispoli, Hadley, & Holt, 2009). Thus, when young children produce these forms, it is possible that they simply activate the memorized chunks/formulae to support their production without the use of their grammatical knowledge. At three years postimplantation, CI-5 produced six obligatory contexts for the *be* verbs, all of which involved the use of pronominal subjects

(e.g., *He's taking a bath*). The child did not produce any errors with these *be* forms. In contrast, at five years postimplantation, she produced six obligatory contexts for the *be* verbs, all of which involved the use of lexical noun phrase subjects (e.g., *The dog is taking a bath*). Two of the contexts had omission errors (e.g., **The girl very happy*) and one had commission errors (e.g., **The boy and the girl was happy*). Inclusion of the Pronoun + contracted *be* combinations in the computation may have overestimated the tense marking ability of CI-5 at three years postimplantation given that these forms may have been produced through the gestalt chunks without the use of her knowledge in tense marking. Had she produced more contexts that involved the use of lexical subjects and *be* verbs, her accuracy of tense marking at three years postimplantation could have been lower.

The role of visual input on the acquisition of tense marking: Facilitative or detrimental?

Recall that six of the children with CIs primarily used total communication (i.e., spoken English and signed English). That is, these children presumably received linguistic input through the auditory and visual

modalities. Given that the signs of tense markers in signed English are clearly separated from the content words (Supalla, 1991) and these children had typical visual acuity, why did not all of these children produce tense markers to a level comparable to typical children (e.g., CI-6 and CI-9 at five years postimplantation in Figure 1)? The potential explanations may include, but are not limited to, the quality of signed English that children received and the cognitive load of signed English processing. In a study of five hearing parent's use of signed and spoken English to their children with profound hearing loss who used hearing aids (ages: from 3 years 6 months to 4 years 9 months), Moeller and Leutke-Stahlman (1990) found that on average, 24% (range: 7% to 49%) of the attempted syntactic structures (including grammatical morphemes) by the parents in 100-utterance language samples were voiced but not signed. Among the syntactic structures that were signed, on average, 57% (range: 15% to 86%) of them were inaccurate. That is, hearing parents tended to either omit the signs or use the incorrect signs for syntactic structures while they spoke to their children with HI. In a case study, Supalla (1991) investigated signed English development of eight children with profound hearing loss who used hearing aids (ages:

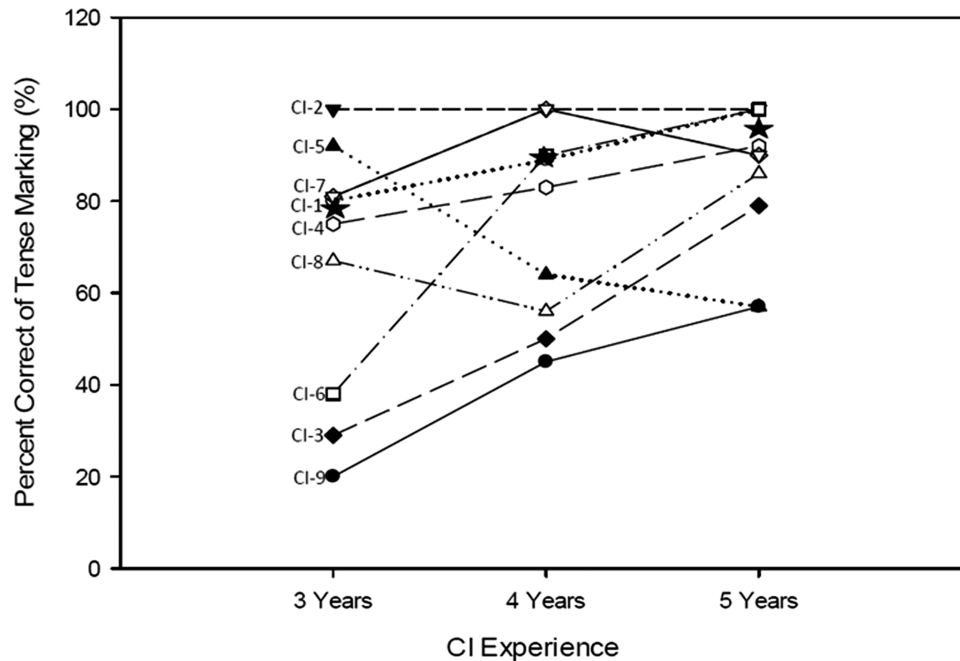


Figure 1 Percent of tense of individual children with CIs over time and the TD groups.

Note. The stars represent the mean of the three TD subgroups.

from 9 years 0 months to 11 years 0 months) in a total communication classroom by examining their development of tense signs and other signs. Although the teacher used tense signs of signed English correctly 88% of the time in a film description task, none of the eight students used tense signs (i.e., 0%) during the task. That is, even if tense signs were consistently used in the input, children did not seem to have the ability to acquire these signs. [Supalla \(1991\)](#) argued that because signed English utilized invented signs that mapped one-to-one to spoken English morphemes, the sequential organization of the signs may overload the cognitive processing of the linguistic information carried by the signs. This may prevent natural language development of English through signed English. The data of [Supalla \(1991\)](#) suggest that tense signs may be one of the most vulnerable areas to the processing difficulties in signed English. However, it should be noted that though signed English may not be ideal for the acquisition of English tense markers, determining the communication efficacy of total communication was not the purpose of the current study.

Like those with hearing aids, children with CIs in the current study who used total communication may also encounter the problems of imperfect input and/or the processing difficulties of tense signs. Though we are not able to rule out the possibility that these children may learn some concepts of tense from signed English, we speculate that children with CIs in the current study who used total communication were likely to learn the tense markers mostly from spoken English. This speculation was supported by the study of [Spencer et al. \(1998\)](#) that compared the use of grammatical morphemes in children with CIs or hearing aids, both using total communication. The children with hearing aids were considered candidates for cochlear implantation but chose to use hearing aids instead of CI devices. As a group, children with CIs used past tense *-ed* in about 50% (40/81) of obligatory contexts whereas those with hearing aids used past tense *-ed* in none (0/40) of the contexts. More importantly, children with CIs marked this morpheme by using spoken English only without signed English. In addition, although children with CIs performed with an average of 58% correct on a close-set speech perception test, children with hearing aids were not able to perform in the test because they were

unable to hear the stimuli. These findings suggest that access to spoken English was the critical factor for the acquisition of tense markers as compared to access to signed English. Thus, though some children with CIs in this study used total communication, we believe that they learn English tense makers mainly through the spoken input. The predictions derived from the surface hypothesis still holds in children using total communication.

On the other hand, would the use of signs in the habilitative/educational program have depressive effect on the acquisition of tense markers in spoken English? Some studies have shown that children with CIs who were in the oral-aural communication (i.e., speech only) program tended to demonstrate better speech and language outcomes than those who were in the total communication (i.e., sign-plus-speech) program (e.g., [Geers, 2002](#); [Geers, Brenner, & Davidson, 2003](#); [Tobey, Geers, Brenner, Altuna, & Gabbert, 2003](#)), whereas other studies did not find such differences (e.g., [Connor, Hieber, Arts, & Zwolan, 2000](#); [Kirk, Miyamoto, Ying, Perdew, & Zuganelis, 2000](#); [Spencer, 2004](#)). Thus, whether different communication modes would lead to significant different speech and language outcomes remains unclear. Even if the oral-aural communication does result in better speech-language outcomes than the total communication program, it does not necessarily mean that the use of signs has detrimental effect on the acquisition of spoken language.

If we look at children's performance at five year postimplantation, in Figure 1, three children reached 100% correct in tense marking. Two of them (i.e., CI-1 and CI-2) used oral-aural communication and one child (i.e., CI-6) used total communication. One child using oral-aural communication (i.e., CI-3) produced tense marking at a lower level than four children using total communication (i.e., CI-6, CI-4, CI-7, and CI-8). Overall, data from the current study did not show a clear advantage of using oral-aural communication or a clear disadvantage of total communication (i.e., the use of signs) on the acquisition of tense marking.

Conclusion

Taken together, the group and the individual data suggested that children with CIs tended to have difficulties

in learning tense markers because of the early deprivation of auditory input and the nature of the electrical signals they receive. However, whether a child with CIs would show noticeable problems in tense acquisition was partly determined by the speech perception they develop over time. The lagged correlations in this study confirmed the role of speech perception in the acquisition of tense markers. The clinical implication of this finding is that when a child with CIs demonstrates limited speech perception skills, the clinician may closely monitor his/her development in tense marking over time. At the same time, the clinician may present tense markers in the salient position of a sentence (e.g., sentence-final positions) to facilitate the acquisition of these markers.

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Conflicts of Interest

No conflicts of interest were reported.

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