Cued Speech (CS) was developed by Orin Cornett in 1966 (Cornett, 1967) and now has been adapted to more than 40 languages and major dialects. CS is neither a sign language nor a manually coded system that uses signs from a sign language in spoken language word order. Instead, it is a mode of communication for visually conveying traditionally spoken languages at the phonemic level (i.e., the same linguistic level conveyed via speech to hearing individuals). In CS, the speaker complements lip gestures of speech with manual cues. A cue is made of two parameters: a hand shape and a hand location around the mouth.

The American English form of CS uses eight hand shapes corresponding to groups of consonants and four hand locations to convey vowels and diphthongs (see figure 9.1). Groups of phonemes that are distinguishable by lipreading (e.g., /p/, /d/, and /z/) are coded by a same hand shape or at the same location. Conversely, phonemes that have similar lip shape are coded with different hand shapes (e.g., /p/, /b/, and /m/) and hand locations (e.g., /i/ and /e/). Information given by the cues and information given by lipreading are thus complementary. Each time a speaker pronounces a consonant-vowel (CV) syllable, a cue (a particular hand shape at a specific position) is produced simultaneously. For example, when saying the words “bell” and “bowl,” two different hand locations would be used to distinguish between the two vowels; when saying the words “but” and “putt,” two different hand shapes would be used to code the initial consonant. Syllabic structures other than CV are produced with additional cues. For example, a vowel-only syllable is represented by the neutral hand
Cued American English Consonant Handshapes:

1. /k/ - vote
2. /p/ - Paul
3. /zh/ - measure
4. /t/ - there
5. /th/ - there
6. /l/ - Lee
7. /s/ - saw
8. /sh/ - shy

Cued American English Vowel Placements:

1. /i/ - see
2. /e/ - her
3. /oo/ - cook
4. /a/ - apple
5. /ue/ - you
6. /ai/ - his
7. /aw/ - hoist
8. /ah/ - my
9. /el/ - sails
10. /eh/ - my

Figure 9-1. Hand shapes and locations in English cued speech.
shape at the location corresponding to that vowel. Syllables including consonant clusters, or codas, are coded using the hand shape corresponding to the additional consonant at the neutral position.

The hand shapes and hand locations used in CS—unlike those of fingerspelling—are not, by themselves, interpretable as language. Instead, the visual information provided by lipreading is also necessary. The integration of labial and manual information points to a single, unambiguous, phonological percept that deaf children could not have obtained from either source alone. They thus can interpret a spoken message as a reliable visual language in which the gestures (i.e., the combination of lip movements and manual cues) are now entirely specified, both at the syllabic and at the phonemic levels. Each syllable (and phoneme) corresponds to one and only one combination of labial and manual information, and vice versa, a characteristic that makes CS (at least in theory) entirely functional for speech perception.

EFFECT OF CS ON THE DEVELOPMENT OF SPOKEN LANGUAGE THROUGH THE VISUAL MODALITY

Traditional oral approaches to language development in deaf children are often unsuccessful because children with significant hearing losses do not have full access to all necessary linguistic contrasts. Indeed, the information they get through speechreading, residual hearing, or the combination of the two is neither sufficiently precise nor sufficiently reliable to allow them to detect the regularities at the root of the phonology and grammar of the language. Yet, it is precisely these qualities that are at the root of the generative system of language (Locke, 1997) and that are at stake in the linguistic development of the deaf child, whatever the modality of language (spoken or signed, with or without information from lipreading). Before considering the effect of CS on the development of phonology and syntax, it is therefore important to evaluate whether CS enhances speech perception.

Effects of CS on Speech Perception

Deaf people's comprehension of spoken language is usually poor. Most speechreaders understand only about one fourth of what is said even in one-on-one conversations (Liben, 1978). However, large improvements of deaf children's speech reception skills have been demonstrated both for English- and French-speaking children when cues from the CS system are added to information from lipreading (Alegría, Charlier, & Mattys, 1999; Nicholls & Ling, 1982; Périer, Charlier, Hage, & Alegría, 1988). Nicholls and Ling (1982), for example, found that the speech reception scores of profoundly deaf children taught at school using CS for at least 3 years increased from about 30% for both syllables and words with lipreading alone, to more than 80% given lipreading plus cues.
Périer et al. (1988) assessed the improvement offered by CS cues on the understanding of sentences having simple subject-verb-object syntactic structure and three levels of speechreading difficulty. This design allowed them to determine the effects of CS on the disambiguation of speechread sentences that do not present linguistic challenges. Children had to choose a picture corresponding to the spoken sentence from among a set of four alternatives (the target and three distractors), all of which appeared identical via speechreading alone. The results showed that perception was enhanced by the addition of cues, with a larger enhancement when the choice between the sentence and the other three distractors was more difficult. The enhancement was also larger for children whose parents used CS intensively to communicate with them at home, from an early age, than for children who benefited from CS later, only at school, usually from the age of 6.

The differential benefit displayed by the early and late CS users may be explained in two ways: Early CS-users might be more familiar with words presented in CS, or, due to their CS exposure, they might have developed a more efficient phonological processor (i.e., that depends on the quality of the mental representations of the phonemes). Alegria et al. (1999) found that early CS users displayed a larger improvement than did later users from the addition of cues in the perception of both words and pseudowords (pronounceable nonwords). Because pseudowords were unfamiliar for both groups of children, these results support the suggestion that early experience with CS enhances the efficiency of the processing of pure phonological information. This result is interesting because the capacity to process “new” phonological information may be at the root of the development of lexical and even morphosyntactic aspects of language, allowing for the efficient combination of multiple meaningful parts in word creation.

Effects of CS on Morphosyntactic Development

Given the above findings, the next question is whether the information provided by CS helps the linguistic development of deaf children. Should this be the case, the effect of CS might be more marked in grammar, one of the domains most difficult to master by deaf children, and, more particularly, morphosyntax. Morphosyntactic ability involves combining morphemes to modulate and add grammatical meaning to lexical items and typically is learned naturally, via early language interactions, rather than being specifically taught at school.

Some studies have suggested that the difficulties in acquiring aspects of grammatical morphology can be greater than for semantic aspects of language. This may be so because morphologically significant features are generally short items, such as closed-class words or affixes (e.g., inflections) attached to words. They generally are produced rapidly and with low stress in normal, fluent language. Grammatical morphemes
can be picked up in lipreading, but only with difficulty, either because they are affixed to words' ends (e.g., plural markers in English or French) or because they are short, unaccented morphemes (e.g., prepositions and articles). A deaf speaker of a language like French or English thus often fails to perceive and encode these morphemes, and, with such a degraded input, deaf children have fewer opportunities to develop mastery of morphological rules.

Taeschner, Devescovi, and Volterra (1988) reported the case of a congenitally deaf woman who had acquired a high level of competence in spoken and written Italian. Despite achievements in lexical and syntactic competence similar to those of a hearing native speaker who was selected as a comparison case, she had a specific impairment of morphosyntactic ability, in particular in the use of free-standing function words such as prepositions. Her morphological deficiencies thus cannot be ascribed to a general linguistic deficit, but are clearly more specific.

Because CS provides unambiguous information that indicates the presence of even unstressed syllables, it may help to ameliorate the challenge deaf children face in the development of morphosyntax. Kipila (1985) recorded language samples of a child exposed to CS since the age of 18 months that support this suggestion. This child was profoundly deaf and received a cochlear implant (CI) before the age of 4 years. One year later, the mean length of his utterances was 4.5 morphemes, corresponding to the mean number of morphemes of hearing children before the ages of 4 or 5 years. The focus of the study, however, was the acquisition of the 14 grammatical morphemes identified by Brown (1973) for English-speaking hearing children:

- present progressive—verb + -ing
- the preposition "in"
- the preposition "on"
- plural inflections (e.g., -s, -es)
- past inflections on irregular verbs
- possessive inflections (e.g., the dog's ball)
- uncontractible copula ("is," "am," and "are")
- articles ("the," "a," "an")
- past inflections on regular verbs (e.g., -ed)
- regular third person forms (e.g., s as in "He writes well")
- irregular third person forms (e.g., "has," "does")
- uncontractible auxiliary forms (e.g., "did")
- contractible copula (e.g., "-s and -re")
- contractible auxiliary forms (e.g., "-d")

Kipila found that the percentage of correct use was 100% for the seven first morphemes normally acquired and varied between 50% and 80% for the seven later-acquired morphemes (see Brown, 1973, for discussion). These observations, although indicating a delay in the
development of some aspects of morphosyntax, reveal linguistic development in children who receive CS to be different from that of deaf children exposed to traditional oral approaches (Kipila, 1985) in that some in the latter group never reach the level of control of these morphemes shown by the CS children.

Périer, Bochner-Wuidar, Everarts, Michiels, and Hage (1986) have documented the French linguistic development of S., a profoundly deaf child exposed since the age of 11 months to "complete signed and cued French," a new method combining CS and Signed French (see Charlier, 1992). The parents of S. offered him more and more CS as his linguistic level increased. S. demonstrated a rapid and regular linguistic development. Language samples at 4 years 6 months showed a correct use of morphosyntactic markers (e.g., "Je m'appelle Cathy comme toi...non parce que aujourd'hui c'est samedi...non, je ne vais pas manger dans le salon, je vais manger au GB..."). The syntactic structures were correctly used, as were the adverbs such as aussi ("too"), comme ("like"), and parce que ("because"). Use of negative forms, first person pronouns, reflexive pronouns, prepositions, and articles was also correct.

Hage (1994; see also Hage, Alegria, & Périer, 1991) conducted a large "paper-and-pencil" study on different aspects of French morphosyntax involving 202 children from different educational backgrounds. The researchers wanted to assess the effect of deaf children's exposure to a linguistic model on the development of prepositions and grammatical gender, the most arbitrary aspects of morphosyntax in French. Indeed, the initial case studies indicated a favorable linguistic development for children exposed early to CS (i.e., before 18 months of age). However, these early observations did not allow separation of the effects of CS per se from parental involvement. If involvement is not controlled, any comparison between a CS group and a non-CS, oral group could be confounded. A particular effort, therefore, was made to select among the children with profound deafness those whose parents were most motivated and convinced about their choice of method of education. It was decided that participation in early intervention (i.e., before 3 years of age) was an indicator of parent involvement, and therefore the sample was limited to such families. Early intervention, in this case, refers to diagnosis of hearing loss, fitting with hearing aids, and commencement of early linguistic stimulation. The study thus compared children exposed to CS from an early age and children educated orally, also from an early age. In addition, factors of degree of hearing loss, deafness occurring before or after the age of 2 years, lack of other handicaps, and exposure to a single language both at home and at school were considered. A subsample of 98 participants fit these criteria.

A first, multiple-choice lexical test (vocabulary) involved presenting children with a target word and four alternatives. The participants had to choose the item that was best related to the target word, for example,
savon (target word: soap): laver (to wash), nager (to swim), fuir (to avoid), or regarder (to watch). Phono logical and morphological relations between the target and the response alternatives were avoided. The second test assessed children’s knowledge of the grammatical gender of familiar words. Participants were asked to underline the article le or la corresponding to familiar words presented as drawings, while the experimenter spoke the word without cueing. Pronouncing the word (requiring speech-reading) was done in order to avoid confusions like velo (masculine) and bicyclette (feminine), which could be represented with the same drawing but are of different grammatical gender. The third test aimed at assessing the knowledge of prepositions and determiners (prepositions and quantifiers). Children received sentences like Papa est parti [en, au, de, sur] avion (Daddy has gone [by, on, with] plane) or Marc mange [le, de, un, de la] tarte and had to underline the correct determiner.

The assumption was that CS offers the necessary information to internalize these arbitrary aspects of the language, those that are less sensitive to explicit teaching. Therefore, children who are exposed to CS were expected to show an advantage for these aspects. The characteristics of the subjects and their results in the three tests are shown in table 9.1.

Comparison of performance in the two groups’ vocabulary and grammatical gender items just failed to reach statistical significance (p = .052), but the two groups differed significantly on preposition items (p<.001). These results indicate that the two groups differed more strongly on knowledge of prepositions than on vocabulary or grammatical indications of gender, although there was also a trend for CS children to also perform higher on these two measures.

It appears in table 9.1 that both groups had a fairly good knowledge of grammatical gender. The next questions, therefore, were how this knowledge was acquired and whether the manner of acquisition was similar in both groups. The effect of age was examined, because a strong

| Table 9-1: Characteristics of the Participants Exposed to an Oral Method of Education or to Cued Speech and Mean Percentage of Correct Responses in Vocabulary, Grammatical Gender, and Preposition Tests |
|------------------|------------------|------------------|
|                   | Oral             | Cued Speech      |
| n                 | 41               | 27               |
| Mean age (years; months) | 14:4 | 12:0 |
| Range             | 8:6-20:3         | 7:6-17:8         |
| % Correct responses | Vocabulary 82 | 93 |
|                   | Grammatical gender | 82 | 96 |
|                   | Prepositions 71  | 89               |
effect of age would be indicative of a training effect through explicit instruction by the parents, the school, or speech therapists. Each experimental group was divided into two age groups, above or below 11 years.

Analyses indicated reliable main effects of age and of method of communication ($p$ values < .001). Although the age by method of communication interaction was not significant, the effect of age did not seem to be the same for children in the oral and the CS groups. Among the oral participants, performance increased dramatically with age, while there was little effect of age in the CS group, where children younger than 11 years already demonstrated performance near ceiling for the three tests. The data of table 9.2 indicate that the participants from the oral group older than 11 years reached the same performance as those in the CS group who were younger than 11 years in the three tests. The oral group thus needed more time to reach the same level of performance. However, their performance on the preposition test remained limited.

Grammatical gender is one of the most important aspects of the French language. Indeed, most utterances have at least one noun that possesses grammatical gender. The determiners around that noun (articles, adjectives) take the gender and the number of the noun. The consequence of this is that children are frequently exposed to gender in French language, but most of the time gender is semantically arbitrary, for example, *la table* ("table," feminine) and *le mur* ("wall," masculine). Gender marking may be acquired as an associative learning process via gender-marked articles, pronouns, adjectives, and particular lexical items. However, phonology also allows one to guess the gender in some cases, but only in a probabilistic way. Thus, nearly all the names ending with */et/* are feminine (e.g., *bicyclette, raclette, poussette*), while names ending with */ot/* are often masculine (e.g., *bateau, râteau, manteau*). Some endings, such as */wa/*, could be masculine or feminine (e.g., *la loi, le
dermogene*).
In order to construct a productive competence of gender morphophonology, children need to establish a link between the cue delivered by the end of the word and other gender markers such as articles and other determiners.

Karmiloff-Smith (1979) has established that 3-year-old hearing children have a productive knowledge of grammatical gender in French, meaning that they are able to correctly guess the grammatical gender of words they do not know on the basis of suffixes. This is extremely difficult for deaf children to acquire because the critical information for gender prediction (in those cases where it is possible) involves relations between spelling regularities at the ends of words and the unstressed nature of determiners, articles, and pronouns. Both of these characteristics are difficult for deaf children to perceive. Moreover, because it is highly arbitrary, grammatical gender is not taught at school but is allowed to develop naturally through language use.

The observations included in table 9.2 show that children from the CS group and those from the oral group in the Hage (1994) study produced the correct gender for common words. However, the fact that the CS group had an earlier knowledge of gender than did children from the oral group leads one to wonder whether the same processes are at the root of the knowledge developed by the two groups. Exposure to cued speech might favor the development of a sensitivity of grammatical gender related to phonology, while children with oral training but no CS may acquire gender more on the basis of learning associations between gender-marked morphemes (articles, pronouns, adjectives) and particular lexical items.

In order to explore this issue, Hage (1994) selected frequent and infrequent French words that ended either with a masculine ending (manteau, lapin, trumeau, troussequin), a feminine ending (cigarette, tartine, girouette, mezzanine), or a neutral ending, meaning that the ending did not allow prediction of the grammatical gender (poire, foyer, verre, sarclor). She asked the children to produce a determiner for nouns represented by drawings. The nouns were given by speech alone (without cues). Two groups of deaf participants were included, one with children educated orally and the other with children educated with CS.

Mean percentage of correct attribution of grammatical gender for infrequent words is shown in table 9.3. The difference between items with neutral endings and items with endings that appropriately indicate masculine or feminine (called "marked" items) was significant in both groups ($p < .0001$). However, the data did not show a larger capacity of the CS group to exploit the words' endings to generate grammatical gender. Actually, the mean percentage of correct responses for the neutral words was above chance for the CS group (66% instead of nearly 50%), indicating that the participants of this group already knew some of these words. Therefore, in a second analysis, only the children who
Table 9-3: Characteristics of the Participants as a Function of Communication Method, and Mean Percentage of Correct Attribution of Grammatical Gender for Infrequent Nouns’ Neutral and Marked (Masculine and Feminine) Endings

<table>
<thead>
<tr>
<th>Communication Method</th>
<th>Oral</th>
<th>Cued Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>21</td>
<td>32</td>
</tr>
<tr>
<td>Mean age (range [year; month])</td>
<td>13;8 (10;10-17;9)</td>
<td>11;3 (6;11-17;8)</td>
</tr>
<tr>
<td>Neutral % correct</td>
<td>48</td>
<td>66</td>
</tr>
<tr>
<td>Marked % correct</td>
<td>61</td>
<td>75</td>
</tr>
</tbody>
</table>

had less than 60% correct responses for the neutral condition were selected.

Table 9.4 shows that participants of both groups succeeded better at producing grammatical gender when items had the appropriate ending to indicate masculine or feminine (i.e., were marked) than when they were neutral \((p < .0001)\). However, a marginal interaction \((p < .10)\) between group and type of items was observed because scores of children in the CS group increased more than did those in the oral group when items were marked for gender.

The relative difficulties of the oral group apparently are not due to a reduced adult input. Although parents’ speech was not measured in this study, parents of the oral children likely did not produce fewer gender-marked morphemes (articles, pronouns, adjectives) than did parents of children in the CS group. Children from both groups also likely had similar difficulties in hearing the small, unstressed articles *le* and *la*, and pronouns *son* and *sa*. What makes the input difference is that these determiners are produced manually in CS by the parents and can be picked up visually by the children of the CS group. Children receiving CS thus appear to develop an implicit knowledge of word gender. Children receiving exposure to spoken language (without CS), by contrast, noun

Table 9-4: Number of Participants and Mean Percentage of Correct Attribution of Grammatical Gender for Infrequent Nouns With Neutral and Marked (Masculine and Feminine) Endings as a Function of Communication Method

<table>
<thead>
<tr>
<th></th>
<th>Oral</th>
<th>Cued Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Neutral % correct</td>
<td>46</td>
<td>56</td>
</tr>
<tr>
<td>Marked % correct</td>
<td>60</td>
<td>78</td>
</tr>
</tbody>
</table>

THE EFFECT OF Cued Speech and of Spoken Language

Since fitting you are confront CS, which stimulate would be contraindicated (Descoutieux, G.) that CIs only give difficult for child created by place a young deaf child. This leads to the users would do: are not CS users. Phosyntax and of Speech productive provided by CS a auditory feedback constructions in relation to this chapter we to CIs. The variability also discussed.

Is CS Useful for Sj

The introduction foundry deaf child hearing has an eff children may learn speaker—and rel the reception of or CI, remains often i have confusions t which will create c information through the CI, oral commi eligibility may in perf, and l layed accordingly.
gender is probably largely learned via associating a particular lexical item with a gender-marked determiner. If the word is less frequent, the strength of the particular article-noun will be weaker and the attribution of gender will be at risk. These results indicate a role played by CS in the acquisition of grammatical gender based on phonology.

THE EFFECT OF CS ON THE DEVELOPMENT OF SPOKEN LANGUAGE THROUGH USE OF CIs

Since fitting young deaf children with a CI has become widespread, we are confronted with new questions about CS. For example, does CS, which stimulates the visual channel, cease to be useful or even be contraindicated for such children either pre- or after implantation (Descourtieux, Groh, Rusterholz, Simoulin, & Busquet, 1999)? Given that CIs only give degraded acoustic information, and it may still be difficult for children to reliably discriminate fine phonetic differences created by place of articulation and voicing (Pisoni, 2000), CS may help a young deaf child with a CI to perceive these fine phonetic differences. This leads to the prediction that profoundly deaf children who are CS users would do better in auditory word identification than those who are not CS users. This, in turn, could help the development of morphology and of accurate phonological representations in CS users. Speech production might be another ability where the information provided by CS and by the CI would converge. Children who receive auditory feedback through a CI might learn to adjust their oral productions in relation to the reference points created by CS. In the rest of this chapter we examine whether CS affords a benefit to children with CIs. The variability of these benefits and the problems encountered are also discussed.

Is CS Useful for Speech Identification for CI Users?

The introduction of pediatric CIs has changed the situation of profoundly deaf children raised with CS, because improvement in their hearing has an effect on strategies of perception of oral language. Many children may learn to understand speech without having to look at the speaker—and reliance on speechreading and CS is reduced. However, the reception of oral language, although more natural than without a CI, remains often imprecise and incomplete. Children may continue to have confusions between word sounds (e.g., manteau with chapeau), which will create confusions between meanings. Perception of auditory information through CIs is also difficult in the context of noise. With the CI, oral communication is more spontaneous and production intelligibility may increase, but language comprehension may still be less than perfect, and both lexical and syntactic development may be delayed accordingly.
The usefulness of CS for children who were raised with it and also have received CIs has been investigated by Descourtieux (2003). The sample consisted of 55 children from 3 to 16 years of age, including 42 who had CIs. Open set perception of words was assessed in three modalities: auditory alone (A), auditory and speechreading (A + SR), and speechreading and CS (SR + CS), without sound. Performance in the A condition increased with age from 3 to 12 years. Participants between 13 and 16 years of age had lower auditory performance than did the other groups, but they represent the "classical" population of children raised with CS, who perceive language through vision and not audition due to having gotten CIs at relatively late ages. For age groups at 5-8 years, 9-12 years, and 13-16 years, visual information seemed to provide important assistance. Performance in A + SR and SR + CS conditions was higher than 80% correct. However, the SR + CS conditions showed a slight advantage over the A + SR conditions.

Speechreading may enhance speech perception for two reasons: It delivers phonetic information, and it enhances the receiver's attention to the incoming auditory information. These two possible effects of speechreading are present in both of the conditions. The slight advantage offered by the SR + CS modality, however, may indicate that there remains a certain amount of phonological information that is perceived more precisely through the CS modality than through the A + SR modality.

In short, although the auditory modality appears to support speech understanding by children with CIs, and development of spoken communication seems to be possible along much the same developmental trajectory as in hearing children, the auditory channel continues to provide less than full access to spoken messages. Even in the group of younger children (3-4 years old) who were implanted before 3 years of age, CS seems to remain an efficient tool for perceiving spoken language.

The Effect of CS Exposure on Word Identification by CI Users

Consider the case of Vincent, a deaf child who received a CI at 2 years, 9 months (Descourtieux et al., 1999). Before implantation, Vincent had accurate phonetic discrimination and a rich lexical comprehension of words delivered through CS and used cues to express himself. What would be the prediction for his word understanding, through audition, after implantation? Will he be able to understand auditorially the words he previously understood visually; that is, will he transfer his word identification competence from one modality to the other? Or, will he experience the same difficulties as children implanted at the same age but not previously exposed to CS? Clinical observations showed that Vincent functioned quite well with the CI: "[A]fter 6 months of CI use, Vincent understood by audition alone the words of his already extensive vocabulary, demonstrating that he had transferred his word identification competence from the visual modality to the auditory modality."

Cued Speech
extensive vocabulary. After 2 years of CI use, he can follow a conversation without lipreading. He speaks with intelligible speech" (Descourtieux et al., 1999, p. 206).

What about group observations? Cochard (2003) assessed the development of auditory speech comprehension and recognition of words in closed sets and sentences in both closed sets (SCS) and open sets (SOS) in a group of deaf children, from 3 months until 5 years after implantation. Before implantation, the children were in an oral setting, a signed French setting, or a CS setting. Children who were raised in a CS setting had better results than did those of the other two modes of communication, but this effect was modulated by time of measurement and type of material. For words and sentences in closed sets, CS users showed an advantage over children from the other two groups at 1 and 3 years after implantation. This advantage vanished at 5 years after implantation, presumably because children from the three groups had ceiling results at this point of measurement. Interestingly, for sentences in open sets, the advantage of children raised with CS was maintained at 3 and 5 years after implantation. At 5 years after implantation, Cochard found the performance of the CS children to be near 100% correct, while the performance of the other two groups was around 60% correct.

The Effect of CS Exposure on the Development of Speech Production/Intelligibility

Vieu et al. (1998) studied a group of 12 French children who had received CIs at a mean age of 7 years, 2 months. The children were assigned to three groups according to their communication mode before implantation: four used auditory-oral communication, four used CS, and the other four used sign language. Word intelligibility was assessed before implantation and at 1, 2, and 3 years after implantation. The scores (number of words correctly pronounced from a set of 20 pictures) steadily improved with more experience with the CI. In the oral group, scores averaged 18.9% before implantation and 55.5% 3 years after implantation. In the sign group, scores averaged 12.5% before implantation and 41.2% 3 years after implantation. In the CS group, scores were 22.5% before implantation and 66.8% 3 years after implantation.

Cochard (2003) found that at 1 year after implantation, children raised with signed French, with CS, or orally did not show any difference in their speech intelligibility scores. Scores for all groups were below 2.0 on a scale from 1 (completely unintelligible speech) to 5 (speech intelligible to everyone). At 3 and 5 years after implantation, children whose mode of communication before implantation was CS had better intelligibility scores (between 4.0 and 5.0) than did those of the signed French group (below 3.0) or the oral group (below 3.0 at 3 years and below 4.0 at 5 years).
Linguistic Development of Children With CS and CIs

In their study, Vieu et al. (1998) presented an open set of 15 sentences, in an open set auditory-alone condition, and the children repeated each sentence following the stimulus. The responses were scored as correct or incorrect for each category of words (i.e., determiners, nouns, verbs, adjectives, and pronouns), and an error score was calculated for each child. By 3 years after implantation, children who used CS demonstrated a tendency for higher scores than did those in the auditory-oral or sign language groups, although the differences were not statistically significant. Vieu et al. also assessed the language level of sentences in spontaneous speech, by recording the storytelling of the children at 3 years after implantation in response to pictures showing various activities. Speech was scored either as an unintelligible production, production of isolated words or approximated words ("cot" for "cat"), production of associated words ("cat gray"), production of pseudosentences (e.g., subject-complement-verb, "cat milk drink"), or production of full sentences (e.g., "the cat drinks the milk"). The results show that by 3 years after implantation, all children receiving CS or auditory-oral instruction produced sentences or pseudosentences, but none of the children in the sign language group did. The authors concluded that syntax had a tendency to be more advanced in the CS group than in the sign language or auditory-oral groups. It must be remembered, however, that the children of this study received their CIs at a relatively late age (around 7 years). Therefore, CS education prior to implantation appears to be a good tool for promoting syntactic development, in this case allowing children to acquire normal sentence structure.

Cochard (2003) classified children according to three "profiles of evolution" as a function of their delay in the development of the different linguistic abilities after implantation, according to the analysis designed by Le Normand (1997). Only those children who were congenitally or prelingually deaf and fitted with a CI before the age of 4 years 5 months were included in the study. Some of these children had experienced rapid and continuous progress since their implantation. They had begun to demonstrate lexical development at 3-8 months after implantation, morphosyntactic development at 11-20 months after implantation, and metalinguistic development at 36 months after implantation. These were labeled the "profile 1" children. "Profile 2" children had experienced a less rapid progression. Their access to the lexical system had required a longer period of 6-24 months after implantation. Their morphosyntactic development started 20-31 months after implantation, and their metalinguistic development began 60 months after implantation. Finally, "profile 3" children were those whose lexical development started at 36 months after implantation or later and who did not reach morphosyntactic development.
The aim of the research was to search for predictors related to the mode of communication used that could be related to the linguistic evolution of these children. A smaller group of 19 children was selected from among the 53 children, who were followed at least since the age of 48 months. This sample included children belonging to profile 1 or profile 2. Children corresponding to profile 3 were deliberately discarded from the study because of the existence of associated disabilities/learning challenges.

Cochard’s results showed that profile 1 children and profile 2 children did not differ in the age at which they began auditory education. Profile 1 children belonged, in most cases (90%), to families who felt they had a good communication with their child, while profile 2 children belonged to families whose parents felt limited in their communication because of a lack of efficiency in their method of communication. The families of the profile 1 children used oral communication (20%) or oral communication with CS (80%), and 60% of the families of children in the profile 1 group were reported to use CS “intensively.” The families of the profile 2 group used signed French with CS (56%), oral communication and CS (33%), or French Sign Language (11%). The use of CS thus seems to contribute to better linguistic development in children fitted with a CI. Also relevant here is the length of time CS was used relative to time of implantation. Cochard found that before implantation, 60% of the families of the profile 1 group already used CS, while only 11% of the families of the profile 2 group did. Forty percent of the families of the profile 1 group and 55% of the families of the profile 2 group began to use CS during the year of implantation. Two years after implantation, all the families of the profile 1 groupstill used CS, while 88% of the families of the profile 2 group began to use CS during the year of implantation. Four years after implantation, CS had been abandoned by nearly 40% of the families of the profile 1 group and 80% of the families of the profile 2 group. According to Cochard, the reasons for dropping CS were different in the two groups: The families of the profile 1 group felt that the receptive and linguistic progress of their children did not necessitate supplemental coding of auditory information. These children made few perceptual confusions, and they also had a good comprehension of the linguistic messages without speechreading. They did not watch their parents’ lips, and the parents had gradually stopped cuing for them. The families of the profile 2 group, in contrast, had less training in CS than the families of the profile 1 group. Cuing required a considerable effort and was slow and frustrating. Therefore, children rapidly stopped watching the code. Taken together, these observations suggest that CS remains a very good tool to help the linguistic development of children fitted with a CI. However, the code seems to be difficult to acquire by some families.

Le Normand (2003) examined the factors at the root of the heterogeneity of the results observed after implantation in the development of language. She assessed 50 French-speaking children, who had received
CIs between 21 and 78 months of age, at 6, 12, 18, 24, and 36 months after implantation. She found that the socioeconomic status of the families and gender were two important predictors of the variability observed among children in her study. She also investigated the mode of communication used by the children: no particular mode, CS alone, CS + signed French + French Sign Language, CS + signed French, CS + French Sign Language, and signed French + French Sign Language. Although there was no significant impact of the mode of communication upon the total number of words produced, the children who used CS alone produced a higher number of content words and function words than did those educated with the other modes of communication. These data must be interpreted with caution because the effect of mode of communication was not significant, possibly because of (uncontrolled) links between mode of communication and other variables, such as socioeconomic level.

Negative Evidence
It is well recognized that not all children who undergo cochlear implantation before the age of 4 years develop near normal language within 2 or 3 years after implantation. Szagun (2001), for example, reported that 55% of the children in her study who received CIs before the age of 4 years remained at the stage of two-word utterances even after 3 years of language development after implantation. Thus, the question is raised of how to support those children who are not acquiring language normally. Szagun (2001) suggested that for children who are trained aurally (which is the favored method in Germany, e.g.), a program of total communication—as is practised in countries such as U.S.A., Great Britain, or Israel—would be of benefit. Using gestures or sign language would promote the use of symbols, which is an essential component of cognitive development, and could prevent a possible negative influence of insufficient symbol use on cognitive development. (p. 297)

Szagun also argued for a strong link between vocabulary and grammar, in that children must have a sufficiently large vocabulary in order to learn grammar (Kelly, 1996). We would like to suggest the use of CS as another alternative. CS could help to disambiguate the information children get through the CI, which could help in the development of vocabulary and, subsequently, of grammar. The combination of CI and CS allows deaf children to interpret the audiovisual input as a reliable language in which the gestures are entirely specified and could be related to meaning.

In a more recent study, Szagun (2004) showed that children with CIs made errors of gender and omissions on articles. To explain this observation, she argued that "due to their hearing impairment, these
children frequently miss unstressed pronominal articles in incoming speech (which) would lead to a reduced frequency of actually processed article input” (p. 26), and that

“[t]he difficulties hearing-impaired children experience in constructing a case and gender system are due to processing limitations. While such processing limitations may have their root in a perceptual deficit, they may become a linguistic cognitive deficit during the children’s developmental history.” (p. 27).

On the basis of the data summarized above, we suggest that the use of CS might help to overcome this “perceptual deficit” in CI children by transmitting complete information about these unstressed elements of language and might help to avoid the development of a “cognitive deficit” during the child’s developmental history of language.

CONCLUSIONS

Data collected in the 1980s and the 1990s demonstrated that the use of CS can be a powerful tool for language development by profoundly deaf children equipped with hearing aids. CS enhances speech perception through the visual modality, the acquisition of vocabulary and morphosyntax, and metalinguistic development (Charlier & Leybaert, 2000), as well as the acquisition of reading and spelling (Leybaert, 2000; Leybaert & Lechat, 2001), at least for children acquiring French.

More recent data seem to indicate that children who have received CIs benefit from previous exposure to CS. However, use of CS before implantation is likely to become more and more rare. Indeed, most children are now fitted with a CI around the age of 1 year. We believe that during the first months or years of CI use, auditory perception of an implanted child remains imperfect. Therefore, the identification of new words would still benefit from the addition of CS to the signal delivered by the CI. Oral comprehension does not develop exclusively by the auditory channel but necessitates audiovisual integration (Schwartz, Berthommier, & Savariaux, 2002). Children fitted early with a CI thus would benefit from multimodal input during the development of phonological representations. These phonological representations then would serve as the platform from which phonological awareness, reading, and spelling acquisition could be launched.

The use of CS by children with CIs is a challenge. Children may not often look at a speaker’s lips and hands, and they may tend to rely on auditory information alone. Parents may lose their motivation to cue, feel discouraged, or simply abandon coding with the hands. Therefore, it would be important to assess regularly whether cuing remains necessary and under what circumstances after implantation. It is likely that after some period of auditory rehabilitation, children fitted with a CI
will be capable of learning new words by auditory means alone (see Geers, chapter 11 this volume).

Continued attention, nonetheless, should be devoted to the development of morphosyntax after cochlear implantation. This domain of language acquisition is particularly important and sensitive to a lack of precise input, as Szagun's (2004) data show. The capacity to develop morphosyntax easily in response to a well-specified input also tends to diminish with age, although the limits of a precise "sensitive period" cannot be fixed at present (for different views on this point, see Locke, 1997; Szagun, 2001). In short, the benefit and limits of the use of CS with children with CI remain to be investigated more extensively. In particular, data from languages other than French are urgently needed.

REFERENCES


