

What in Practice Should We Teach to Children with Hearing Loss Using Cochlear Implants in Speech Learning Activities at the Auditory-Oral School for the Deaf

Yasuto Itabashi

The objectives of this study were to investigate the speech production skills of children fitted with cochlear implants (CI) in comparison with children using hearing aids (HA) and consider the perspectives of speech learning activities of elementary-aged CI users at the auditory-oral school for the deaf in Japan. A test for the articulation intelligibility was conducted once every year throughout the elementary school. Utterances produced by 14 pre-lingually deafened children with CIs (6 yrs. of age at the beginning) were observed in class. All of these children have been received regular speech lessons individually, and used CI customarily for 2 and half yrs. to 10 and half yrs. (mean = 4.6 yrs.) in the end of this study. As a whole, the articulation intelligibility of 14 CI children seemed to have a tendency toward improvement with an increase in amount of implant experience and speech learning activities. The latest intelligibility scores of these children were distributed from 34.0 to 86.0 % (mean = 60.1 %). The average articulation intelligibility score exceeded those of the other 49 HA hearing impaired peers at the same school (from 9.3 to 85.1 %; mean = 48.9 %). Although linguistically inappropriate utterances were often observed in some cases in CI children, the natural prosody such as rhythm intonation and phrasing and pitch control, and accuracy of consonant-vowel (CV) syllables of the conversational speech of these children were frequently observed. These findings suggest that teacher / clinicians working with this population may still need to focus their efforts on (a) inquiring into what extent the intelligible speech may be attainable for the most CI children, (b) how to emphasize the crucial role of high-quality auditory input in speech sound acquisition, and (c) how to introduce an authentic experience of listening and speaking activities.

Keywords : cochlear implant speech learning activities spoken language

Recently, an enrollment of children with CI (in this paper, CI means cochlear implant) is on the increase in the elementary department in my school. In this school year, 13 out of 67 children are CI children.

A number of studies have demonstrated that the use of CI can facilitated the development of speech and language skills of children who are prelingually profound hearing impaired, although the extent to which performance in such domains remains unclear (Ertmer, 2007; Flipsen & Colverd, 2006; Flipsen, 2008; Flipsen & Parker, 2008; Ouellet & Cohen, 1999; Tobey et al., 2010).

The objectives of this study are (a) to describe the change of articulation intelligibility of CI Children over the year, (b) to investigate the speech production skills of children fitted with cochlear implants (CI) with reference to children using hearing aids (HA), and (c) to consider the perspectives of speech learning activities of elementary-aged CI users at the auditory-oral school for the deaf (that is my school) in Japan.

Method

Participants. Sixty three children participated, of whom 14 are CI children and 49 HA children. All the class-work is a completely oral-based approach (i.e., no signing is involved). Academic ability, language

skills, and reading ability of the children are met a standard. None of the children has any other known physical, cognitive, or emotional disability. Parents of the CI children are all reported to have normal hearing. All of these individuals had significant exposure to spoken language at school and at home following implantation. **Table 1** shows a summary of the demographic characteristics of the participants.

Table 1 Descriptive status of studied group

	N	School year (age)	Unaided pure-tone average, dB HL	Aided pure-tone average, dB HL	Implant experience, year	Articulation intelligibility score,%
CI children	14	1st-6th (6-11yrs.)	106.9*(8.0)	39.6 (5.6)	2.5-8.5	60.1 (16.0).
HA children	49	1st-6th (6-11yrs.)	100.5 (11.5)	51.9 (6.1)		48.9 (20.2)

*Anti-implant aided ear. Each parenthesis means standard deviation.

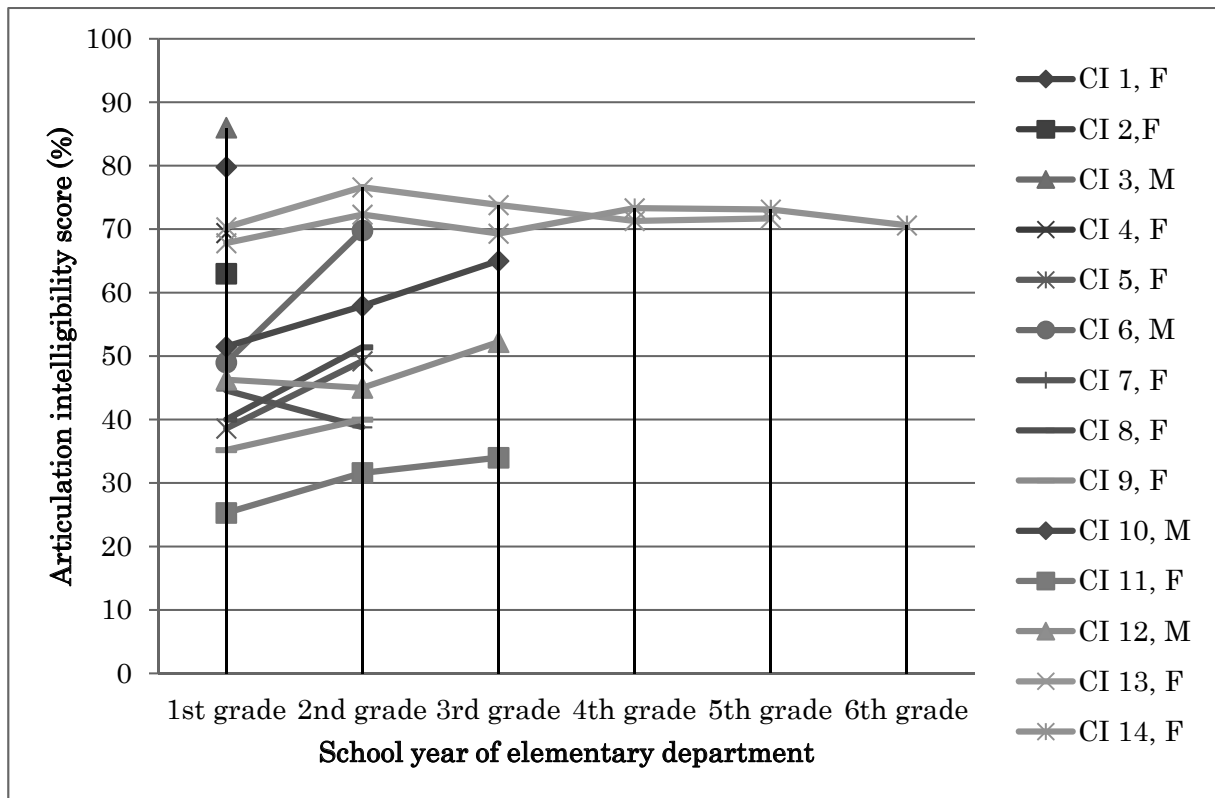
Procedure. The speech skills of the children are annually evaluated by the 100 syllabic Japanese Articulation Test (cf. 板橋, 1999; 2006). MD recordings of the elicited mono-syllabic pronunciation were conducted throughout the elementary school. The MD recorded utterances were presented to normal hearing listeners at a comfortable listening level in a quiet room. This investigation was intended to compare the speech intelligibility score of CI children and HA children. Besides, to grasp CI children's speech characteristics, the utterances produced by 14 prelingually deafened children with CIs (6 yrs. of age at the beginning) were observed by a skillful teacher in charge. All of these CI and HA children have been regularly received individual speech lessons ever since. CI children used CI customarily for 2 and half yrs. (the minimum use case) to 8 and half yrs. (the maximum use case). Their average CI using period was 4.5 yrs. in the end of this study.

Results

Articulation intelligibility. As shown in **Figure 1**, on the whole, the articulation intelligibility of 14 CI children seemed to have a tendency toward improvement with an increase in amount of the implant experience and speech learning activities. The latest scores of these children were distributed from 34.0 to 86.0 %. The average score was 60.1%. The average articulation intelligibility score exceeded the other 49 HA hearing impaired peers at the same school at the moment of the evaluation. The distribution of HA hearing impaired peers' score was from 9.3 to 85.1 %. The average score of HA children was 48.9 %.

Table 2 showed articulation intelligibility scores of 14 CI children at the function of year of CI experience. It seems that this result glanced at the relationship between the amount of CI usage and speech production skills.

Vowels and consonants. Vowels were produced completely in most of the CI children. In consonants, however, because it is rather difficult for the hearing-impaired children to pronounce fricative sounds (Itabashi, 2009), consonants /s/, /ʃ/, /z/, /ʒ/, and /r/ elicited by the articulation test were picked out. **Figure 2** displayed those proportion corrects produced by CI children in comparison with HA children. With respect to proportion corrects in CI children, /ʃ/ was ranked highest, the second was /r/, the third was /s/, the fourth was /r/, and /z/ was ranked the lowest. CI children exceeded HA children in those productions. Though the most high-frequency mispronounced sounds of /s/, /ʃ/, /z/, and /ʒ/ occurred within the same articulation place, that was alveolar, the most high-frequency mispronounced sounds of /r/ occurred at bilabial.



F means female, M means male.

Figure 1 Transition of 14 CI children's articulation intelligibility scores per year.

Table 2 Mean articulation intelligibility scores and year of CI experience

Yrs. CI ex.	2	2.5	3	3.5	4	4.5	5	6.5	8.5
N	1	1	2	3	1	2	1	1	2
Mean AI (%)	49.2	38.8	60.5	57.5	52.2	56.9	86.0	65.0	71.2

"Mean A I" is mean articulation intelligibility. "Yrs. CI ex." is year of CI experience.

As shown in **Table 3**, adding up /b/ and /m/, the total proportion of plosives had a majority of the mispronunciation of /?/. Based on professional observation of utterances produced by HA children, it is seldom that /?/ sounds were substituted for /m/ or /b/. Because, HA children participated in this investigation used speech reading habitually in speech perception, they know intuitively the difference between the bilabial sounds and the alveolar sounds.

Characteristics of the spoken language. Among CI children, linguistically inappropriate utterances were often observed in some cases. For example, "Kama de kusa wo kiru" (this means "I cut weeds with a sickle"), which is wrong expression in Japanese. In this case, we do not use the verb "kiru" , which means "clip" , but use "karu" , which means "cut" . Such a linguistically inappropriate expression was also observed frequently in HA children being in my charge. It appeared to the person in charge that this was the serious problem of ordinary usage of spoken language in hearing impaired children.

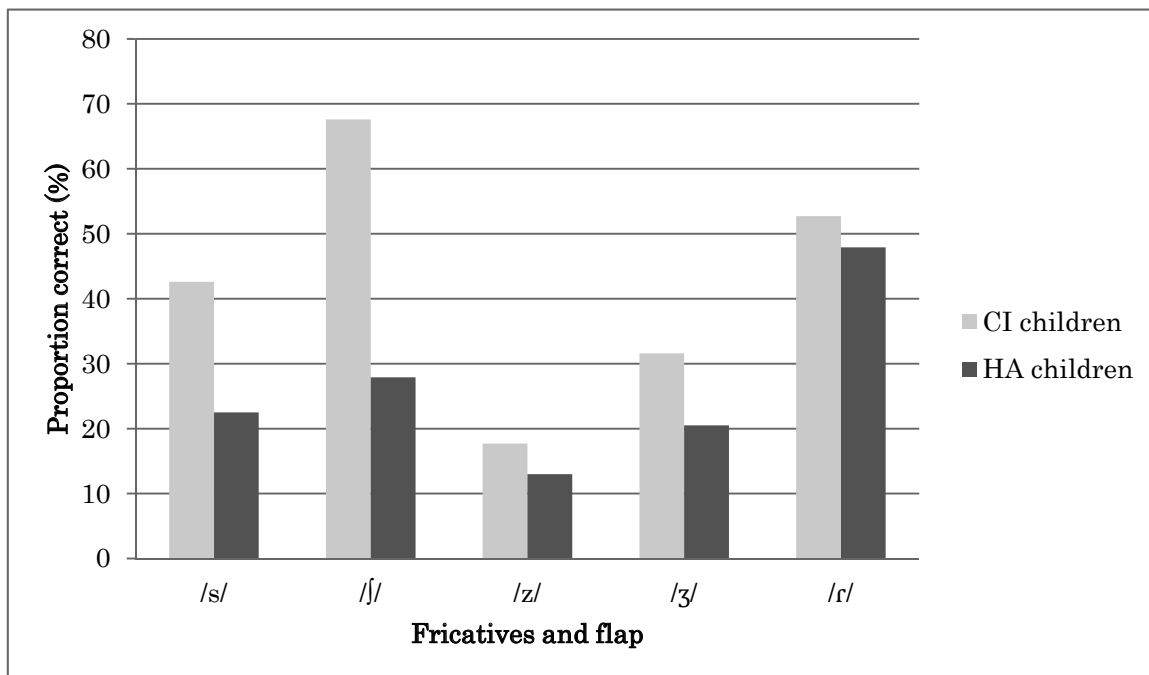


Figure 2 Proportion correct for fricatives /s/, /ʃ/, /z/, and /ʒ/, and flap /ɾ/ in CI children compared with HA Children.

Table 3 Details of mispronounced sounds for fricatives /s/, /ʃ/, /z/, and /ʒ/, and flap /ɾ/ in CI children

Mispronounced sounds and its proportion rate (%)		Characteristics
/s/	/ʃ/(55.2), /tʃ/(24.1), /h/(12.5), /ts/(3.4), /ʒ/(3.4), /ʧ/(3.4).	Dominant sounds are Fricatives.
/ʃ/	/tʃ/(63.6), /s/(18.2), /ts/(9.1), /ʧ/(9.1).	Dominant sounds are Affricates.
/z/	/tʃ/(22.2), /ʒ/(16.7), /d/(13.9), /s/(11.1), /ɾ/(11.1), /ʃ/(8.3), /g/(5.6), /ʧ/(2.8), /k/(2.8), /t/(2.8), /u/(2.8).	Affricate heads the list, many consonants are contained.
/ʒ/	/tʃ/(39.3), /ʃ/(14.3), /ɾ/(10.7), /s/(10.7), /z/(7.1), /d/(7.1), /ʃ/(3.6), /i/(3.6), /j/(3.6).	Affricate heads the list, many consonants are contained.
/ɾ/	/b/(28.6), /m/(21.4), /n/(21.4), /ʃ/(21.4), /d/(7.1).	Dominant sounds are both plosives and nasals.

Another example was the pronunciation of the greeting phrase “GokjigeN yo:” , which means “Take care ! ” or “Look after yourself” . CI children and HA children also often pronounced this phrase like /ogeŋkji jo:/ or /gokji geŋkjo:/ after the speech activities. Those utterances might be just caused by ignorance about the remark of leave-taking. Even if the CI or HA children knew the phrase “GokjigeN yo:” , the utterance of /ogeŋkji jo:/ or /gokji geŋkjo:/ produced by them contained obviously mispronunciations.

In spoken language, some substitutions of consonants were frequently observed in CI children. CI children tended to substitute /ʒ/ for /z/, /tʃ/ for /ts/, and /d/ for /r/. For instances, the pronunciation of /nezumji/, which means “mouse” , was substituted for /neʒumji/, the pronunciation of /hatsuoN/, which means “pronunciation” , was for /hatʃuoN/, and the pronunciation of /ʃaʃ iN o toru/, which means “take a photograph” was for /ʃaʃ iN o todʊ/. From those observed utterances and Table 3, it is suggested that

the error patterns of monosyllabic articulation do not always explain the mispronunciation characteristics of word and phrase level CI children.

However, the natural prosody or suprasegmental aspects such as rhythm, intonation, phrasing and pitch control, and accuracy of consonant-vowel (CV) syllables of the conversational speech by CI children were also observed frequently in the speech lesson. So far as I know from my personal experience, those characteristics of the speech cannot be observed so much in the speech of HA children.

Consideration and Educational implications

On the most conservative assumption, CI children have the advantage over HA children of acquiring speech skills, of pronouncing accurately vowels and consonants, and knowing living spoken language. This means there is a strong opportunity for CI children to make themselves understood orally throughout the class activities in the school. At the same time, it would be pointed out that not only HA children but also CI children were paid close attention to practical use of hearing in school hour, and that speech learning activities customarily carried out during their school days, if necessary.

Findings of this investigation may be extremely suggestive in regard to thinking about CI children's learning style of pronunciation. It is inferred that CI children depend upon using their CI with intense, so that they might pay little attention to speech reading or visual information of speech sounds such as mouth shape, tongue movement, and locations of tongue by looking at the face. In order to show articulation manner, I, as a teacher of speech training, use mirror for tongue movement, tactual perception for voiced sounds, cellophane for warm exhaled air, a handmade instrument for finding exhaled air of fricative, a stick showing the transition from exhaled air to voiced sound or from nasal sound to voiced sound (**Figure 3**), and an impression of the teeth dental student model showing tongue movement by manipulating it (**Figure 3**), and so on. It seems that traditional technique of teaching HA children to acquire articulation and intelligible speech may be also helpful for CI children. It is important to inherit such a practical knowledge by word of mouth.

I would like to notify the limitation of this study. It is unclear whether the high performance of fricative sounds produced by CI children and the tendency of pronouncing /r/ toward bilabial sounds /b/ or /m/ in CI children are applied to every case or not. Because CI children participated in this investigation belonged to the one school for the deaf, whose families are intensely involved in the program and because the number of CI children participated was too small.



Figure 3 A handmade stick (the above) and an impression of the teeth dental student model with tongue made of sponge (the below).

Conclusion

In summary, these findings suggest that teachers / clinicians working with this population may still need to focus their efforts on (a) inquiring into whether fully intelligible speech may be an attainable or not for the CI children attending AO school for the deaf, (b) emphasizing the crucial role of high-quality auditory input in speech sound acquisition, (c) introducing an authentic experience of listening and speaking activities and (d) developing phonological awareness of Japanese that serves to bridge the gap between the listening and speaking language and the reading and writing language .

The last comment may be beyond the scope of this report. As Geers et al. (2011) pointed out in the follow-up study of CI children that reading outcome was most highly predicted by linguistic competence and secondly by speech production skills (p. 4S), it is a matter of great significance in speech learning activities to nurture the spoken language skills and pronunciation skills at the auditory-oral school for the deaf.

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Correspondence to : Yasuto Itabashi, Dr. Edu., Managing Teacher, Instructor of Speech Training, University of Tsukuba, Special Needs Education School for the Deaf, 2-2-1, Kohnodai, Ichikawa City, Chiba Prefecture, 272-8560 Japan. E-mail: itabashi@deaf-s-tsukuba.ac.jp, <http://www.deaf-s-tsukuba.ac.jp/>