

SPEECH SELF-MONITORING BY CHILDREN USING AN ELECTROTACTILE SPEECH PROCESSOR

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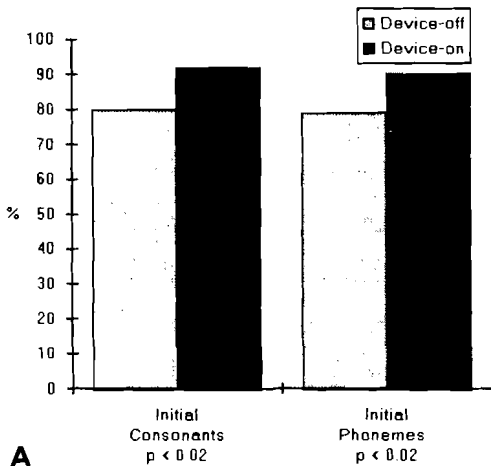
INTRODUCTION

For the profoundly and severely-to-profoundly hearing-impaired child, lipreading and hearing aids are not always sufficient to develop adequate speech perception and production skills. Tactile devices have been investigated as a source of supplementary speech information, with most research focusing on speech perception benefits. However, speech production difficulties are also a major issue for these children, and research into tactile devices should include investigation of the option to use them as speech production aids. This paper will present the results from an initial examination of the suitability of one tactile device for speech production

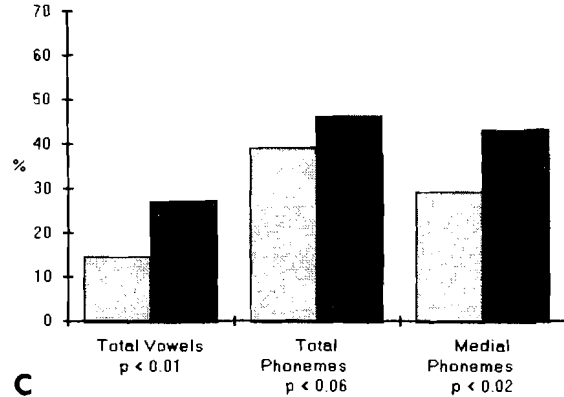
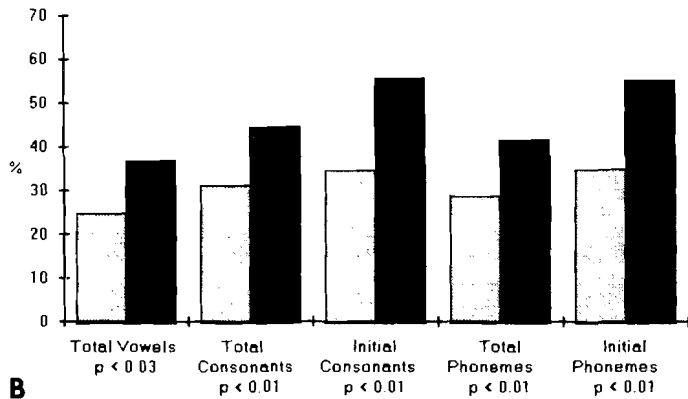
monitoring.

METHOD

The Tickle Talker was developed by the University of Melbourne and consists of a speech processor, a ring handset, and a microphone. Eight electrodes, positioned on each side of the four finger rings, stimulate the digital nerve bundles. The speech processor, based on the Nucleus cochlear implant speech processor, presents the fundamental frequency of speech, the second formant frequency of speech, an indication of the presence of high-frequency information, and an unvoiced signal. Earlier studies have shown speech perception benefits for children using the Tickle Talker with aided residual



Articulation improvements. A) Subject 1. B) Subject 8. C) Subject 16.



hearing and/or lipreading.¹

The six subjects of this study were profoundly hearing-impaired, with onset of deafness between birth and 2 years, and were between 11 years 4 months and 16 years 9 months of age. The children had received weekly speech perception training with the Tickle Talker during the school term for at least 18 months. However, no speech production training with the tactile information had been provided. The children were video-recorded speaking with the Tickle Talker on (device-on) and with the Tickle Talker off (device-off) during a conversation between each child and a research audiologist. The 12 speech samples (six subjects by 2 conditions) were orthographically transcribed. The first 50 words of each sample were discarded, and the next 100 original words phonemically transcribed by means of a narrow transcription method. The number of vowels, consonants, and overall phonemes correctly articulated in each sample was calculated. A χ^2 analysis of 2 by 2 contingency tables was carried out to assess the significance of differences in the frequencies of correct and incorrect vowels, consonants, and phonemes in the device-on and device-off conditions for each subject.

RESULTS

The analysis indicated significant improvements in the accuracy of device-on articulation for subjects 1, 8, and 16. Subject 1 significantly improved ($p < .03$) on the accuracy of device-on articulation of initial consonants and initial pho-

nemes (see Figure, A). The device-off errors of this subject included consonant deletion (most common), voicing, devoicing, stopping, and frication, and all of these errors were reduced in the device-on condition. Subject 8 significantly improved ($p < .04$) on the accuracy of device-on articulation of total vowels, total consonants, initial consonants, total phonemes, and initial phonemes (see Figure, B). The most common device-off vowel errors for subject 8 were shortening, reduction, nasalization, elongation, and, to a lesser extent, deletion, with the incidence of reduction and deletion decreasing in the device-on condition. In subject 8's device-off articulation of total consonants, deletion, backing, voicing, and no sound were the most common errors, and all were reduced in the device-on condition. The incidence of deletion, voicing, and backing also decreased in this subject's device-on articulation of initial consonants. Subject 16 significantly improved ($p < .02$) on the accuracy of device-on articulation of total vowels and medial phonemes (see Figure, C). This subject also improved on the device-on articulation of total phonemes ($p < .059$). The most common device-off vowel errors made by this subject were shortening, nasalization, and reduction, with shortening errors on medial vowels and reduction errors on initial and medial vowels decreasing in the device-on condition. The decrease in the incidence of vowel shortening, vowel reduction, and, to a lesser extent, consonant deletion, consonant voicing, and consonant backing in the device-on condition by subject 16 resulted in a significant improvement in the articulation of medial phonemes.

DISCUSSION

The results of this study suggest that the Tickle Talker may be useful for some subjects as an aid to the self-monitoring of articulation. The significant improvements shown by three of the subjects will be considered in light of the information transmitted by the device. The most common device-off error of subjects 1 and 8, consonant deletion, was reduced in the device-on speech of both subjects. The durational and spectral cues to consonant manner and the high-frequency information provided by the Tickle Talker may have contributed to this improvement. Subjects 1 and 8 also reduced the incidence of device-on initial consonant voicing errors, perhaps through use of the unvoiced signal provided by the Tickle Talker. Subjects 8 and 16 both decreased the incidence of vowel reduction errors when the tactile information was present. This may have been achieved by using electrode position to monitor second formant frequency. Subject 16 was also able to reduce the incidence of vowel shortening in device-on articulation, and may have used the durational information easily available through the Tickle Talker to make this improvement.

The lack of significant improvement shown by subjects 5, 6, and 7 also merits examination, in an attempt to establish if certain individuals will be more likely to use the Tickle Talker in the self-monitoring of articulation. Variables such as the subjects' device-off articulation performance, their levels and use of aided hearing, and their ability to use the tactile information in speech perception may be relevant to this question. The device-off articulation performance of the subjects may indicate varying scope for improvement. Subject 8, with the poorest total phoneme articulation score (28.8%), showed the most device-on articulation improvements. However, after subject 8, subject 5 had the poorest total phoneme articulation score (34.7%), yet showed no significant device-on improvements. In addition, significant device-on articulation improvements were made by subject 1, who had the highest device-off phoneme articulation score (67.9%). Use of the tactile information in articulation self-monitoring does not appear to be predictable from device-off articulation score.

The aided residual hearing of the subjects may be relevant, as those receiving less auditory information may make more use of the tactile information in articulation self-monitoring. Subject 16, who received no auditory feedback, showed some significant articulation improvements. However, subject 5, whose aided hearing levels were vibrotactile, did not show any improvements. In addition, subject 8, who showed significant device-on articulation improvements, had aided thresholds that were not consistently poorer across the frequencies than those of subjects 6 and 7, who showed no improvements. Further to the issue of aided hearing levels is the subjects' use

of their hearing as an indication of actual auditory discrimination ability. Auditory-alone scores on the Bamford-Kowal-Bench (BKB) Sentence Test² are only available for subject 8 (10% and 26%, on two separate occasions) and subject 1 (0%). These scores suggest that the hearing thresholds of these two subjects do not reflect their actual poor levels of auditory discrimination. It appears that along with aided hearing thresholds, the subject's use of aided residual hearing in speech perception may be relevant when predicting the use of the Tickle Talker in articulation self-monitoring.

Previous studies have shown variation between subjects in their use of the Tickle Talker to benefit speech perception, and similar variation is likely for speech production. Scores on the BKB Test² of the six subjects in the evaluation periods prior to and following the collection of the speech production samples indicate their use of the tactile information in speech perception. The greatest improvements in perception when the Tickle Talker was used were shown by subjects 8 and 16, with at least one improvement each over 22%. Subject 1 improved an average of 12% when using the Tickle Talker. It is possible that subjects 1, 8, and 16 were more aware of and able to use the tactile information in speech production, as well as in speech perception.

It may be suggested that some benefits to speech production from use of the tactile information may be integrated into the speech of the subject with experience, and will not be evident in a device-on versus device-off comparison. Subjects 5 (5 years 1 month) and 6 (3 years 9 months) had received more experience with the device than subjects 8 (2 years 10 months) and 16 (1 year 6 months). However, subject 1 (4 years 10 months) had extensive experience, yet still showed significant improvements in device-on articulation. It is not therefore possible to conclude that subjects 5 and 6 have integrated articulation improvements into their device-off speech production.

Although no one factor accounts for only three subjects' showing significant improvements in articulation, the results support the potential of the Tickle Talker as a speech production device. Further training aimed specifically at the use of the tactile information in speech production monitoring with a larger subject group will provide further information on the full potential of the device to the speech production benefits of hearing-impaired children.

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