CHANGES IN SPEECH PRODUCTION FOLLOWING HEARING LOSS DUE TO BILATERAL ACUSTIC NEURAMAS

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ABSTRACT

This is a report of speech production changes in a patient who lost hearing due to bilateral acoustic neuromas and received an auditory brainstem implant to provide some "auditory" stimulation. Speech production and perception and neurological status were measured multiple times before and after onset of hearing loss. "Postural" parameters, such as average vowel SPL, duration, and F0 changed with hearing status, whereas phonemic parameters, such as fricative formants, which in some cases could be observed separately [1-4]. The purpose of this study is to further investigate these hypotheses by studying speech changes in a patient who loses, rather than gains hearing.

METHODS

Bilateral acoustic neuroma (Neurofibromatosis 2, or NF2), is a rare hereditary disease characterized by benign tumors of the central nervous system, which tend to arise bilaterally on the eighth nerves and may lead to hearing loss, first on one side and then on the other (often from surgery that is required to remove the tumors to prevent more serious consequences). The symptoms and severity can vary widely among patients, but a significant proportion have their most severe symptoms confined to bilateral hearing loss [5]. Such cases are rare, but are not covered in this report.

The subject of this report is the first patient (a 30-year-old female) who met the criteria and, during the course of the research, suffered profound hearing loss in her remaining good ear; we will refer to her as NFA (for NF2 Female subject A). During her surgery for tumor removal, the auditory nerve had to be severed, and the electrode array of an auditory brainstem implant was placed.

The auditory brainstem implant (ABI) has been developed and NFA was implanted at the House Ear Institute, Los Angeles, CA. It consists of an electrode array placed on the cochlear nucleus, trans-cutaneous electromagnetic signal transmission and an external microphone and signal processor. The electrode array has seven active electrodes and one reference electrode, forming seven channels that are stimulated with an F0 F1 F2 strategy, intended to provide spectral, amplitude and temporal information, including voicing. NFA's ABI processor was activated several weeks after implant surgery.

Recording sessions were conducted at -20, -10, -1, 11, 35, 60, 76, and 83 weeks relative to the time of the surgery that produced NFA's onset of hearing loss (OHL). Pre-OHL testing was done with NFA wearing her CROS hearing aid, and post-OHL testing was done with NFA using her ABI.

Assessments and complications

Each two-day session typically included: one or two recordings of speech acoustic and physiological parameters, a neurological exam, a set of speech perception tests, and, to monitor for motor changes, tests of non-speech oral-motor capabilities and a videotaping of the subject's face while reading a passage. Each post-OHL session also included an "on-off" experiment, described below.

Speech perception tests consisted of combinations of auditory-alone, visual-alone and auditory-visual presentations of: 12 consonants in a /Cac/ utterance, 8 vowels in /bV/, 10 vowels in /bVd/, monosyllabic words (NU-6), suprasegmentals (SPAC) and sentences (CUNY).

Speech production measures were made of: SPL, F0, ITI, H1-H2 (low-frequency spectral slope), F1 and F2 of the vowels /i, t, e, a, a, u/ spoken in /bV/ in a carrier phrase; VOT for /p, b, t, d, k, g/ in /Cac/ in a carrier phrase, spectral properties of the syllables /s/ and /t/ in /sOd/ and /tOd/ in readings of the Rainbow Passage. This set of materials (or a subset) was repeated five times for each recording. (Aerodynamic and acoustic parameters of voice production were also measured, but are not covered in this report.)

The "on-off experiment" involved having NFA turn off the speech processor of her ABI for 24 hours, then recording five five-minute blocks of 10 repetitions of a subset of speech materials in which her speech processor was: off (1), on (2), on (3), off (4) and off (5) [4].

Motor losses were induced by two surgical procedures. The tumor removal resulted in damage to the left facial nerve which caused a readily-apparent left facial palsy. At week 72 (prior to the last two recorded sessions), the left hypoglossal nerve was anastomosed to the facial nerve in an attempt to restore some left facial function. This procedure resulted in a tongue motor deficit. The tongue deficit was not obvious, but it was confirmed by the non-speech motor test. Clearly, the deficits influence the interpretation of much of the production data. In addition, NFA had an upper respiratory tract infection during the recording one week before surgery, which might also influence some results.

RESULTS

Speech perception

NFA had good aided hearing pre-OHL. For example, auditory-alone consonant scores were close to 90%. Post-OHL, those scores were consistently poor (about 17% correct). It appears that by week 83 NFA was getting some benefit from her ABI (mainly indicated by improvement in consonant scores, but less improvement in auditory-visual). NFA had good visual-alone speechreading scores (about 74% correct) which remained consistent pre- to post-OHL.

Results for the suprasegmental materials were generally also good pre-OHL and dropped dramatically post-OHL. Scores for these tests post-OHL were better in the auditory-visual than the visual-alone condition. Thus the ABI seems eventually to have provided some additional cues to speechreading.

These results were consistent with clinical reports that NFA does not discriminate well among the different channels of her ABI. Presumably, then, the ABI provides her with limited spectral information, but does convey some F0, loudness and voiced/unvoiced information, which she was beginning to use by week 83.

Speech production

In general, the left facial palsy could have a post-OHL effect on many supra-glottal parameters; however, some of those parameters should be more affected than others. For example, bilabial consonants are obviously influenced and
velars shouldn't be. Parameters that reflect laryngeal and respiratory function should be uninfluenced. The anastomosis surgery at 72 weeks should have only influenced subsequent tongue articulations. Nevertheless, it is possible that NFA developed compensatory strategies using structures that were not directly affected by the surgeries.

**Postural parameters**

- Figure 1 shows mean duration (ms) for the eight vowels vs. weeks re time of OHL.

The results presented support our hypotheses about differences between postural and phonemic settings, and they are consistent with the following interpretation. Soon after experiencing a surgical procedure, parameters were sensitive to hearing status, i.e., relatively labile; however, it took NFA about a year to learn how to use the relatively crude auditory input to re-adjust her postural settings to the level of the newborn. This work was supported by N.I.D.C.D.

**REFERENCES**


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