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Performance of 3M/House Cochlear Implant Users on Tests of Speech Perception

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Abstract

This report documents both closed- and open-set speech recognition performance for 18 adult experienced users of the 3M/House single-channel cochlear implant. The stimuli included tape-recorded, standard word and sentence recognition tests, an environmental-sounds test, nonsense syllables, and sentences presented in auditory (implant-only), visual, and auditory-visual modes. All subjects were tested individually in a single session using their own cochlear implants, set to typical comfort use settings for running speech. Subjects' oral responses to the stimuli were transcribed by the experimenters and scored for percent correct. The results revealed considerable individual differences among the subjects and their performance on different tests. All subjects scored better than chance on the closed-set tests. Although they performed considerably poorer on the open-set tests, approximately half of these subjects demonstrated at least some open-set word recognition, a finding not previously reported in the literature for this device. All subjects performed better on the auditory-visual sentences than on either the auditory or visual conditions alone. These results contribute to the database on speech perception by cochlear implant users and show that open-set word recognition performance was somewhat better for these subjects using this implant than would have been predicted from the literature.

Key Words: Single-channel cochlear implants, open- and closed-set word recognition, audiologic test results, speech perception

More than 3000 patients have been implanted with single- or multi-channel cochlear implants (NIH, 1988). Although patients' performance on speech perception tests varies widely with different types of cochlear implants (Gantz et al, 1988), adult 3M/House implant users have not demonstrated open-set speech recognition. The results presented here contribute to the database on speech perception with cochlear implants and document speech recognition performance for several patients using the 3M/House single-channel device.

METHOD

Subjects were 10 women and 8 men who had used their 3M/House cochlear implants for at least one year. Subjects were undergoing routine follow-up at the House Ear Institute and the Otologic Medical Group or were in Los Angeles for a meeting of cochlear implant users. All subjects volunteered their participation.

Subjects were from 26 to 65 (M=49.6) years of age and their age at onset of deafness ranged from 6 to 53 (M=28.3) years. Age at implantation ranged from 19 to 61 (M=42.2) years. Cause of deafness, and unaided and implant-aided audiometric data were representative of those

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of 3M/House cochlear implant users reported in the literature. Unfortunately, few preoperative speech perception data (and no auditory-only speech recognition scores) were available in the subjects' files. Generally, the subjects met the criteria for implantation with this device, which included no speech recognition with the use of traditional hearing aids prior to implantation. Although performance on the stimuli used in this study was not assessed preimplant, our experience with other users of this device suggests that these stimuli probably would have been too difficult for them preimplant.

The speech perception tests used to evaluate the subjects ranged from easy closed-set discrimination to more difficult open-set materials. Tests included: (1) most comfortable loudness level (MCL) for speech, (2) 20-item five-choice House Ear Institute (HEI) Environmental Sounds Test (EST), (3) 20-item four-choice Spondee Test (4-SPON), (4) 50-item W-22 word lists, (5) 50-item NU-6 word lists, (6) 20-item CID Everyday Sentences Test (CID), (7) 63-item vowel-consonant-vowel (VCV) test, (8) 39-item consonant-vowel consonant (CVC) test, and (9) 20-item sentences presented in auditory (A), visual (V), and auditory-visual (AV) modes.

The EST and 4-SPON materials were presented in a closed-set forced-choice format where the subjects selected the item they perceived from the foils on the answer sheets. The VCV and CVC tests were also presented in closed-set (i.e., the subjects were given a list of the consonants and vowels used in the stimuli during testing). The open-set materials were presented as typically used in the clinical administration of these tests. Although the subjects may have received these tests previously, they did not receive practice on them prior to their administration in this study.

The stimuli were audio cassette recordings presented via the auditory (implant-only) condition except for the sentences, which were presented on audio-video tape. The Four-choice Spondee, W-22, NU-6, and CID Sentences tests were Auditec of St. Louis recordings; the EST, VCV, CVC, and the sentences were produced at the House Ear Institute for evaluating cochlear implant patients. The same general American male talker produced the VCV, CVC, and sentence items.

The VCVs consisted of 21 consonants, /p, b, t, d, k, g, f, v, θ, ð, s, z, ʃ, r, l, m, n, w, j, tʃ, dʒ/, in an /ʌ C ʌ/ context. The CVCs were 13 vowels and diphthongs, /i, ɛ, e, I, æ, a, o, ɔ, u, U, ʌ, ɚ, aɪ/ in a /hVd/ context. Each VCV and CVC item was presented in random order three times to each subject. The sentence materials were different lists of 20 sentences each and were scored for the number of syllables identified correctly for each list.

The stimuli were routed from a tape deck through an audiometer to a speaker in a sound-treated suite. Subjects were tested individually in the sound field. The microphone of each subject's implant was attached to a plumb line suspended from the ceiling to maintain the same microphone position of 1 m from the speaker for all subjects. Subjects sat 1 m from and directly in front of a 21-inch color video monitor for the V and AV presentations of the sentences.

New batteries were inserted into the implant and all subjects reported that their implants were functioning properly during testing. Subjects wore their implants at the same comfort settings used for typical daily listening (i.e., the subjects adjusted their devices while listening to the experimenter's live-voice running speech presented at 70 dB SPL). All stimuli were presented to the subjects at 70 dB SPL re the calibration tones provided on the tape for each test. Each subject's warble-tone and speech awareness thresholds were first established without the implant; all remaining testing was completed with the implant on. Each subject received the various tests in a different presentation order.

Subjects responded to the stimuli by repeating each test item aloud orally and by circling the perceived response from the foils on the EST and 4-SPON tests. All subjects had clearly intelligible speech and two experimenters transcribed (phonemically for the nonsense syllables and orthographically for the meaningful word and sentence tests) all responses. All test scores were based on a possible 100 percent correct. The standard tests were scored in percent correct as they are typically used clinically; the CVCs and VCVs were scored one percent for each vowel or consonant correct, respectively; the sentences were scored one percent for each word identified correctly.

RESULTS AND DISCUSSION

Table 1 summarizes the results. The data show considerable individual differences

Table 1 Percent Correct Scores at Each Subject's MCL (In dB SPL).

		Closed-Set				Open-Set					
Subject	MCL	EST (22)	4-SPON (27)	VCV (5)	CVC (8)	W-22	NU-6	CID	A	Sentences V	AV
1	70	75	70	15	14	0	4	15	8	52	95
2	72	70	30	13	8	0	0	1	3	29	45
3	80	55	60	11	8	0	0	4	1	9	32
4	70	60	35	12	13	0	0	0	—	—	—
5	74	75	80	30	18	0	0	26	6	9	46
6	75	85	50	14	15	2	0	9	4	6	42
7	70	80	90	22	41	6	2	34	7	20	69
8	60	80	85	21	29	8	0	21	1	14	49
9	68	65	60	18	15	0	0	0	0	19	59
10	62	75	50	19	15	0	2	2	0	23	59
11	55	80	95	36	32	6	0	28	40	25	90
12	55	75	45	13	15	2	2	1	2	12	24
13	70	60	65	22	12	4	0	0	1	22	54
14	60	—	100	42	31	8	0	20	1	20	79
15	60	65	85	22	17	2	2	0	6	14	86
16	76	55	45	11	8	0	0	0	0	11	31
17	90	25	45	—	—	0	0	0	—	—	—
18	72	55	50	15	22	0	—	0	0	14	55
Mean	68.83	66.76	63.33	19.76	18.41	2.11	.71	8.94	5.0	18.69	57.19
SD	9.01	14.57	21.42	8.90	9.49	2.95	1.21	11.75	9.72	10.98	21.55

Chance scores at the 95% confidence interval are shown in parentheses for the closed-set materials

within and across tests for all subjects, which reflect the heterogeneity among implant patients in general. Although the large standard deviations noted on many of the tests reflect the difficulty of the tasks for these subjects, the scores in Table 1 reveal that some subjects received considerable benefit from their implants. All subjects scored significantly better than chance (at the 95 percent confidence interval) on all closed-set tasks. It was assumed that any score better than zero on the open-set tests was above chance since chance scores and significant confidence levels are not typically computed for these materials.

Interestingly, 10 of these single-channel subjects achieved minimal open-set word recognition for the W-22s or the NU-6s. Further, 11 of them recognized at least one key word on the CID Sentences test. The scores for the AV sentences were considerably better than those in either the A or V presentations for all 16 of the subjects tested with those materials. Obviously, not all subjects demonstrated open-set word recognition and the scores were low (in some cases, only one or a few test items were identified correctly) for those who did. Thus, it could be argued that these results fail to demonstrate impressive open-set word recognition by these subjects. However, the fact that the literature mentions no open-set speech recognition by adult users of the 3M/House single-channel implant may be somewhat misleading, since our subject-selection criteria and test stimuli were not dramatically different from those of other studies in the literature.

Further, except for the EST, all correlations between the open-set CID sentences and the closed-set tests were significant ($p<0.01$): 4-Spon (.77), VCV, (.65), CVC (.80), and EST (.58), suggesting that scores on the open-set CID test may be predicted from those on these closed-set materials. However, such correlations might be affected when different types of stimuli are used.

In summary, the subjects' scores on the tests used here suggest that these materials assessed a wide range of performance and that evaluations of implant patients should incorporate speech perception materials that vary in difficulty in order to show patients' strengths and weaknesses. The overall pattern of the results generally agrees with the literature, with the exception that a few of these subjects did achieve some open-set speech recognition. Although the open-set scores were not high and some subjects may have received these stimuli in the past, five subjects had CID sentence

scores of 20 percent or better with their implants alone. This finding has not been reported previously, and should be of interest to those working with cochlear implants.

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