INITIAL RESULTS WITH SINGLE-CHANNEL AND MULTI-CHANNEL COCHLEAR IMPLANTS

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SUMMARY

A uniform comprehensive clinical evaluation of different cochlear implant prostheses is ongoing at the University of Iowa. Preliminary results from nine patients with three different intracochlear implants (Los Angeles - single-channel, Vienna - single-channel, and Melbourne - multi-channel) are presented. Early results indicate only minor differences in patient performance among implants and suggests audiologic performance depends upon a high-level cognitive skill related to lip reading ability.

INTRODUCTION

Cochlear implants have become a realistic alternative for the management of profoundly deaf patients. A variety of implants, each with differing electrode designs and unique speech coding strategies, have been developed. With so many design variables and the successes reported by each center, comparative measurements of the present generation of cochlear implants is vital to the development of future prostheses. Comparable data is difficult to obtain since uniform measures of performance have not evolved as rapidly as implant technology. Our research efforts have been directed toward establishing an independent center where uniform comprehensive unbiased investigation of different cochlear implants can be performed. This report provides preliminary audiologic results on nine patients with three different cochlear implants.

METHODS

Nine post-lingually deafened adults with three or more months experience with their device are included in the study. Relevant biographical data on the nine patients is found in Table I. Four patients are using the Los Angeles (LA)/1/ implant, three patients wear the Vienna (V)/2/ single-channel intracochlear device, and two patients are implanted with the Melbourne (M)/3/.

Table I. Biographical data on patient

Patient	Age (yrs)	Etiology of Deafness	Duration of Hearing Loss (yrs)	Duration of Profound Hearing Loss (yrs)	Time Since Implantation (months)
LA1	62	otosclerosis	57	10	21
LA2	64	otosclerosis	22.5	3	7
LA3	53	skull fracture	8	8	29
LA4	66	otoxicity	4	4	60
V1	53	congenital syphilis	45	9	7
V2	23	skull fracture	2.5	2.5	7
V3	56	otosclerosis	45	9	7
M1	39	sudden deafness	30	0.5	4
M2	37	Cogans syndrome	10	8	4

All patients except LA2 had profound bilateral hearing loss and appropriate hearing aids were not useful. LA2 had some residual hearing in his non-implanted ear, routinely wore a hearing aid, but was not able to repeat any W-22 words at any presentation. Tests were performed without his hearing aid.

The audiologic battery is a combination of selected tests from the Minimal Auditory Capabilities (MAC) battery /4/ and 12 additional tests called the Iowa Cochlear Implant Tests /5/. The tests are organized into five categories - everyday sounds, prosody tests, closed-set and speech related tests, open-set speech, and audiovisual tests.

Three randomizations of each of the Iowa tests were produced and three randomizations were re-recorded from the MAC tests. The order of presentation of the tests were randomized within and across subjects. In the audiovisual tests, the sound only version was presented before either the vision or sound-plus-vision tests. All three modality versions of the audiovisual tests were separated by at least three hours of testing with the other tests.

All tests were presented at about 70 dB SPL, and subjects were allowed to adjust their implant to a comfortable setting. The audiovisual tests were presented in a sound field in a large quiet room (background level 43 dBA). All other tests were recorded on Maxell UDBXL-II cassette tapes, played back on a Nakamichi LX-5 tape recorder (with Dolby on) and presented in a single-walled sound treatment room.

RESULTS

A. Everyday sounds All patients except LA4 were able to discriminate some everyday sounds, performance on the identification task was poorer. V3 and M1 were able to identify 50% of the sounds while LA2 could not identify any.

B. Prosody tests Only four patients were able to significantly distinguish whether a sentence was a question or a statement. However, eight patients scored above chance on the accent test (fig 1), and all but one patient scored above chance on the number of syllables test (fig 2). There was a slight tendency to do better with plosive or fricative boundaries than with glide/nasal boundaries on the syllables test.

Fig 1 ACCENT

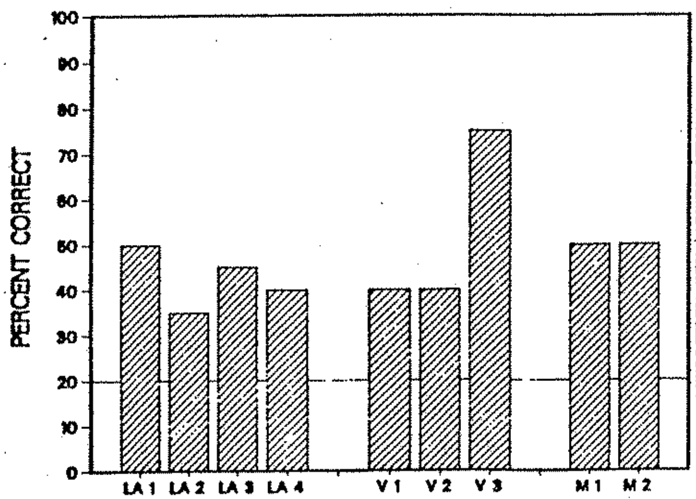
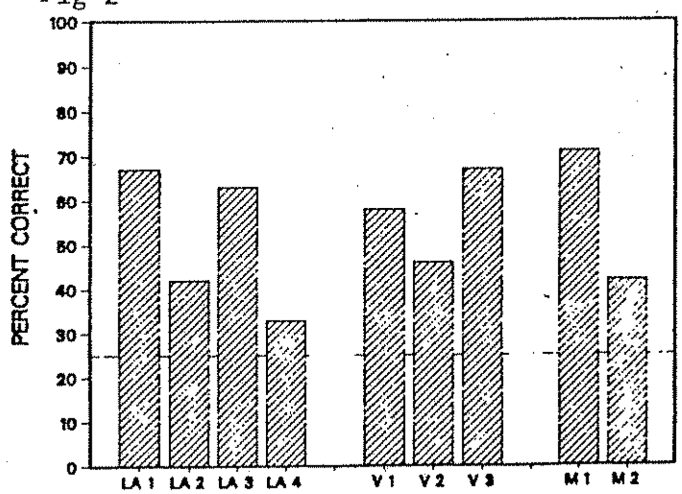


Fig 2 NUMBER OF SYLLABLES



C. Closed-set speech tests and speech related The four-choice spondee and four-choice spondee in noise tests are closed-set. Seven of the patients scored above chance on the four-choice spondee test (fig 3). The dramatic effect of adding noise (at a signal-to-noise ratio of 10 dB) is demonstrated by the observation that only one patient scored above chance on the four-choice in noise test (fig 4).

Most of the patients do very well in the speech related tests. Seven patients performed above chance on the noise/voice test (fig 5) and the female/male test (fig 6). No one, however, could distinguish different speakers if they spoke different sentences.

D. Open-set speech understanding The sound only conditions of the audiovisual tests

Fig 3 SPONDEE TESTS

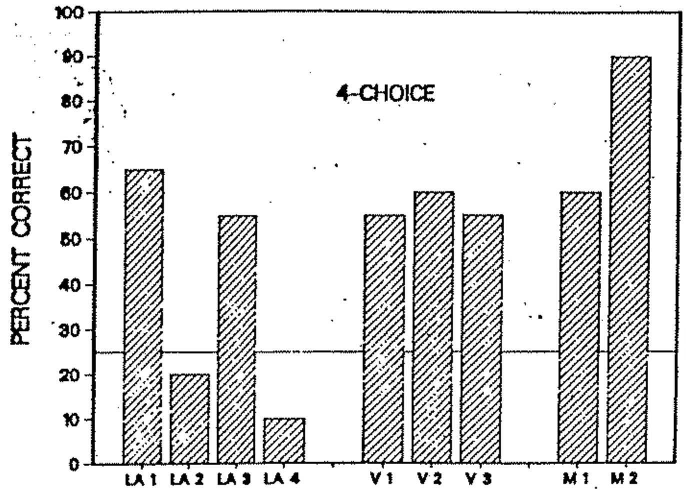


Fig 4 SPONDEE TESTS

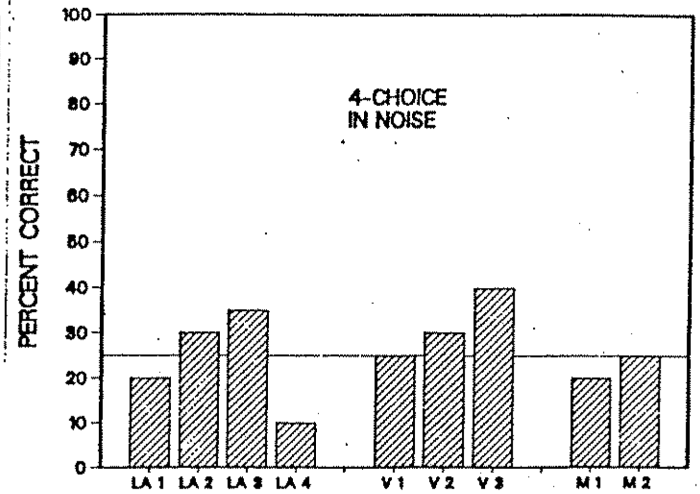


Fig 5 NOISE/VOICE

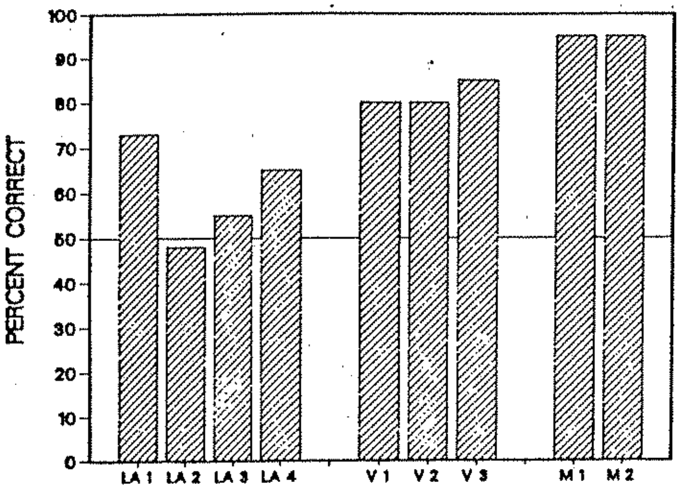
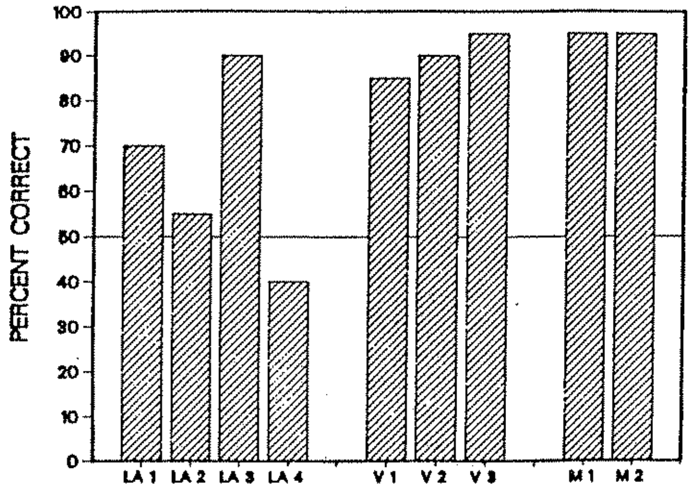


Fig 6 FEMALE/MALE



illustrating one word in the sentence was presented before the sentence is spoken (fig 8), seven of the patients repeated some of the words correctly. In addition, LA3, V1 and M2 got some sentences correct when presented live voice by a companion.

Fig 7 SENTENCE TEST WITHOUT CONTEXT

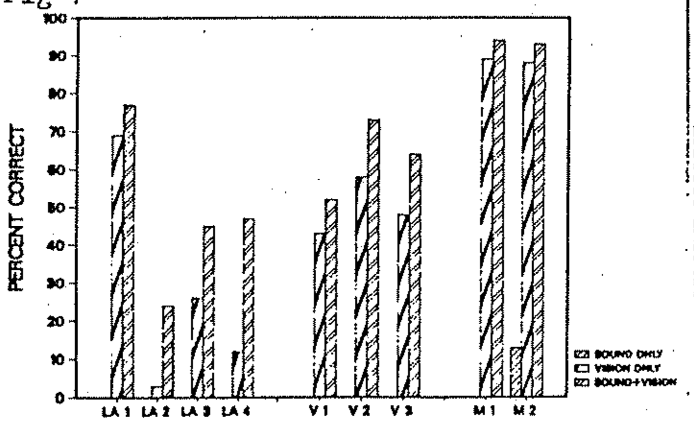
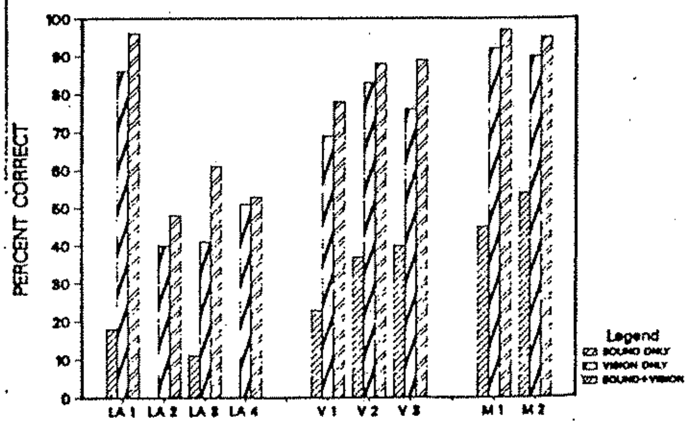


Fig 8 SENTENCE TEST WITH CONTEXT



E. Audiovisual tests Binomial confidence intervals applied to the different scores /6/ were used to determine if the implant provided any additional benefit to speech reading (i.e. vision-plus-sound compared to vision only).

On the sentence test without context (fig 6) LA2, LA3, LA4, and V3 showed a significant improvement with the device. In the sentence test with context (fig 7) LA1, LA3, V3, M1 and M2 scored significantly better with the implant.

DISCUSSION

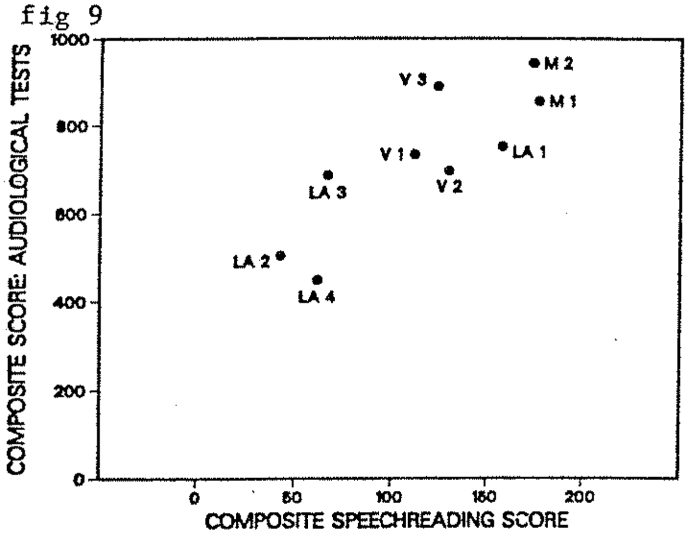
The cochlear implants evaluated in this study provide all patients sufficient information to improve their ability to communicate. They also supply information regarding environmental sounds and warning signals and in some instances it is sufficient for identification of the sound.

Even though most patients performed better than chance on the prosody tasks (question/statement, accent and number of syllables test), it is surprising that their level of performance was not better. All of the implants evaluated in this study should be able to process the voicing frequency (Fo). Even patients with the Melbourne implant which specifically codes Fo as pulse rate, show limited performance on the prosody tests. Some voicing frequency information is being conveyed by all devices as evidenced by the results on the female/male voice test but the processing is not sufficient to discriminate between different speakers of the same gender. Another problem with the present generation of implants is their universal poor performance in noise. Only patient M2 has been able to identify words in open-set presentation of sentences. If, however, contextual information is provided a dramatic improvement was noted. Up to 55% of the words were identified by patient M2. Limited open-set word discrimination was also noted with all three implants in a live-voice test with a familiar speaker such as a spouse. This emphasizes the importance of experience and familiarity with the speaker.

It is obvious from the results that there are large differences among patients. There is also some variability in the rank-ordering among the patients on different tests. Because of these differences, and the fact that the number of patients with each device is small, it is inappropriate to make definitive statements concerning the comparative performance of the three implants at this time.

It is interesting to note that lipreading ability (vision only) correlates ($r = 0.84$; $p < .01$) with audiologic performance (total scores on all tests)(fig 9) irrespective of implant design. One must be careful in emphasizing this point in light of the small number of patients, but lipreading ability may reflect a general high-level cognitive skill necessary to synthesize the limited information provided by the implants. Individual patient differences, i.e. cognitive skills and neuron survival, may effect patient performance more than implant design at this early stage of implant development.

fig 9



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