Speech perception in noise in CI systems with different microphones

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Introduction

Two different tests are used in the rehabilitation program of our clinic to explore the development of speech perception in noise in cochlear implant users:

(1) HSM sentence test (Hochmair, Schulz and Moser, 1997), which was designed especially for cochlea implant users
(2) Oldenburg sentence test (Wagener, Kühnel and Kollmeier, 1990). The patients at our clinic consist of COCHLEAR and MED-EL users in equal parts.

The TEMPO+ system (MED-EL, implant C40+) is using an omni directional microphone, whereas the ESPrit 3G implant system (COCHLEAR, implant CI24R(CA)) is equipped with a frontal designed directional microphone (Fig. 1).

We compared speech perception in noise in recipients of the Nucleus CI24R(CA) implant system (Cochlear, Melbourne) and the Combi 40+ system (MED-EL, Innsbruck) to investigate in what conditions a directional microphone setup can improve speech perception in noise.
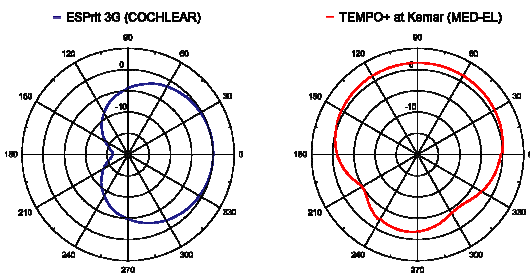

Fig. 1:
Polar diagrams of the microphone charakteristic of ESPrit 3G (left) and TEMPO+ (right) speech processor

Subjects and methods

A group of 11 subjects (Tab. 1) was implanted with the CI24R(CA) device, 9 subjects received the C40+ implant (Tab. 2). The speech tests took place between 2000 and 2005. All patients are post lingual deaf and thus have developed a good spoken language. The average age of the COCHLEAR group was 54±13 years, in the MED-EL group it was 56±14 years. The period of hearing impairment before the date of implantation was 24±18 years in the COCHLEAR group and of 18±12 years in the MED-EL group. Except for 2 patients with an ototoxic cause in the COCHLEAR group, the majority of cases had suffered from an acute hearing loss or a progressively increasing hearing loss as cause of deafness.

The Oldenburg sentence test is composed of 40 test lists of 20 or 30 sentences. Each sentence comprises of 5 words (name, verb, numeral, adjective and object) and ten possible words exist for each of these five positions that can be combined at random. With this test the speech reception threshold L_{50} (speech level that corresponds to 50% intelligibility) is determined.

The HSM sentence test (Westra CD Nr. 15) is composed of 30 test lists with 20 everyday sentences and each list consists of 106 words.

The loudspeaker set-up was S_0N_{180} for the HSM sentence test and S_0N_0 for the Oldenburg sentence test. Both tests were presented with a fixed speech level of 65 dB. The noise level was modified adaptively in the Oldenburg test, whereas the HSM test was carried out at four fixed signal to noise levels (15, 10, 5 and 0 dB).

patient COCHLEAR	age	gender	deafness cause of the implanted ear	period of impairement	testing time OLSA after initial fitting	testing time HSM after initial fitting
C 1	66	m	progressive	40 years	3 months	12 months
C 2	60	f	ototoxic	7 years	3 months	3 months
C 3	60	f	acute hearing loss	10 years	3 months	12 months
C 4	43	f	ototoxic	17 years	6 months	12 months
C 5	40	f	progressive	8 years	12 months	12 months
C 6	35	m	perisynaptic audiopathy	8 years	12 months	12 months
C 7	62	m	progressive	56 years	12 months	12 months
C 8	47	f	meningitis	48 years	12 months	12 months
C 9	72	f	progressive	8 years	12 months	12 months
C 10	43	f	acute hearing loss	35 years	36 months	12 months
C 11	66	f	acute hearing loss	20 years	36 months	12 months

Tab. 1: Subject data COCHLEAR group

patients MED-EL	age	gender	deafness cause of the implanted ear	period of impairement	testing time OLSA after initial fitting	testing time HSM after initial fitting
M 1	51 years	m	Otosklerose	25 years	12 months	12 months
M 2	28 years	f	acute hearing loss	20 years	12 months	12 months
M 3	67 years	f	Otosklerose	40 years	12 months	12 months
M 4	69 years	f	progredient	25 years	12 months	12 months
M 5	50 years	f	progredient	8 years	12 months	12 months
M 6	65 years	m	acute hearing loss	7 years	24 months	12 months
M 7	45 years	f	progredient	3 years	36 months	12 months
M 8	55 years	m	progredient	25 years	48 months	12 months
M 9	74 years	m	acute hearing loss, M. Menière	10 years	48 months	12 months

Tab. 2: Subject data MED-EL group

Results

Compared to the MED-EL subject group the COCHLEAR group showed significant higher speech recognition in the HSM sentence test set-up. In noise significant differences at 10 dB and 15 dB signal-noise-rate (p<0.05) were shown. At 5 dB and 0 dB SNR the results in the COCHLEAR group were highly significant better than in the MED-EL group (p<0.001). Since 6 subjects of the COCHLEAR group were able to understand more than 75% at 0 dB SNR, the test was also performed at -5 dB SNR; the median then was 77%.

As long as the HSM test was presented in quiet, there was no difference in the results of sentence recognition between the two groups, i.e. the results of all patients were located between 80% and 100%.

The average L_{50} (speech level that corresponds to 50% intelligibility) of the Oldenburg sentence test was 1,3 dB SNR for the COCHLEAR group and 2,7 dB SNR for the MED-EL group. The better results of the COCHLEAR group are not significant (T-test, p=0,32) due to their large range (standard deviation: COCHLEAR 2,9 and MED-EL 3,4). The individual L_{50} varied from -1,8 dB SNR (COCHLEAR) respectively -1,5 dB SNR (MED-EL) and 7,7 dB SNR in both groups (Fig. 3).
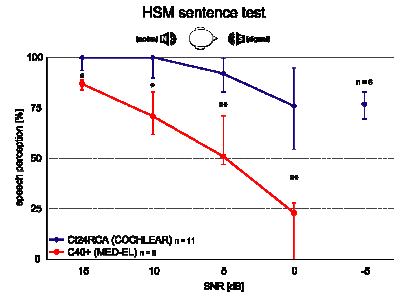

Fig. 2:
Speech perception in noise in two groups of CI recipients. Presentation of speech frontal, noise from behind. Results with median and interquartile ranges (* p<0,05; ** p<0,01).
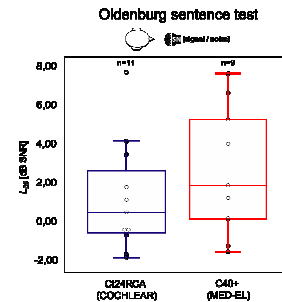

Fig. 3:
Speech perception in noise in two groups of CI-recipients. Speech and noise are presented from the front. Results with median and interquartile ranges.

Conclusions

The test results in our group of subjects do show that directional microphones can improve speech perception in noise of cochlear implant patients under certain circumstances, as already described for hearing aids (Greenberg & Zurek, 1992).

In comparison to an omni directional microphone, a directional microphone does improve speech perception in situations, where a single noise source from behind is the masker.

It is obvious that the selection of test method and loudspeaker set-up is essential to assess and compare speech perception performance in noise. The S_0N_{180} loudspeaker setup showed an improvement of about 10 dB of speech perception in noise in a cochlear implant system which featured a directional microphone.

References

- Greenberg J E, Zurek P M (1992) Evaluation of an adaptive beamforming method for hearing aids. J. Acoust. Soc. Am. 91 (3).
- Hamacher V, Mauer G, Döring W H (1996) Untersuchung eines adaptiven Beamforming-Systems zur Störschallunterdrückung für Hörgeschädigte In: Plenarvorträge und Fachbeiträge der 22. Deutschen Jahrestagung für Akustik (DAGA 96 – Bonn).
- Handbuch und Hintergrundwissen zum Oldenburger Satztest, HörTech, Oldenburg (Version vom 25.07.00).
- Schmid M, Hochmair-Desoyer I, Schulz E, Moser L (1997) Der HSM-Satztest. In: Forschritte der Akustik – DAGA 1997, 93-94.
- Wagener K, Kühnel V, Kollmeier B (1999) Entwicklung und Evaluation eines Satztests in deutscher Sprache. I. Design des Oldenburger Satztests, Zeitschrift für Audiologie 1/1999.