Examining ‚Informational Masking' in cochlear implant users.

Verena Pyschny[1], Markus Landwehr[1], Martin Walger[2], Hasso von Wedel[2], and Hartmut Meister[1]

[1] Jean-Uhrmacher Institute for Clinical ENT-Research, University of Cologne
[2] University ENT-Hospital Cologne, University of Cologne

Introduction

Due to technical progress, cochlear implant (CI) users have improved their speech perception in quiet. Nevertheless, speech recognition in noisy environments still remains challenging. Poor perception in noise is mainly due to the CIs' inability to encode pitch as well as to the restricted resolution of spectral, temporal and amplitude cues. These aspects are of important relevance with regard to the so called "Informational Masking, (IM)".

IM corresponds to the problem of understanding target speech in the simultaneous presentation of a masking speech signal. Stickney et al (2004) examined cochlear implant speech recognition with speech maskers to determine if CI users are able to segregate competing speech stimuli and thus experience a reduction in informational masking. The study revealed that a release from masking could not be found even when the single-talker masker differed from the target speaker. The present study aims to examine to what extent Cochlear Implant (CI) users are able to understand a target signal if it is masked with a simultaneously presented speech masker differing in fundamental frequency (Δf0) and in target-to-masker ratio (TMR).

In contrast to the study of Stickney et al (2004) who used natural utterances differing in several speaker characteristics the present study is based on artificial modifications of f0. Thus, other voice cues remained unchanged and do not play a role in the data collected.

It is hypothesized that with the addition of different parameters (f0 and TMR) a release from masking occurs which yields improved perception of the target talker in CI-users.

Methods and Subjects

Stimuli were derived from the German Oldenburg-sentence-test (OlSa) (Wagener et al., 1999a-c). The OlSa presents nonsense – phrases such as "Stefan malt acht nasse Sessel". An important advantage of the OlSa in view of IM is that a keyword can be defined in order to assign the target sentences. In this case the name "Stefan" was chosen as a keyword. In contrast, the masker sentences contained randomly selected words other than in the target sentence.

With a pitch-synchronous overlap and add (PSOLA) algorithm used in the software package 'Praat' (Boersma et al., 1996) the original male voice was modified with respect to the fundamental frequency (f0). For the sentences f0 was manipulated within 20 Hz steps, yielding a range from 100 Hz to 180 Hz. Further, target-to-masker ratios (TMR) within 5 dB steps were introduced covering a span from 0 dB to 20 dB TMR.

The target and masker sentences were superimposed and the following three conditions were tested: (1) Target and masker sentence with differences in f0, (2) target and masker sentence with differences in TMR and (3) the combined modification of both parameters.

For each condition 4 test lists with 15 sentence pairs were presented. All conditions were tested in a randomized order. Prior to the test, two lists of 10 sentences each were presented in quiet so that subjects could familiarize with the procedure and the test material. Further, to get used to the specific demands of IM one training list of 20 sentence pairs was presented.

Signals were presented over a single loudspeaker with 0 azimuth at 70 dB SPL in a sound proofed booth.

The requirement to participate in the study was a speech intelligibility of 100% in quiet tested within the OlSa. Subjects were six postlingually deafened adult CI-recipients with an average age of 50 years (39-69 years) and a control group of six normal hearing listeners (NL) with an average age of 45 years (27-63 years).

Results

Fig.1 shows percent correct scores for speech intelligibility as a function of the TMR for the differences in f0 for NLs and CI-users.

For the normal listeners, a Wilcoxon's matched pairs test indicated significant differences for the same talker condition and the remaining f0 alterations ($p < 0.05$). A ceiling effect occurred from 40 Hz difference upwards. The TMR showed the same pattern. Significant difference could be shown between 0 dB and all other TMRs ($p < 0.05$). Due to the ceiling effects no statement could be made about the combination of f0 and TMR.

In the CI-users the Wilcoxon test indicated no significant differences ($p > 0.05$) at 0 dB TMR with respect to alterations in f0. In contrast, the TMR showed significant differences ($p < 0.05$) between 0 dB and all other TMRs as well as between 5 dB and the remaining TMRs for all conditions. A significant difference could also be measured between 10 dB TMR and 20 dB TMR in all conditions. From 15 dB upwards a ceiling effect occurred. The combination of f0 and TMR indicated an additional effect at 5 dB ($p < 0.05$) between0 Hz and 60 Hz and between 0 Hz and 80 Hz difference. All other comparisons revealed non-significant effects.

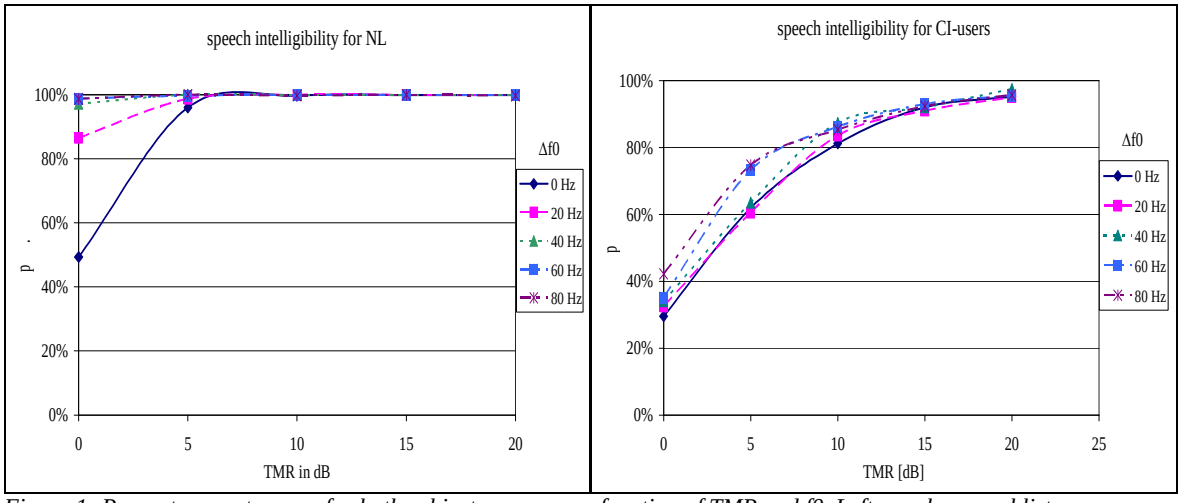

Figure 1: Percent correct scores for both subject groups as a function of TMR and f0. Left panel: normal listeners, right panel: CI-users

Discussion

This study investigated CI-users' ability to understand speech whilst a competing talker was present and evaluated a release from masking due to different f0s and TMRs. The results for NL shown in Fig. 1 revealed significant improvement for the smallest difference in f0 as well as the smallest TMR. Ceiling effects occurred for larger changes in both parameters. In a study by Brungart (2000) performed with normal hearing listeners effects of IM were similar. Pitch differences as well as level differences had an influence on performance whereas the TMRs dominated speech intelligibility and caused the greater release from masking.

In contrast, our experiments show that CI-recipients are not able to separate two competing talkers with alterations based only on f0. The explanation for this are the restrictions in signal processing of the CI mentioned before. However, there is a clear benefit from changes in TMR. The combination of both factors revealed improved speech intelligibility only at 5 dB TMR (Fig. 1, right panel). Larger TMRs dominate speech perception whereas the influence of f0 decreases.

Regarding our hypothesis it is clear that, in contrast to NL, CI-recipients benefit from improved TMR but hardly obtain any release from masking with different fundamental frequencies of the competing talkers.

Acknowledgments

We would like to thank our subjects for their time and dedication. This research was supported by Cochlear ltd, Germany.

References

Boersma P, Weenink D (1996) Praat, a system for doing Phonetics by Computer, version 4.4.22. Institute of Phonetic Sciences, University of Amsterdam; www.praat.org.

Brungart D S (2001) Informational and energetic masking effects in the perception of two simultaneous talkers. J. Acoust. Soc. Am. 109 (3), 1101 – 1109.

Stickney G, Litovski R, Assmann P (2004): Cochlear implant speech recognition with speech maskers. J. Acoust. Soc. Am. 116 (2), 1081 – 1091.

Wagener K, Brand T, Kollmeier B (1999a): Entwicklung und Evaluation eines Satztests für die deutsche Sprache II: Optimierung des Oldenburger Satztests. Z Audiol 38 (2), 44 – 56.

Wagener K, Kühnel V, Kollmeier B (1999b): Entwicklung und Evaluation eines Satztests für die deutsche Sprache I: Design des Oldenburger Satztests. Z Audiol 38 (1), 4 - 15.

Wagener K, Brand T, Kollmeier B (1999c): Entwicklung und Evaluation eines Satztests für die deutsche Sprache I: Evaluation des Oldenburger Satztests. Z Audiol 38 (3), 86 - 95.