Application of a model for the auditory comfort prediction for hearing impaired persons

G. Schmalfuß, J. Haubold

ciAD® – Competence in AudioDesign, D-44287 Dortmund, Witthausstraße 42,
{schmalfuss, haubold}@audioquality.de

Contents

Introduction

- Objective: Improvement of the comfort of ICF settings
  - ICF = hearing aid (fitting) with increased high cut-off frequency (8 kHz ...10 kHz)
- Practical part: demonstration software for ICF HI's
  - Software simulates ICF and Standard HI's
  - Hearing impaired persons can compare the simulated devices
- Scientific part: presetting of ICF range for the demonstration case (adapted to "first listening")

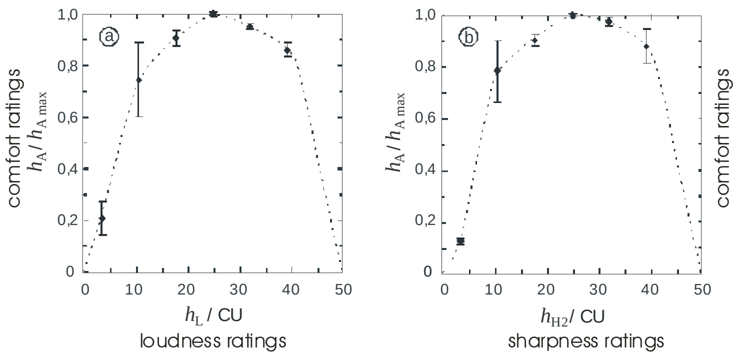
ICF problems

- Standard fitting rules are not sufficient for the ICF range
- Exact fitting is needed
- Hearing impaired persons have small range of acceptance tolerance
- It is difficult to fit the ICF-range
- To much ICF gain:
  - Risk of reduced hearing comfort
  - Increased high cutt-off frequency is equal to increased sharpness
  - Sharpness is strongly dependent on signal energy above 12 Bark
- To less ICF gain:
  - No effect is audible

Approach

- Main idea
  - The negative influence of more sharpness will be compensated with a low frequency boost
  - Possible following Zwicker
  - "first listening"
- Question: How should this boost be realized?
- Study to find correction rule and factors
- Usage of a model of auditory comfort for hearing impaired persons MCHI

MCHI - basics

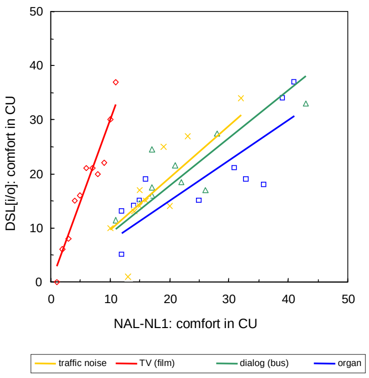


- The adaptation of the auditory preprocessing in models of auditory comfort is not sufficient to get results for hearing impaired persons
- Different fusion rules of hearing dimensions to comfort between HIP and NHP are needed

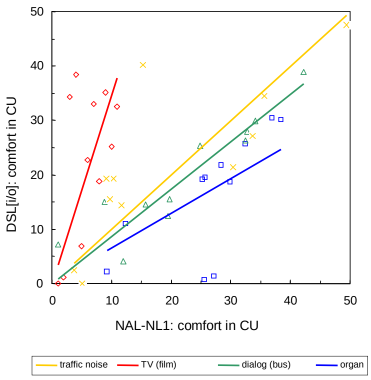
MCHI - validation results

Validation results of a SIEMENS-study 2004 (Fröhlich, Schmalfuß, Haubold):

Probands:

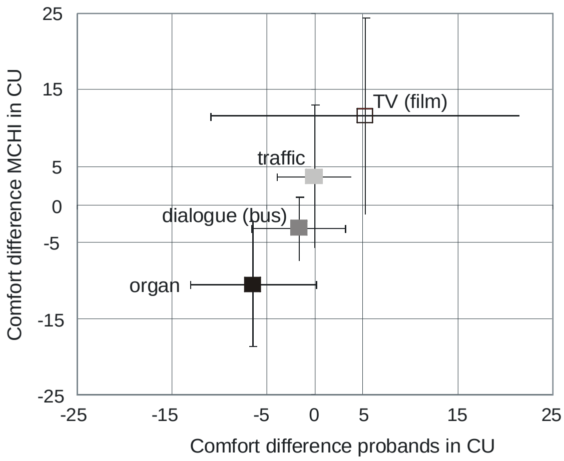


MCHI:



MCHI - validation results

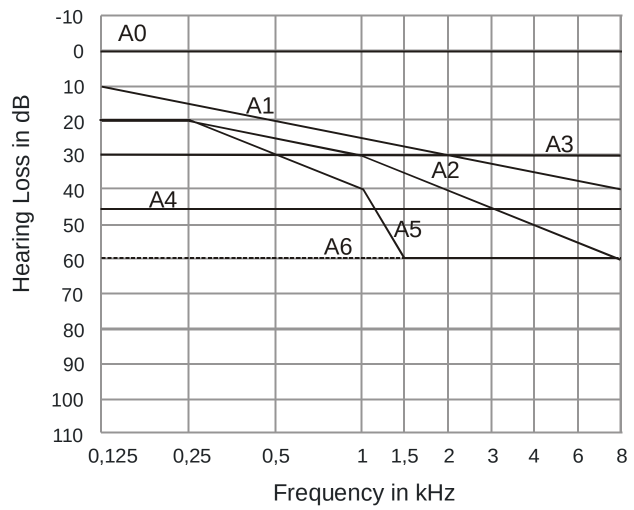
Validation results of a SIEMENS-study 2004 (Fröhlich, Schmalfuß, Haubold):



MCHI - application

- The MCHI was used to find the right low frequency boost to get comfortable settings for an ICF demonstration tool.
- Steps:
  - select prototype audiograms
  - prepare HI-sound examples with different compensation curves
  - use MCHI to calculate comfort instead of performing listening tests

Application: prototype audiograms



Application: sound examples

- speech in quiet (conversation in living room)
- speech in party noise
- speech in traffic noise (conversation at the street)
- classical music
- pop music
- stream
- forest (chirping birds)

Application: compensation curves

- Boundary conditions for the compensation peak:
  - boost:
    - ✓too low: no compensation effect
    - ✓too high: audio quality decreases
  - centre frequency :
    - ✓too low: not possible with hearing aids (lower cut-off frequency)
    - ✓too high: too large boost is needed to get influence on sharpness
  - bandwith:
    - ✓too low: drone sound
    - ✓too high: affecting the speech region

Application: compensation curves

- tested compensation curves:

frequency in Hz	80	100	125	160	200	250
gain in dB	0.8 1.5 2.2 3 3.8 4.5	1.5 3 4.5 6 7.5 9	3 6 9 12 15 18	3 6 9 12 15 18	1.5 3 4.5 6 7.5 9	0.8 1.5 2.2 3 3.8 4.5

Application: results

- MCHI calculations were performed

  effort = 7 audiograms x 7 sound examples x 6 compensation curves
- A correction rule with the following properties was found:
  - strong dependency on sound environment
  - increasing gain: broader gain shape
  - dependency on low frequency hearing loss:

$$HV_T = \max\left(\frac{HV_{125Hz} + HV_{250Hz}}{2}, 60\,\mathrm{dB}\,HL\right)$$

Application: results

sound example	comfort difference in CU (0 ... 50)		
	ICF without correction vs. standard setting	ICF with correction vs. standard setting	**improvement by correction**
speech in quiet	-5.7	0	**+5.7**
speech in party noise	-19.2	-8.2	**+11.0**
speech in traffic noise	-10.2	-7.8	**+2.4**
classical music	-3.3	-0.3	**+3.0**
pop music	-13.3	-0.4	**+12.9**
stream	-9.3	-6.1	**+3.2**
forest	-6.4	-4.6	**+1.8**

- **The preferences were confirmed by subjects**

Summary (1)

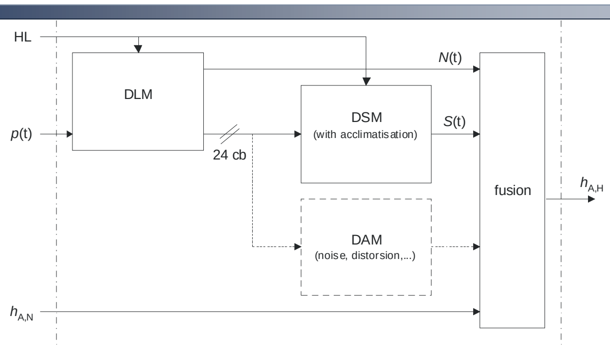
- A model for the calculation of hearing comfort for hearing impaired persons MCHI was shown
- Some validation results were presented
- It was shown that the MCHI is able to calculate comfort differences of presettings (like NAL-NL1 or DSL [i/o])
- The MCHI was applied to find a presetting modification for simulated ICF-hearing aids
- The presetting rule was used in a demo tool and therefore optimized to "first listening"

Summary (2)

- The simulation results recommend an adapted presetting rule also for real ICF hearing instruments to make ICF devices more comfortable
- The MCHI can be used also to accelerate the development process of such an ICF presetting rule

Thank you for your attention.

MCHI - model overview



(Schmalfuß, 2004)

p(t)	Sound-pressure-time-function of the processed sounds
$h_{A,N}$	Subjective reference of the comfort of only the original sound, judged by NHP
$h_{A,H}$	Comfort regarding the processed sound calculated for HIP