Frequency Compression Technology in Hearing Aid Fitting in Children

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Speechspectrum

Identification/Intelligibility of high frequency sounds

- **Severe Hearing loss:**
  Difficulty in recognizing high frequency speech sounds like: /f/, /s/, /sh/

- **Grammatical Information:**
  - Plurality of pronouns
  - Possessive pronouns

*Pat Stelmachowicz et al., 2000 – 2004, Boys Town*
Speechspectrum

/S/ male, female, child speaker

~ 5 kHz male
~ 6-9 kHz female
~ 9 kHz child

Boothroyd et al, 1992
Stelmachowicz et al, 2001
Hearing instruments

More gain in high frequencies?

- Increased risk of feedback
- More high frequency gain is often considered uncomfortable – too loud, too shrill, too sharp
- Dead Regions - „off frequency listening“
Hearing Impairment

**Dead Regions**

„... regions in the cochlea with no or few functioning inner haircells and /or neurons“

*(Moore 2004)*
Frequency compression (FC) = SoundRecover

Launer, Chicago 2007
Frequency Compression (FC)

Original signal

Simulated high frequency hearing loss

Non-linear frequency compression

Launer, Chicago 2007
Frequency Compression (FC)

- Cut-off frequency between 1.5 and 6 kHz
- Compression ratio between 1.5:1 and 4:1
- Compression is only applied to frequencies above the cut-off frequency

Launer, Chicago 2007
Some studies on Frequency Compression

Glista et al., 2009a, *Int J Audio* 1-13, DOI: 10.1080/14992020902971349

Glista et al., 2009, *Hearing Review*, 16 (12): 20-24
- FC improves detection/recognition (group vs individual)
- Significant candidacy factors (hearing loss, age group)

Wolfe et al., 2010, *J Am Acad Audiol* 21 (10): 618-628
- FC improves audibility for sounds and speech recognition in quiet
- FC offers improvement in recognition in noise

Bohnert et al., 2010, *Eur Arch Otorhinolaryngol*, DOI 10.1007/s00405-009-1170-x
- FC improves speech recognition in quiet and in noise
Pediatric Fitting Method for FC

Protocol developed by

Glista & Scollie

*Audiology Online* 2009

Scollie, Glista, Bagatto, Moodie

*Ontario Infant Hearing Program* 2011

Frequency-Lowering Hearing Aids

Protocol Addendum and Support Document
Fitting Method for FC (pediatric)

1. Frequency response should be based on DSL 5 m [i/o] child

2. Fit to target with FC \textit{disabled}
   
   Provide audibility of high frequency cues as good as possible
   
   Measure with speech shaped signal / ISTS

3. \textit{Enable} FC

4. Measure with speech shaped signal / ISTS \textit{and} with filtered high frequency speechband stimuli

5. Life voice - /s/ and /sh/
Verification

- Speech shaped signal / ISTS Signal (International Speech Test Signal)

- Filtered high frequency speech band signal
Verification

- Filtered high frequency speech band signal (Speechsignal)

Screenshot from Audioscan Verifit

Centre frequencies:
- 3150 Hz
- 4000 Hz
- 5000 Hz
- 6300 Hz

Notch filtered speech signal

High frequency band is left

The notch lets you observe lowering the high frequency band
FC disabled / enabled

- Filtered high frequency speech band signal (Speechsignal)

Without FC, 6300 Hz below threshold
FC disabled / enabled

- Filtered high frequency speech band signal (Speechsignal)

With FC, 6300 Hz above threshold

/\s/ is audible now!

Without FC, 6300 Hz below threshold
FC settings

- Software provides default setting for FC
- Cut off frequency / Compression ratio set to audiogram better ear
- Verify the audibility of /s/ and /sh/
- Fine-tune if necessary...!!!!!!!

Default setting
FC settings

- Software provides default setting for FC
- Cut off frequency / Compression ratio set to audiogram better ear
- Verify audibility of /s/ and /sh/
- Fine-tune if necessary....!!!!!!!

Fine-tuning
Fine tuning hints for FC setting

FC is too weak – not audible enough

- High frequency cues are not audible
- No improvement, neither in measurements nor in verbal reports
Fine tuning hints for FC setting

FC is too strong - overlapping

- /s/ and /sh/ cannot be distinguished
- Patient hears him/herself lisping
- Everything sounds sharp, shrill, too loud
- Issues may occur mainly with female voices (start with weaker settings and let acclimatize)
Fine tuning hints for FC setting

FC well adjusted:

- Difference between /s/ and /sh/ is audible
- Patient perceives everything a bit „softer“
- Speech is perceived as clearer
- Patient may hear sounds not heard before
Two examples.....

Sub A steep loss

10 y, good speech development
Traditional HI = Eleva 411

Sub B flat loss

8 y, good speech development
Traditional HI = Siemens Artis P
Two examples..... Sub A steep loss

Traditional HI

NLFC HI
Two examples.....

Sub B flat loss

Traditional HI

NLFC HI
## Case studies

### Speech Scores open and closed sets

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<tr>
<th></th>
<th>Subj A</th>
<th>Subj B</th>
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<tbody>
<tr>
<td></td>
<td>T2 = 1 week / T5 = 6 months</td>
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<tr>
<td><strong>Open set words</strong></td>
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<td>Trad HA</td>
<td>30 %</td>
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<td>50 %</td>
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<td><strong>Freq Comp T2</strong></td>
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<tr>
<td><strong>Closed set quiet 65 dB SRT</strong></td>
<td>36 dB</td>
<td>56 dB</td>
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<td></td>
<td>32 dB</td>
<td>42 dB</td>
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<td></td>
<td>27 dB</td>
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<tr>
<td><strong>Closed set noise 65 dB SNR</strong></td>
<td>2 dB</td>
<td>9 dB</td>
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<td></td>
<td>-5 dB</td>
<td>7,7 dB</td>
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<tr>
<td></td>
<td>-3,5 dB</td>
<td>3 dB</td>
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</tbody>
</table>

T2 = 1 week / T5 = 6 months
Case studies

**Subject A**

Hears new sounds, birds etc.

More relaxed after school

Rather relaxed facial expression

Trivial sounds are recognized earlier

TV set to normal volume

Speaks with clearer voice – more self confident

**Subject B**

Teacher can be heard with less effort

More relaxed after school

Audio books can be heard with normal volume

More open-minded – takes part in holiday camps with 50 children

Does not accept everything in conversation, but argues
Summary

Several studies showed significant improvements in…….

- Aided sound detection
- Speech recognition in quiet and in noise
- Subjective benefit
- For mild to moderate, severe and profound HL
- Acclimatization effects for newly audible HF sounds
Summary

✓ Viable and robust technology for all hearing losses
✓ It does need to be individually and carefully fitted

Respect the protocols for fitting Lowering Technologies!!
Clinical implications - future questions....?

*We still need to learn more.......for example:*

- Cochlear implant candidacy
- Asymmetrical hearing loss
- Auditory neuropathy disorders
- Bimodal fittings
Clinical implications - future questions....?

- Test results may be not always consistent
- Do we have the right tests to show all effects of modern technology?

_We should always listen to our children....._