A review of the benefits of SoundRecover for children

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Identification of high frequency speech 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
Identification of high frequency sounds

- Identification of many types of sounds....
  - Birdsongs
  - Alarms
  - Doorbells
  - Telephone ring tones etc.

- Sounds are valuable – enhance the quality of a child’s overall experience of hearing

*Refers to children with tonal and non-tonal languages*
Speech spectrum

\(/S/\) 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)

- Different FC settings
- FC is only applied to frequencies above the cut-off frequency
- FC output signals do not overlap lower frequencies
- Global relations between different speech components remain intact
Frequency Compression (FC)

What happens if we use frequency lowering?
Who is a candidate?
Does it help?
Is there evidence .....?

A lot of studies are available from.........
Studies on Frequency Compression

Glista et al., 2009a  *Int J Audio1-13, DOI: 10.1080/14992020902971349*

Glista et al., 2009  *Hearing Review, 16 (12): 20-24*

Scollie et al., 2011  *ENT & Audiology News, vol. 20, no. 5, pp. 83–87*


Glista et al., 2012  *American Journal of Audiology, 21: 76-81*

Glista et al., 2012  *Journal of Speech, Language, and Hearing Research. Vol. 55,1-23*
Studies on Frequency Compression

Wolfe et al., 2009  *The Hearing Journal* 2009  62(9): 32- 35

Wolfe et al., 2010  *J Am Acad Audiol* 21 (10): 618-628

Bohnert et al., 2010  *Eur Arch Otorhinolaryngol*, DOI 10.1007/s00405-009-1170-x

Wolfe et al., 2013  *The Hearing Journal*, 66(9), 26-29

Wolfe et al., 2014  *The Hearing Journal*, in press

Wolfe et al., 2014  *J Am Acad Audiol*, submitted

Wolfe et al., 2014  *J Am Acad Audiol*, submitted
Studies on Frequency Compression

They found ..... 

- Significant improvements in high frequency speech sound detection and recognition
  - No decrement for vowel recognition

- Improved audibility for sounds and speech recognition in quiet

- Offers improvement in recognition in noise
Studies on Frequency Compression

They found ..... 

• Significant candidacy factors
  
  - Greater degree of high frequency hearing loss
  - Children had more benefit and preference
  - Individual variability
  - Possible acclimatization effects
  (6 to 8 weeks, may relate to degree of HL)
Frequency Compression – own studies

Children with a severe to profound loss:

- Can we demonstrate speech recognition benefit?
- In quiet as well as in noise conditions?
- How long will it take for children to acclimatize?

Which configurations of hearing loss will benefit....

Steep or flat losses???
Clinical field trial

- 13 children (4 f, 9 m)
- 6-15 years of age (Mean Age: 10 years, 5 mths)
- Full-time users of digital behind-the-ear hearing aids.
- Fitted on DSL basis with high quality HA
- No previous experience with frequency lowering technology
- Oral-Aural communicators with German as primary language
Study - Group results – GII T1 vs T5
Study – Group results – HF-AAST in quiet

Spondee Test in quiet
- high frequency words -

SRT (dB)

SPIQ HI on T1
SPIQ SR on T2
SPIQ SR off T2
SPIQ SR on T5
SPIQ SR off T5

Subject 1
Subject 2
Subject 3
Subject 4
Subject 5
Subject 6
Subject 7
Subject 8
Subject 9
Subject 10
Subject 11
Subject 12
Subject 13
Study – Group results – HF-AAST in noise

Spondee Test in noise
- high frequency words (trochee) -

Subject 1-13

T1 vs T5 on  p<0.001 on / T1 vs T5 p<0.005 off
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)

Notch filtered speech signal

High frequency band is left

The notch lets you observe lowering the high frequency band

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

Screenshot from Audioscan Verifit
**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)

Without FC, 6300 Hz below threshold

With FC, 6300 Hz above threshold

/s/ is audible now!
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....!!!!!!!
FC settings

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

Fine-tuning
Take home message for FC fitting

- Fine tuning is possible!
- Gain and FC interact
- Less high frequency gain use a stronger FC setting to make /s/ audible

Use always the weakest setting that has positive effects to make /s/ audible
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 adults and children
✓ It does need to be individually and carefully fitted

Respect the protocols for fitting Lowering Technologies!!
What about FC and tonal languages...?

A language difference is expected due to........

- **Lexical tone** contribution

- The consonant-vowel syllable structure in Mandarin differs significantly from the complex syllable structure of English

- Mandarin sentences result in a larger proportion of sentences being identified based on vowel segments (i.e., 66% in Mandarin vs. 45% in English [Chen, Wong and Wong, JASA 2013; Fogerty and Kewley-Port, JASA 2009])

- The statistical probability of syllable identification in Mandarin based on vowel segment is much higher than in English
What about FC and tonal languages...?

- HF information is important, but not to the same extent as in non-tonal languages.
- Low frequency information - vowel carries about 3 times more information as e.g, in English (2:1) (Chen, Wong and Wong, JASA 2013)
- HF consonants do not carry lexical information

HF are important carriers of speech information

eg. distinguishing different words
What about FC and tonal languages...?

- Most tonal information is contained in frequencies below 1500 Hz
- Therefore FC do not harm tonal languages

*High pitched environmental information is important for the quality of a child’s overall experience of hearing.*
Clinical implications – future questions...?

*We still need to learn more.........*

....about the effects of *FC and tonal languages*

**Studies**
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**Team of Dr. Anna Kam**
„Clinical Evaluation of Frequency Compression Technology”

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**Team of Dr. Chen**
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