

# Frequency lowering hearing aids: New techniques for fitting

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# Historical evolution:

60's 70's

- Earliest attempts
- Not all were real time

80's 90's

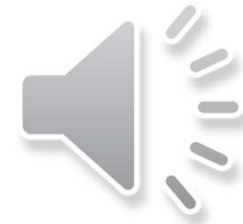
- Early commercial products

2000's

- First nonlinear frequency compressors
- Ongoing development of multiple types of frequency lowering

# Clinical uses of Frequency lowering?

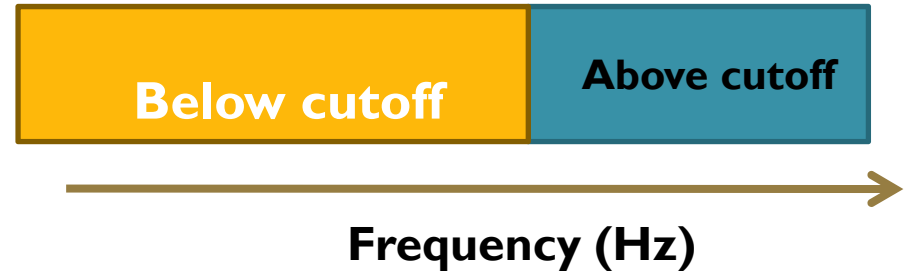
- Frequency lowering can be used to overcome bandwidth limitations of:
  - The ear
  - The device
- What cues are missing if you cannot hear above 2k?



# Frequency Lowering (FL): three types

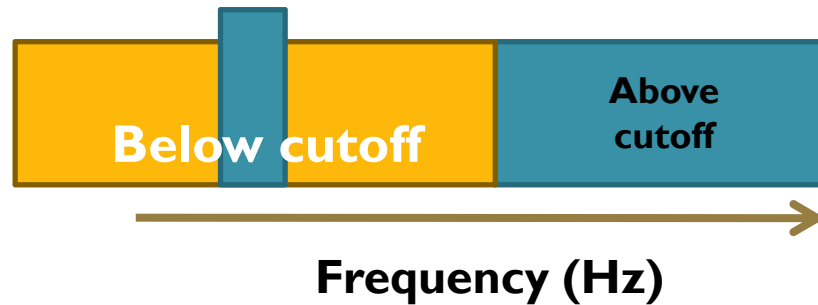
- Frequency Compression (FC)

- Phonak SoundRecover<sup>®</sup>
- Siemens FC



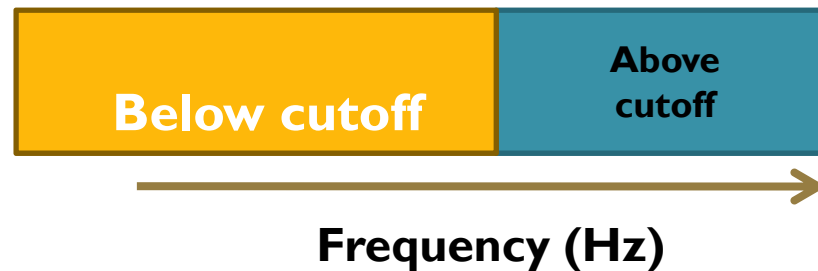
- Frequency Transposition (FT)

- Widex AudibilityExtender<sup>®</sup>



- Frequency translation

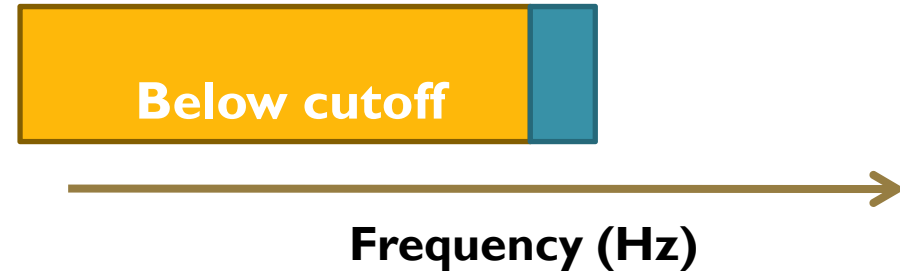
- Starkey Spectral IQ<sup>®</sup>



# Frequency Lowering (FL): three types

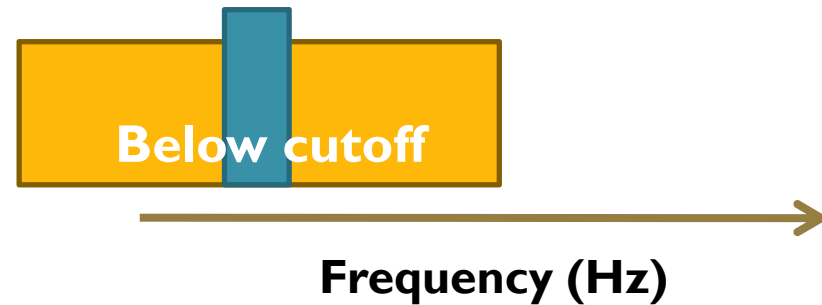
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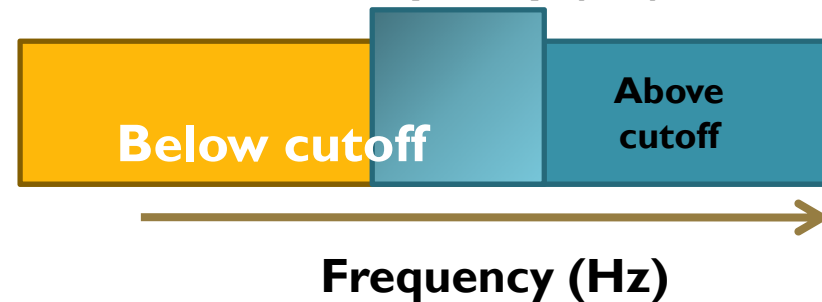
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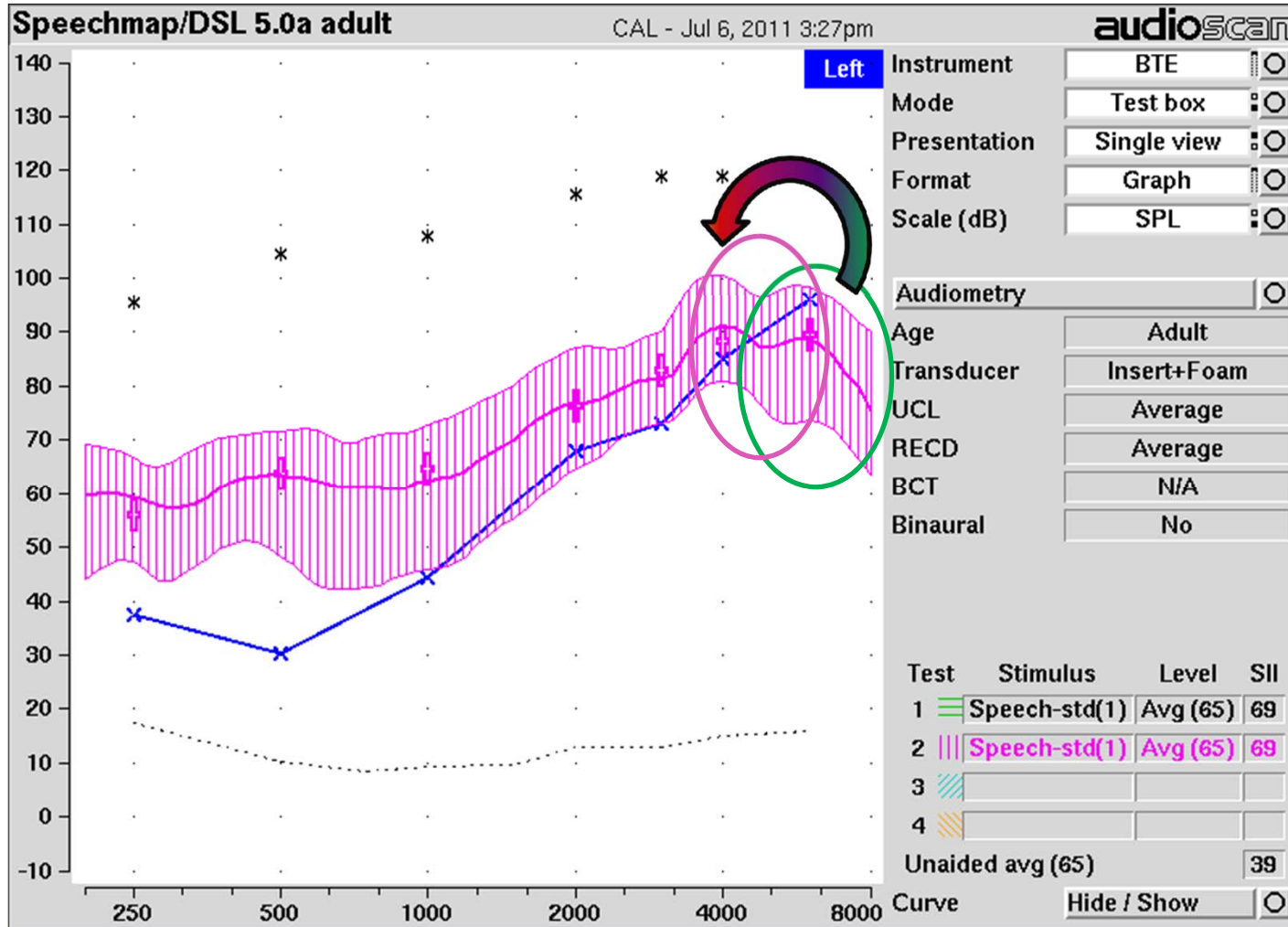



- Frequency translation

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# Why might we use it?





**What happens if I use frequency lowering?  
Does it help and for whom?**

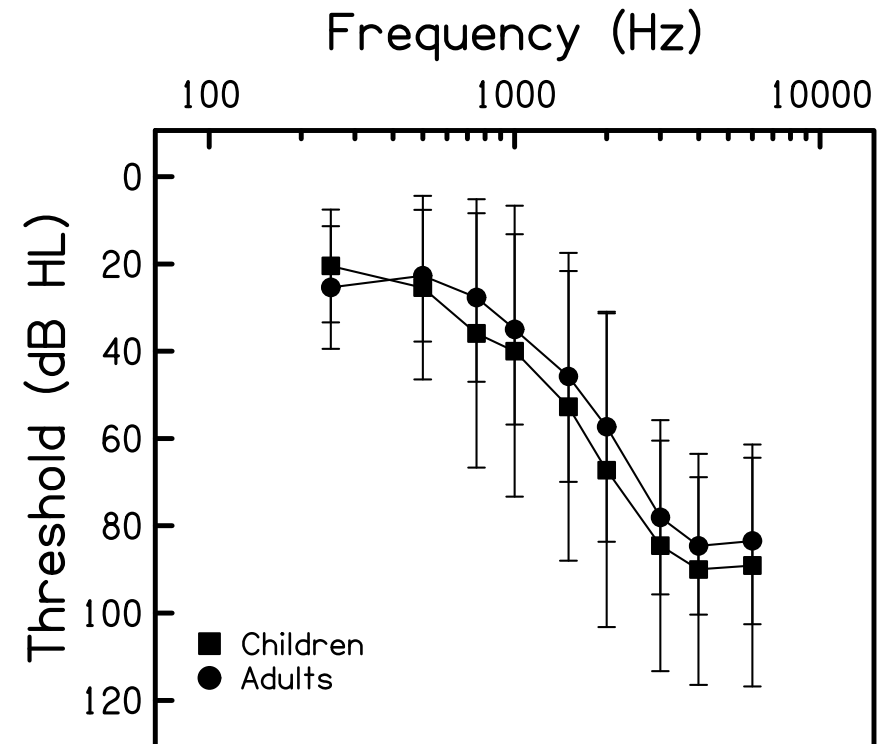
For reprints of published work, go to:

[http://www.dslio.com/page/en/pubs\\_downloads.html](http://www.dslio.com/page/en/pubs_downloads.html)



# Outcomes in adults and children:

- 24 patients: 11 children and 13 adults
- Phonak frequency compression (pre-commercial, ear level devices)




Glista et al (2009a), IJA, (2009b)

Hearing Review

Support: NSERC-CIHR CHRP, Hearing Foundation of Canada, Phonak AG

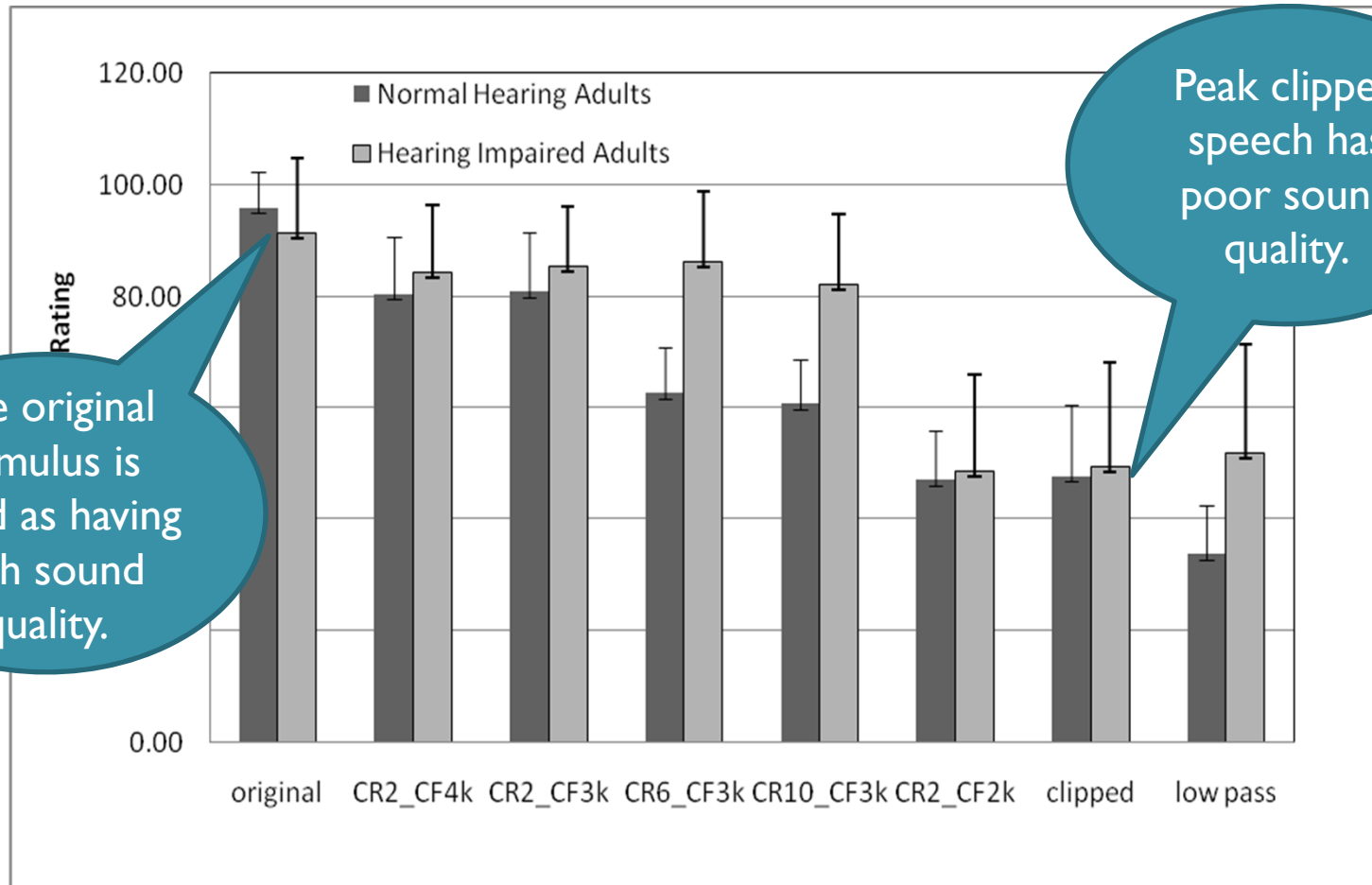




## Our adults with High Frequency Hearing losses $\geq 65$ dB HL:

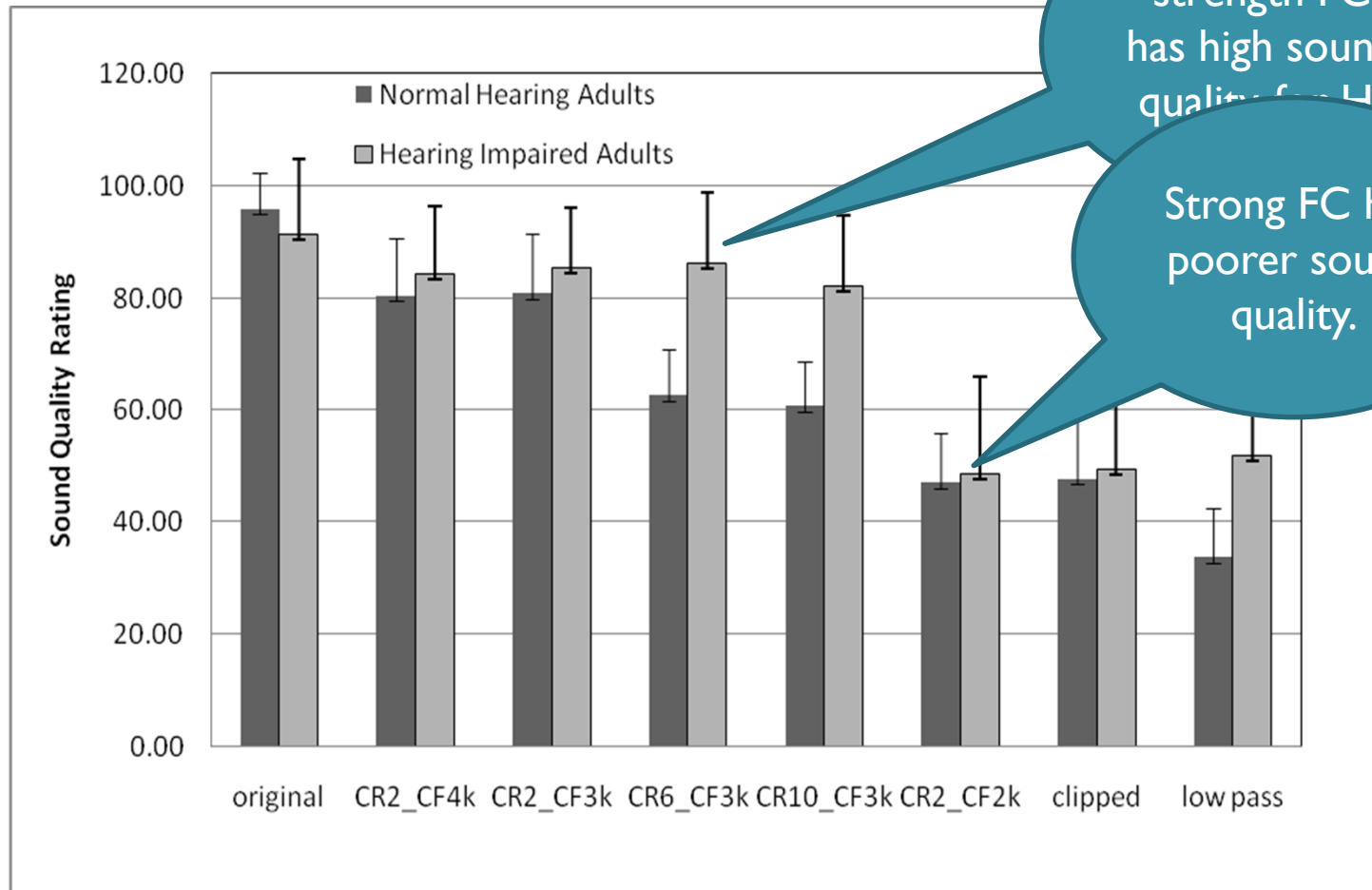
- 4 out of 6 improved in S or SH detection
  - 1 other was poorer, 1 had no change
- 4 out of 6 improved in detection of word-final plural cues (e.g., book vs. books).
  - Two of these had significant double blinded preference for frequency compression.
  - The other two had no preference for either frequency compression or conventional.

# Our adults also rated the sound quality of female speech:



(Parsa et al, accepted)

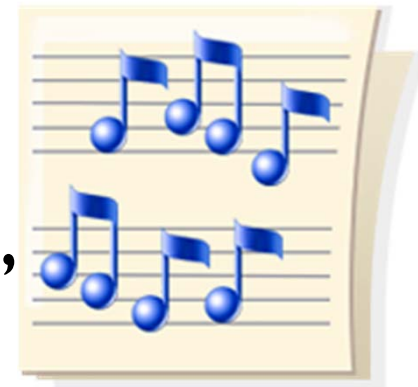
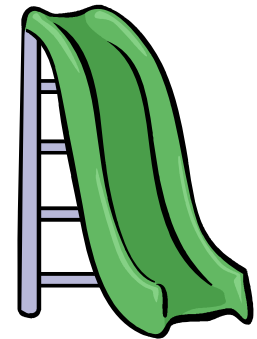
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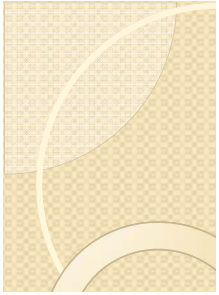
(Parsa et al, accepted)

# Other sound quality results:

- Sound quality declines gradually across the range of cutoff frequencies from about 3000 Hz to about 1600 Hz.
  - No abrupt steps in sound quality change
  - More noticeable for female speech
  - Implications for fine tuning?
- For speech in noise and for music, listeners with hearing loss rated fewer changes in sound quality than they did for speech in quiet.

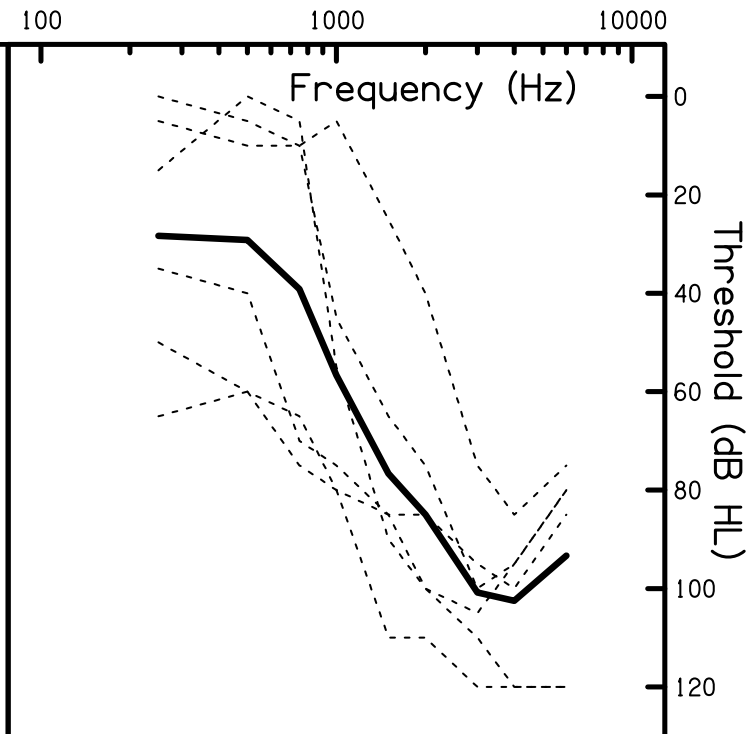


(Parsa et al, accepted)



# Acclimatization?

- 6 participants (11-18 years)
  - DSL5 at baseline trial
  - Four month trial with frequency compression, no training.
- Some participants had significant acclimatization trends: 6 to 8 weeks.
- May relate to degree of hearing loss?



Glista, Scollie, and Sulkers (2012, JSLHR)  
Support: CIHR Banting & Best, Phonak AG

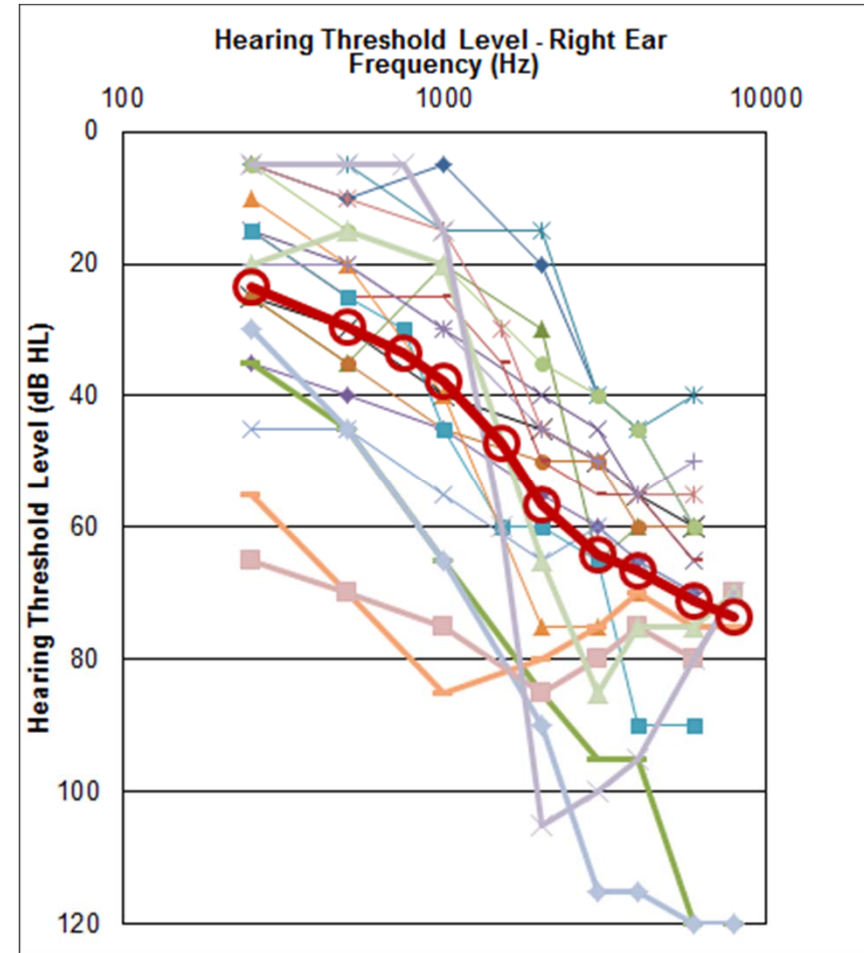
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# **FINETUNING FREQUENCY COMPRESSION?**



# Testing multiple FC settings:

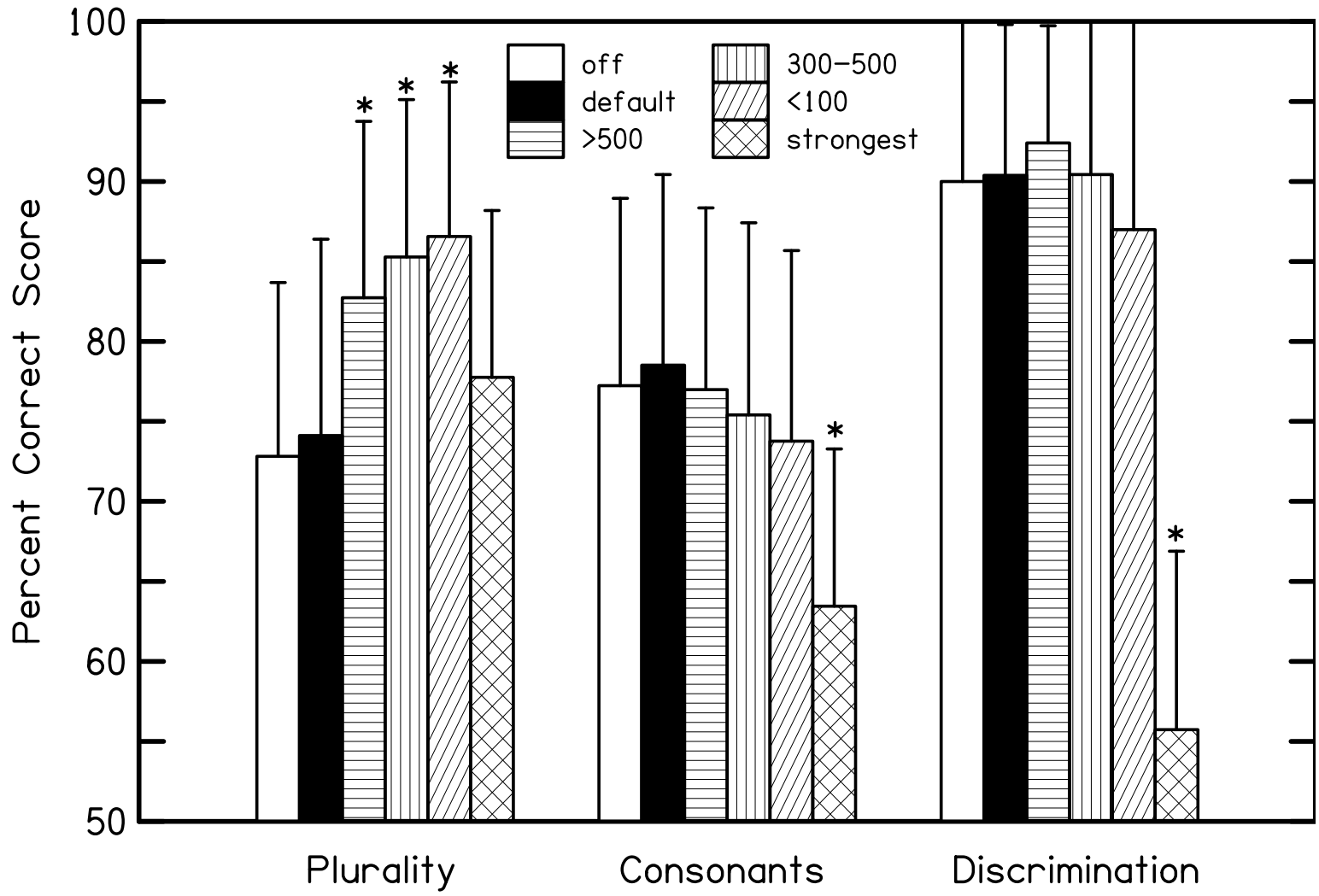
- 21 adults (mean age 66, range 25-87 years)
  - 14 were hearing aid users
  - 5 had frequency lowering hearing aids
- 3 with dead regions
- Fitted with DSL5, verified with speech in the ear canal.
  - FC off + 5 FC strengths





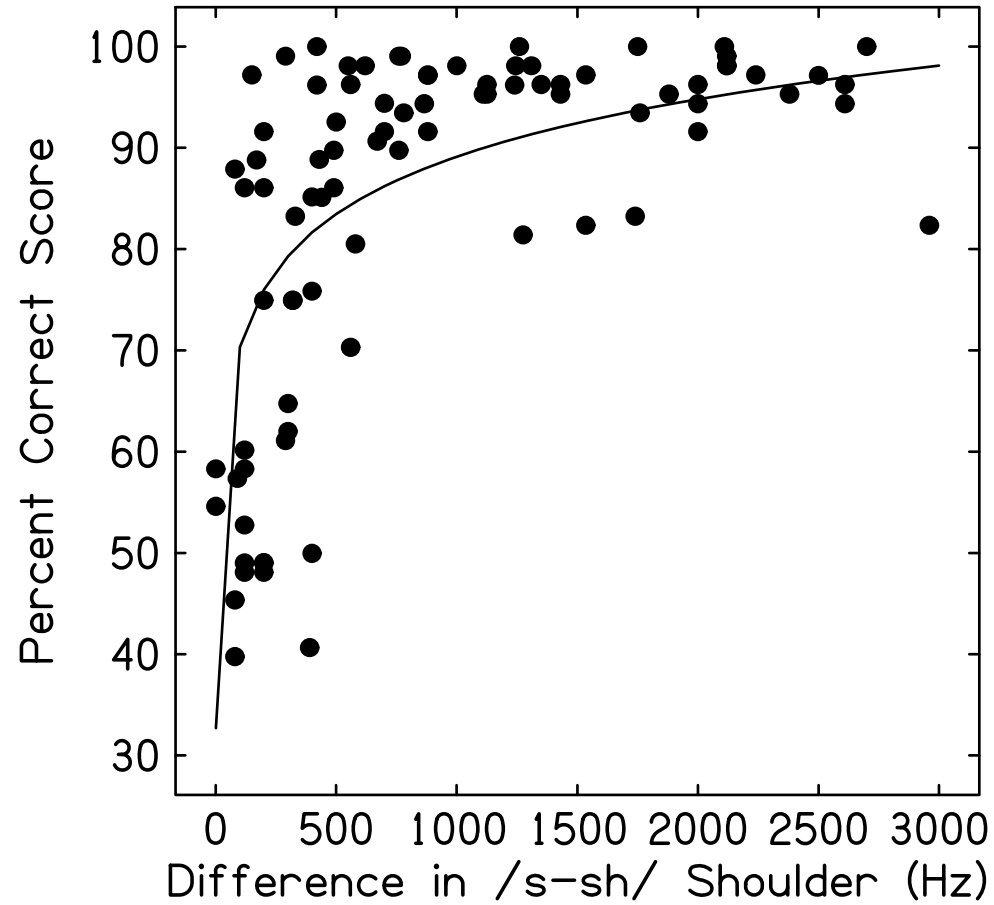
# Study Design

- Settings (6 in total):
  - Off, default, strongest, and:
    - 100 Hz separation between S and SH
    - 300 to 500 Hz separation
    - > 500 Hz separation
  - Randomized presentation order, no trial period
- Outcome measures
  - Detection of word-final fricatives (2 AFC, 60 dB SPL)
  - Discrimination of /s/ and /sh/ (3 AFC, 65 dB SPL)
  - Recognition of consonants (21 AFC, 65 dB SPL)

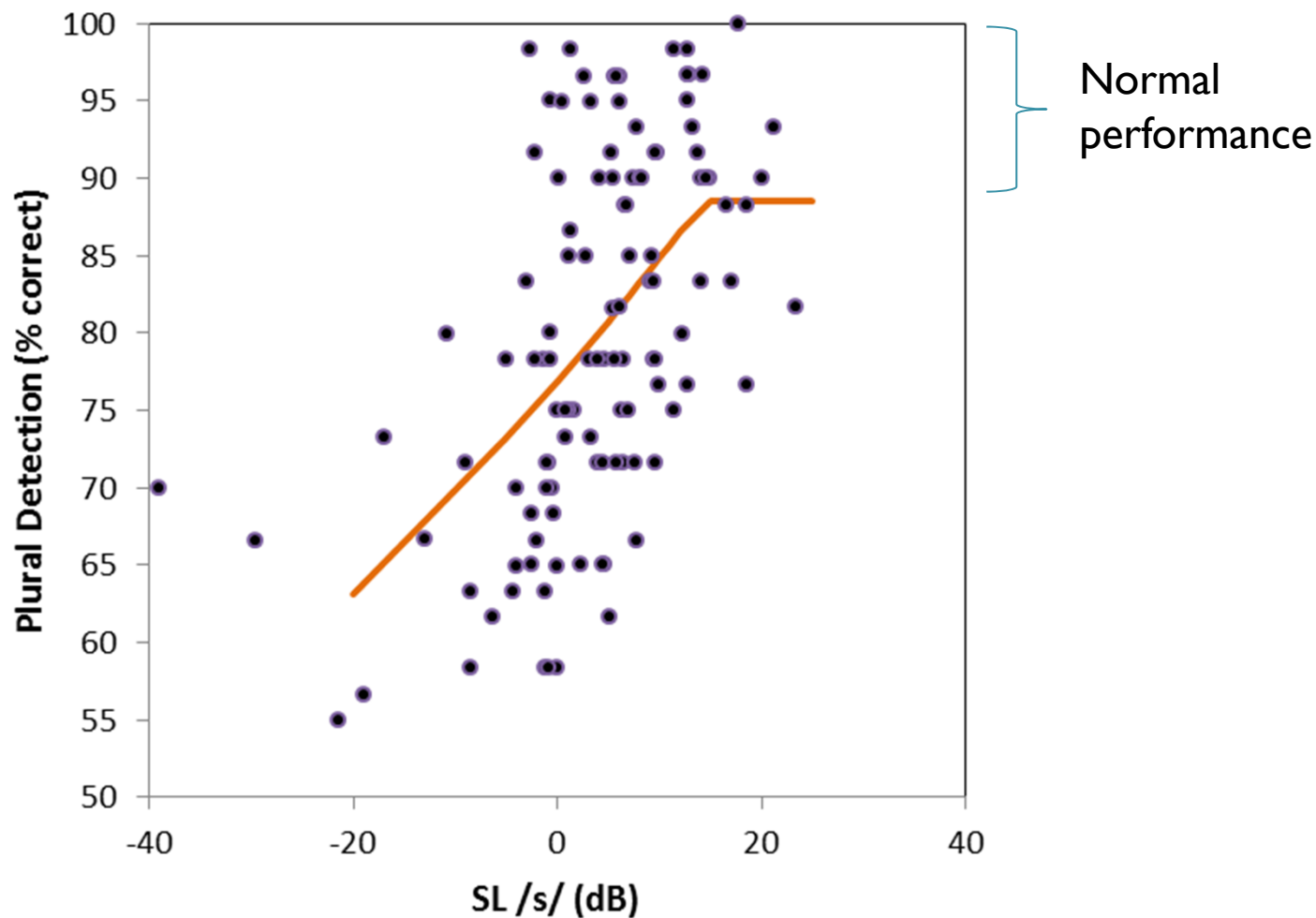


Glista, Scollie, et al (in preparation)

# Is discrimination of /s/ and /sh/ predictable



# Is detection of word-final frication predictable from real ear measurement?





# Clinical implications:

- Verification results are related to outcomes.
  - Audibility for “S” is associated with good detection of word-final /s/.
  - S can be slightly below threshold and still heard... due to broadband effects.
  - At least 200 Hz separation of S and SH is needed for good s-sh discrimination.
    - Separation may be at peak or at shoulder.

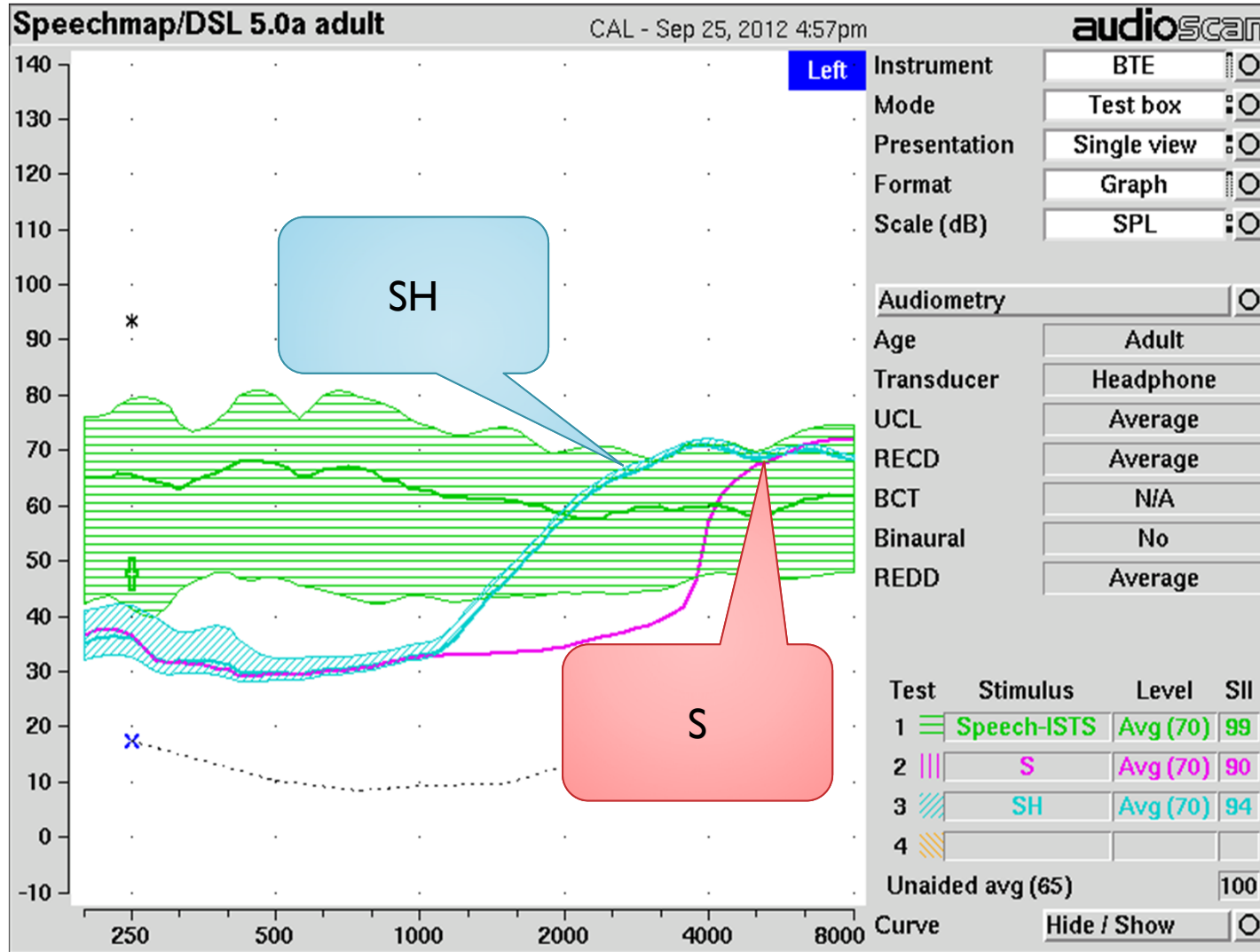


# Let's practice reading fittings

Remember, we want:

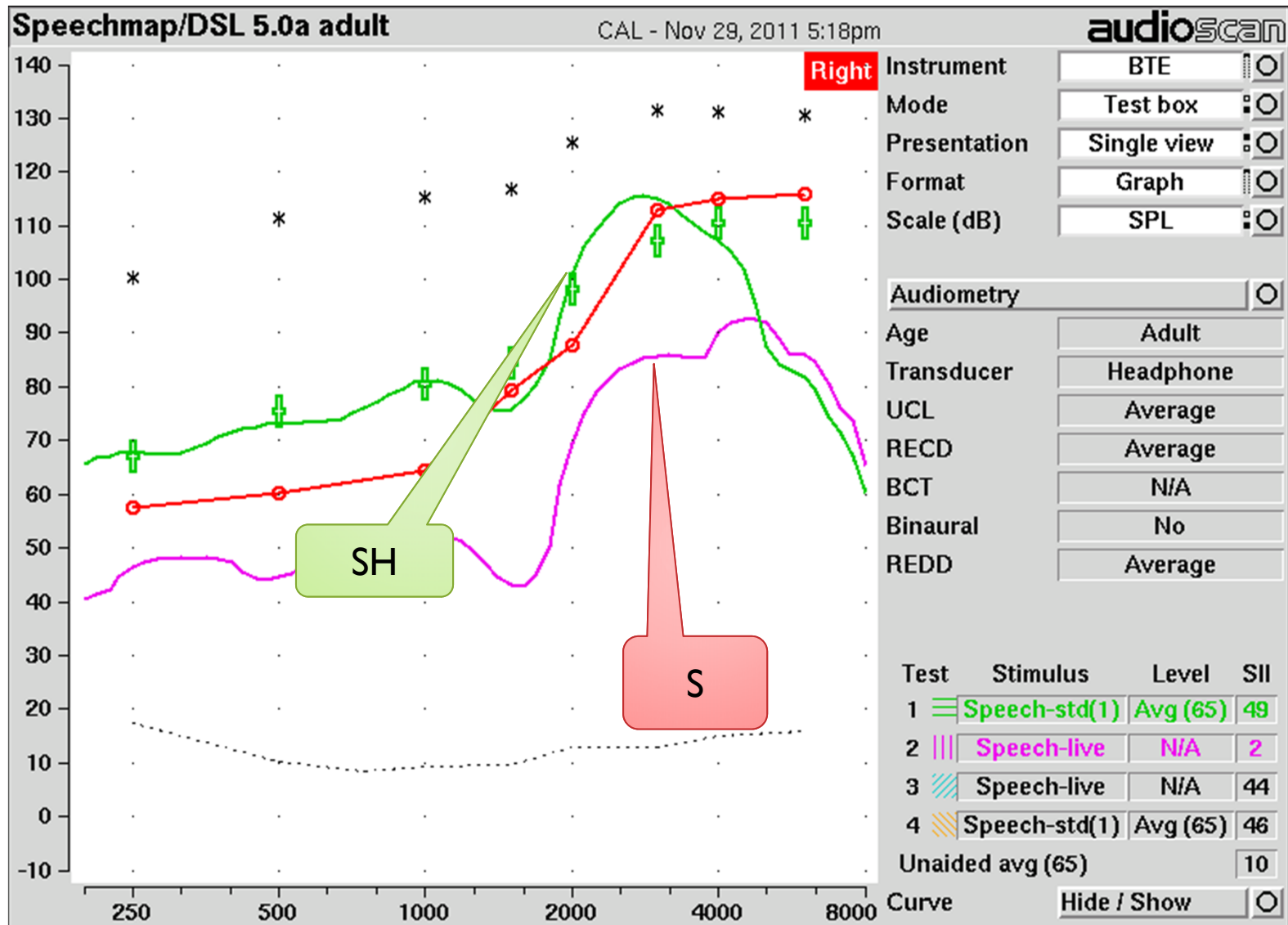
- S to be at least close to threshold, preferably 5 dB sensation level.
- S and SH should be separated by at least 200 Hz in frequency, preferably 500 Hz.

# Here's the test signals:



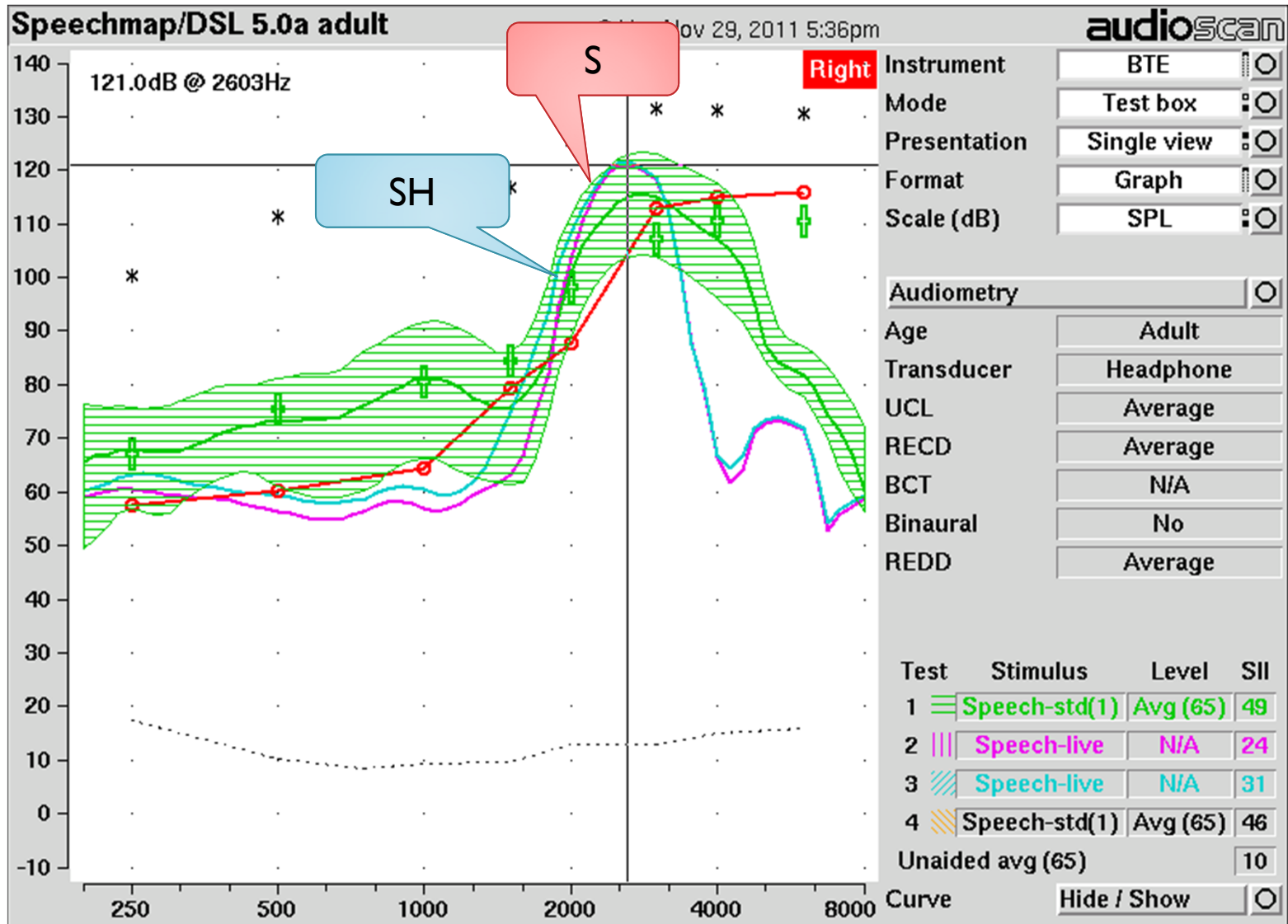


# SoundRecover off:



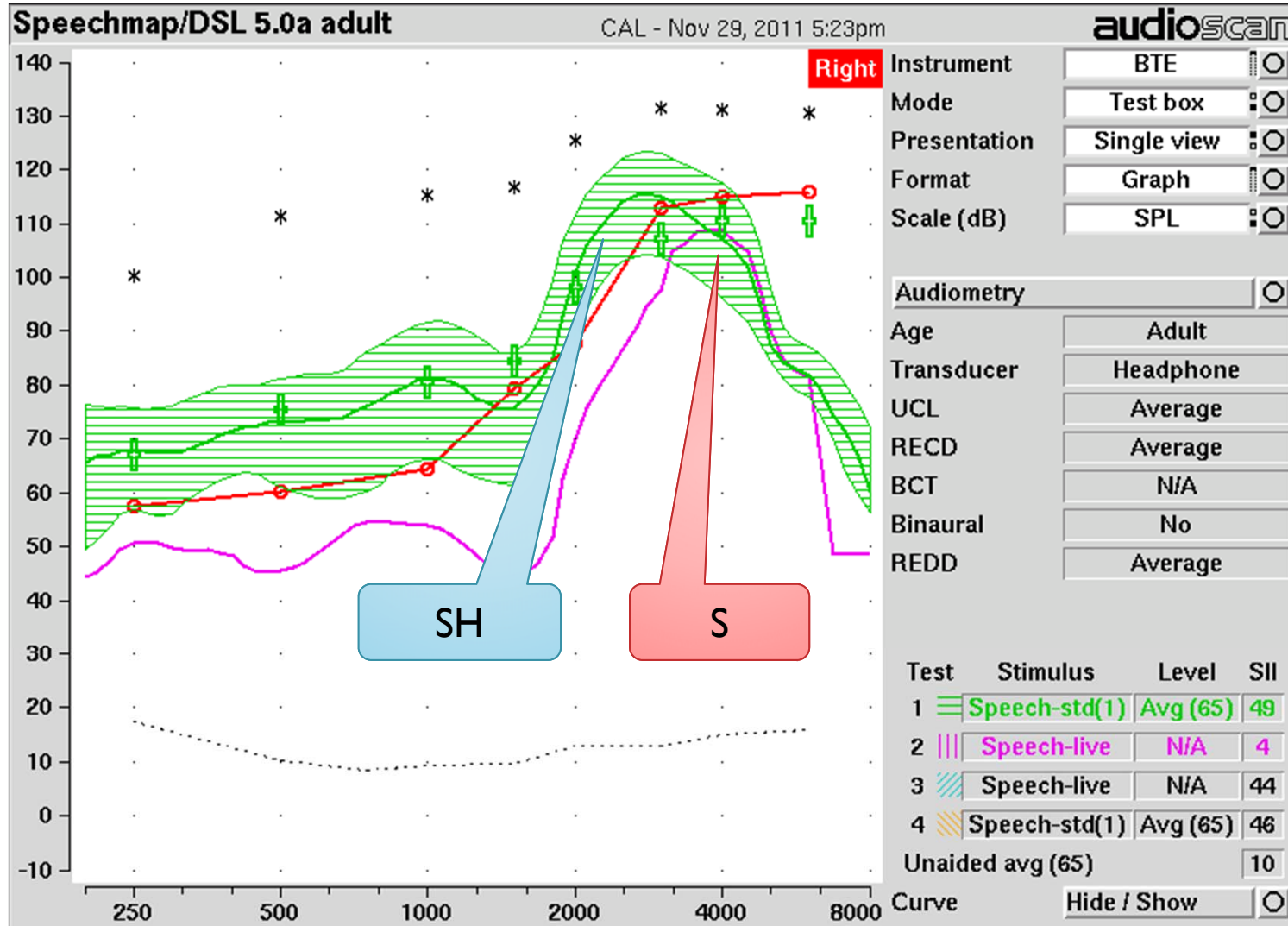
Connect coupler and instrument to coupler microphone. Select one of Test 1 through Test 4.

# SoundRecover A:



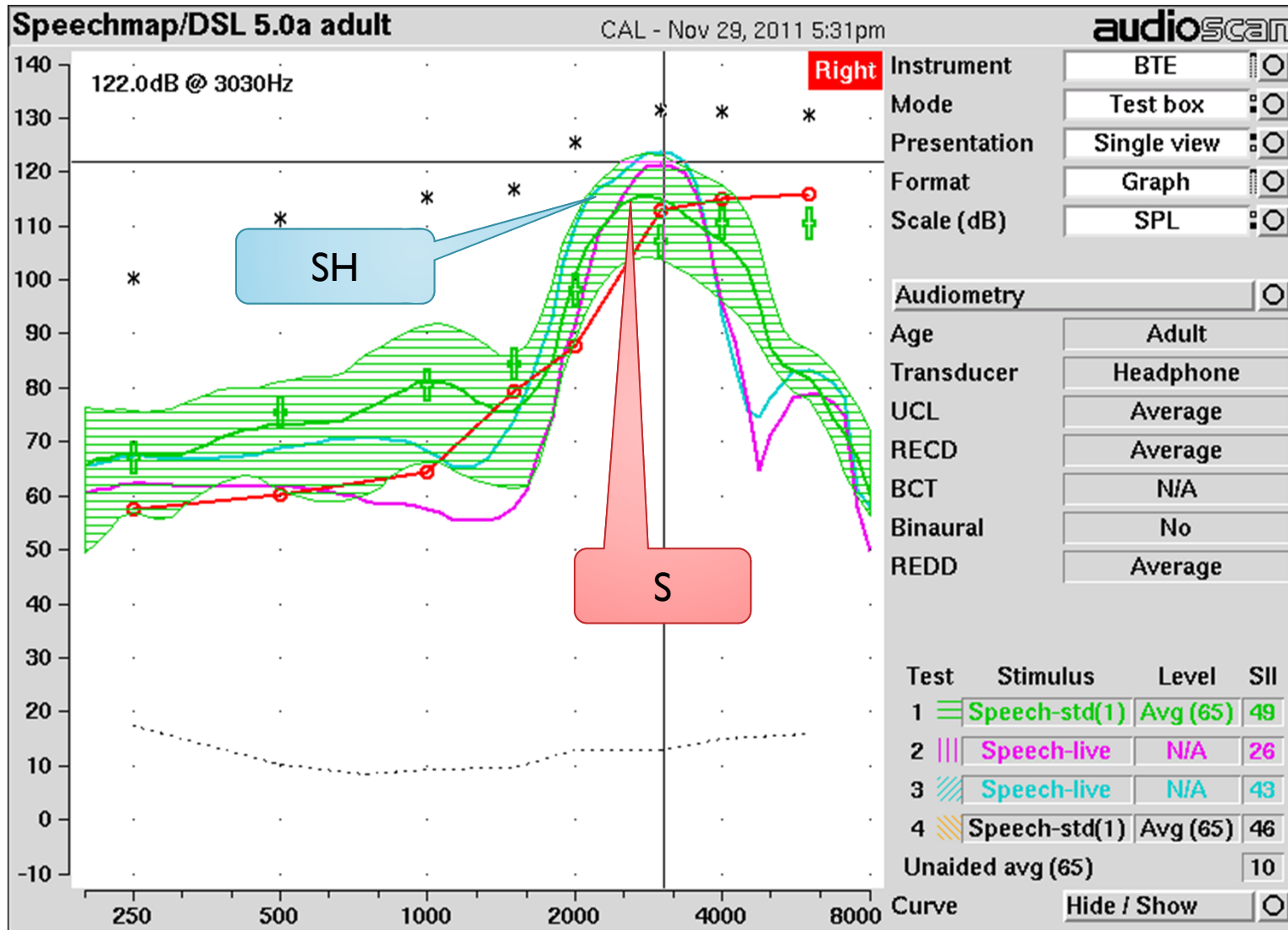
Connect coupler and instrument to coupler microphone. Select one of Test 1 through Test 4.

# SoundRecover B:



Connect coupler and instrument to coupler microphone. Select one of Test 1 through Test 4.

# SoundRecover C:



Connect coupler and instrument to coupler microphone. Select one of Test 1 through Test 4.

# Fine tuning lessons learned?

- The hearing aid's gain and FC interact:
  - If you have less high frequency gain, you will need to use a stronger FC setting to make S audible.
  - FC strength is correlated with sound quality changes... use the weakest setting you can that has positive effects.
  - Fine tuning is possible.
  - Verification and real ear measurement is possible and meaningful... but new.



# Clinical implications

- Have a look at Glista & Scollie, 2009, AudiologyOnline and give fine tuning a try!
  - It shows a “speech bands” test signal and live s - sh.
  - Same principles as discussed today.



# Clinical implications

- Interested in knowing if people can hear new sounds with frequency lowering?
- Interested in knowing if your extended bandwidth fittings are providing access to /s/ without frequency lowering?

- New clinical test:

- Glista, D. and Scollie, S. (2012). Development and Evaluation of an English Language Measure of Detection of Word-Final Plurality Markers: The University of Western Ontario Plurals Test. *American Journal of Audiology*, 21: 76-81.





# Colleagues and support

- Thanks to the organizing committee!
- Project coordinator for this work: Danielle Glista, Ph.D.
- Lab members and NCA Colleagues:
  - Vijay Parsa, Paula Folkeard
  - Andrea Dunn, Melissa Polonenko, Jacob Sulkers, Julie Seto
  - Sheila Moodie, Marlene Bagatto, Viji Easwar
- Research Funding and Collaboration: Phonak for ongoing support and Widex for project collaboration. Past support from Mason's Foundation of Ontario, CIHR, and NSERC.

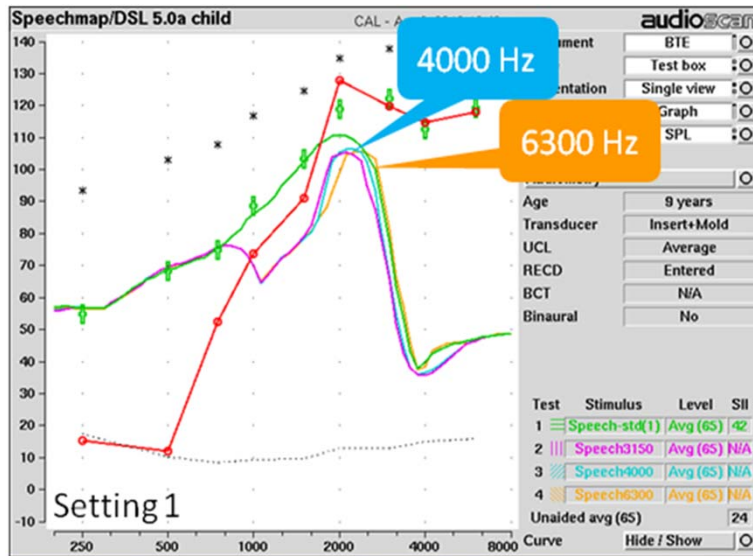


# References

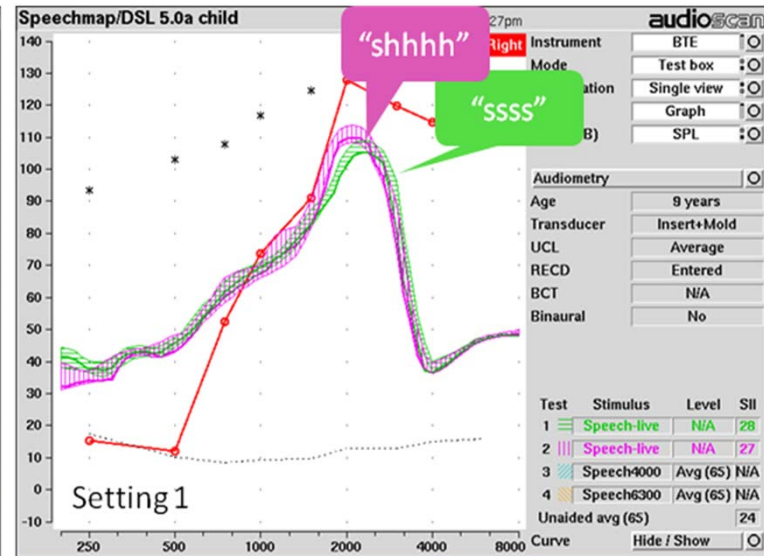
- Glista, D., & Scollie, S. (November, 2009). Modified Verification Approaches for Frequency Lowering Devices. *Audiology Online*, 1-11. Retrieved from [http://www.audiologyonline.com/articles/article\\_detail.asp?article\\_id=2301](http://www.audiologyonline.com/articles/article_detail.asp?article_id=2301)
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- Glista, D., Scollie, S., Polonenko, M., & Sulkers, J. (2009). A comparison of performance in children with nonlinear frequency compression systems. *Hearing Review*, 16, 20-24.
- Glista, D., Scollie, S., & Sulkers, J. (in press). Perceptual acclimatization post nonlinear frequency compression hearing aid fitting in older children. *Journal of Speech, Language, and Hearing Research*. Vol. 55, 1-23 .
- Parsa, V., Scollie, S., Glista, D., Seelisch, A. (accepted). Nonlinear Frequency Compression: Effects on Sound Quality Ratings of Speech and Music, *Trends in Amplification*.



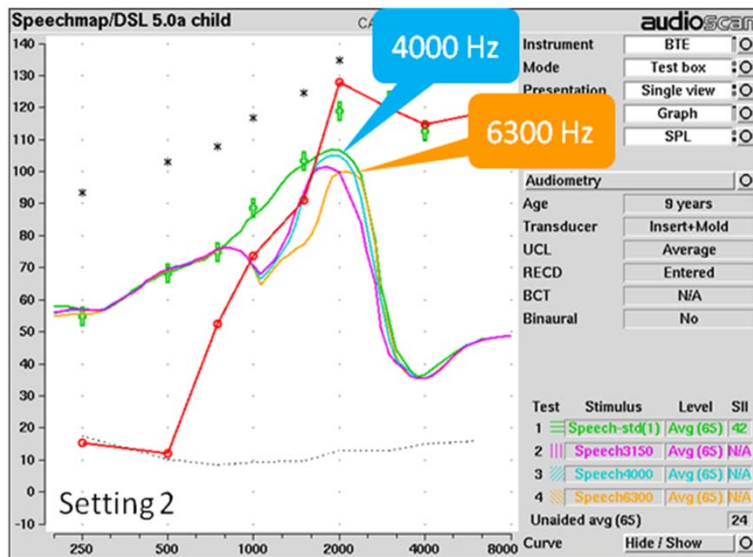
# Real Example: Tuning



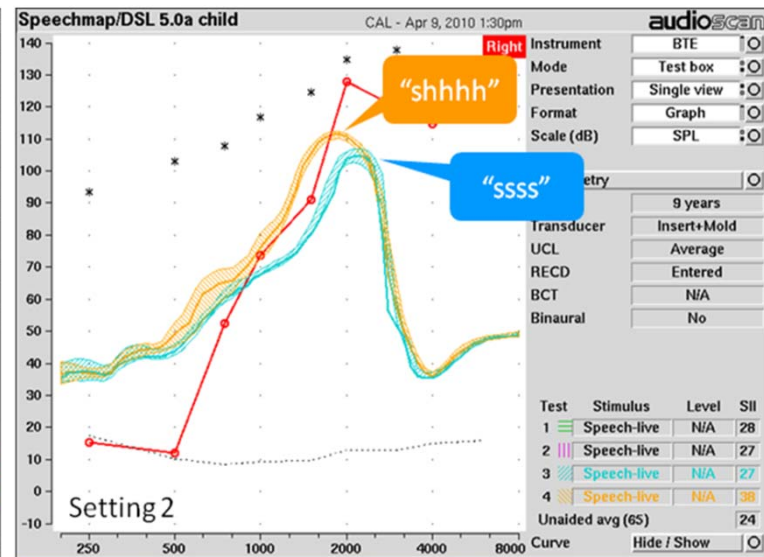
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# And the winner is...

<b>Test</b>	<b>Percent Correct Score Setting 1</b>	<b>Percent Correct Score Setting 2</b>	<b>Interpretation</b>
Nonsense syllables	56%	69%	Significant improvement with the revised setting
Discrimination of S/SH	37%	65%	Significant improvement with the revised setting





# FAQS...

# I. When should I enable FC in a fitting?

- Some important considerations:
  1. Is the listener receiving sufficient audibility across frequencies without using frequency lowering?
    - Start with a scientifically based prescriptive method to assess fit-to-targets (i.e., provide as good of a fitting as possible without NFC enabled)
  2. Have you verified this using appropriate techniques? (e.g., using advanced verification techniques)
  3. Consider the literature! Aim to provide audibility of energy well above 4000 Hz for developing infants & children (refer to start of presentation) – what we can accomplish with conventional amplification is ever evolving!



## 2. Should we be providing asymmetrical NFC settings?

- Studies thus far include symmetrical NFC settings only (i.e., the same NFC setting in each ear, with the exception of one published case)
- This included fitting NFC based on “better ear” thresholds
- What would an asymmetrical NFC setting mean for the listener? They would be receiving asymmetrical frequency allocation between the two sides... Can the listener adapt to this?
- We need more research to directly evaluate how this will affect speech understanding

### 3. Is it ok to enable NFC for mild to moderate hearing losses?

- Studies on this topic have included listeners with mild to moderate PTA values and significantly more hearing loss in the high-frequencies (i.e., moderately severe to profound in the high-frequencies)
- We do not have any evidence suggesting that NFC technology should or should not be used in cases presenting with a mild amount of hearing loss in the high-frequencies
- Think back to FAQ #1
  - Aim to provide FC in the case where a conventional fitting cannot provide sufficient audibility of high-frequency sounds
  - Err on the side of providing frequency compression to only the highest frequency part of each fitting
- Further research is needed - for discussion on this topic refer to: Scollie (ASHA Division 9, 2010), Wolfe et al. 2010