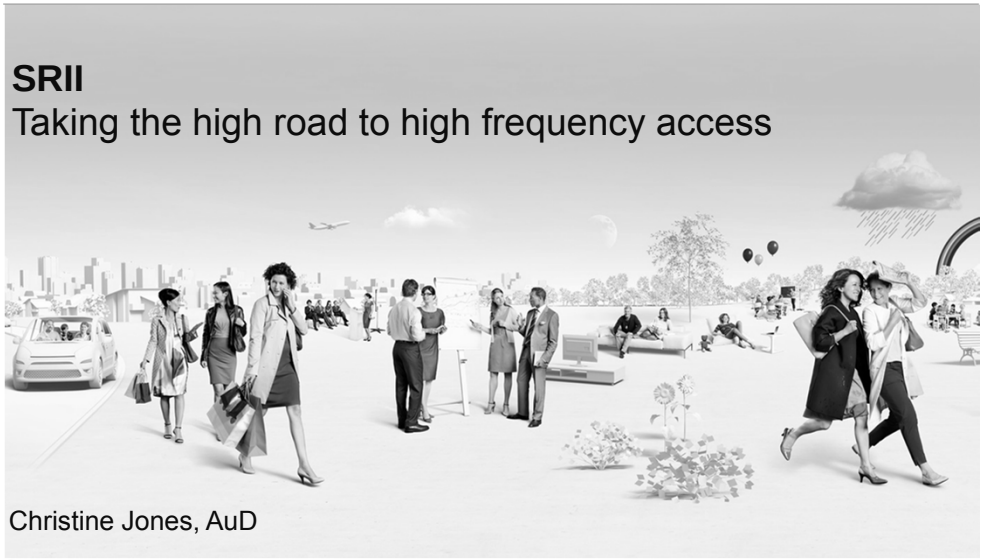
SRII
Taking the high road to high frequency access



Christine Jones, AuD

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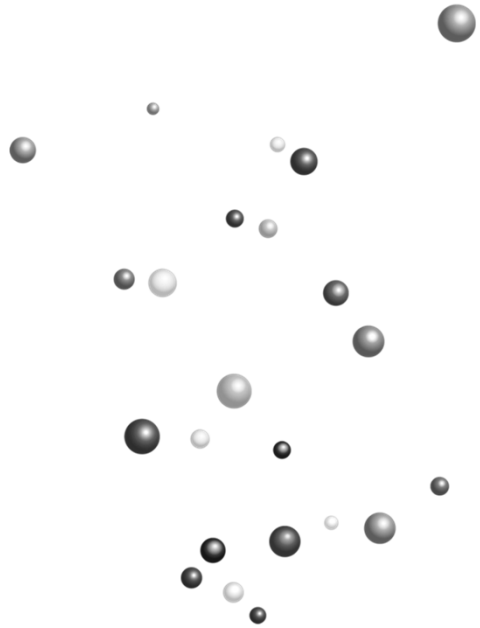

A1

Aided Perception of /s/ and /z/ by Hearing-Impaired Children

Patricia G. Stelmachowicz, Andrea L. Pittman, Brenda M. Hoover, and Dawna E. Lewis

Objective: The overall goal of this study was to determine the accuracy with which hearing-impaired children can detect the inflectional morphemes /s/ and /z/ when listening to speech through hearing aids.

Design: In the first part of the study a perceptual test was developed with equal numbers of singular and plural nouns spoken by both a male and female talker. Thirty-six normal-hearing children (3 to 5 yr) were tested to determine the age at which children could perform this test without difficulty. In the second part of the study, 40 children with bilateral sensorineural hearing losses (5 to 13 yr) were tested while wearing personal hearing aids. Stimuli were presented in the sound field at 65 dB SPL.

Results: For the normal-hearing children, mean performance increased and inter-subject variability decreased through age 5 yr 3 mo when performance reached ≥90% for all children. No significant talker or form (plural versus singular) effects were noted for this group. For the hearing-impaired children, performance varied considerably across all ages. For these subjects, significant effects of talker and form were observed. Specifically, plural test items spoken by the female talker showed the highest error rate.

Conclusions: In general, mid-frequency audibility (2 to 4 kHz) appeared to be most important for perception of the fricative noise for the male talker while a somewhat wider frequency range (2 to 8 kHz) was important for the female talker.

(Ear & Hearing 2001;22;114–124)

Although the speech, language, and academic characteristics of children with severe-to-profound sensorineural hearing losses have been studied extensively, fewer studies have been conducted with children who have mild-to-moderately severe hearing losses. The lack of focus on the performance of these children may be explained, in part, by the fact that their speech and language problems are likely to be subtle compared to children with greater hearing losses and thus, they may not be referred for comprehensive evaluations. The studies that have been conducted suggest that even mild hearing loss can compromise communication abilities, academic performance, and psychosocial behavior (Bess, Dodd-Murphy, & Parker, 1998; Davis, Elfenbein, Schum, & Bentler, 1986; Davis, Shepard, Stelmachowicz, & Gorga, 1981; Elfenbein, Hardin-Jones, & Davis, 1994; Markides, 1970, 1983).

Although Elfenbein et al. (1994) reported that the speech of children with mild-to-moderate hearing loss was intelligible, misarticulation of fricatives and affricates was common, particularly for children with three-frequency pure-tone average thresholds >45 dB HL. In addition, language samples from these children were characterized by frequent semantic and syntactic errors involving the use of complex sentence structures (e.g., imbedded phrases, dependent clauses), bound morphemes (e.g., plurals, possessives), and the unstressed components of speech (e.g., articles). In general, these findings may be related to inaudibility of various aspects of the speech signal as a consequence of hearing loss.

To assess the consequences of mild-to-moderately severe hearing loss, it may be necessary to focus on specific properties of speech that are most likely to be affected by the reduced audibility of speech due to factors such as degree of hearing loss, distance, environmental noise, and the current limitations of amplification systems. In addition, reduced audibility may be expected to impact the acquisition of language. From a developmental perspective, /s/ is known to be of high linguistic importance in the English language. It is the 3rd to 4th most frequently occurring phoneme and serves multiple linguistic functions, denoting plurality, tense, and possessiveness (Doran, 1962; Redman, 1963; Tobias, 1959). Among children and adults with hearing loss, /s/ is one of the most frequently misperceived phonemes (Bilger & Wang, 1976; Dunhaver, Abdala, Johnson, & Asp, 1986; Dubno & Dirks, 1982; Owens, 1978; Owens, Benedict, & Schubert, 1972). In addition, Elfenbein et al. (1994) have reported that the language samples of children with mild-to-moderate hearing losses often reveal increased errors in both noun and verb morphology (e.g., cat versus cats, keep versus keeps). Studies with children having a positive history of otitis media also have shown a significant reduction in the perception of morphological inflections denoting plurality (Pelstone, Schwartz, Gravel, & Raphael, 2001; Teele, Klein, Chase, Menyuk, & Rosner, 1990). It is likely that these findings are related to a reduction in audibility of the fricative noise and/or the formant transition due to the presence of hearing loss. These results suggest that a

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115

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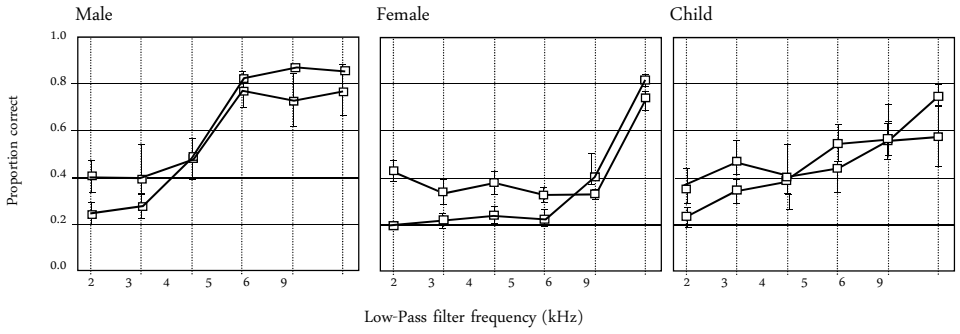
Stelmachowicz, Pittman, Hoover, & Lewis (2001). JASA

Stelmachowicz, Pittman, Hoover, & Lewis (2002). Ear and Hearing

The effects of high-frequency amplification on the perception of /s/ - children

Stelmachovicz et al. 2001



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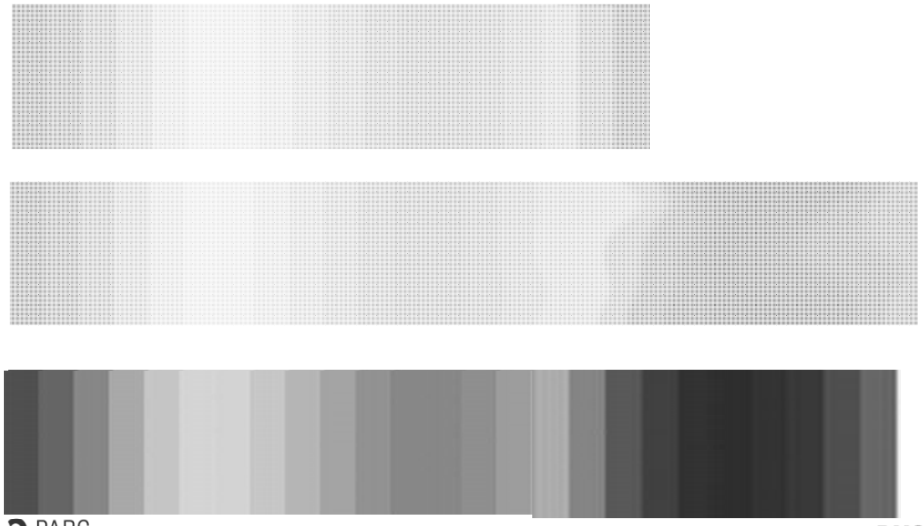
Slide 3

A1 Add screen shot and referencec

Author, 3/2/2016

Searching for the optimal solution…



SoundRecover evidence

Peer reviewed

Glista D, Scollie S, Sulkers J Perceptual Acclimatization Post Nonlinear Frequency Compression Hearing Aid Fitting in Older Children. J Speech Lang Hear Res. 2012 May 21. [Epub ahead of print]

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, Caraway T, Hudson M. Long-term effects of non-linear frequency compression for children with moderate hearing loss. Int J Audiol. 2011 Jun;50(6):396-404

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, Caraway T. Evaluation of nonlinear frequency compression for school-age children with moderate to moderately severe hearing loss. J Am Acad Audiol. 2010 Nov-Dec;21(10):618-28

Bohnert A, Nyffeler M, Keilmann A. Advantages of a non-linear frequency compression algorithm in noise. Eur Arch Otorhinolaryngol. 2010 Jul;267(7):1045-53

Glista D, Scollie S, Bagatto M, Seewald R, Parsa V, Johnson A. Evaluation of nonlinear frequency compression: clinical outcomes. Int J Audiol. 2009;48(9):632-44

Simpson A. Frequency-lowering devices for managing high-frequency hearing loss: a review. Trends Amplif. 2009;13:87-106.

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Non-peer reviewed

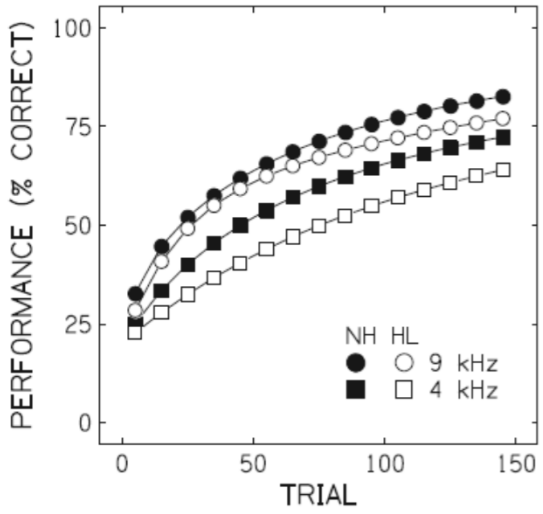
McDermott HJ. A technical comparison of digital frequency-lowering algorithms available in two current hearing aids. PLoS One. 2011;6(7):e22358

Timmer B. 2010: Neue Ansätze bei direktionalen multi-mikrofonsystemen.Hörakustik 11/2010:12-16

Nyffeler M. 2010: Geschaffen für erstklassigen Hörgenuss,tatsächlich binaural. AudioInfos 10:78-82

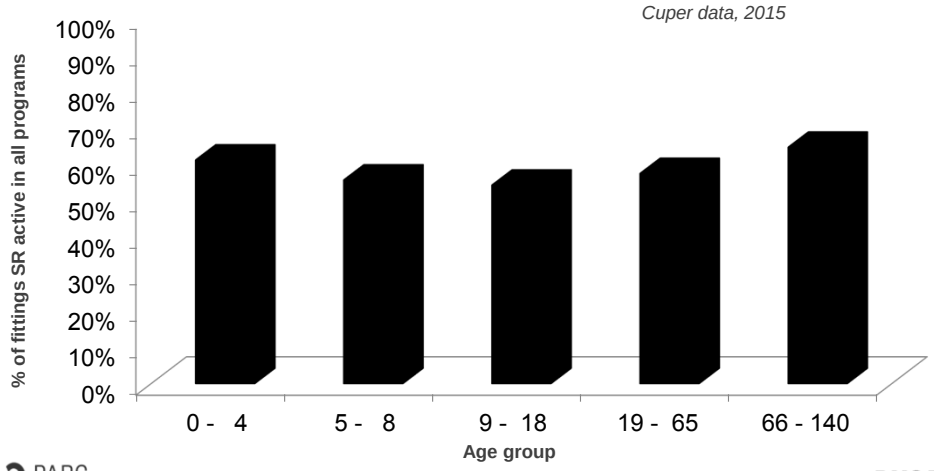
Wolfe, J., Caraway, T., John, A., Schafer, E. C., & Nyffeler, M. (2009). Study suggests that non-linear frequency

Word learning improves as a function of bandwidth



» Pittman, 2010

SR activated commonly for all ages



A3

Clinician recognized benefits

Better detection, distinction recognition of high frequency consonants	Improved access to environmental sounds
Improved vocal quality	Reduced feedback

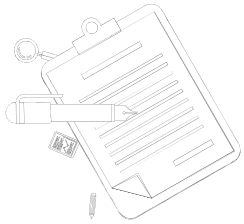
Slide 10

A3 Include picture icons here

Author, 3/2/2016

Why SoundRecover is disabled

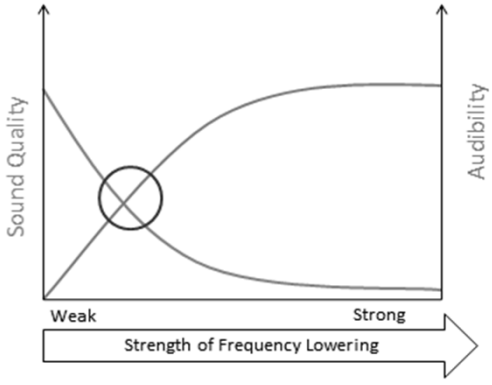
Of those surveyed:	In open question, they report	Concerns mentioned:
☐ 40% routinely disable SoundRecover for mild losses	☐ Disabled for rising, flat or mild hearing losses	☐ Always enabled in the fitting software
☐ 85% report that age does not seem to be a factor	☐ Disabled when Targets could be matched without it	☐ Default settings seem too aggressive
		☐ Patients report unnatural sound quality



Challenges from our own experience

We know for more profound hearing losses and for left corner and ski slope hearing losses

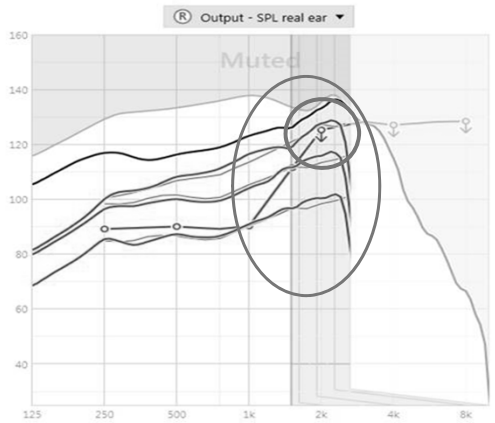
Trade-off between audiological benefit and sound quality



Trade-off – audiological benefit and sound quality

- Severe to profound hearing loss with no responses beyond 2 kHz
- SoundRecover enabled at maximum

- Minimal benefit – only loud inputs
- Stronger setting needed



But such settings introduce unacceptable sound quality

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AudOnline Aug 2016

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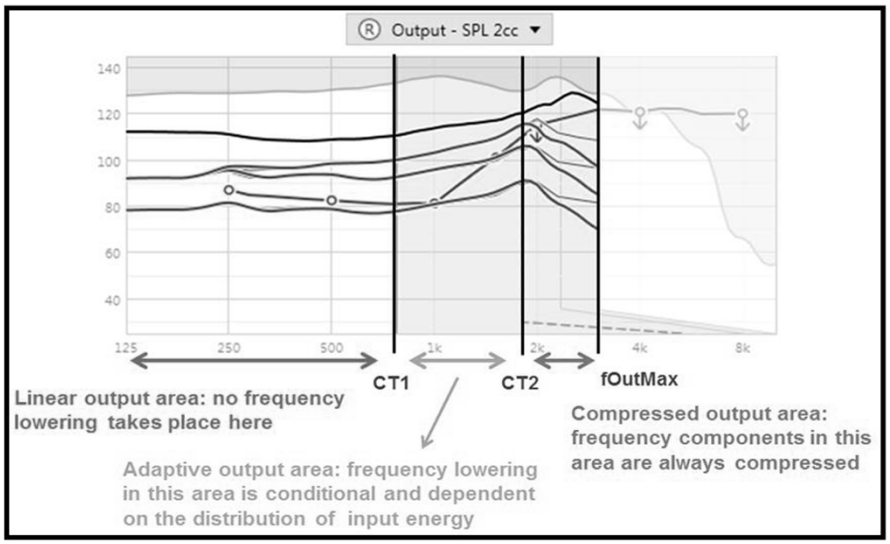
Phonak has led the way in modern day frequency lowering and we won't rest on our success.

We will continue to innovate and develop this technology so that more people can experience the benefit of high frequency audibility and improved sound quality.

SoundRecover2 - intelligent adaptive frequency lowering algorithm

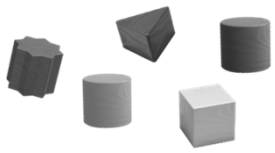


Parameter explanation

- **CT1**: below this lower cut-off frequency the output is always linear, no frequency compression applied
- **CT2**: beyond this upper cut-off, compression s always active, as with the original algorithm
  - between the cut-offs frequencies, compression is applied only when significant high frequency energy is present thereby protecting and maintaining the familiarity of mid and low frequencies sounds
- **fOutMax:** maximum output frequency after frequency lowering - depends on audiogram
- Compression Ratio (**CR**): constant, fixed across the compressed range. SR2 allows an overall lower compression ratio.

The philosophy of SoundRecover2

- Maximize stimulation of the hearing nerve
- Protect the mid and low frequencies.
- Extend the benefits for more severe-profound hearing losses



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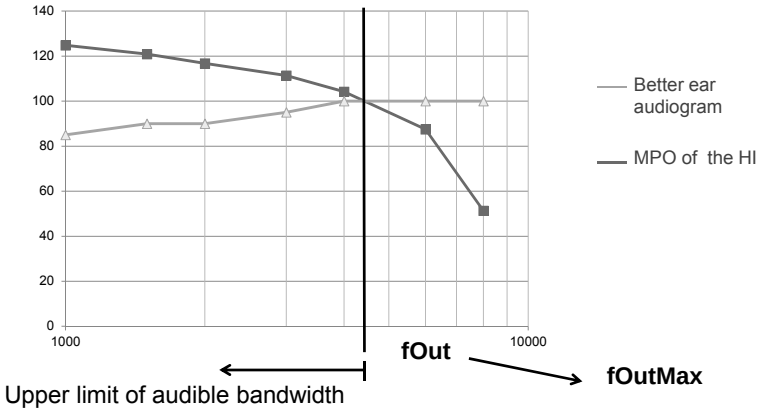
Philosophy of the SoundRecover2

- **Maximize stimulation of the hearing nerve** by setting the initial **fOutMax** at the upper limit of audible bandwidth.



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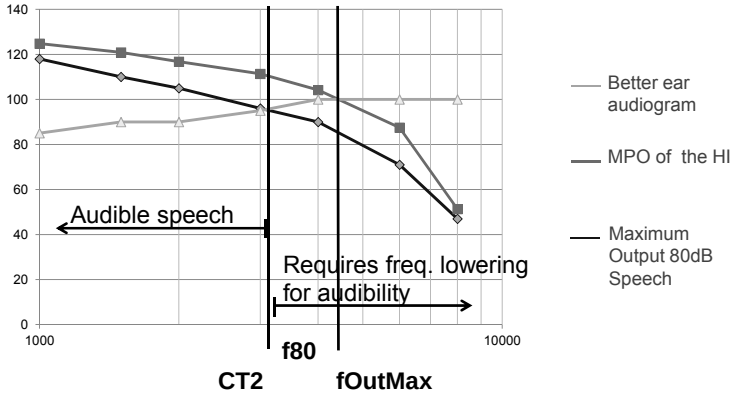
Philosophy of the SoundRecover2 pre-calculation

- **Protect the mid-frequencies** by setting **(CT2 or upper cut-off)** high enough so that audibile speech (without compression) is <u>not</u> affected.



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Benefits of SoundRecover2 pre-calculation

Maximize stimulation of the hearing nerve by setting the **fOutMax** at the upper limit of the individual's audible bandwidth.	**Protect the mid and low frequencies** by setting **(CT2 or upper cut-off)** high enough so that audibile speech (without compression) is <u>not</u> affected.	**Extend the benefits of SoundRecover2 for severe-profound losses** by combining a lower starting point for compression (CT1 or lower cut-off) with a weaker compression ratio
No risk of deprivation	No risk for distortion of mid and low frequencies	Overcomes the constraints of SoundRecover and provides benefit for more users

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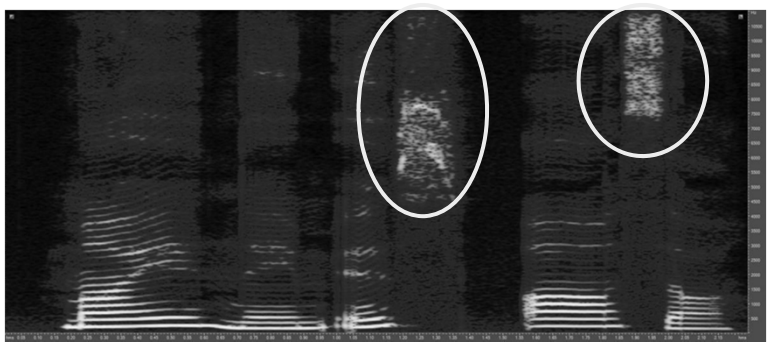
Original sound spectrogram



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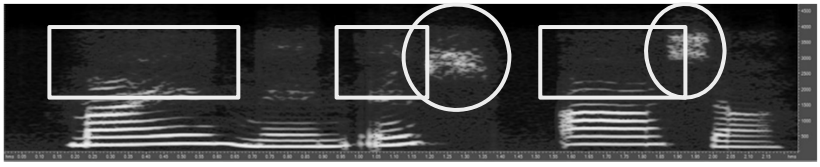
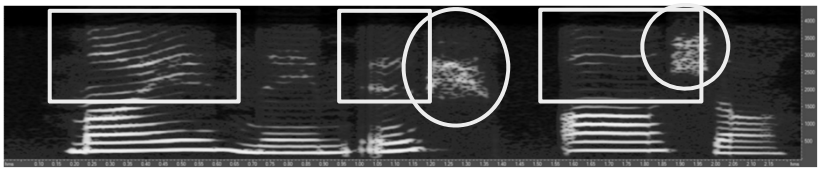
SoundRecover vs SoundRecover2

SoundRecover at strongest settings



SoundRecover2



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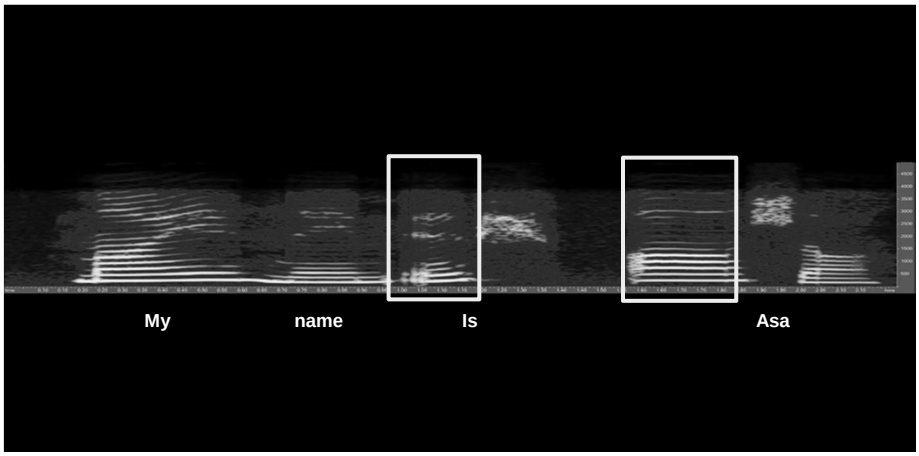
Protecting the vowel formants at various settings



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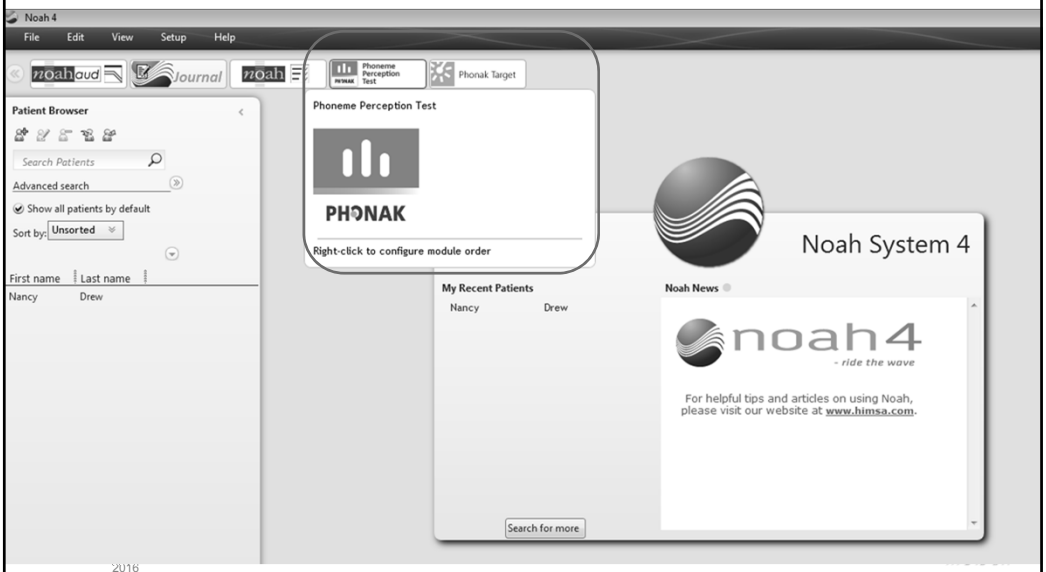
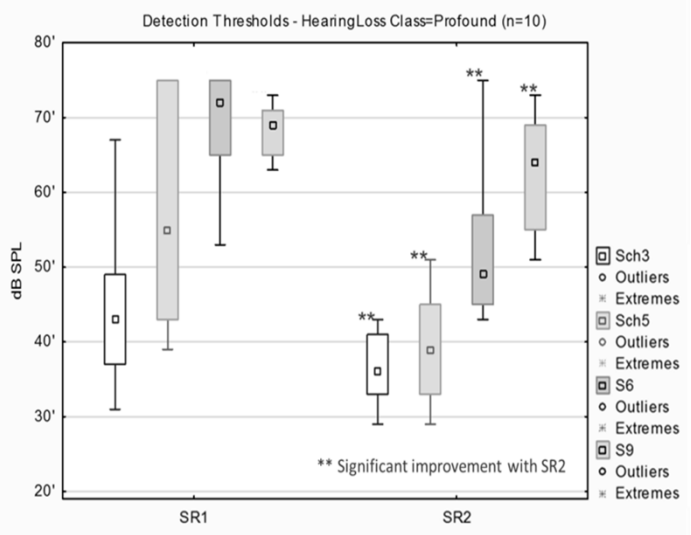
Phoneme perception test



PPT: Detection



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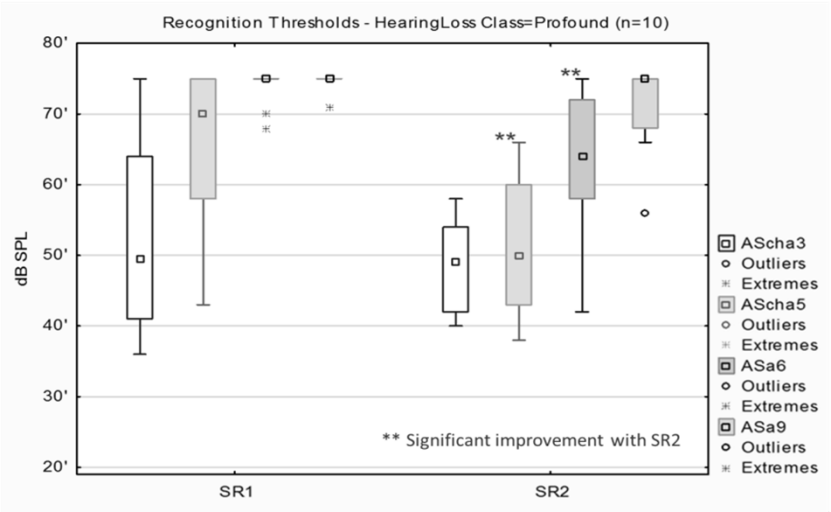
PPT: Recognition



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Scientific evidence – in progress

- Studies ongoing with
  - Susan Scollie and Danielle Glista at Western University (UWO)
  - Jace Wolfe at Hearts for Hearing, OK
  - Andrea Bohnert at Mainz University, Germany
- IJA in review: Jace Wolfe
- Publications:
  - Field Study News SoundRecover2
  - SoundRecover Insight
  - Best Practice Protocol Verification of SoundRecover2 for Pediatrics

SoundRecover2 and Phonak Target 4.3

SoundRecover2 will be available in all new pediatric and power form factors and technology levels.

- Naida V SP and RIC
- Preorders for UP

- Enabled by default for moderate to profound hearing losses.
- Can be enabled for mild losses

Parameter limits

	SoundRecover2
CT1	≥ 800Hz
CT2	≥ 1.6kHz
CR	1:1.05 to 1:4
fOutMax	≥ 2.7kHz

SoundRecover2 – overcomes the constraints

Restores access to high frequency information while preserving high frequency discrimination and sound quality

Maintains the familiarity of low and mid frequency sounds

Retains the essence of our SoundRecover strategy, while allowing lower cut-off frequencies with weaker compression ratios

Extends the benefits of SoundRecover to those with

- more profound hearing loss
- left corner audiogram
- ski slope audiogram