Optimization and Evaluation of a Language-Independent Hearing Screening Test based on Sound-Perception-in-Noise

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Study Phases

- Selection of sounds

- Optimization wave 1

- Development and evaluation of adaptive procedure + test validation

- Optimization wave 2

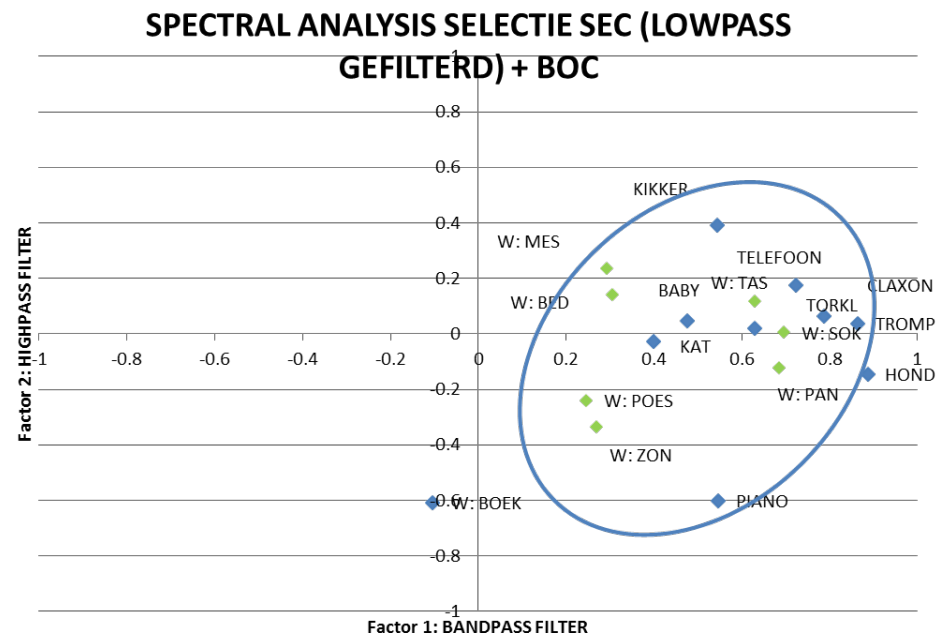- Optimization wave 3

- Tablet implementation

Future steps:

- Optimization and evaluation of adaptive procedure

  o Investigate sensitivity & specificity of test to detect HI

- Feasibility in children (6 yrs)

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Selection of sounds

- Spectro-temporal analysis of sounds and factor analysis (31 sounds)
  - Selection of sounds that resemble speech (BOC-words)
  - Low-pass filtering of sounds to enhance resemblence, provided that it remains recognizable

- 9 sounds selected:
  - Baby*
  - Claxon*
  - Dog
  - Cat
  - Piano
  - Telephone*
  - Church bell*
  - Trumpet*
  - Bird

SPECTRAL ANALYSIS SELECTIE SEC (LOWPASS GEFILTERD) + BOC

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Optimization Wave 1

- **Goal**: perceptual homogenization of sound material

- **Method**:

  - <u>Participants</u>: N = 10 (AMC) + 10 (Leuven) NH adults
    - Thresholds 500 – 4000 Hz ≤ 20 dB HL

  - <u>Materials</u>: laptop connected to external soundcard (FireFace UC) - HDA200 Headphones (Sennheiser) – stimuli played via APEX 3.1 software* - quiet room or sound-proof booth

  - <u>Procedure</u>: each sound was randomly presented 6x at different fixed SNRs: 0, -5, -8, -10, -12, -14, -16 and -18 dB SNR (noise at 65 dB SPL) – monaurally

  - <u>Analysis</u>: PI-curves were fitted, averaged across participants

- AMC evaluated filtered set, KU Leuven evaluated unfiltered set

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Optimization Wave 1
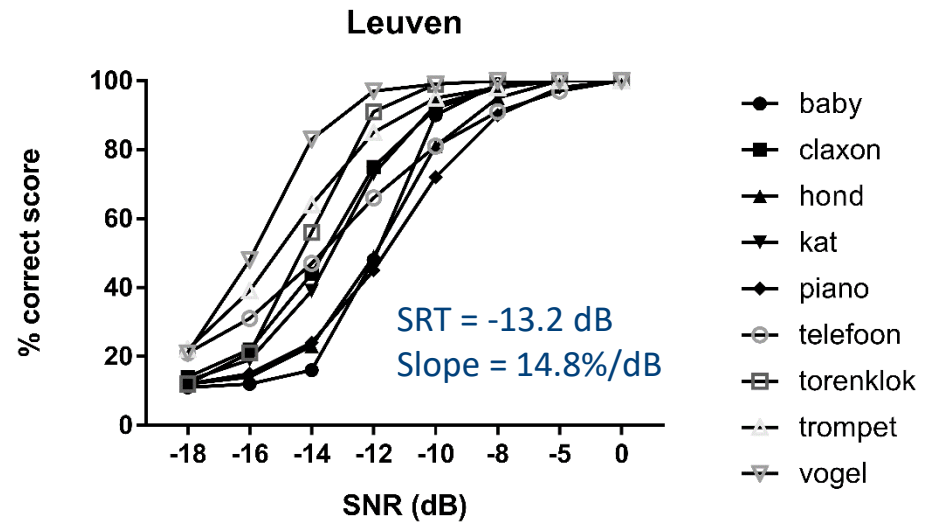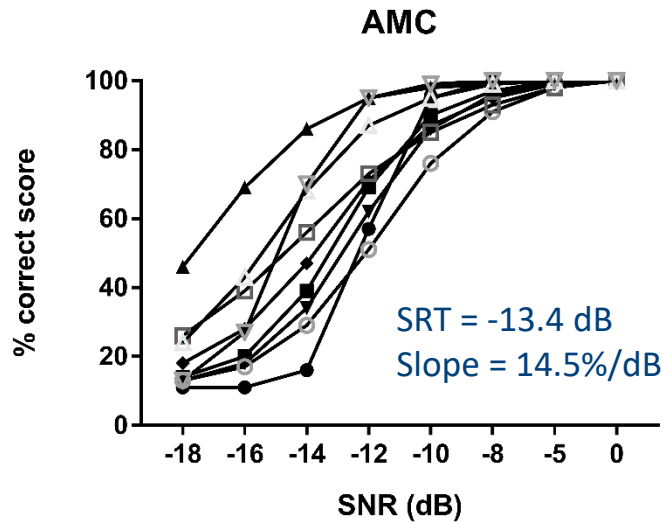
- Little differences between both sets: we use **unfiltered** test
- Token-specific level adjustments were done (shift to mean)
  - Adjustments varied between -1.9 to 1.5 dB
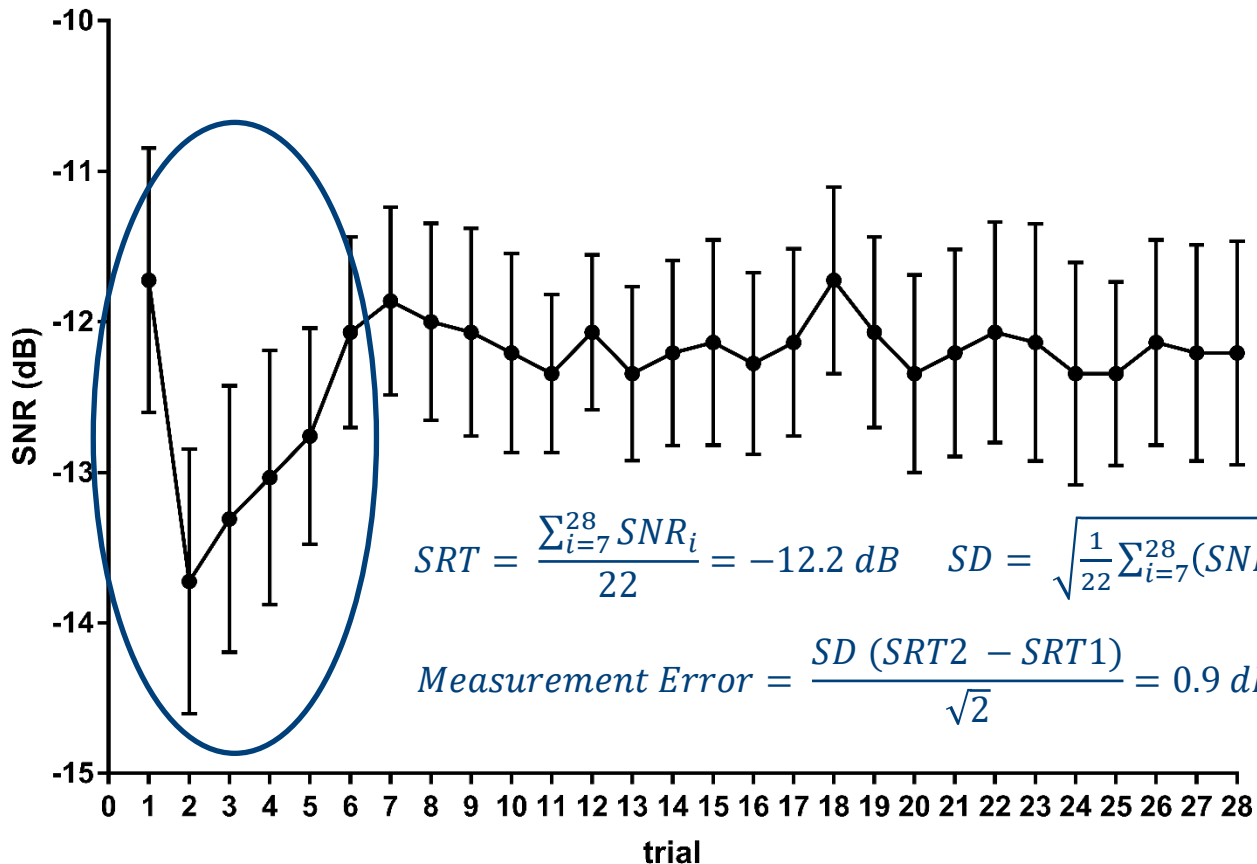
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Evaluation of Adaptive Procedure

- **Participants**
  - N = 44 NH (thresholds 500 – 4000 Hz ≤ 20 dB HL) + 8 HI
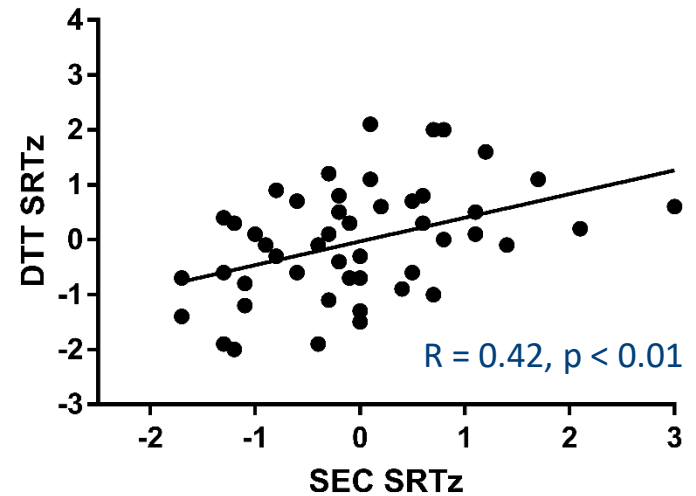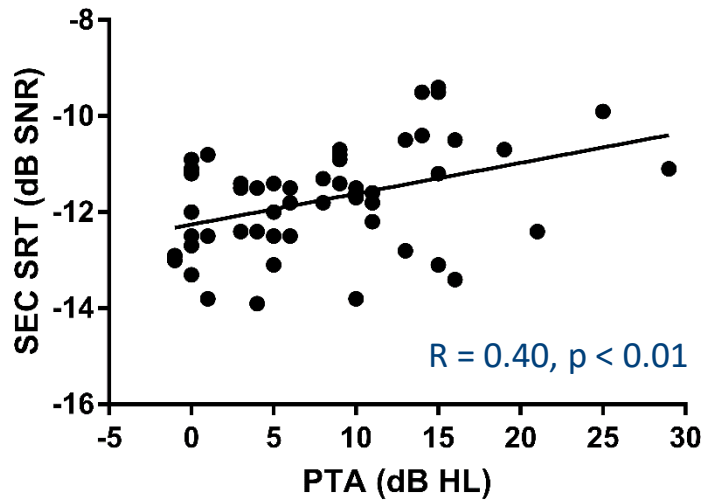 - 39 ± 16 years (age range: 20-68)

- **Procedure**
  - Pure tone audiometry → $PTA_{500-4000\ Hz}$
  - SEC training (monaurally)
    - Each sound was randomly presented 3x at 0 dB SNR with feedback (right or wrong)
  - SEC test-retest (monaurally) → SRT
    - Each sound was randomly presented 3x
    - Level of sounds varied adaptively in 2 dB steps (noise level = 65 dB SPL)
    - Start-SNR = -17 dB, repeat first until correct
  - Digit Triplet Test (KU Leuven) or DIN Test (AMC) (monaurally) → SRT
    - Prototype adaptive SPIN screening test using digits-in-noise

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Evaluation of Adaptive Procedure

$$SRT = \frac{\sum_{i=7}^{28} SNR_i}{22} = -12.2 \ dB \qquad SD = \sqrt{\frac{1}{22}\sum_{i=7}^{28}(SNR_i - SRT)^2} = 2.1 \ dB$$

$$Measurement \ Error = \frac{SD \ (SRT2 - SRT1)}{\sqrt{2}} = 0.9 \ dB$$

Data shown: young (<40 yrs) NH participants, N = 29
Test-retest data are pooled

Test Validation

Left plot: X-axis "PTA (dB HL)" ranging -5 to 30; Y-axis "SEC SRT (dB SNR)" ranging -16 to -8. Annotation: R = 0.40, p < 0.01

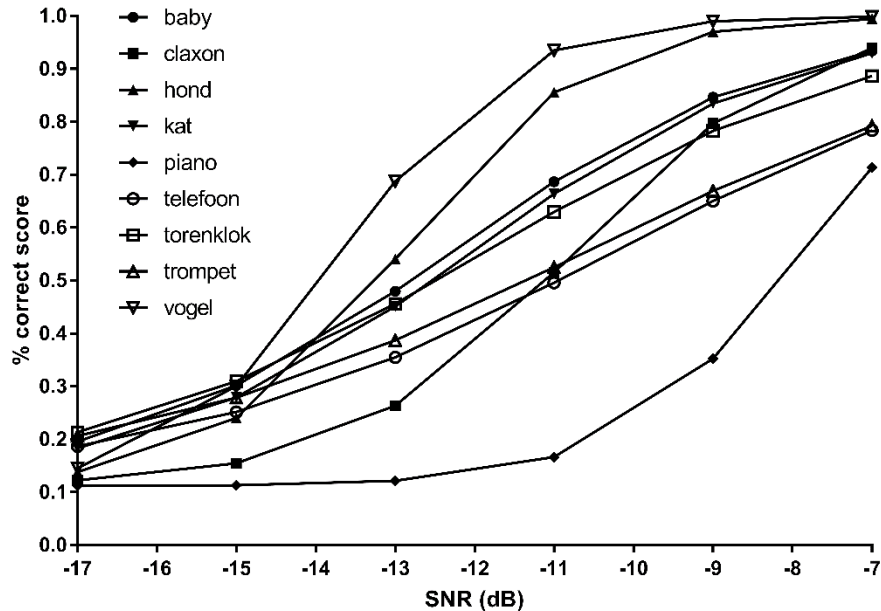Right plot: X-axis "SEC SRTz" ranging -2 to 3; Y-axis "DTT SRTz" ranging -3 to 4. Annotation: R = 0.42, p < 0.01

- Significant correlations with PTA and DTT SRT

Optimization Wave 2

- Based on the adaptive tracks, PI curves per sound were fitted

- Despite previous homogeneization, still **huge variability** in SRTs!

  o   Level adjustments were done (-1.3 to 2 dB)

- Many piano-trumpet confusions

  o   Trumpet removed from set

Optimization Wave 3

- **Goal**: FINAL perceptual homogenization of sound material

- **Method**:

  - <u>Participants</u>: N = 10 NH adults

    - Thresholds 500 – 4000 Hz ≤ 20 dB HL

  - <u>Materials</u>: laptop connected to external soundcard (FireFace UC) - HDA200 Headphones (Sennheiser) – stimuli played via APEX 3.1 software* - quiet room or sound-proof booth

  - <u>Procedure</u>: after training experiment, each sound was randomly presented 12x at different fixed SNRs: -9, -11, -13, -15, -17 dB SNR (noise at 65 dB SPL) – monaurally

  - <u>Analysis</u>: PI-curves were fitted, averaged across participants

Optimization Wave 3

SRT = -12.4 dB
Slope = 21%/dB

Legend: baby, claxon, hond, kat, piano, telefoon, torenklok, vogel
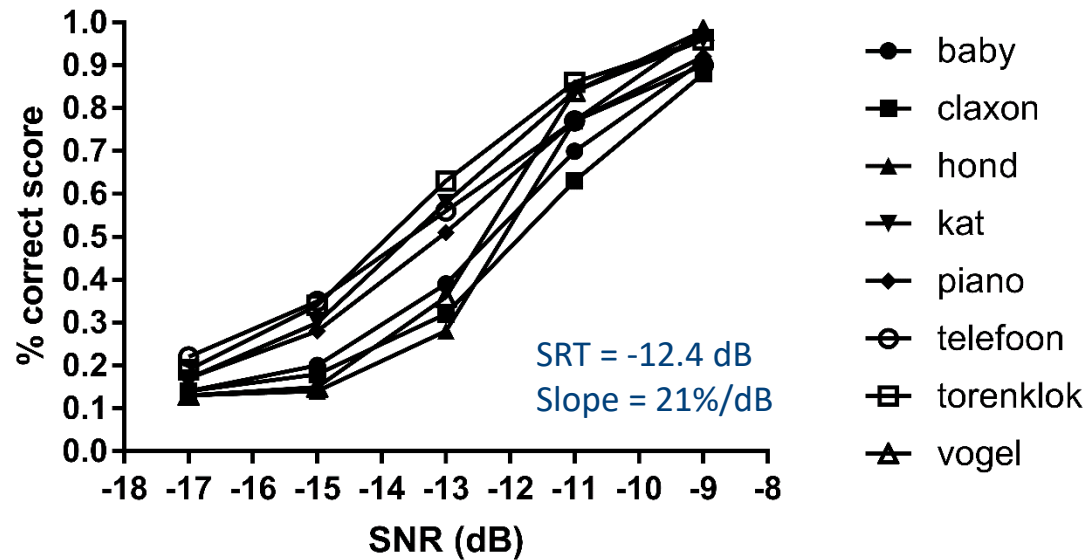
- Little variability in SRT (homogeneous set)
- Steep slope!
- Final adjustments were done (-0.5 to 0.5 dB)

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Tablet Implementation

DD45 transducer in peltor cups

7" Samsung Galaxy Tablet

Cloud storage of results

De gehoortest

Jouw LINKER oor wordt nu getest.

Reeks: 27/27

245

7	8	9
4	5	6
1	2	3
←	0	OK

- Geef telkens drie cijfers in en klik daarna op Ok.
- Indien je niets hebt verstaan, moet je gokken.
- Je kunt een fout corrigeren door op de rode knop te tikken.

DTT
NL & FR

SEC

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Questions?

Contact information: sam.denys@kuleuven.be

Online hearing test: m.testjegehoor.be