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# Single channel noise reduction in hearing aids

Recordings for perceptual evaluation

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# Introduction

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- Hearing impaired have difficulty understanding speech in noise
- Most modern hearing aids have a noise reduction algorithm implemented

# Introduction

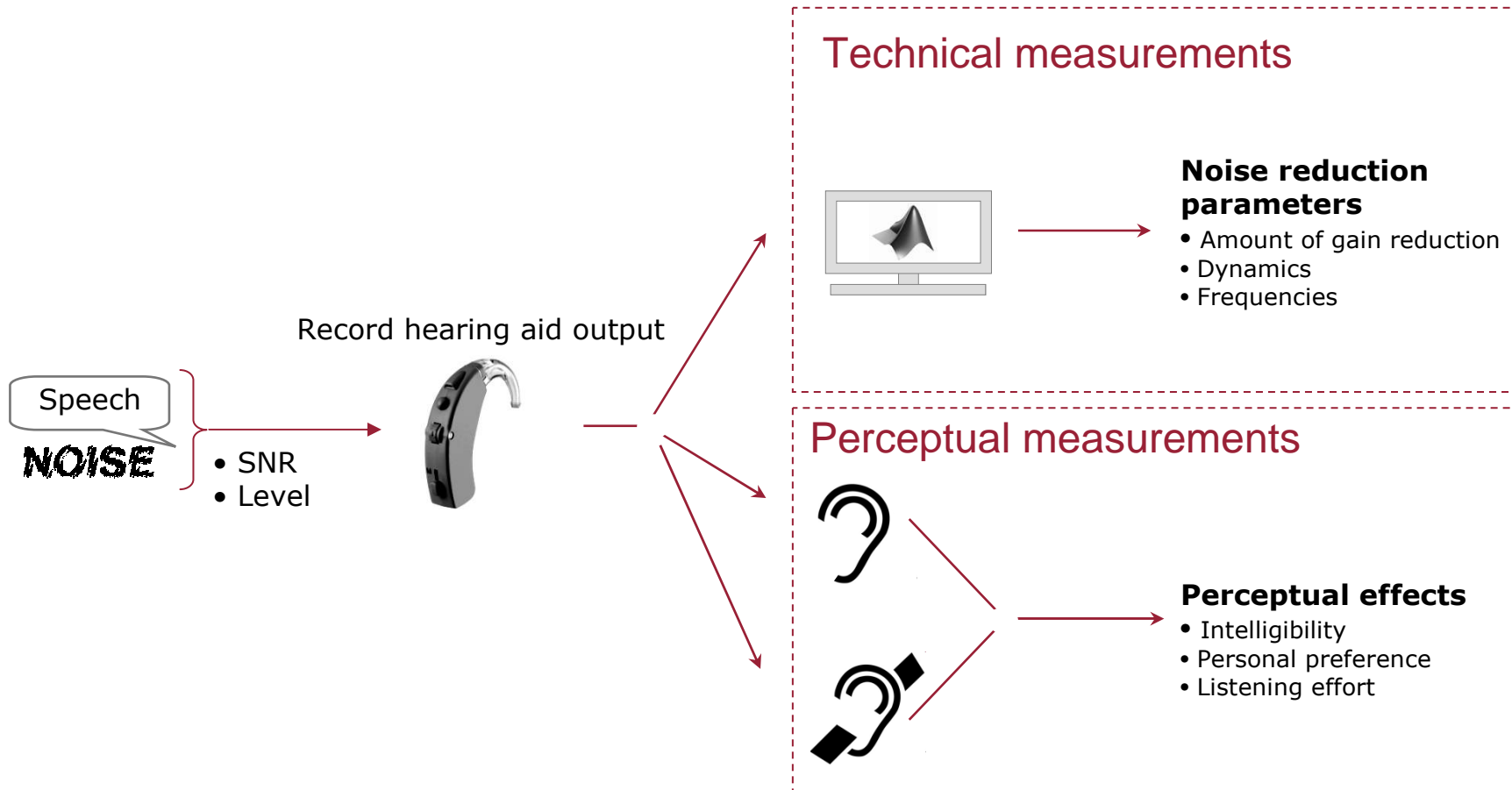
The screenshot displays a software interface for noise management. At the top, a 'Lawaaimanagement' section has a dropdown menu with 'Aan' selected and 'Uit' as an option. Below this, the 'NoiseBlock Processing' section has a dropdown menu with 'Uit' selected and options for 'Licht', 'Middelsterk', and 'Sterk'. The 'NoiseTracker' section has a dropdown menu with 'Uit' selected and options for 'Licht', 'Standaard', 'Sterk', and 'Zeer sterk'. The 'Akoestisch' section contains four sub-sections: 'Stilte', 'Mechanische geluiden', 'Overige Geluiden', and 'Windgeruis'. Each sub-section has a vertical column of three radio buttons labeled 'Uit', 'Gemiddeld', and 'Maximum'. In the 'Stilte' section, the 'Uit' button is selected. In the 'Mechanische geluiden' section, the 'Uit' button is selected. In the 'Overige Geluiden' section, the 'Uit' button is selected. In the 'Windgeruis' section, the 'Uit' button is selected. The 'Sprak en lawaaimodus' section has a dropdown menu with 'Uit' selected and options for 'Lawaaionderdrukking', 'Lawaaionderdrukking minimaal', 'Lawaaionderdrukking uitgebreid', 'Lawaaionderdrukking comfort', and 'Speech Enhancer'.

# Introduction

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- Hearing impaired have difficulty understanding speech in noise
- Most modern hearing aids have a noise reduction algorithm implemented
- Exact implementations of noise reduction in hearing aids are unknown to clinicians
- Technical properties of noise reduction differ between hearing aids
  - In terms of amount of gain reduction and its dependence on frequency, SNR, level and hearing loss (Hoetink et al. 2009)
- Perceptual effects of these differences are as yet unknown

# Study design



# Input

## Input signal

- Speech
  - VU sentences; female speaker (1s pause between sentences)
- NOISE**
  - Speech shaped steady state noise
  - Car noise
  - ICRA 6 (3 band speech modulated noise; 1 female, 1 male)
  - Multitalker babble
- Speech
  - NOISE**
  - SNRs: -12 -10 -8 -6 -4 -2 0 2 4 6 8 10
  - Level: ~70 dB SPL
  - ~ 2 Minutes per condition (1 min pre-conditioning)



# Recording – hearing aids (1)

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- Hearing aids (BTE)



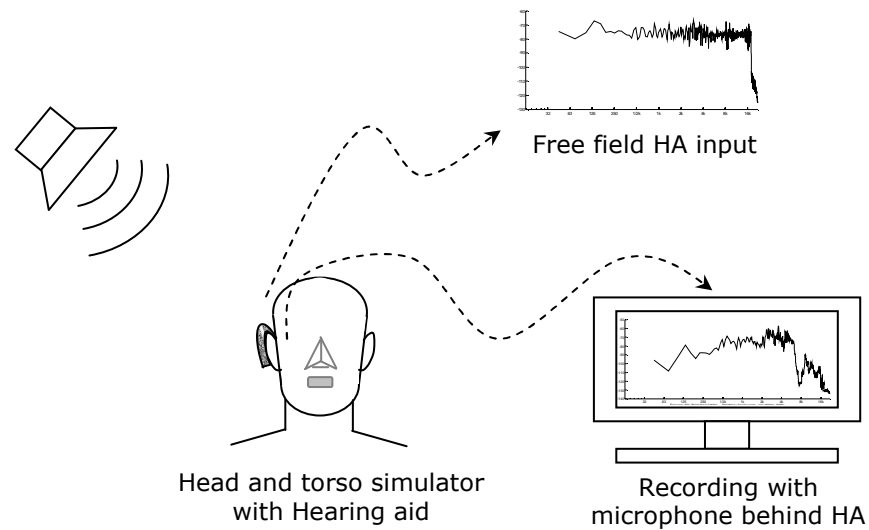
- Oticon Vigo Pro
- Phonak Exélia M
- ReSound Azure AZ80-DVI
- Widex Mind 440
- Starkey Destiny 1200

- Programming

- Audiogram: 50 dB sensorineural loss at all frequencies
- Gain function: NAL-NL1 or default prescription
- Omnidirectional
- All other features OFF
- Noise reduction OFF and MAX



# Recording – setup (1)





# Recording – examples (1)

SNR = +4 dB



- Effect of hearing aids >> effect of noise reduction
- Equalization of response without noise reduction required

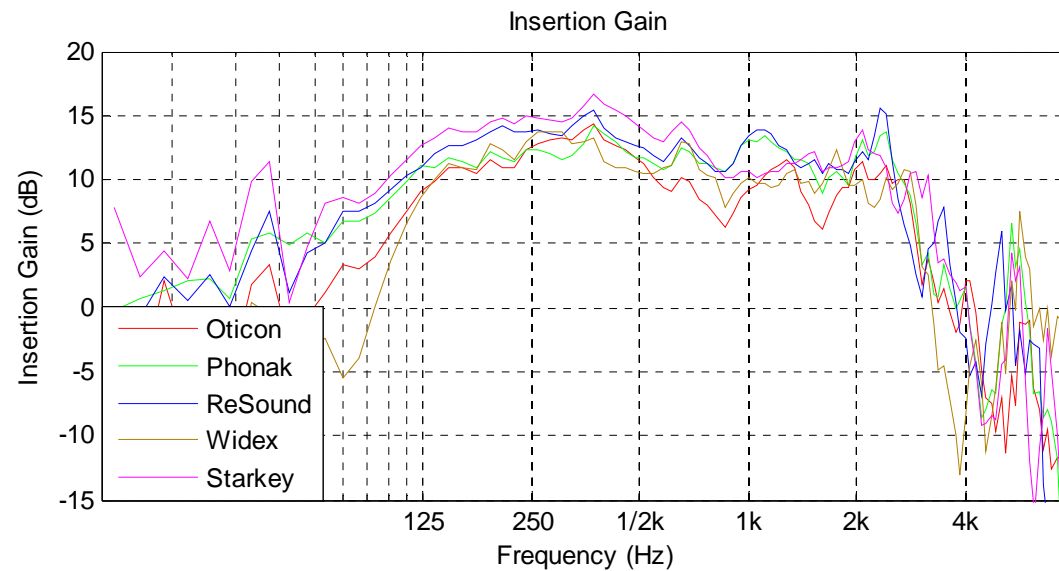


# Recording – hearing aids (2)

## ■ Programming

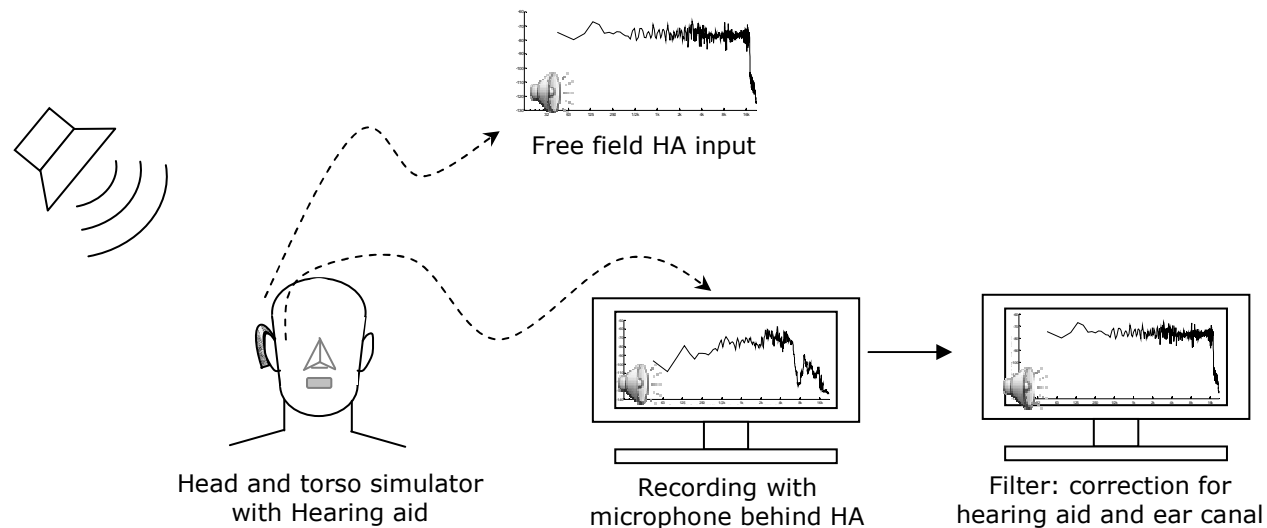


- Equal insertion gain (difference between aided and unaided response)
- Compression ratio 1.0 (= no compression)
- Microphone omnidirectional
- All other features OFF
- Noise reduction OFF and MAX

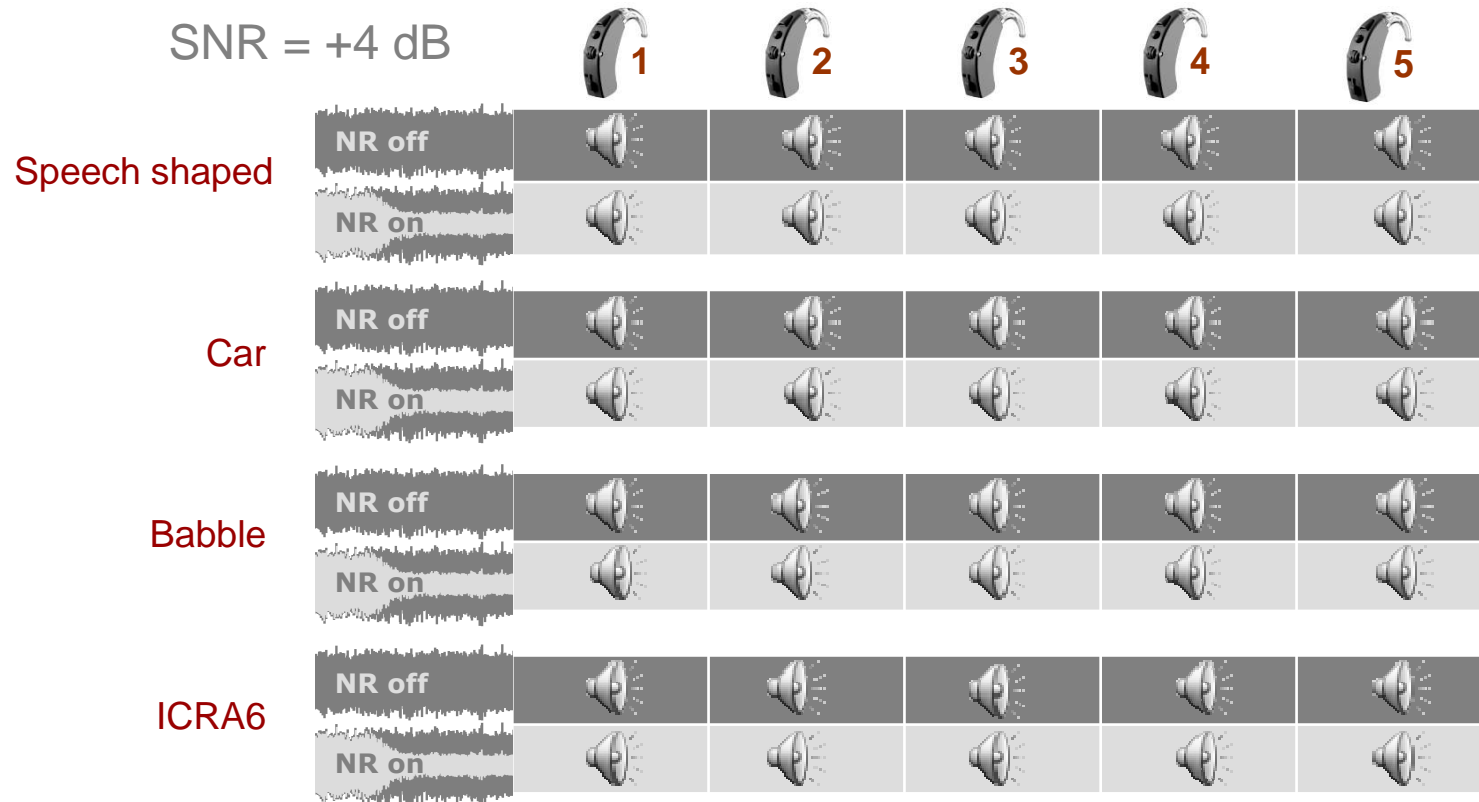


# Recording – setup (2)

- Added: filter after recording
  - Correction for ear canal
  - Correction for frequency response of hearing aid (with NR off)
  - Band pass limitation



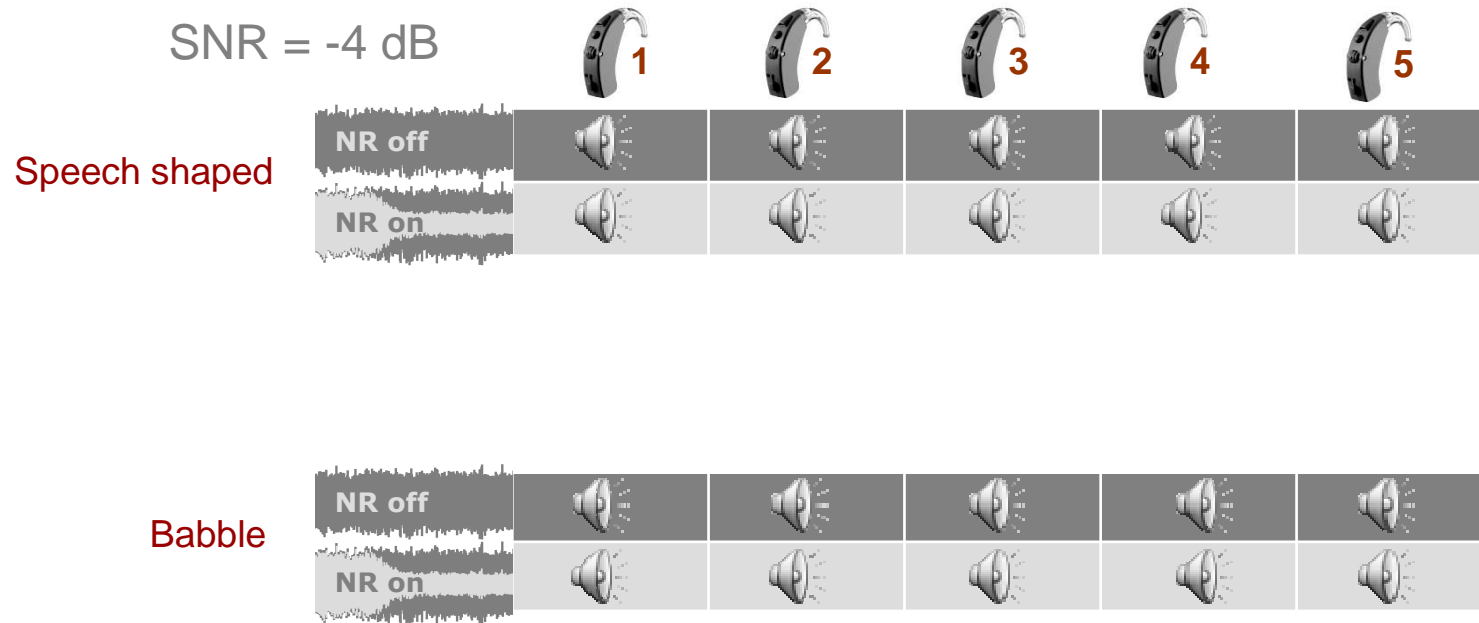
# Recording – examples (2)



- Effect of hearing aids << effect of noise reduction
- Comparison of noise reduction methods possible



# Recording – examples (2)

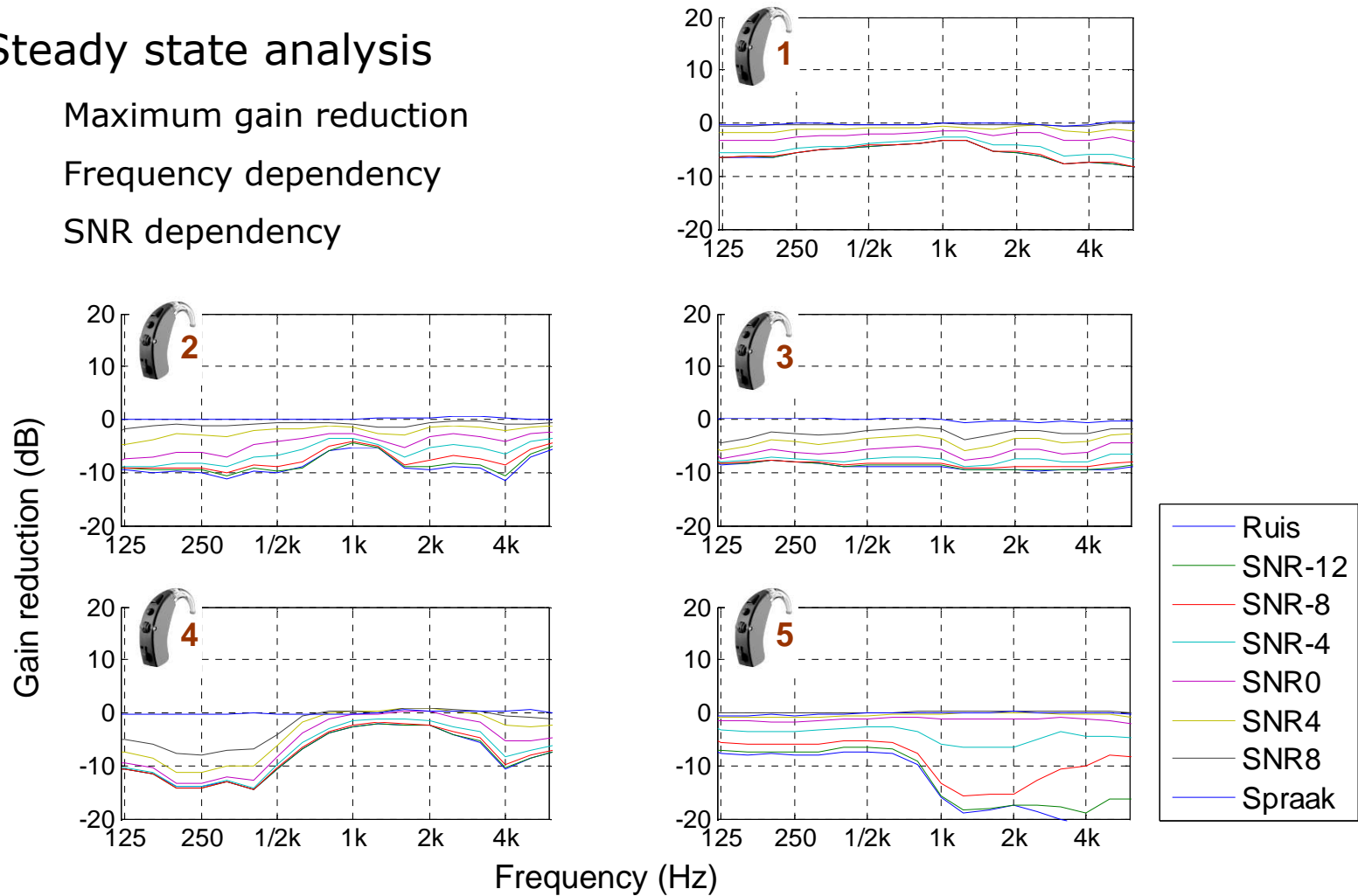


- Effect of hearing aids  $\ll$  effect of noise reduction
- Comparison of noise reduction methods possible



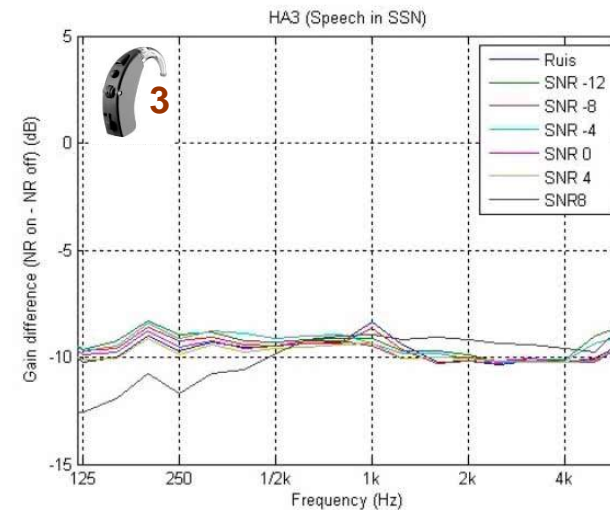
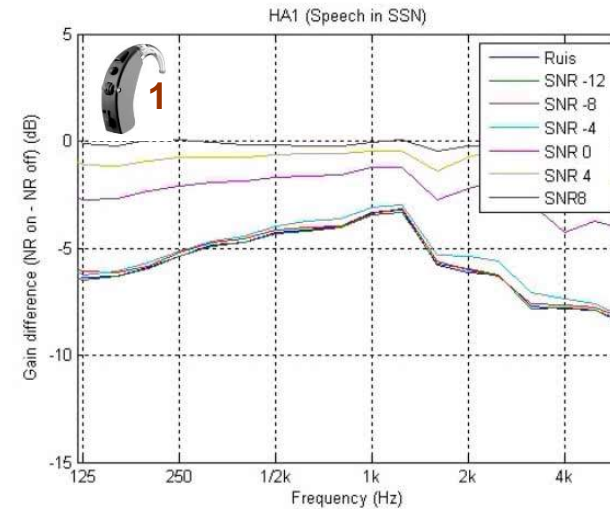
# Technical measurements

- Steady state analysis
  - Maximum gain reduction
  - Frequency dependency
  - SNR dependency



# Technical measurements

- Steady state analysis
- Dynamic analysis
  - Maximum gain reduction
  - Frequency dependency
  - SNR dependency
  - Speed of changes
    - From noise to speech in noise
    - From speech in noise to noise



# Conclusion

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- Large differences between noise reduction strategies
  - In terms of amount and velocity of gain reduction and its dependency on noise, SNR and frequency
  
- Method for recording and filtering facilitates perceptual evaluation
  - Effect of noise reduction >> effect of hearing aid
  
- Follow-up research: perceptual effects of noise reduction
  - Intelligibility
  - Preference: comparison category rating
    - Distinction between *signal*, *noise* and *overall* quality
  - Listening effort: rating scale