



# **Practical Benefit of Extended Bandwidth Hearing Aids**

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# Background

- General study design:
  - Compare normal hearing with hearing impaired listeners
    - Adults and children
  - Ideal testing situation
    - Filtered signal presented through headphones/earphones
      - Often shaped to accommodate hearing loss
      - 1-2 syllable nonsense words or sentences (in noise with positive SNR)
- Conducted evaluations at first fitting
  - No training provided for listeners

# Findings of past studies: Inconclusive

- Mixed results
  - Not all hearing impaired listeners have shown benefit from extended high frequency amplification (e.g., Hornsby and Ricketts, 2003, Hornsby and Ricketts, 2006, Horwitz et al, 2008, Pittman, 2008, Plyler and Fleck, 2006, Ricketts et al, 2008, Stelmachowicz et al, 2001).
  - Improvements seen under some conditions
    - Milder hearing losses
    - Subjective tasks vs. objective tasks
  - Improvements not always significant
- Results obtained under headphones may not translate to hearing aids
  - MPO of headphones is greater than hearing aids

# Hearing Aids with Extended Bandwidths Are Available...

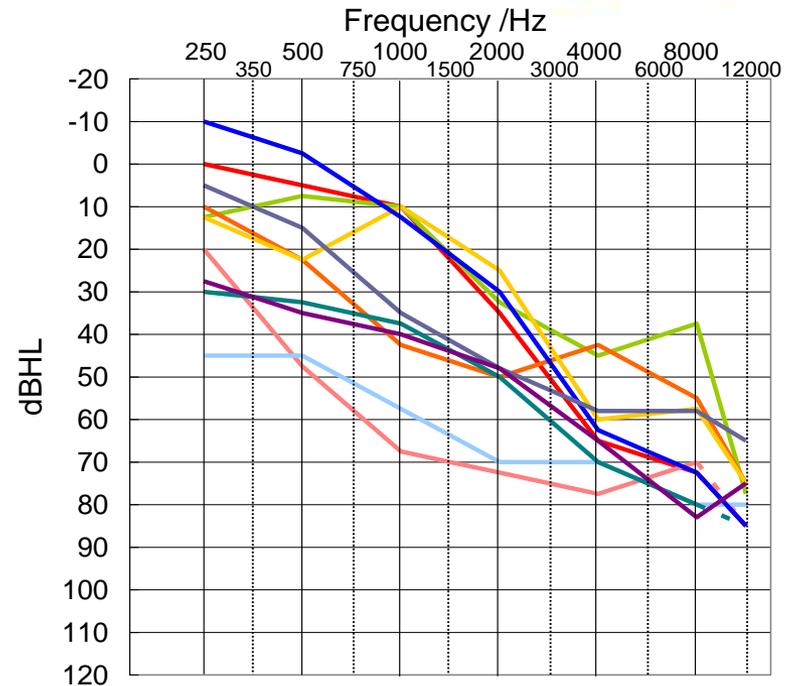
- Implications for hearing aid fittings
  - Would accuracy of speech recognition be different as the bandwidth is changed?
  - Are changes in speech recognition apparent in all listening situations?
  - What are the consequences on perceived sound quality?

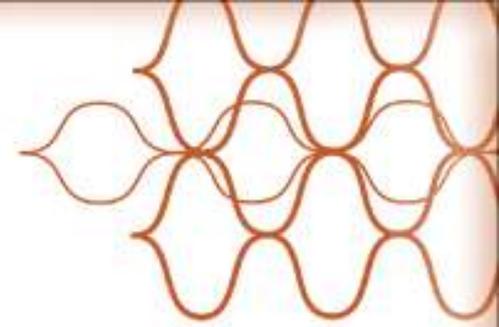
- **Purpose:**

To evaluate the efficacy of extended bandwidth and high frequency output using a nonsense speech test with high frequency emphasis following a brief training period.

# Participants

- Ten adults
  - 3 males and 7 females
  - 47 to 80 years old with a mean age of 66 years  
(11 participants needed for power of 0.8 based on this preliminary data)
- Bilateral SNHL, sloping HF HL
  - 6 mild-to-moderate
  - 4 moderate-to-severe
- 8 experienced wearers and 2 new wearers



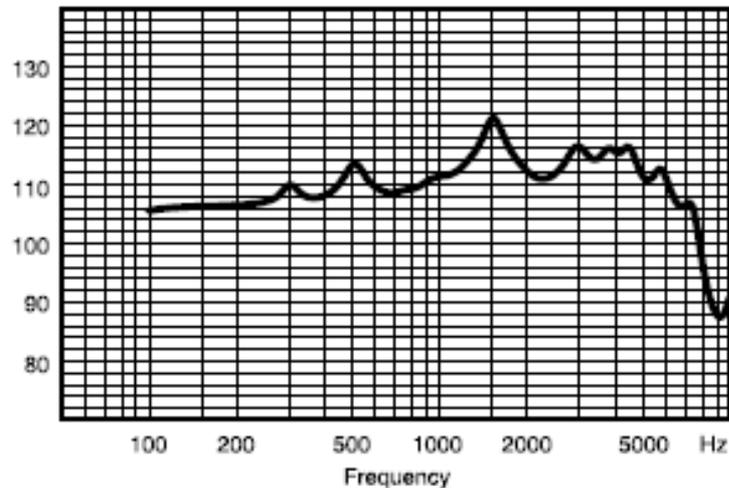


# Study Hearing Aid

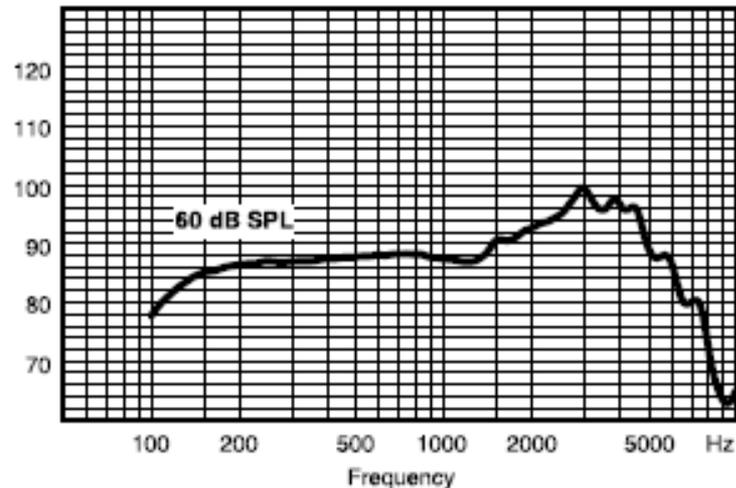
- Widex mind440-m-CB micro-size hearing aid
  - Custom acrylic earmolds with a large bore/horn effect and short canal length
  - Adaptive algorithms deactivated
- TWFK-60173 Knowles Electronics receiver
  - Two receivers, output frequencies beyond 10 kHz (measured 100-8150 Hz on HA-3 coupler)

IEC 60118-7 / ANSI S3.22-2003

Output dB SPL

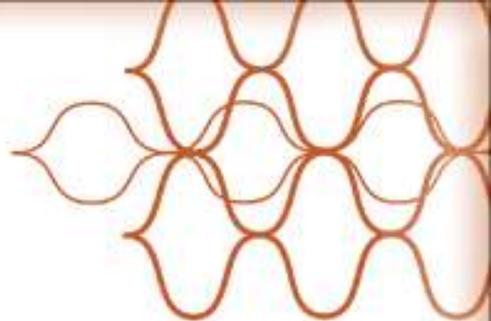
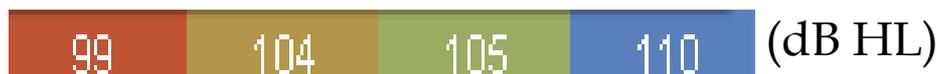


Output dB SPL



# Study Hearing Aid

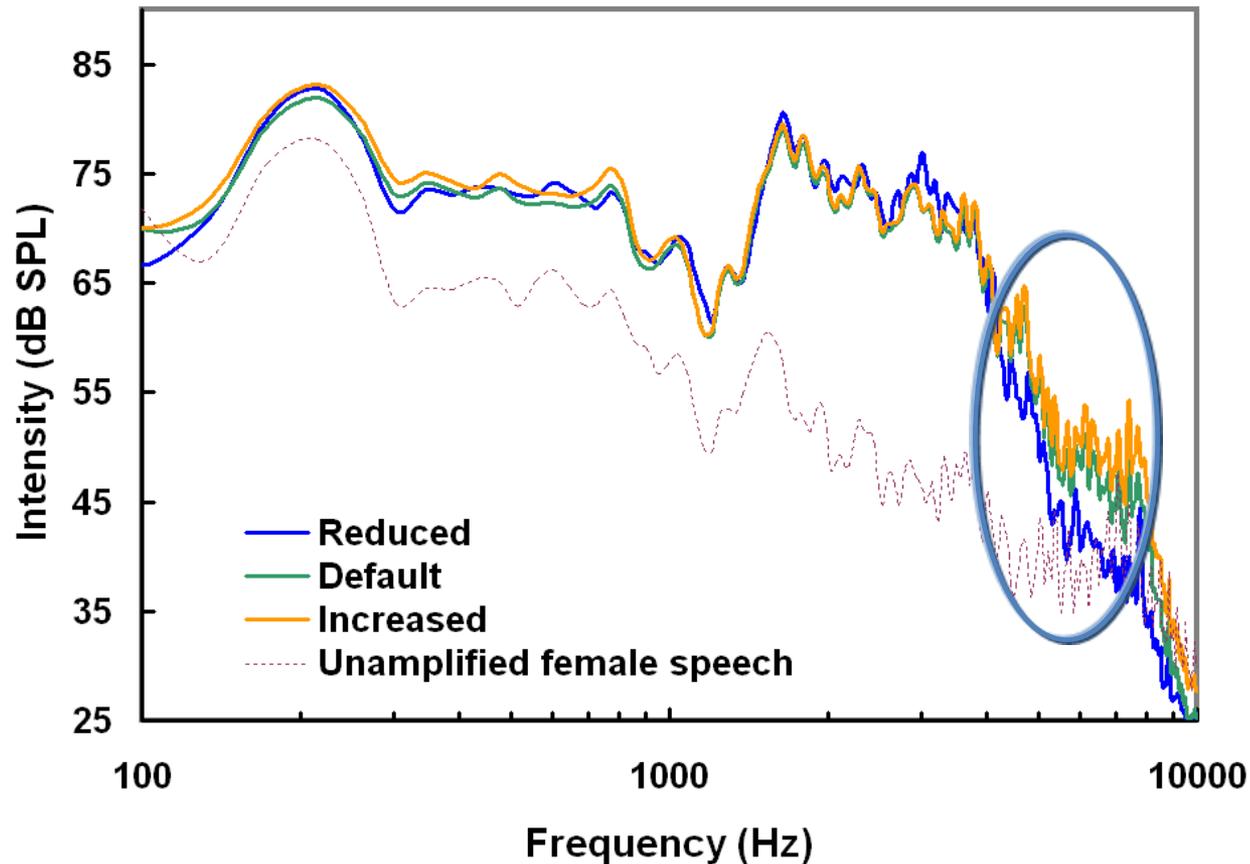
- Dual Integrated Signal Processing (Dual-ISP)
  - 15 channel hearing aid
  - enhanced dynamic range compression
  - compression threshold as low as 0 dB HL
- Input dynamic range of 107 dB SPL
- High sampling rate of 32 KHz
- MPO: 5 kHz 1 kHz 2 kHz 4 kHz



# Procedure

- Three hearing aid conditions: gain was adjusted in the highs to be different between programs
  - Reduced program: High frequency gain decreased
  - Default program: No changes
  - Increased program: High frequency gain increased
- Participants completed speech recognition in quiet and noise
- Participants completed paired comparison tasks with speech and music samples
- Single- blind design

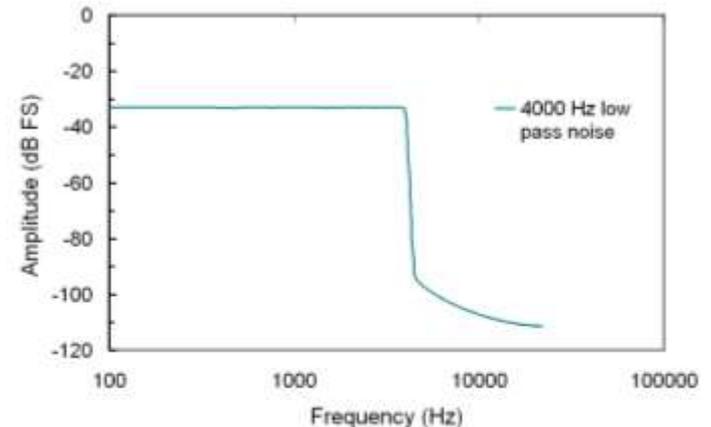
# Hearing aid output



# Method: ORCA HF Speech Test

## Office of Research in Clinical Amplification (ORCA) Speech Test

- List of 32 nonsense words with CVCVC structure
  - Each phoneme is scored
- Speech and noise were both presented from 0° azimuth
- Female talker –
  - Quiet
    - 50 dB SPL
    - 68 dB SPL
  - Low pass noise with 4000 Hz cutoff
    - Speech at 68 dB SPL
    - SNR of +10 dB
    - SNR of 0 dB
- Testing was conducted at first fitting and after a one month take-home period
- Test conditions counterbalanced



# Method: Paired comparison task

- Sound quality judgments of 10 music samples and 10 spoken sentences
- Round robin comparison of experimental programs (i.e. Increased vs. Default, Default vs. Reduced, Increased vs. Reduced)
- Number of wins for each program were compared (in %) for music and speech separately
  - Music samples
    - Various types of music including instrumental and vocal
    - Each 10 s long
    - 65 dB SPL from 0° azimuth
  - Speech samples
    - Female talker
    - “Summer in Sweden” passage (from Hearing Rehabilitation Foundation; Jeff Plant)
    - 68 dB SPL from 0° azimuth

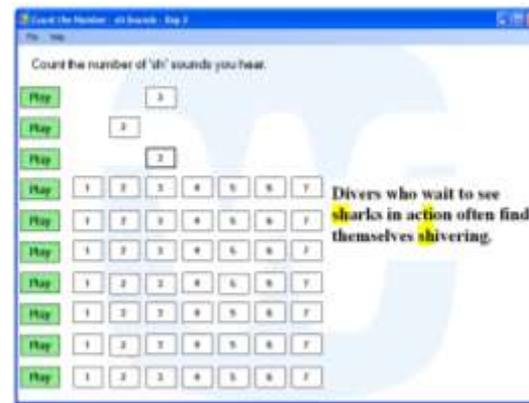
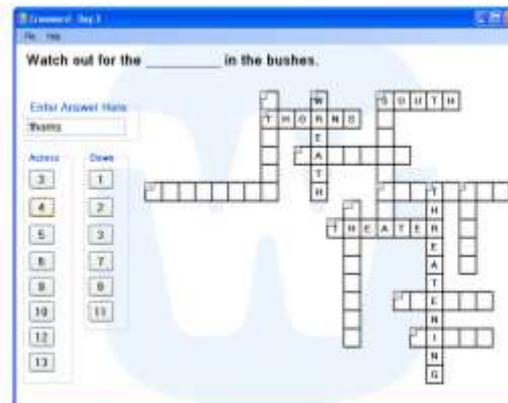
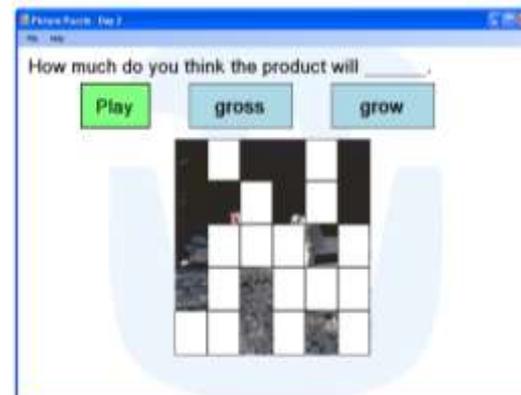
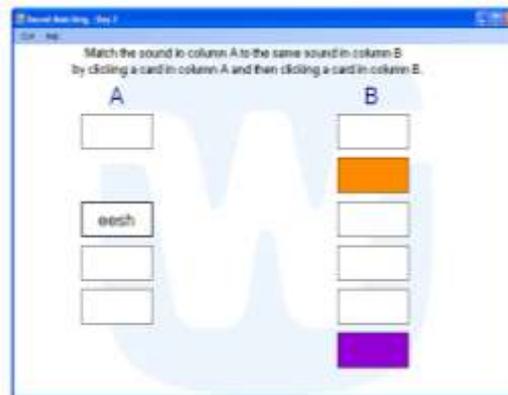
# Method: Training

- Provided listening practice in a listener-controlled format
  - 10 days of computer based consonant listening training
  - Activities centered around target sounds
    - /s, ʃ, ð, f, p, t, k/
  - 2 adult female talkers, 1 adult male talker

Here's what was involved...

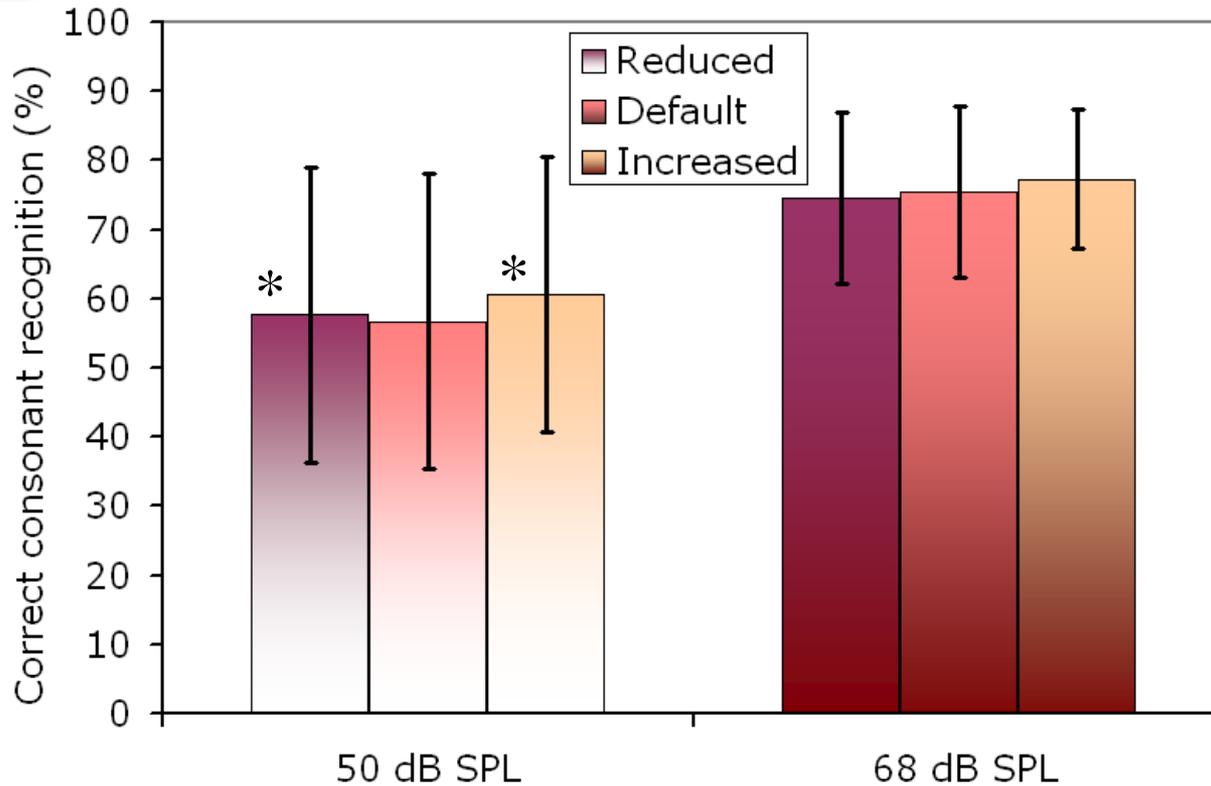
# Widex take-home listening practice

- Goal: provide listening practice with target sounds in a listener-controlled format
- Prepare listeners to focus on target sounds, not visual representation



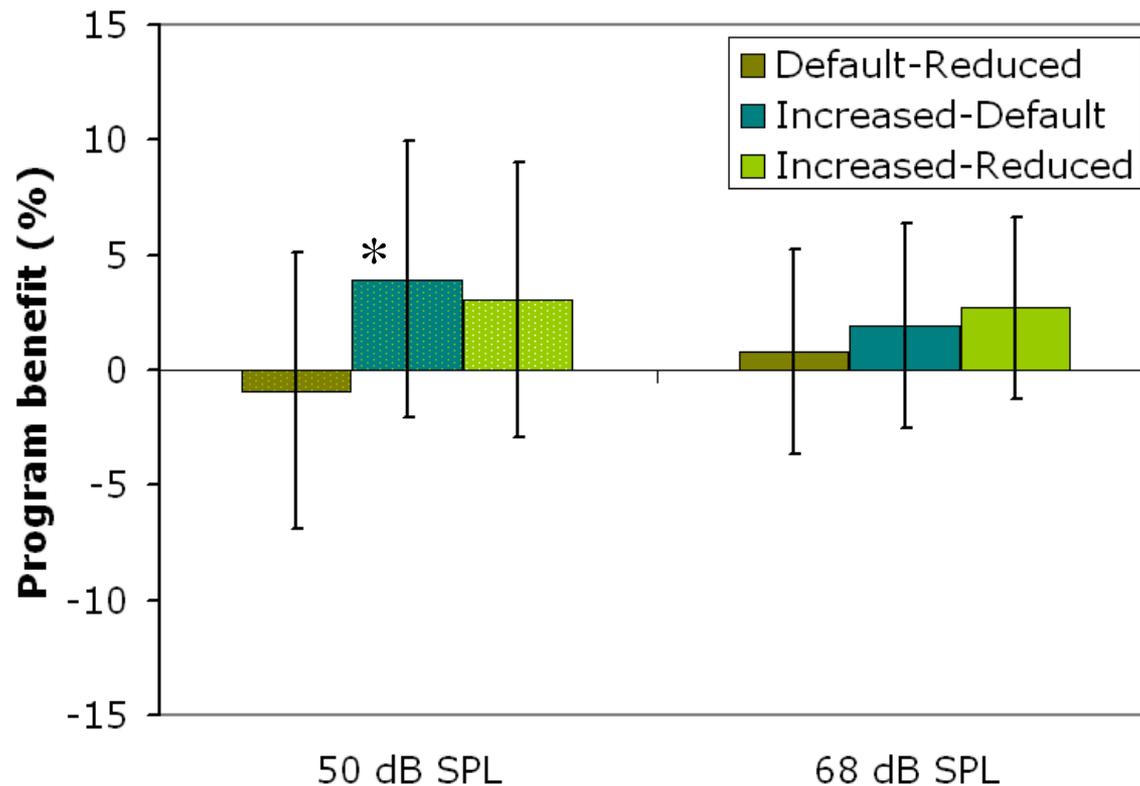
# Effect of bandwidth: Initial fitting

## Consonants in quiet



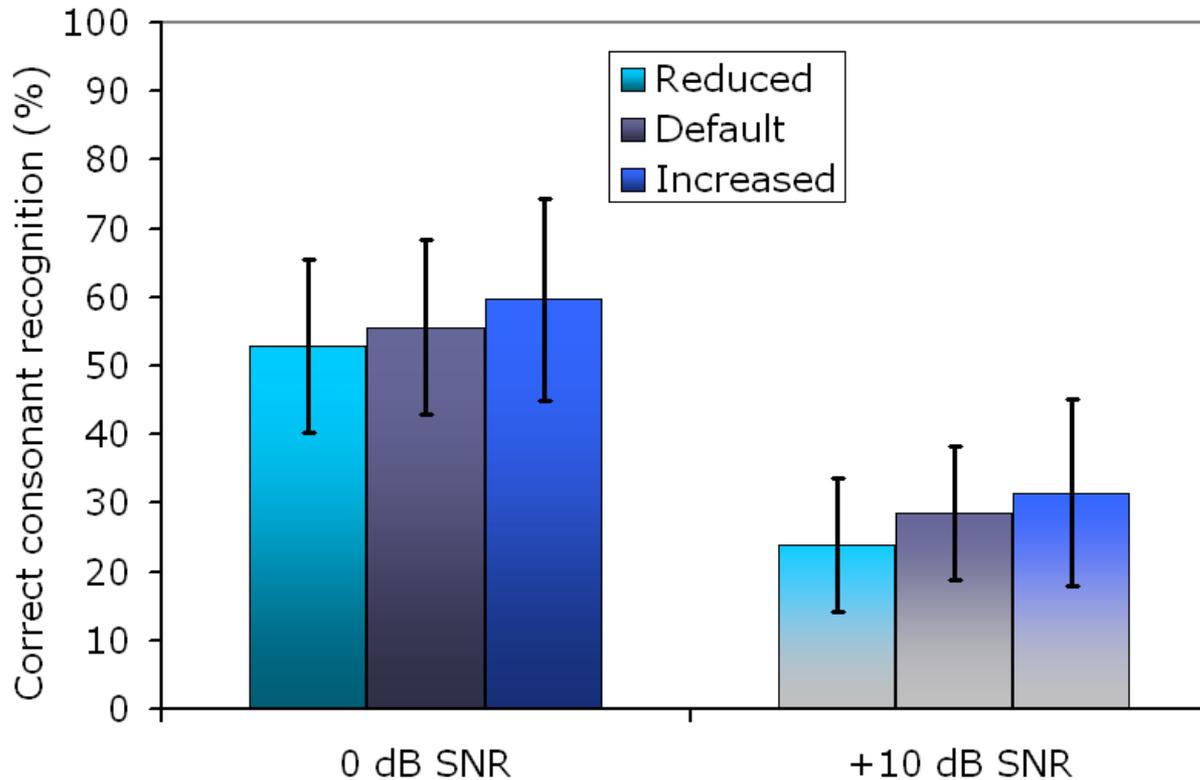
# Effect of bandwidth: Benefit at initial fitting

## Consonants in quiet



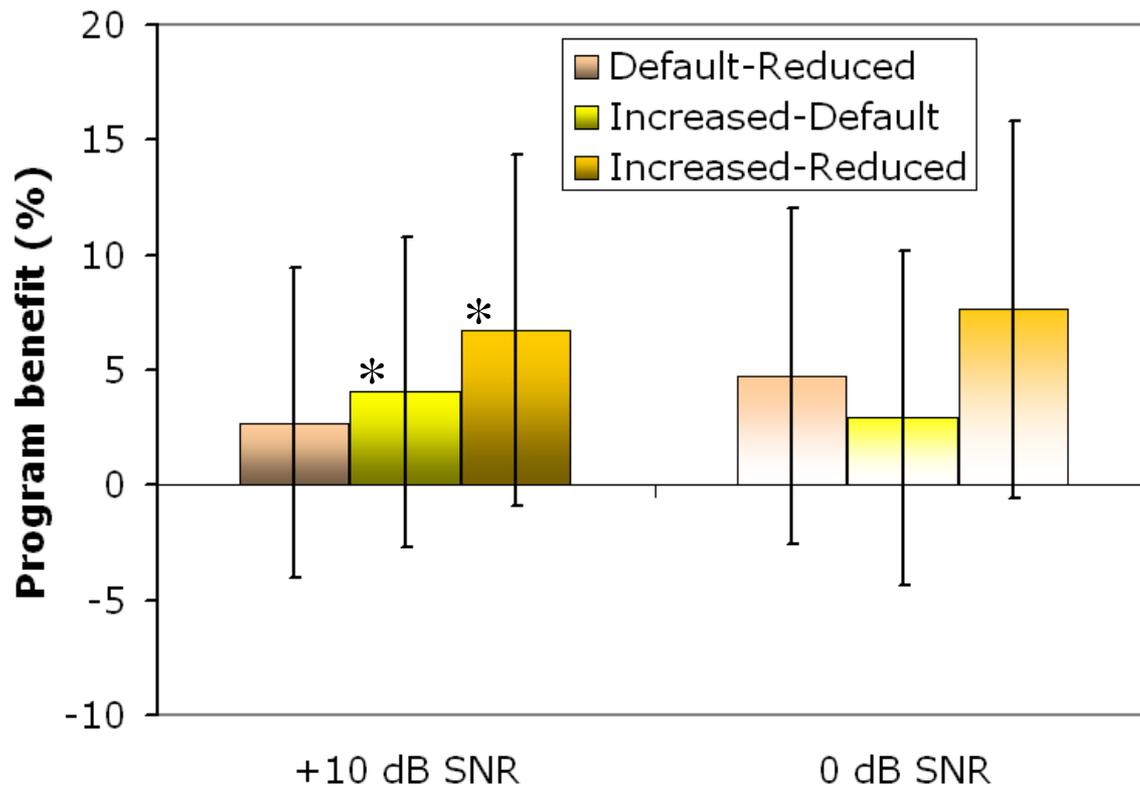
# Effect of bandwidth: Initial fitting

## Consonants in noise



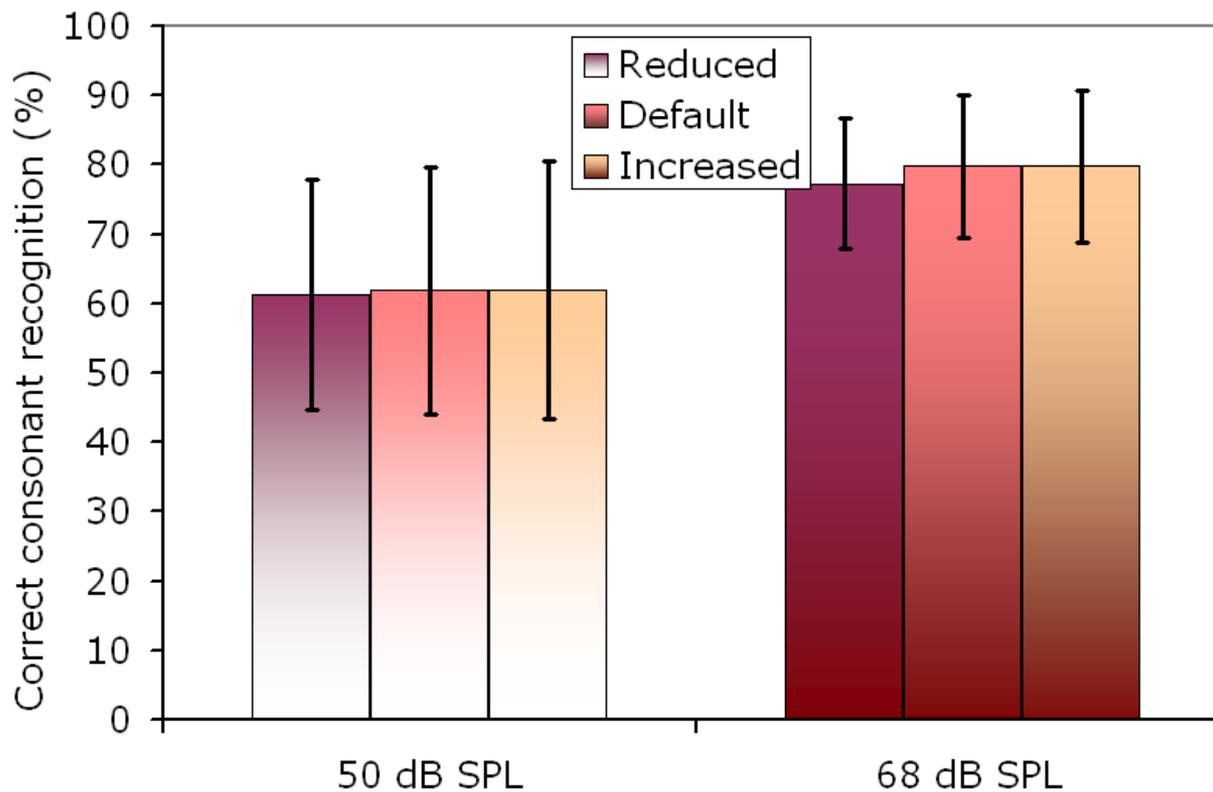
# Effect of bandwidth: Benefit at initial fitting

## Consonants in noise



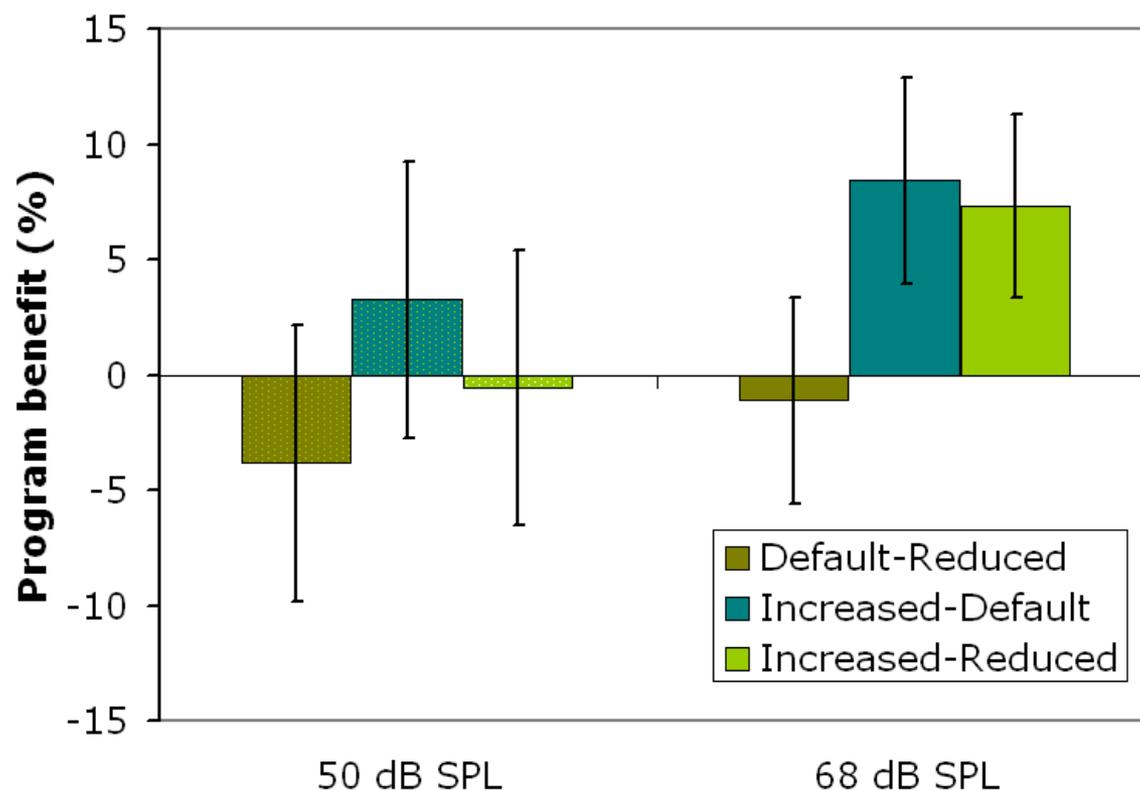
# Effect of bandwidth: Final evaluation

Consonants in quiet



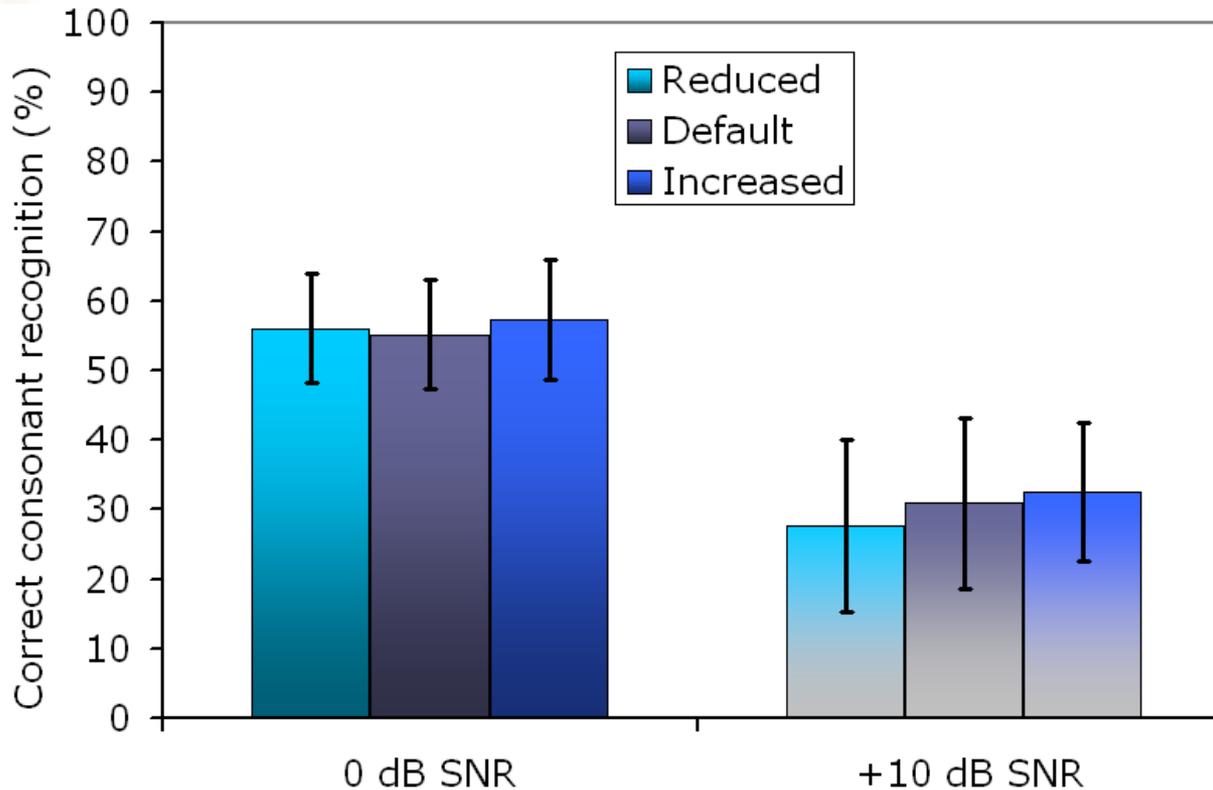
# Effect of bandwidth: Benefit at final evaluation

## Consonants in quiet



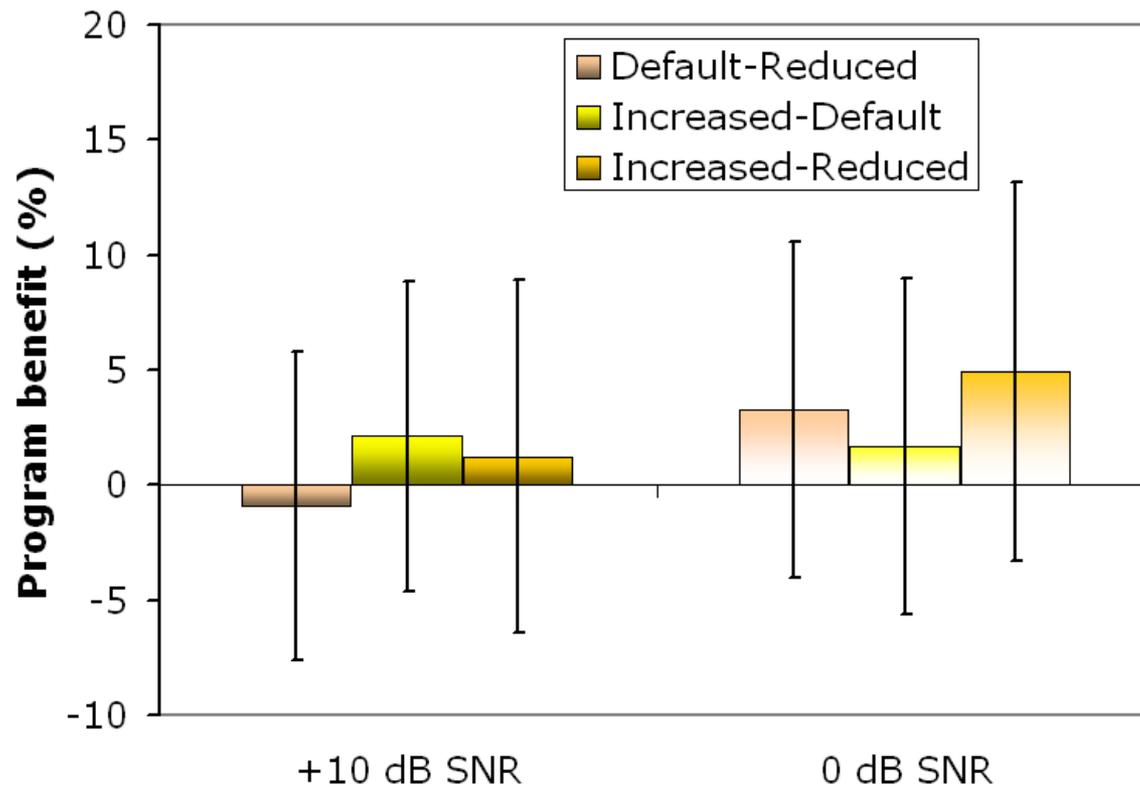
# Effect of bandwidth: Final evaluation

## Consonants in noise



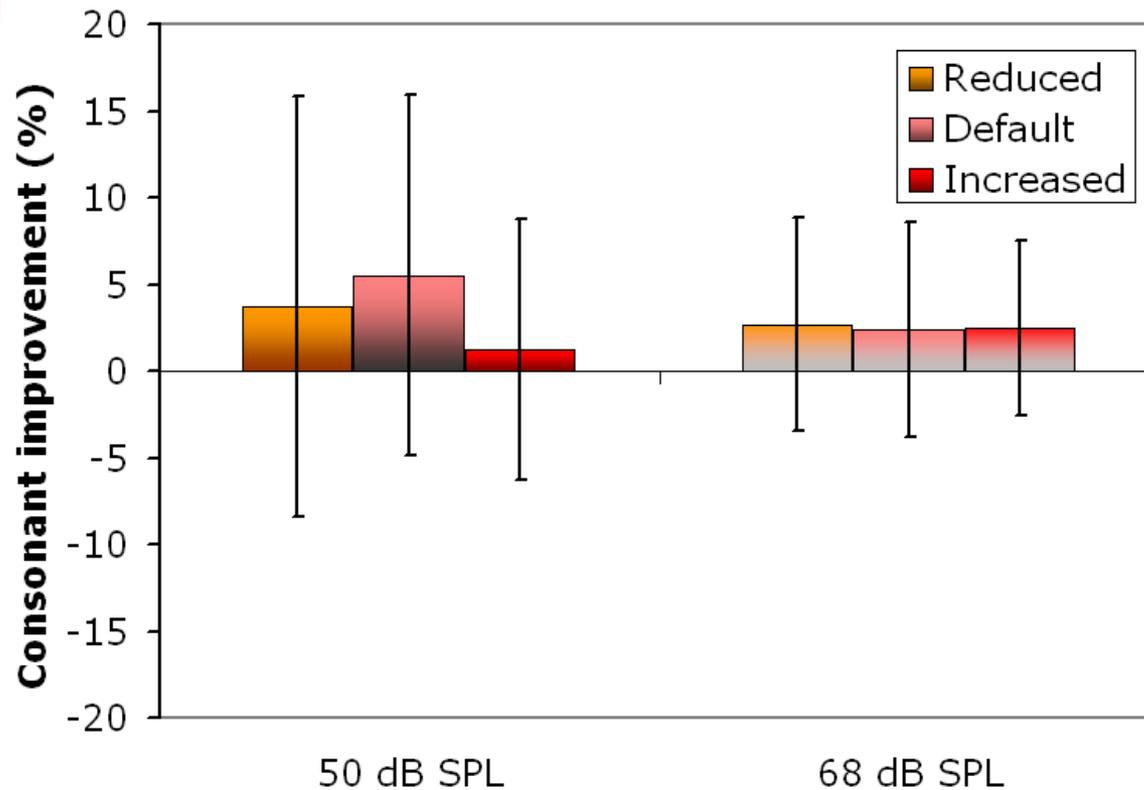
# Effect of bandwidth: Benefit at final evaluation

## Consonants in noise



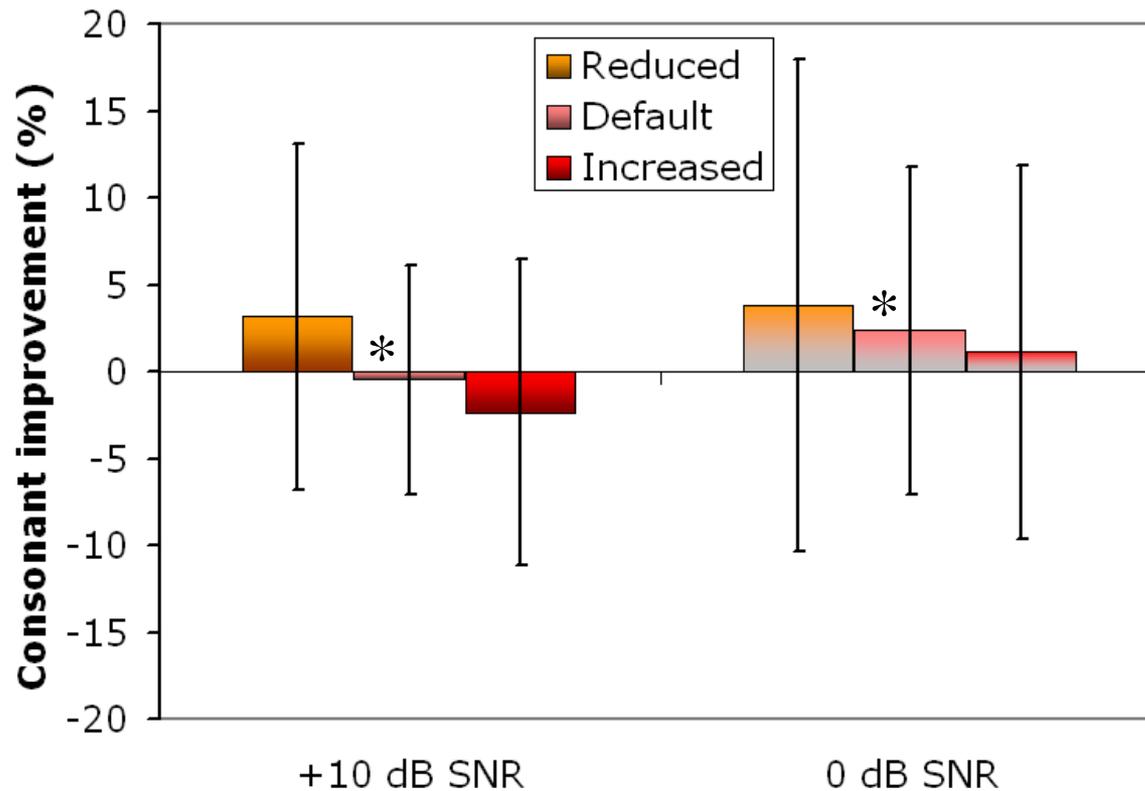
# Effect of training: Consonants in quiet

Consonant scores improved 3.7% on average



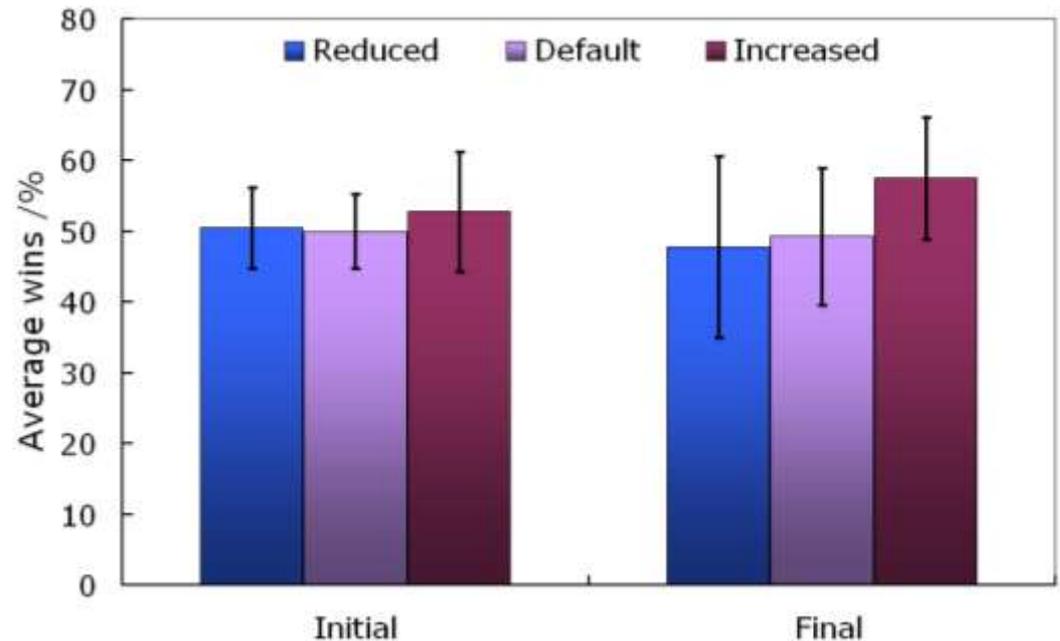
# Effect of training: Consonants in noise

Consonant scores improved 3.82% on average



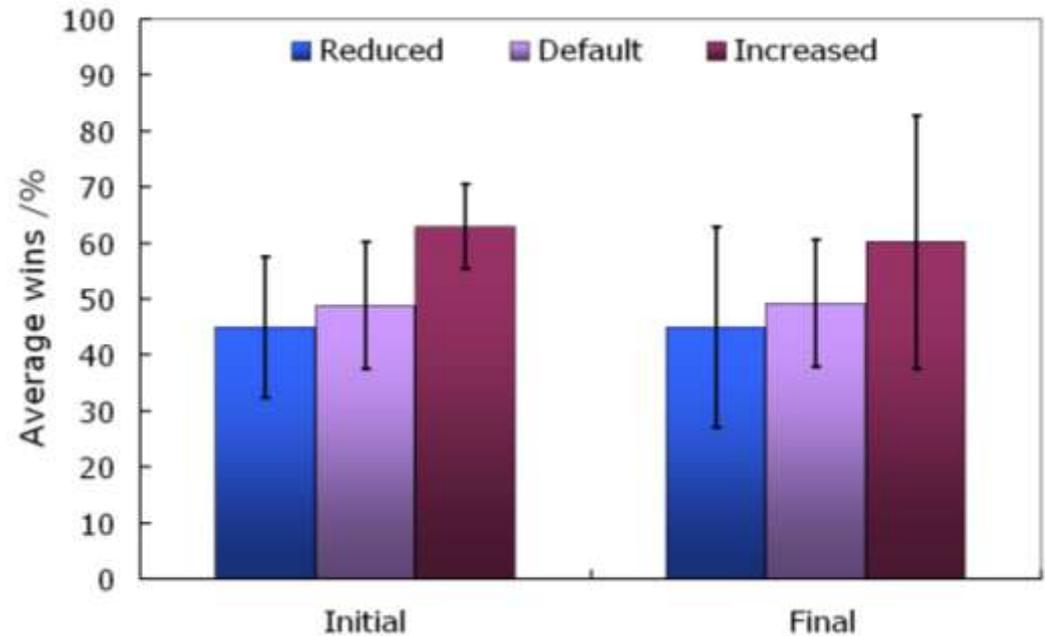
# Subjective preference: Music

- Initially no preference for a particular program
- Post-training the Increased program was preferred most often



# Subjective preference: Speech

- Initially a preference was seen for the Increased program and was also seen post-training

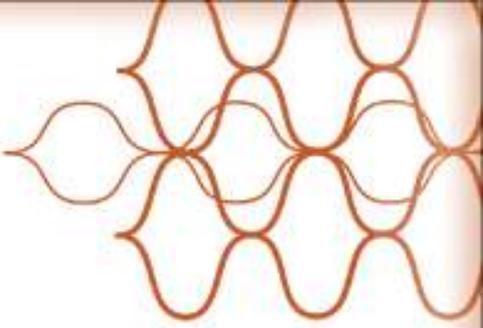


# Discussion

- Improvement was seen in speech recognition following one month training with mind440-m CB hearing aids. Improvements did not reach significance likely due to the test design.
  - Not enough difference between experimental programs?
  - Program 'reduced' already provided enough gain?
    - Female talker had greatest energy in low to mid frequencies
  - Too much hearing loss?
    - More improvement or perceptual preference may be demonstrated by a group with thresholds no worse than 55-60 dB HL at 4000 Hz and above.

# Conclusions

- Would accuracy of speech recognition be different as the bandwidth is changed?
  - Yes, performance with the increased gain condition was slightly better than with default and reduced gain settings.
- Are changes in speech recognition apparent in quiet and noise?
  - Yes, equal improvement on the ORCA speech test was seen in quiet conditions (0-3.7%) and noise conditions (0-3.8%), although the degree of improvement was not statistically significant.
- What are the consequences on perceived sound quality?
  - Listeners prefer the sound quality of extended bandwidth when listening to music and speech.



**Thank you!**

