



# **Study on Frequency Transposition – Part I**

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# Performance in Noise with Frequency Transposition

# Background

- English language contains high frequency information (such as /s/)
- Spectral distribution of /s/ investigated by Boothroyd et. al. 1992
  - Initial and medial position with /a/ /i/ /u/
  - Peak range between 3200 Hz and 8400 Hz
  - Amplify up to 10,000 Hz or use frequency transposition
- For hearing losses above 70 dB HL, the prevalence of dead regions can exceed 50% (Aazh and Moore, 2007) (Vinay and Moore, 2007)

# Background

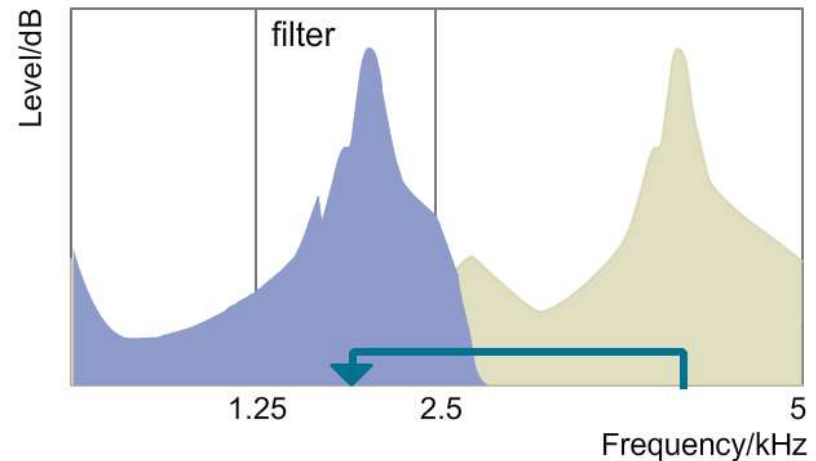
- Mixed suggestions on amplifying dead regions
- Frequency transposition not a new concept
  - 1960's (Bennett and Byers) - 1970's (Gengel and Foust)
  - 1990's AVR TranSonic
  - Today: Frequency Transposition (Audibility Extender)
    - Improved reception of environmental sounds
    - Shown to improve reception of consonants in quiet

# Sound Processing – Audibility Extender (linear frequency transposition)

True linear frequency  
transposition

- *Analyse spectrum*
- *Find sound*
- *Set target*
- *Transpose sound*
- *Filter sound*
- *Overlay sound*

Preserves the temporal  
structure of sounds



# Study Objectives

Compare performance of frequency transposition to no transposition

- 50 dB SPL and 68 dB SPL in quiet
- In noise at 68 dB SPL
  - Continuous speech shaped noise
  - Multi-talker babble noise

Observe performance over time and after auditory training

# Participants

Eight people with a severe-to-profound high frequency hearing loss

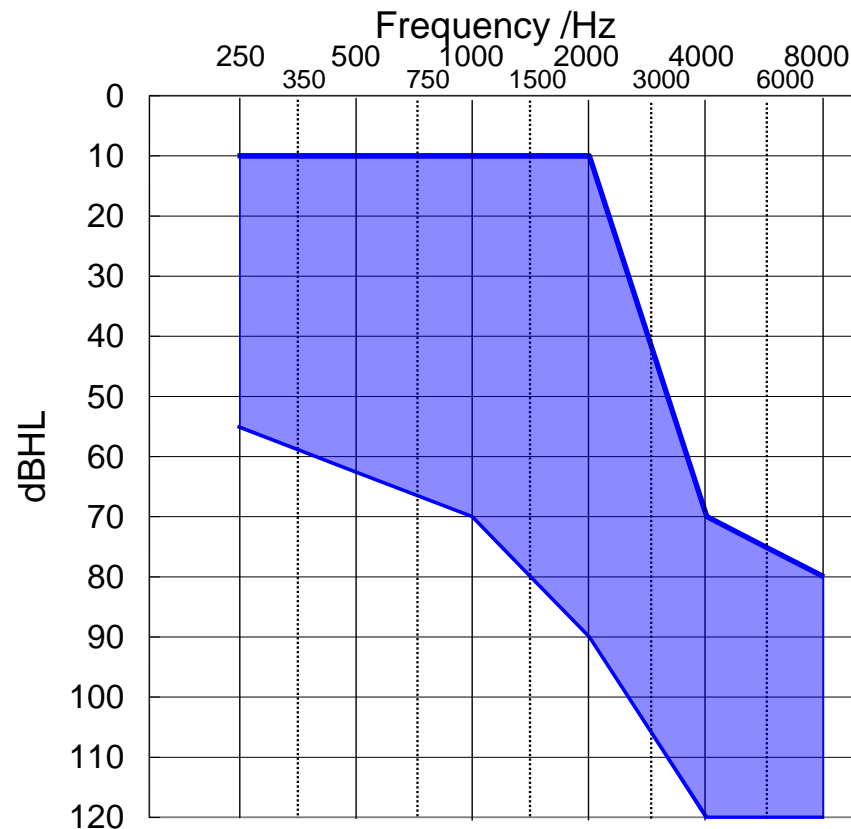
- Seven male; one female
- All native English speakers
- Age range: 30-86 years

Previous hearing aid experience

- Three currently use amplification
- Three had stopped using their own hearing aids due to no perceived benefit
- Two only experience through research

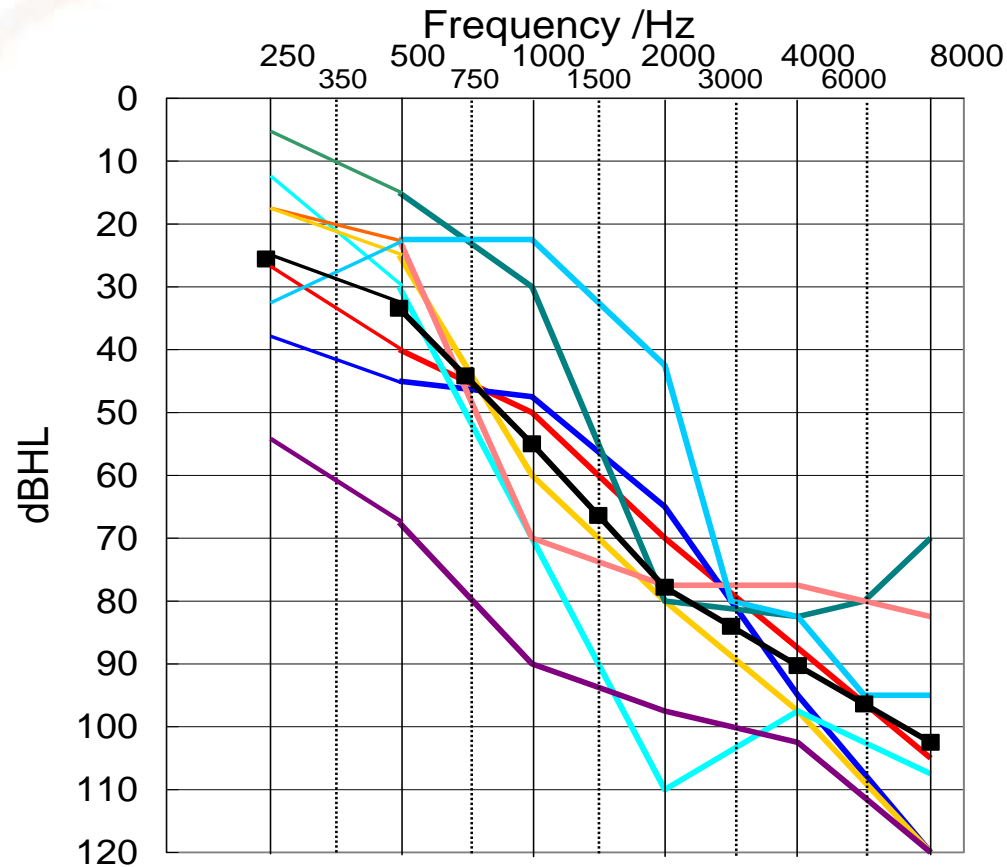
No prior experience with frequency transposition

# Recommended Audiogram for Transposition





# Hearing Loss of Participants



# Sequence of Visits

## Four visits

- Visit 1: Master testing (no frequency transposition)
- Visit 2: Initial AE testing
  - Start frequency determined individually
  - Given home training program for the next month
- Visit 3: After one month training
- Visit 4: Final visit; one more addition month of use (no additional training)

# Audibility Extender: Start Frequency

P1 Audibility Extender P2 Master

dB HL  
dB SPL

Microphone modes  
Hd Locator with Speech Tracer

Speech and noise modes  
Noise reduction

Feedback cancelling modes  
SuperGain

Start frequency  
2000

Microphone modes  
Hd Locator with Speech Tracer

Speech and noise modes  
Noise reduction

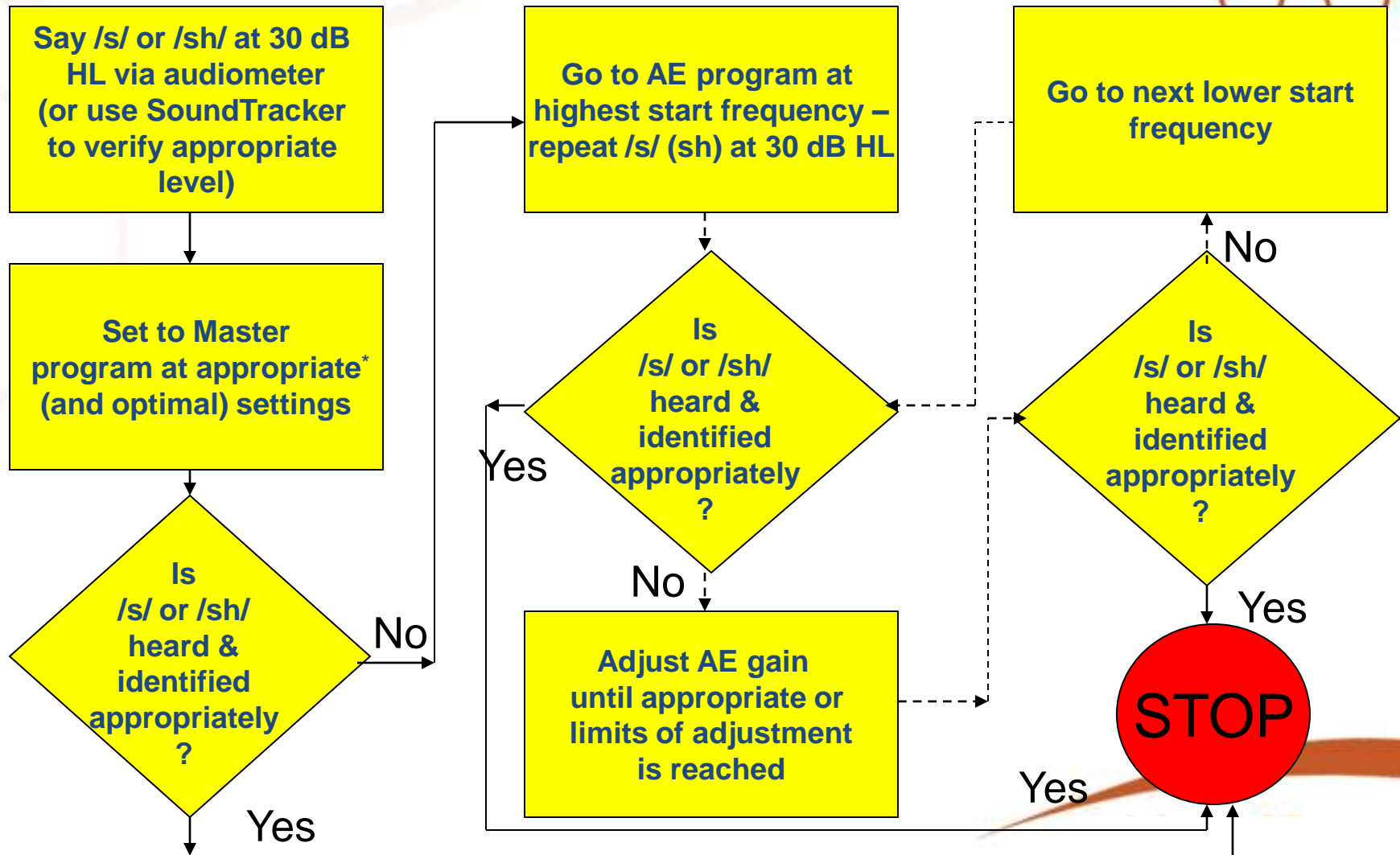
Feedback cancelling modes  
SuperGain

Start frequency  
2000

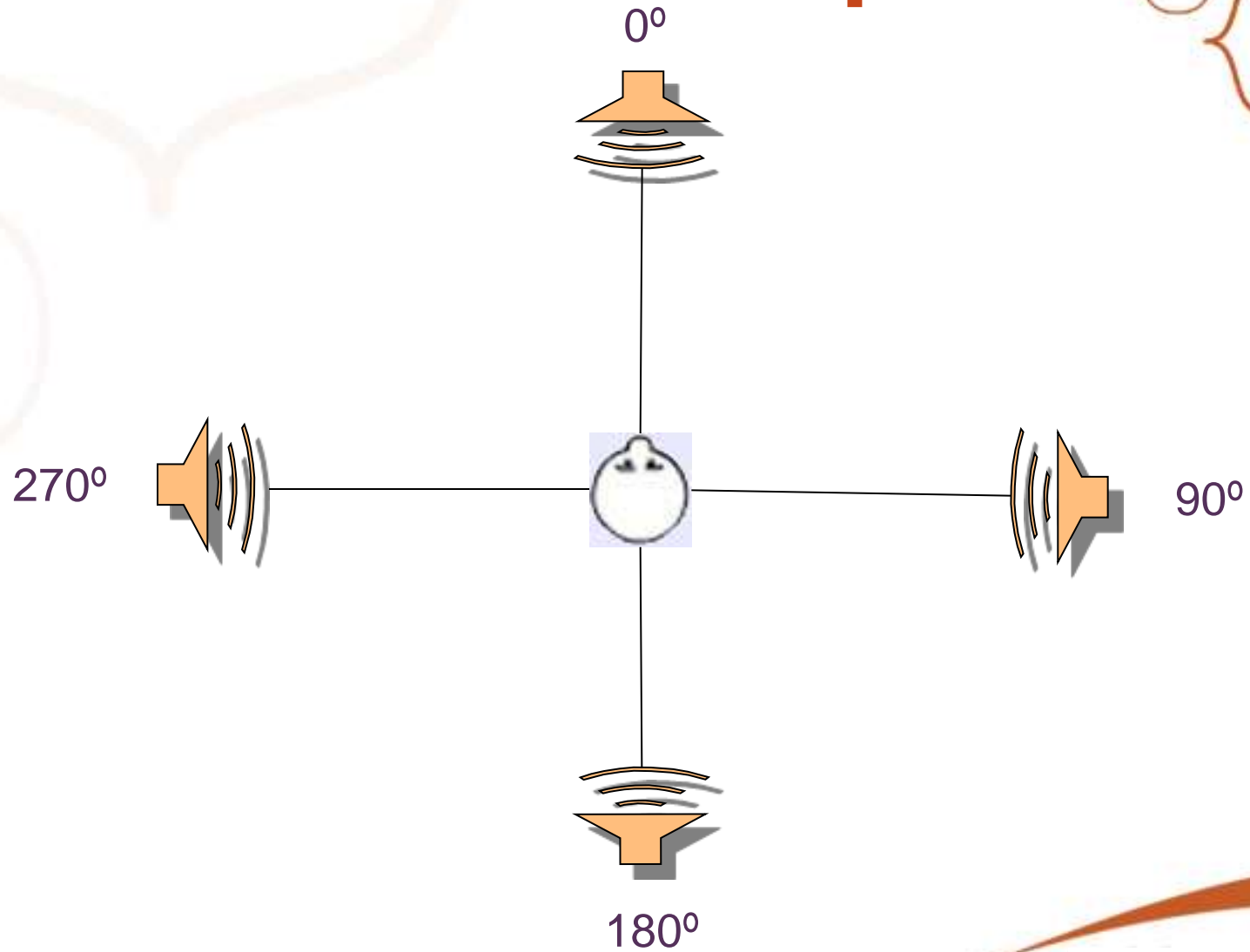
Frequency range  
 Basic  Expanded

AE gain  
0

# Steps in Individual Approach



# Test Set Up



# Office of Research in Clinical Amplification (ORCA) Nonsense Syllable Test

- 32 item test
- C-V-C-V-C format
- Preceded by phrase "Please say the word..."
- Computerized
  - Random presentation
  - Scoring by computer

# Response Screen

The screenshot shows the Widex software interface for a hearing aid fitting. The main display area is titled "Response Screen" and features three columns of phonetic symbols:  $/\delta/$ ,  $/\alpha/$ , and  $/d/$ . Below each column are three vertical panels (C1, V1, C2, V2, C3) containing a grid of phonetic symbols. The "No Response" button is highlighted in red, and the "Next" button is highlighted in green.

Word Number: 8

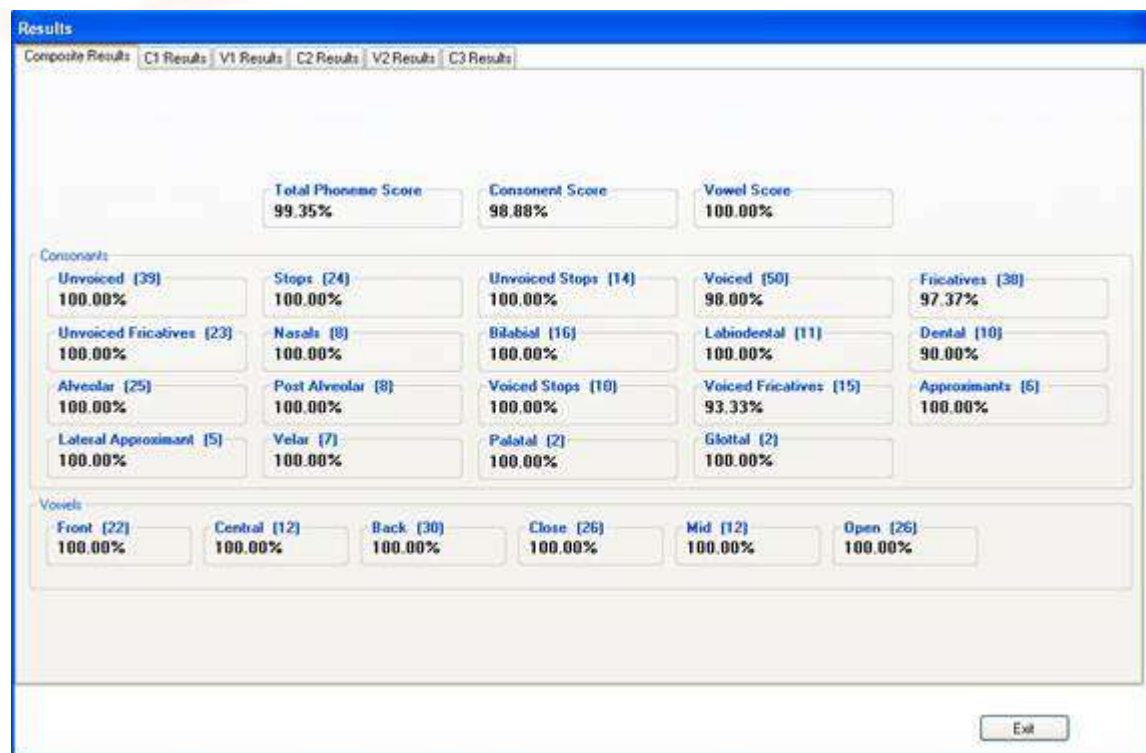
Words Played: 1

Exit

No Response

Next

# Test Results Screen





# ORCA Home Training Program

- Bottom up approach (sound / word / sentence)
- 30 days of training
  - 13 days: focus on vowels
  - 14 days: focus on consonants
  - 3 days: listener's choice
- 15-20 minutes per day
- Not the same material as the test material
- Computerized for home use

# Training Activities

**Sound Matching - Day 1**

Match the sound in column A to the same sound in column B by clicking a card in column A and then clicking a card in column B.

**A**

gek

**B**

Radio Type:  Static  Poly

**Sound Matrix - Day 1**

	Maught	Meat	Set	Et	Maat	Grabbit
Maught	Grey	Yellow	Yellow	Yellow	Yellow	Yellow
Meat	Yellow	Grey	Yellow	Yellow	Yellow	Yellow
Set	Yellow	Yellow	Grey	Yellow	Yellow	Yellow
Et	Yellow	Yellow	Yellow	Grey	Yellow	Yellow
Maat	Yellow	Yellow	Yellow	Yellow	Grey	Yellow
Grabbit	Yellow	Yellow	Yellow	Yellow	Yellow	Grey

Can You Hear A Difference?

Radio Type:  Static  Poly

Level: 10

**Picture Puzzle - Day 1**

As she entered the room, she could see the \_\_\_\_\_.

clock clocks

Radio Type:  Static  Poly

Level: 10

**Crossword - Day 2**

Watch out for your \_\_\_\_\_ when trimming the trees.

S H E D

Enter Answer Here:

Radio Type:  Static  Poly

Level: 10

Access: 1-12 Down: 1-10

**Count the Number of Sounds - Day 2**

Count the number of 'sh' sounds you hear.

Many types of sharks share the ocean.

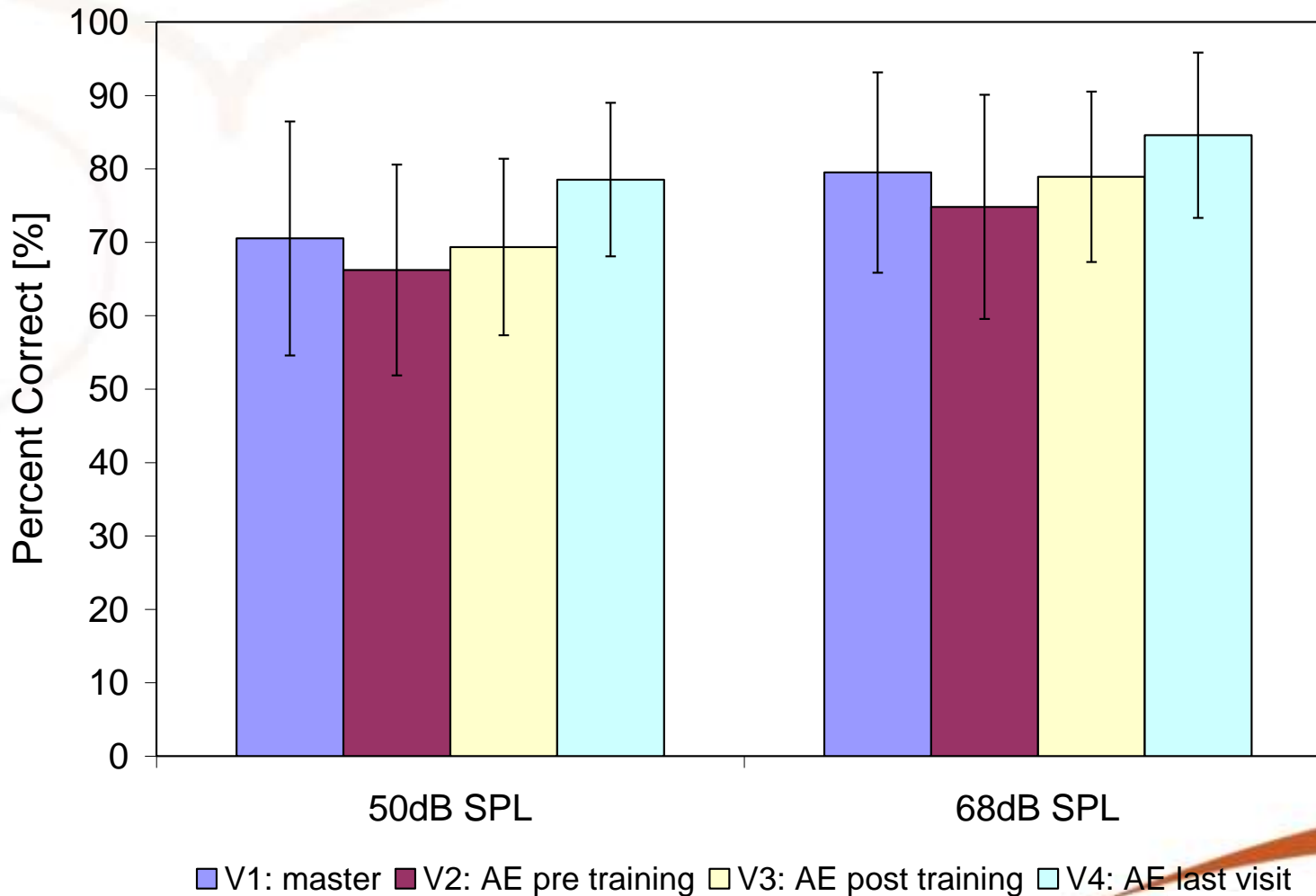
Radio Type:  Static  Poly



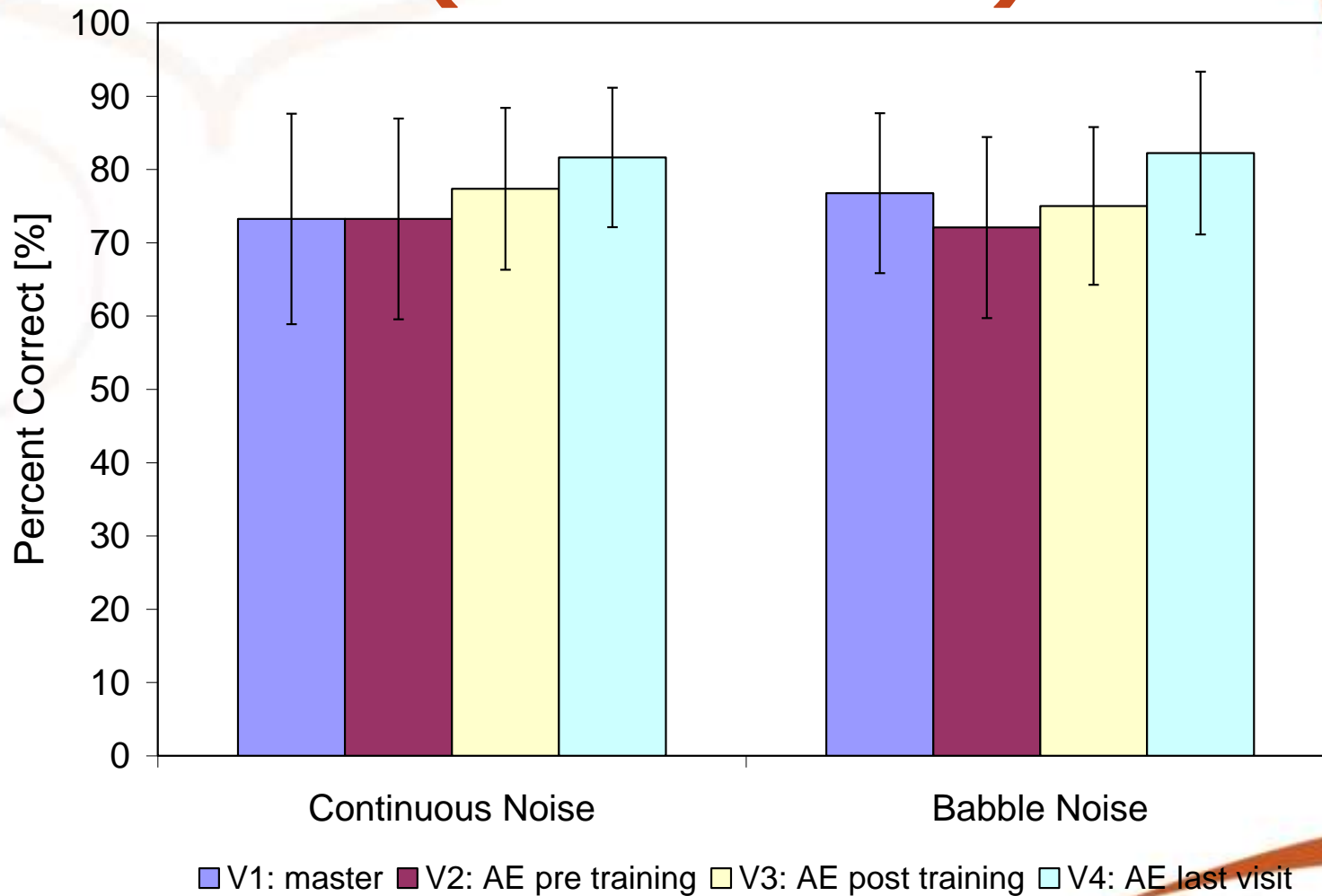
# RESULTS



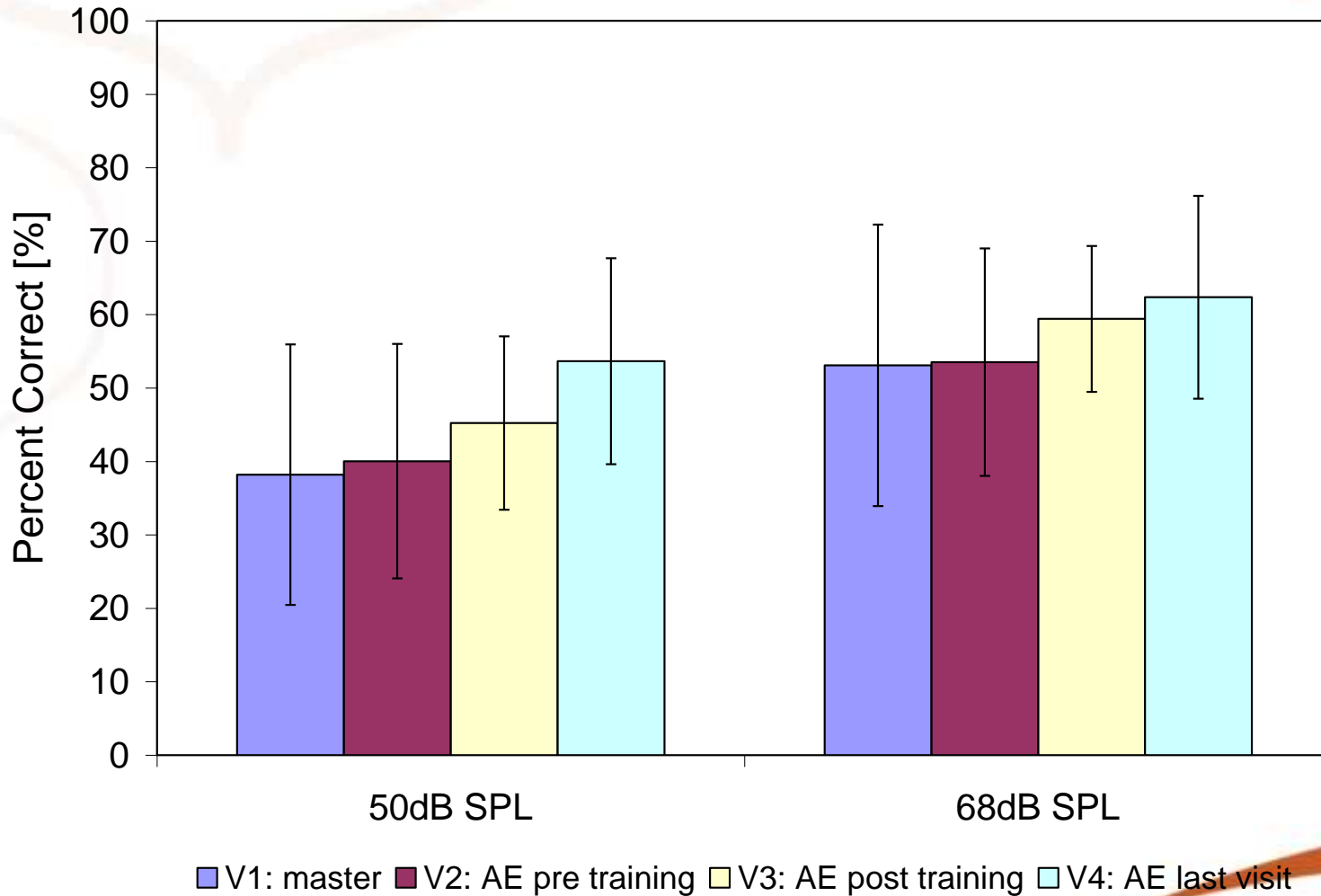
# All Vowels in Quiet



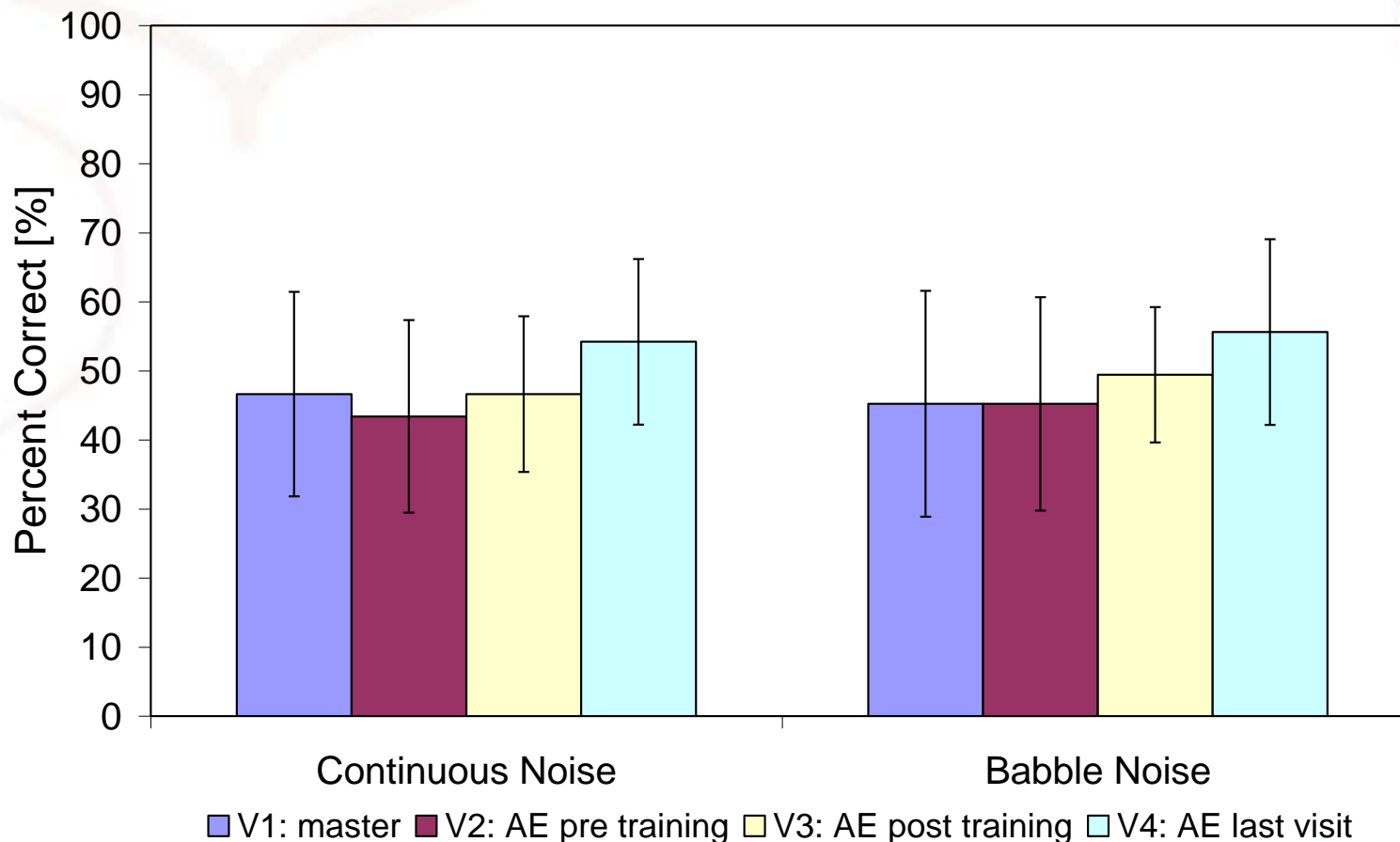
# All Vowels in Noise (+5 dB SNR)



# All Consonants in Quiet



# All Consonants in Noise (+5 dB SNR)



# Summary

Perception of vowels were not adversely affected by transposition either in quiet or in noise

Frequency transposition did not adversely affect understanding of consonants in quiet or in noise

- Some consonants, such as fricatives, showed immediate improvement with frequency transposition and continued improvement over time
- Some consonants, such as stops and nasals, showed initial confusion with frequency transposition which disappeared over time
- Similar performance between continuous noise and multi-talker babble noise



# Conclusions

- Linear Frequency Transposition was successful for this test group in quiet and in noise.
- An acclimatization period was necessary to see the advantage in more than one phoneme class.
- Guided listening tasks seemed to be helpful in the acclimatization process.



**Thank You!**

