Verification of soft speech amplification in hearing aid fitting: A comparison of methods

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Introduction

- There are three widely accepted goals of hearing aid fitting:
  - Make soft sounds (speech) audible
  - Make average sounds comfortable
  - Make loud sounds loud but tolerable
- Each goal must be verified in a unique manner to ensure an appropriate hearing aid fitting

Introduction

- Two objective clinical methods for verifying soft sounds specifically
  - Aided thresholds
  - Real ear aided response (REAR) with a probe microphone system

Introduction

- Recent literature has questioned the utility and accuracy of aided soundfield measurements in the verification of non-linear hearing aids
- With the advent and increased availability of real-ear measurement systems, some have suggested abandoning aided threshold measurements altogether

(Stelmachowicz et al., 2003)

Introduction

- However, others, such as Fabry (2003) and Kuk and Ludvigsen (2003) support the continued use of aided thresholds as well as probe microphone measures during hearing aid verification
- Fabry (2003) has supported this dual use, citing that aided measures supply a different type of information than that provided by real ear measures (hearing vs. gain)

Introduction

- The purpose of this study was to see if sound field threshold measurement and real ear measurement lead to consistent conclusions regarding audibility of soft speech.
- A secondary goal was to compare the analysis of soft speech by two popular clinical systems – the Audioscan Verifit and the Fonix 7000 real ear analyzers.

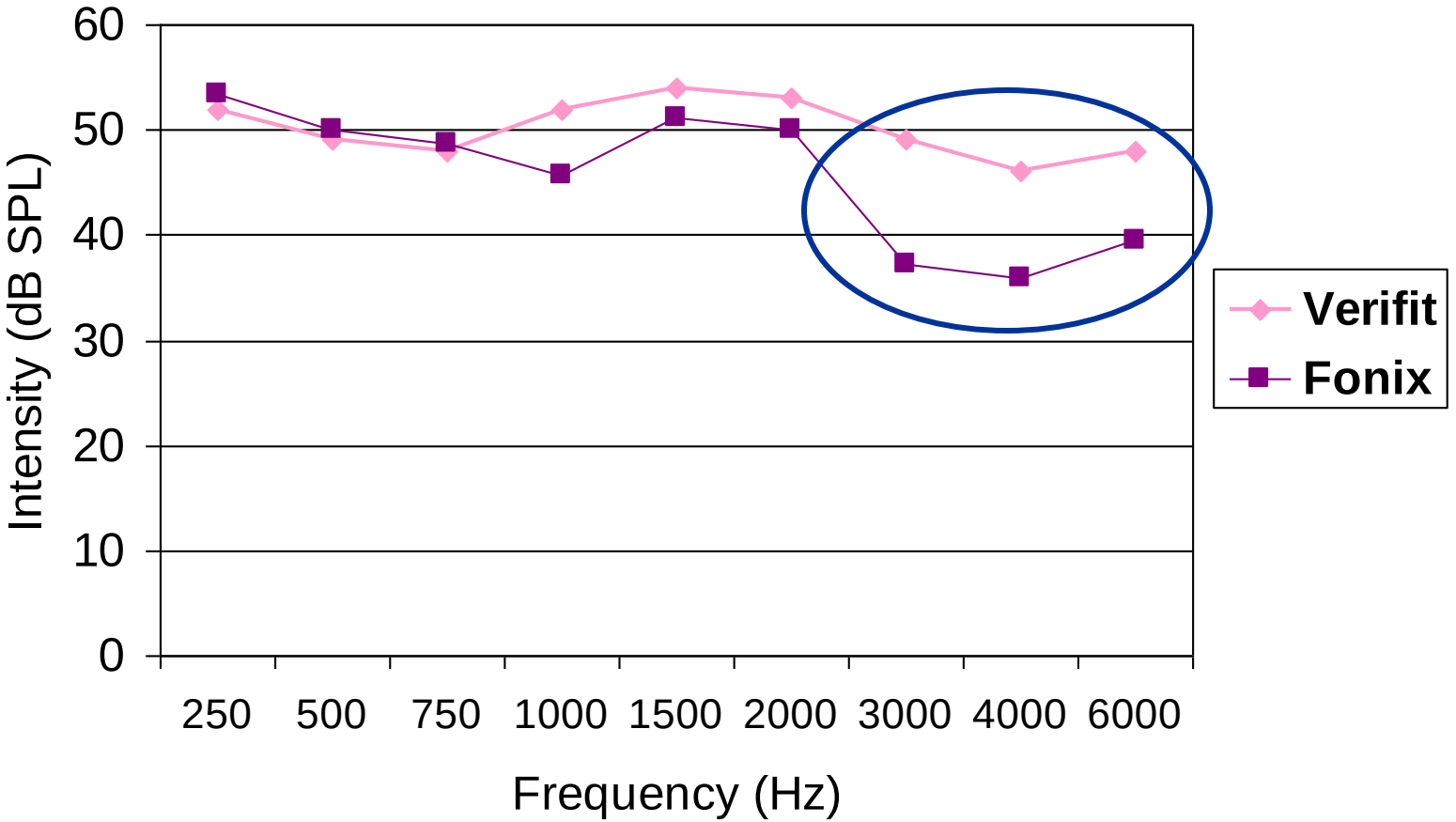
Bandwidth analysis characteristics

- Verifit
  - 1/3 octave BW analysis
  - Proportional BW across measured frequency range
  - *9 1/3 octave band levels (points) are shown*
- Fonix 7000
  - 100 Hz BW analysis
  - Constant BW used across frequency range
  - Number of points is different per octave; analysis of higher frequencies contains more bands per octave than that of lower frequencies
  - *79 100 Hz band levels are shown*

Sample analysis – pink noise

- Recording presented 12 inches from probe microphones of both hearing aid analyzer systems
  - External speakers routed through a portable CD player
  - Probe mic was placed on microphone stand at 0° azimuth to the speakers
- Spectral analysis performed with the manufacturer's stimulus off, and pink noise on (10 seconds for the Fonix, normal running time for Verifit)

Comparison


60
50
40
30
20
10
0
Intensity (dB SPL)
250
500
750
1000
1500
2000
3000
4000
6000
Frequency (Hz)
Verifit
Fonix

Other notable differences

Verifit

- Uses RECDs for SPL values (REAR as well as targets)
- Speakers in front
- Transducer used for thresholds taken into account for HL to SPL transform

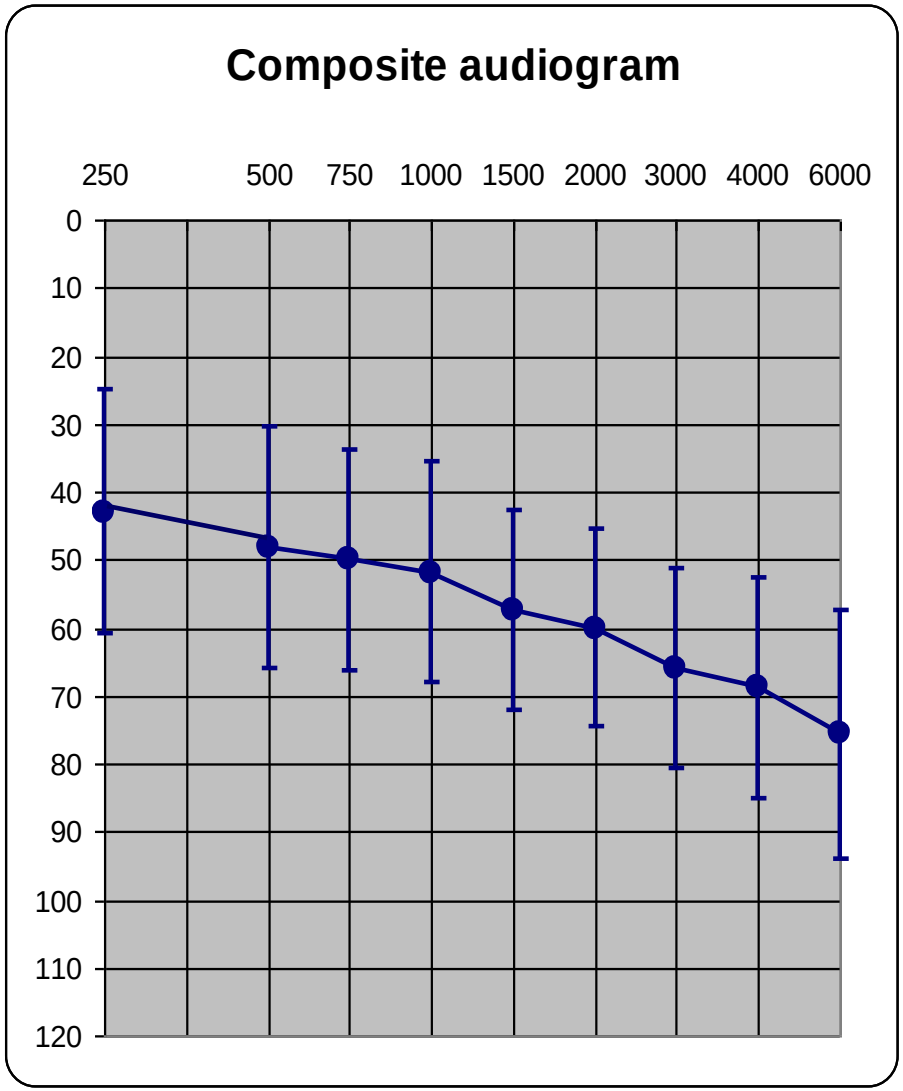
Fonix

- RECDs not used for SPL REAR values or targets
- Speakers at 45° azimuth to subject's nose on side of HA
- Transducer for threshold is not used; SPL thresholds are derived from HL to SPL transform, ANSI S3.6-1989 table G.1

METHODS

Subjects

- Potential subjects were selected from the Hearing Aid Research Lab's database
  - Adult hearing aid users (bilateral or unilateral) with any degree of hearing loss
- Of the 55 people contacted, 12 were ultimately scheduled to participate
- Data was taken for 22 ears



METHODS

- Protocol
  - Otoscopy and immittance screening; Jerger Type B tympanograms would exclude subjects from participation in the study for that ear
  - I/O function of HA (at least 5 dB gain at 3 out of 5 frequencies to be included in study for each aided ear)
  - Unaided thresholds were obtained using ER-3A insert earphones
  - Aided thresholds were obtained for each ear separately
    - Soundfield speaker was at 0 degrees azimuth to the subject
    - The unaided ear was plugged with a foam earplug, and volume control of hearing aid was taped, if applicable
    - Randomly pulsed FM stimulus was used

METHODS

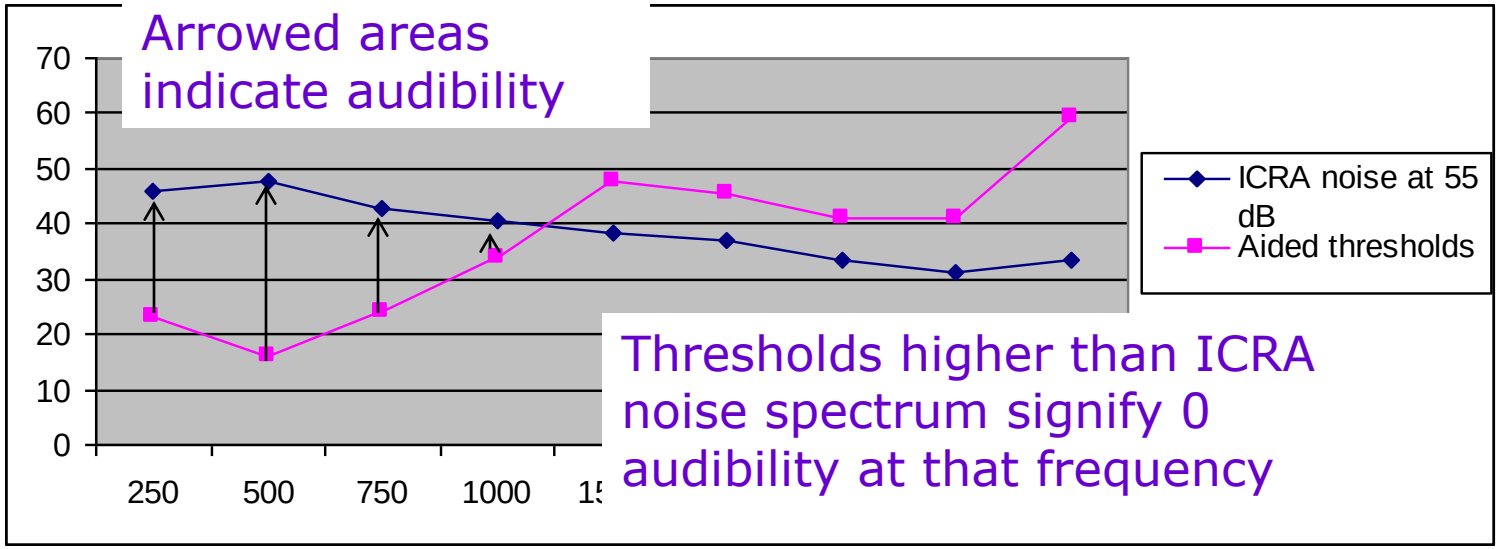
- RECDs were measured in the Verifit system
- REAR was measured using a 55 dB input (real speech “carrot” passage in the Verifit and Digi-speech in the Fonix)
- Audiometric results were discussed with the subjects, and a copy was supplied to them if so requested

Data Management

- After all subjects were run, the data were separated to obtain three sets of information:
  - Soundfield Audibility
  - Verifit Audibility
  - Fonix Audibility

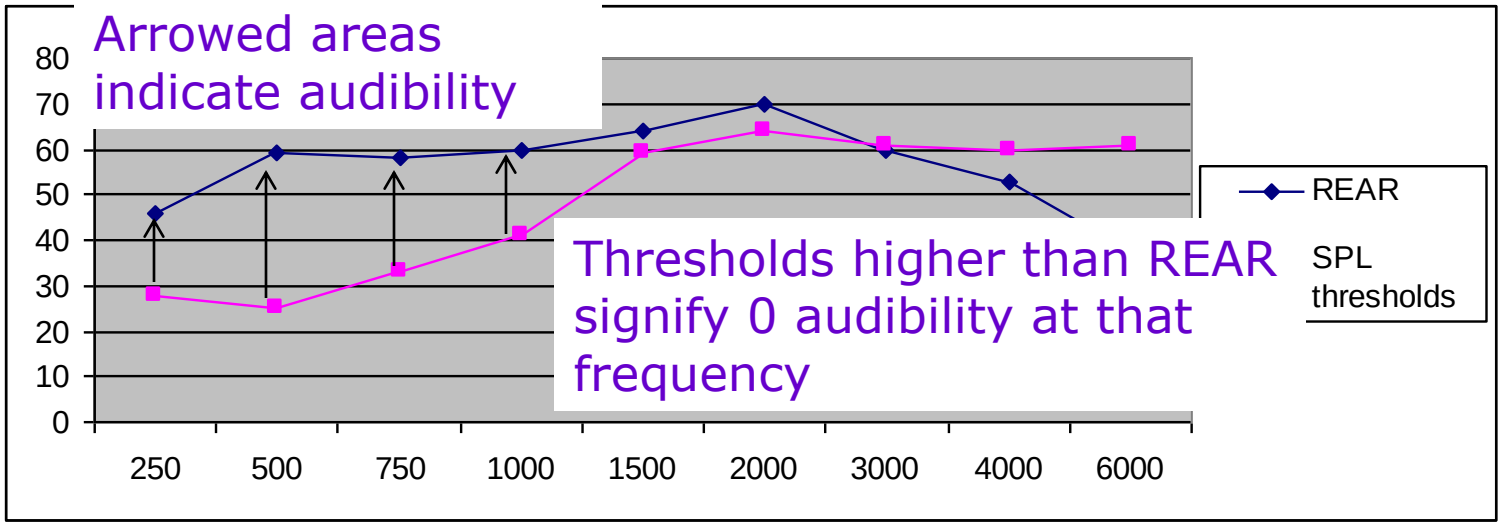
Soundfield Audibility

- Audibility in soundfield is equal to the 1/3 octave band ICRA speech spectrum noise level minus a subject's aided threshold at a given frequency
- SF audibility = ICRA noise – aided threshold



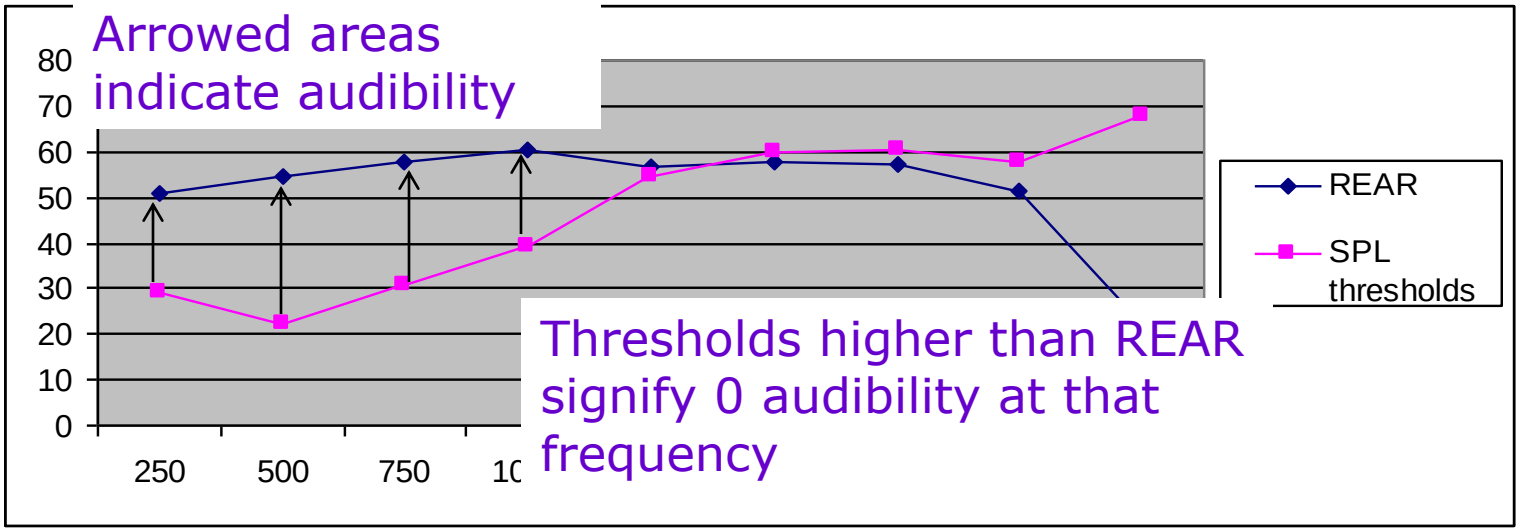
Audibility with Verifit

- With the Verifit system, audibility for soft sounds is found by taking the difference between the level in the ear canal and the threshold in SPL for a given frequency
- Audibility = REAR – SPL threshold
- Verifit does take into account transducer used for threshold measurement as well as RECDs for the SPL transform

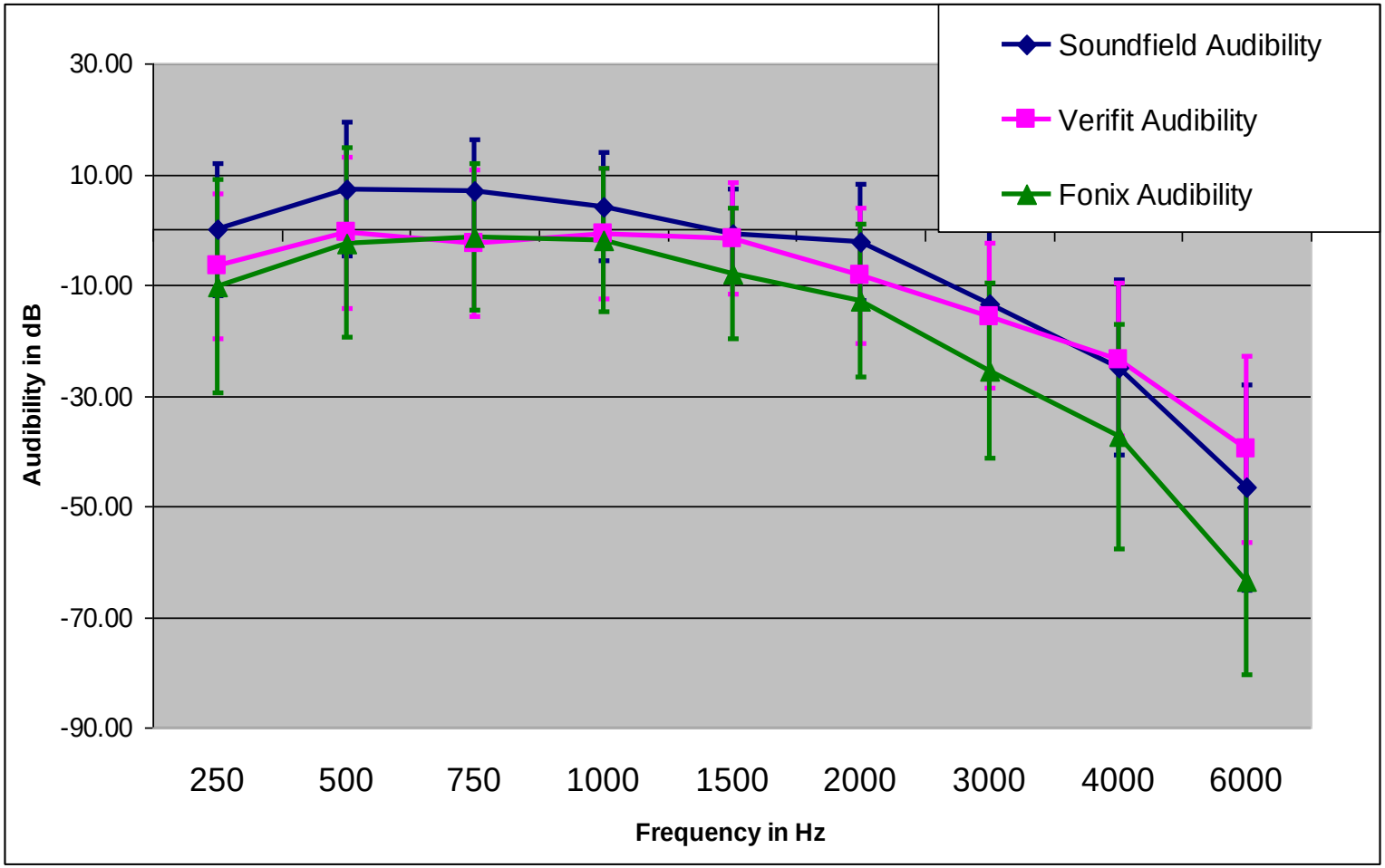


Audibility with Fonix

- With the Fonix as well, audibility for soft sounds is found by taking the difference between the level in the ear canal and the threshold in SPL for a given frequency
- Audibility = REAR – threshold in SPL
- Fonix system does not make adjustments for transducer used or RECD measurements



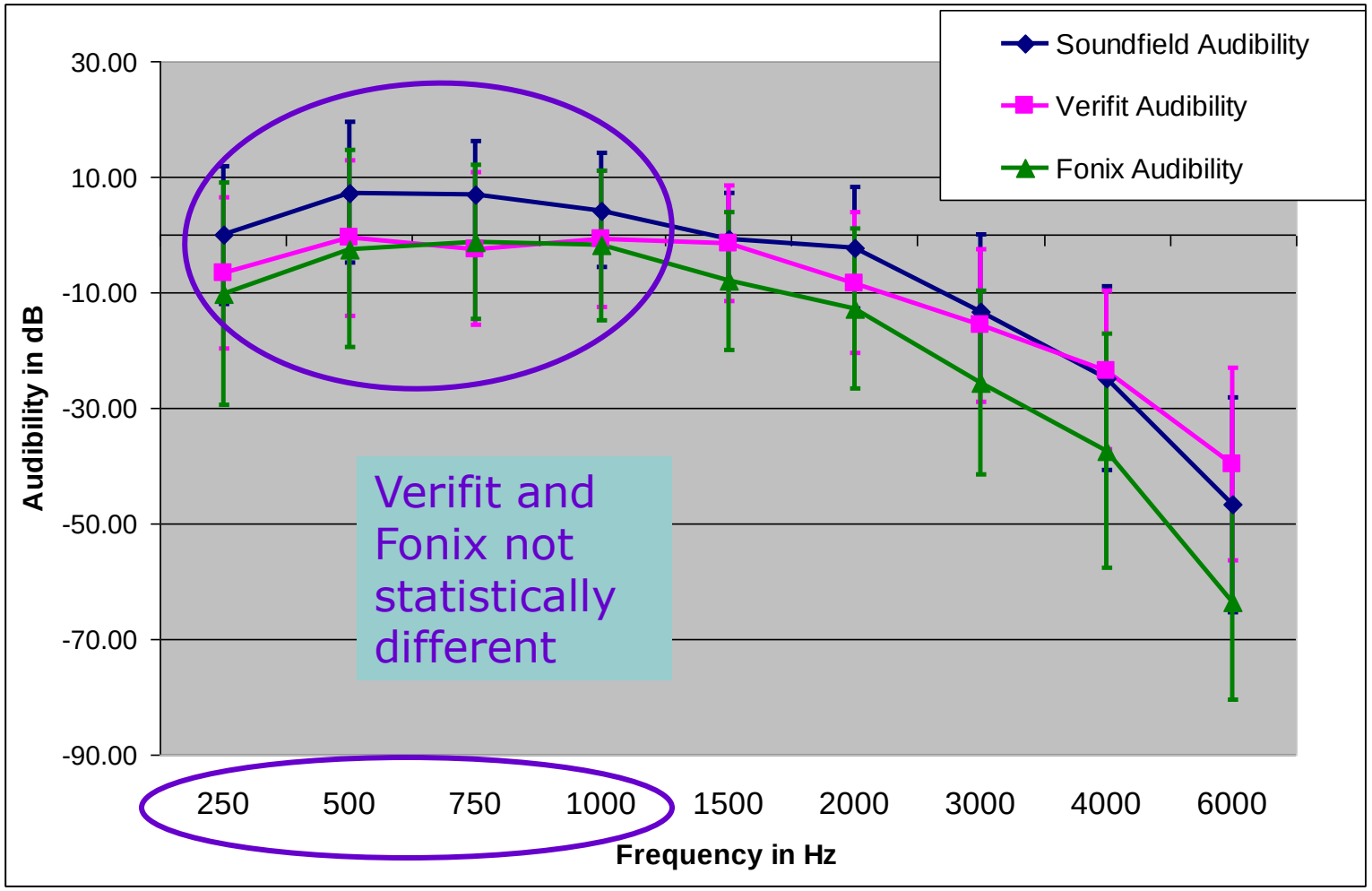
RESULTS


Soundfield Audibility
Verifit Audibility
Fonix Audibility
30.00
10.00
-10.00
-30.00
-50.00
-70.00
-90.00
Audibility in dB
250
500
750
1000
1500
2000
3000
4000
6000
Frequency in Hz

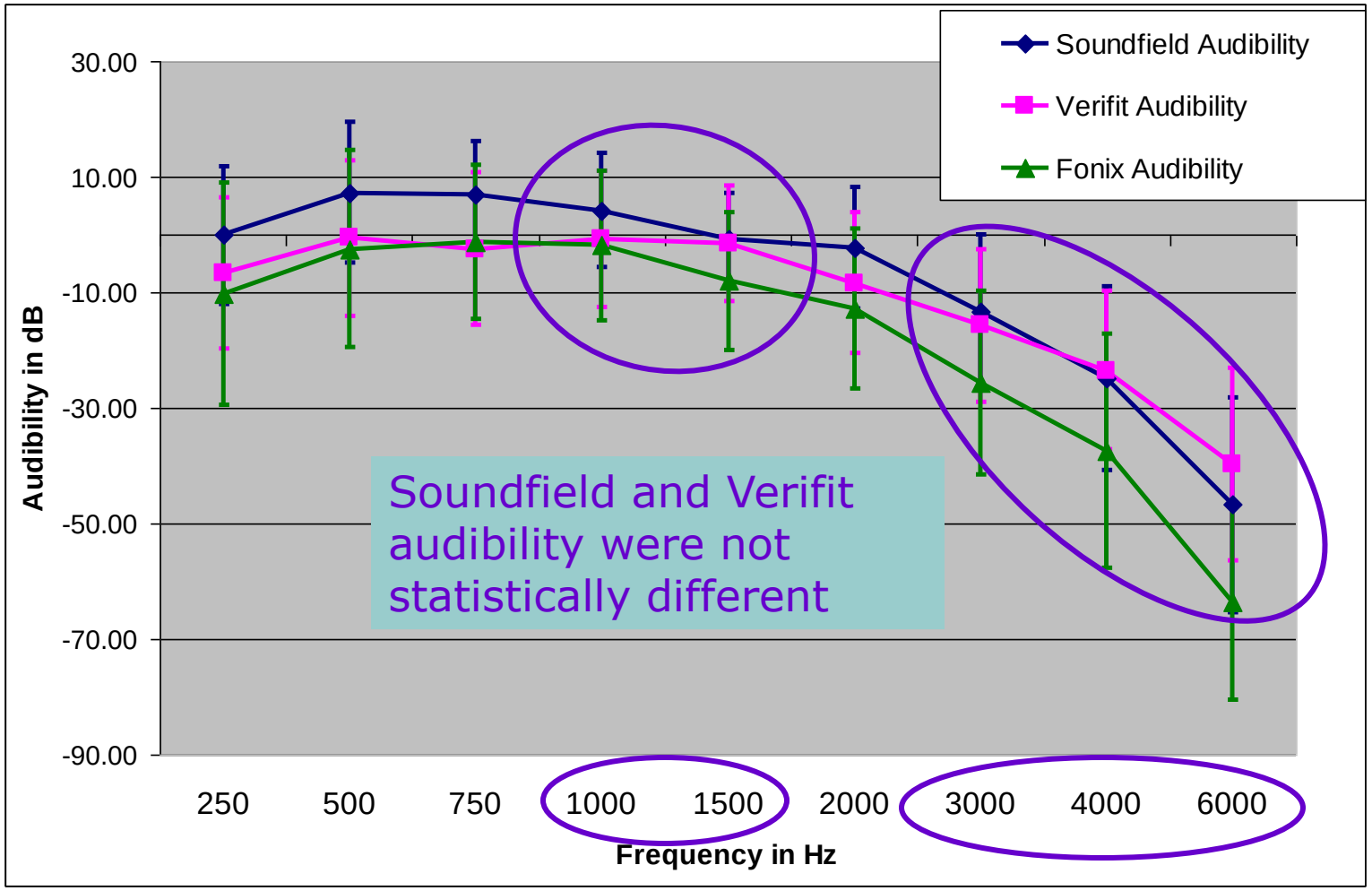
Data analysis

- Statistical analysis was completed on the data using a repeated measures ANOVA
- A Bonferroni post hoc adjustment was used to correct the alpha level for number of measures used

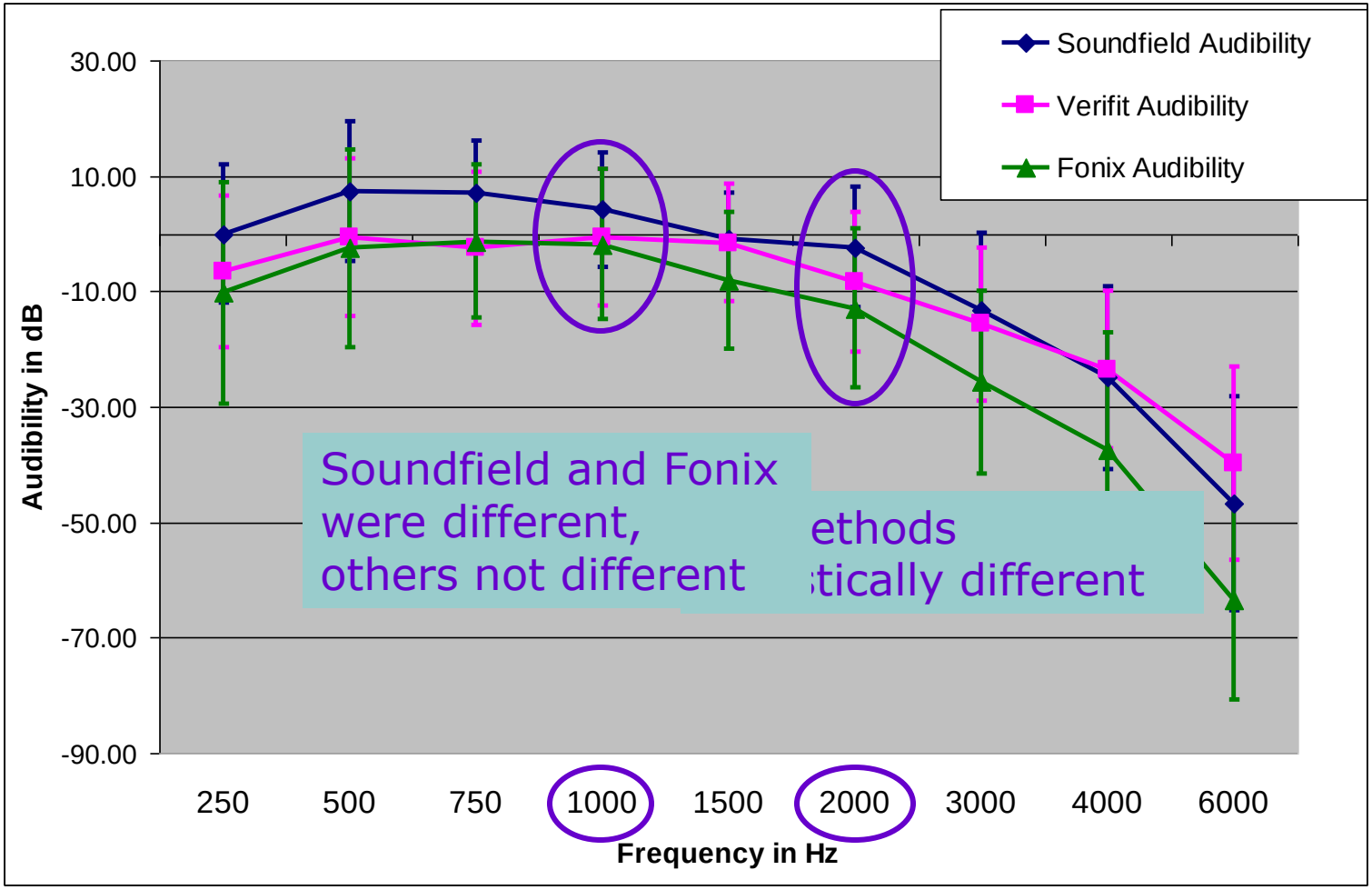
RESULTS


Soundfield Audibility
Verifit Audibility
Fonix Audibility
30.00
10.00
-10.00
-30.00
-50.00
-70.00
-90.00
Audibility in dB
250
500
750
1000
1500
2000
3000
4000
6000
Frequency in Hz
Verifit and Fonix not statistically different

RESULTS


Soundfield Audibility
Verifit Audibility
Fonix Audibility
30.00
10.00
-10.00
-30.00
-50.00
-70.00
-90.00
Audibility in dB
250
500
750
1000
1500
2000
3000
4000
6000
Frequency in Hz
Soundfield and Verifit audibility were not statistically different

RESULTS


Soundfield Audibility
Verifit Audibility
Fonix Audibility
30.00
10.00
-10.00
-30.00
-50.00
-70.00
-90.00
Audibility in dB
250
500
750
1000
1500
2000
3000
4000
6000
Frequency in Hz
Soundfield and Fonix were different, others not different
ethods
tically different

DISCUSSION

- Results of this study show that aided threshold and probe microphone measures do not lead to consistent conclusions across the frequency range
- However, results did reveal two trends according to frequency:
  1. Low frequency soundfield audibility is greater than that of probe mic audibility in both systems
  2. In general, high frequency soundfield audibility is comparable to Verifit audibility

  The crossover frequency seems to be 1000 Hz

DISCUSSION

- Two possible explanations for the low frequency audibility inflation in the soundfield:
  - Probe microphone placement may cause a small leak during REAR measurement
  - Hearing aids may provide more gain at low frequencies for aided soundfield thresholds in response to warble tones than they do for speech spectrum noise/real speech in the real ear analyzers presented at 55 dB

DISCUSSION

- The secondary goal of this study was to compare the Verifit and Fonix systems' measurement of soft speech audibility
- High frequency discrepancy between the Fonix and Verifit
  - Analysis bandwidth difference
  - Consideration of RECD/transducer adjustments for threshold and REAR calculations in each system
  - These help to explain why high frequency audibility can be comparable in soundfield and in the Verifit, but not in the Fonix system

Comparison to other studies

- A wealth of research exists on functional gain and verification of hearing aids with aided thresholds as well as probe microphone measures
- However, the comparison of audibility between methods has not received much attention; therefore these data do not lend themselves to comparison with previous research

Practical relevance

- This study examined an aspect of only one goal of hearing aid fitting:
  - Make soft sounds audible
- These results have no implications for average or loud sounds
- Does statistical significance equal clinical significance?
- An additional point:
  - Soundfield audibility was statistically different from Fonix audibility at every frequency

Closing remarks

- Different methods of verification will yield different results
  - At a minimum, clinicians should state how audibility was assessed
- Not all real ear systems behave equally, even with the same inputs (RECDs, transducer for threshold measures, etc.)
  - Just because you enter the data does not mean they are included in the computer's algorithm when displaying REAR
- Verification of soft speech audibility alone does not mean you have verified the hearing aid fitting
  - Entirely different methods for average and loud sounds

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Thank you for your time.