



The Auditory Range

Remote Auditory Diagnosis System in Hearing Screening Tests

Course JEB1447H F
Sensory Communication

Yichun Zhang
Yi Zhu

Motivation: Remote Hearing Tests

Telemedicine

- Reduce wait time and travel time
- Reduce physical contacts

Increase health care delivery efficiency

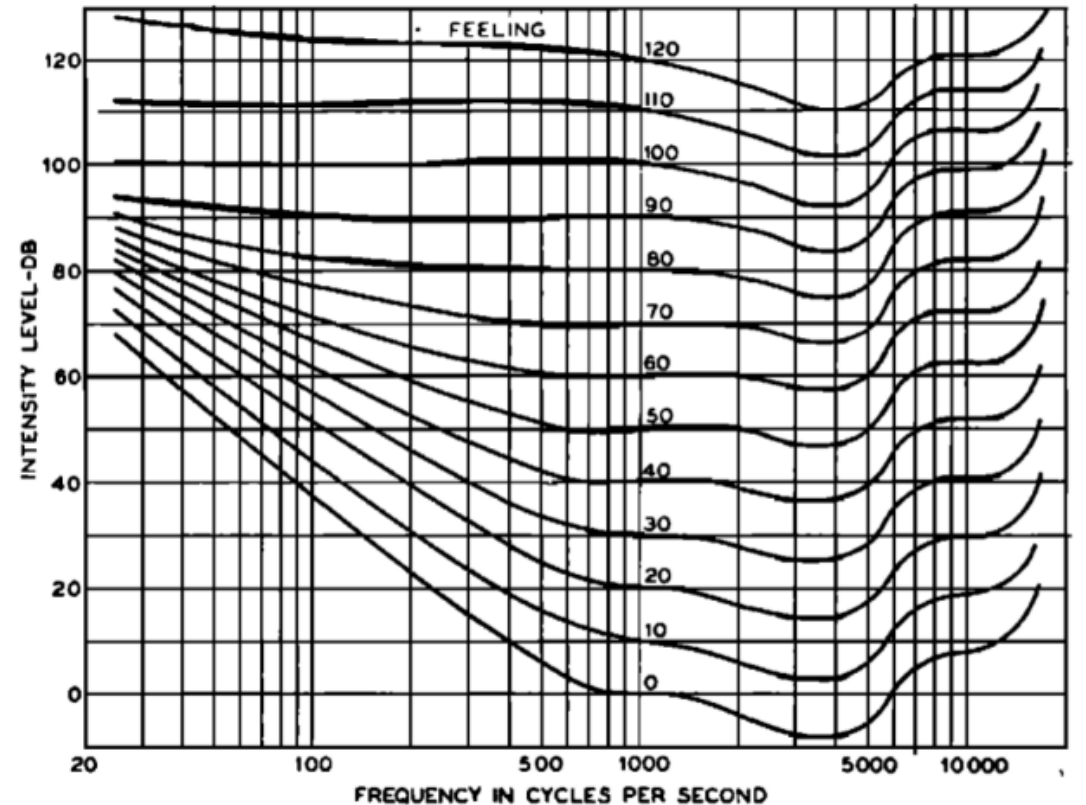
- Ease workload of audiologists

Motivation: Study of Hearing Thresholds



[2]

- Study of equal loudness contour or Fletcher Munson curves
- Hypothesis: hearing thresholds increase by age.

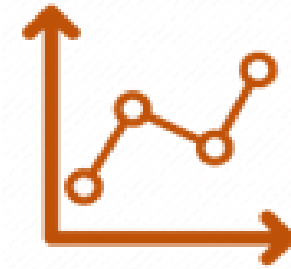


[1]

Motivation: Study of Weber Fraction



Find the minimal detectable
 ΔdB



Investigate Weber Fraction
 $\Delta I / I = f(I)$

Project Objective

1

Develop an audiometer software application

2

Perform hearing thresholds tests on different age groups

3

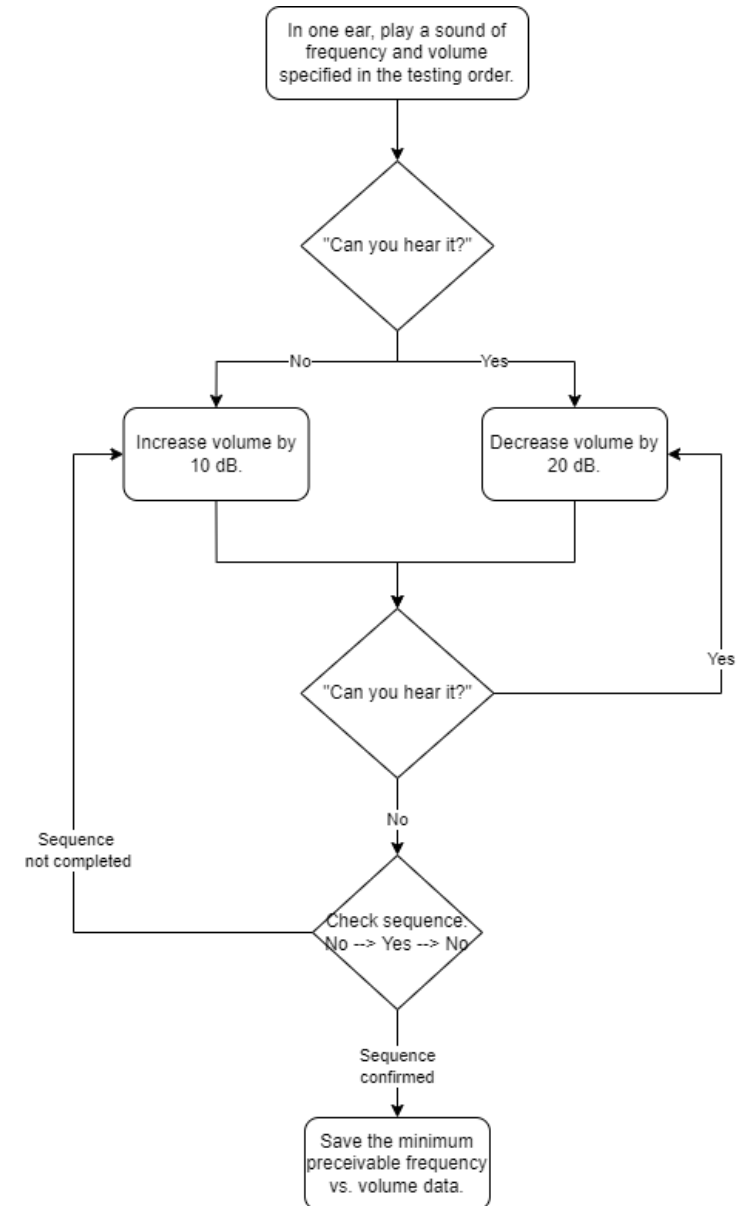
Design application and perform step-size tests

Methodology: Tone Generation

- Sinusoidal sound wave signal
 - $A = 10^{\frac{Lp}{20}}$
 - $signal = A * \sin(2\pi ft)$
- MATLAB function
 - $player = audioplayer(signal, Fs)$
 - $play(player)$
 - $right_signal = [zeros(size(s)); s]$

Methodology: Audiometer Architecture

- Test Audio
 - Both ears
 - 40dB, 1kHz
- Left ear tests
 - 40dB, 1kHz
 - Hear or not?
 - Decrease 20dB or increase 10dB
 - Change frequency SPL accordingly
 - 40dB, 250Hz
 - ...
- Right ear tests
 - Repeat but with right ear



Methodology: Application Design

MATLAB App

Simple Audiometer

☐ I have read the instructions on the right and agreed with the privacy statement

Name Age

Please make sure you are in a quiet environment and put on your headphones
When you are ready, turn the Test Audio switch on

Off ☐ On

Test Audio

Adjust your device volume until the test audio sounds soft to both ears

When everything sounds smoothly, turn the test audio off and press READY to begin the test

Testing in progress ☐

Left ear ☐ Right ear ☐

Can you hear it?

All done ☐

Instruction

Please read instructions below carefully before starting the test

Warning: This program assists you in measuring the frequency response of your ears. But this application is NOT a medical testing device, please consult your doctor for any possible hearing loss.
Long time exposure under loud noise may cause permanent damage to hair cells, please stop the test immediately whenever you feel uncomfortable.

1. Please make sure you are in a quiet environment and put on your headphones, when you are ready, start preparation by playing the test audio. A pure tone at 1 kHz and 40 dB will be generated and played to both ears.
2. Adjust your device volume to when the test audio sounds soft to both ears.
3. When you are comfortable with the volume, turn the test audio off and click "Ready" to begin the test. A new frequency will be selected among 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz.
4. When the "Testing in progress" lamp is on, click "Yes" or "No" button to the response.
5. When all frequencies have been tested, tones will be played again at the other ear.
6. After both ears have been tested, an audiogram with sound pressure level recorded versus corresponded frequencies will be plotted. You can save the plot and data for comparison with the reference.

The resulting plot illustrates the "Threshold of Hearing", the minimum loudness required for you to hear a tone.

Privacy Statement: Your hearing test data may be used for academic research. However, your personal information will not be shared with anyone other than the two developers below. If you have any questions or concerns, please feel free to reach us:

Yi Zhu
yiyi.zhu@mail.utoronto.ca

Yichun Zhang
yichun.zhang@mail.utoronto.ca

Reference
[1] Lee, Jungmee et al. "Behavioral hearing thresholds between 0.125 and 20 kHz using depth-compensated ear simulator calibration." Ear and hearing vol. 33,3 (2012)

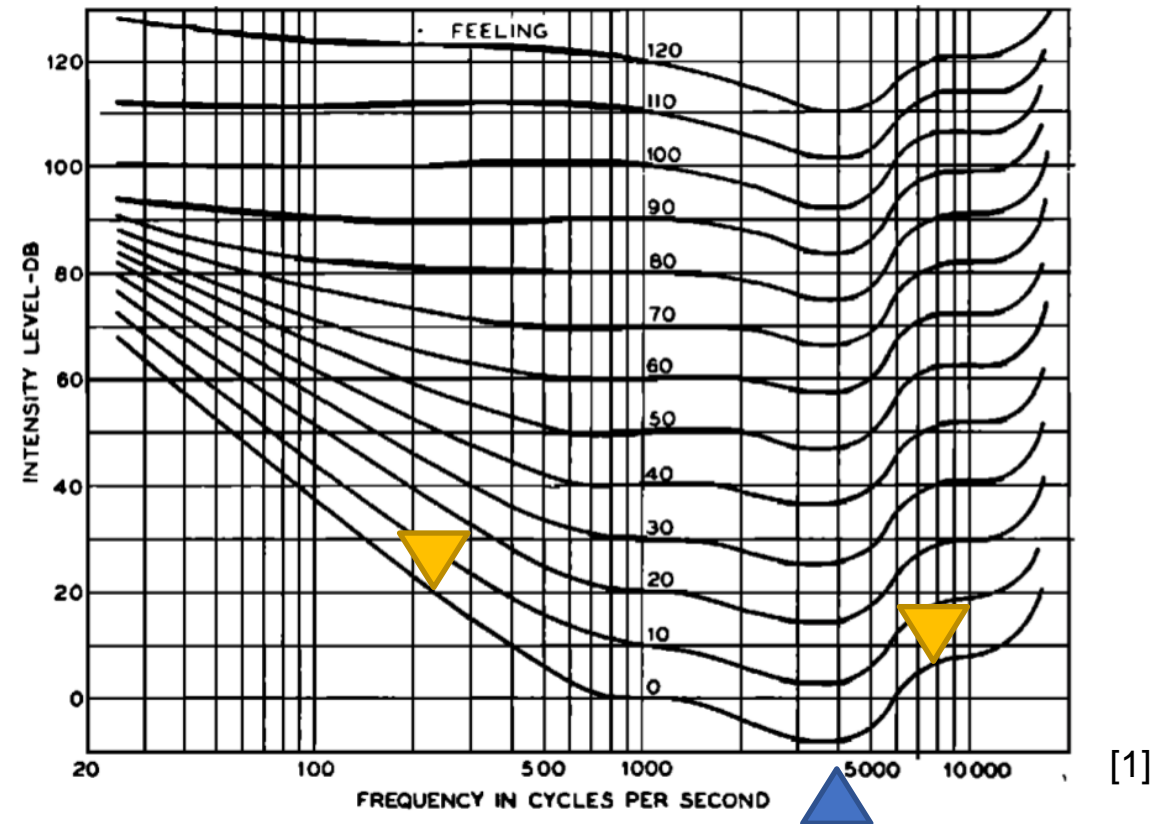
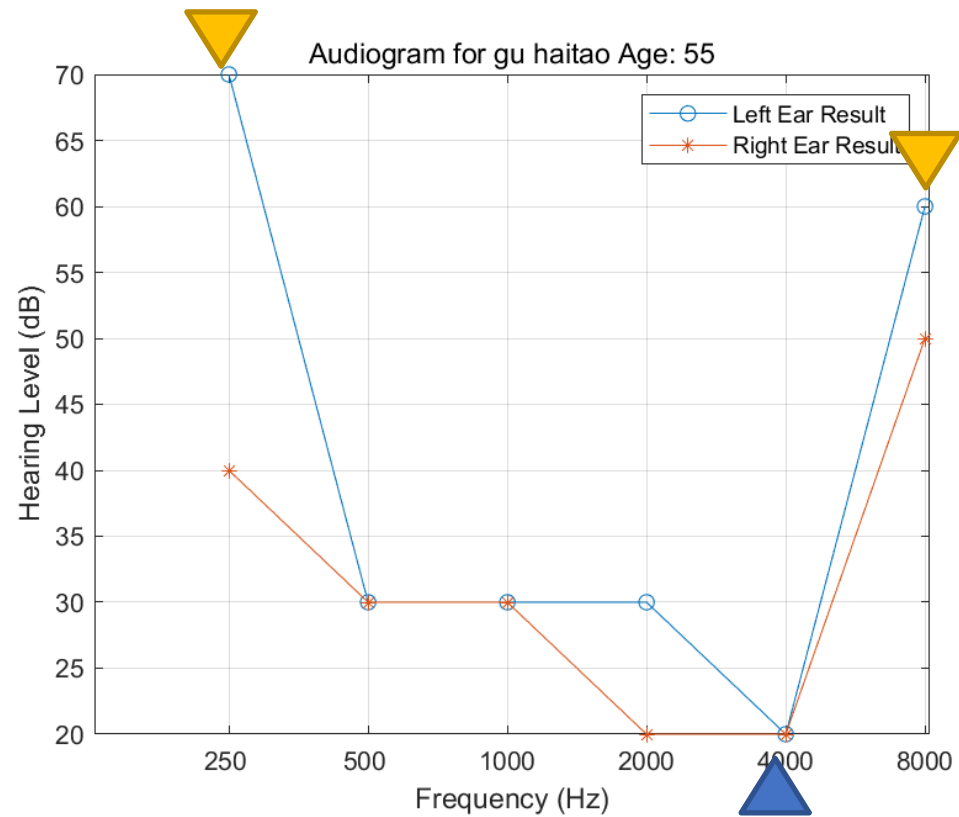


Methodology: Experimental Group

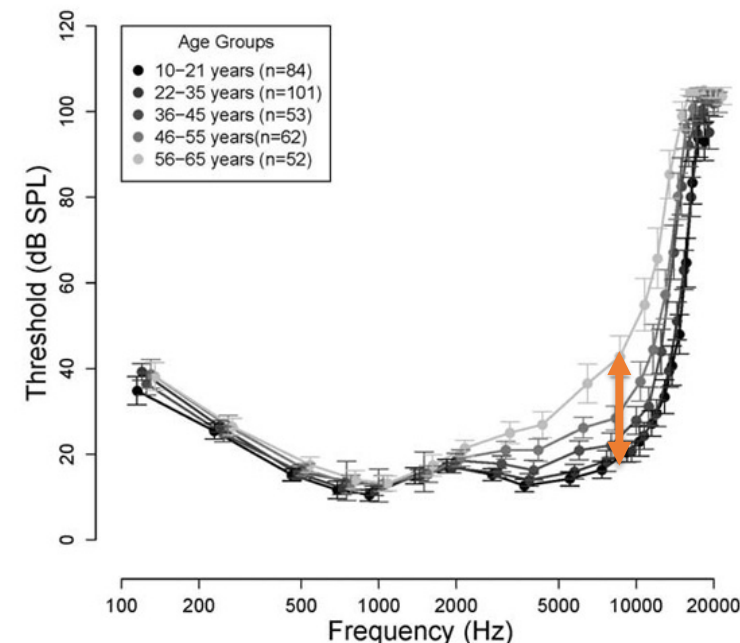
Human Subjects Categorized by
Age Groups:

- 10s
- 20s
- 30s
- 40s
- 50s

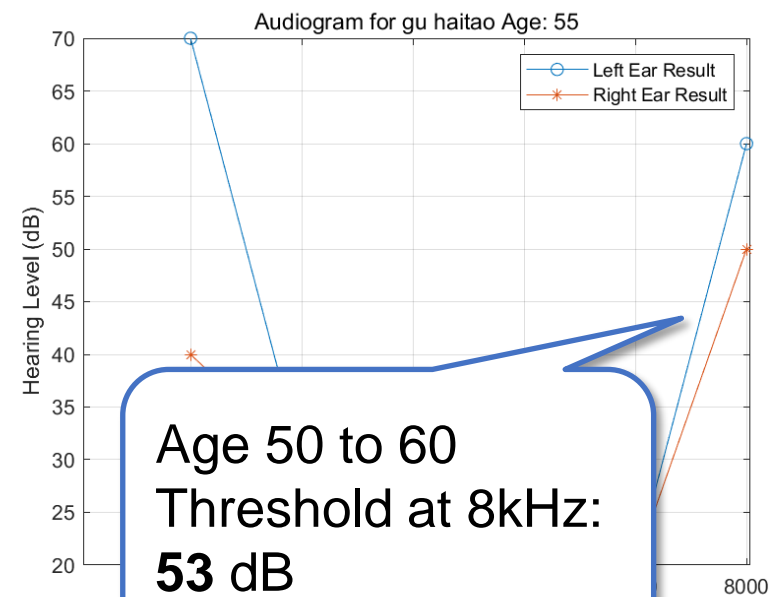
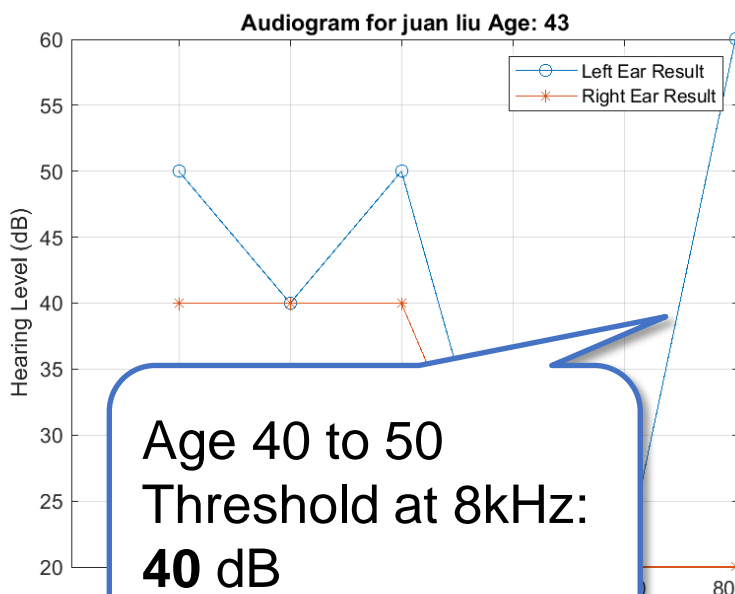
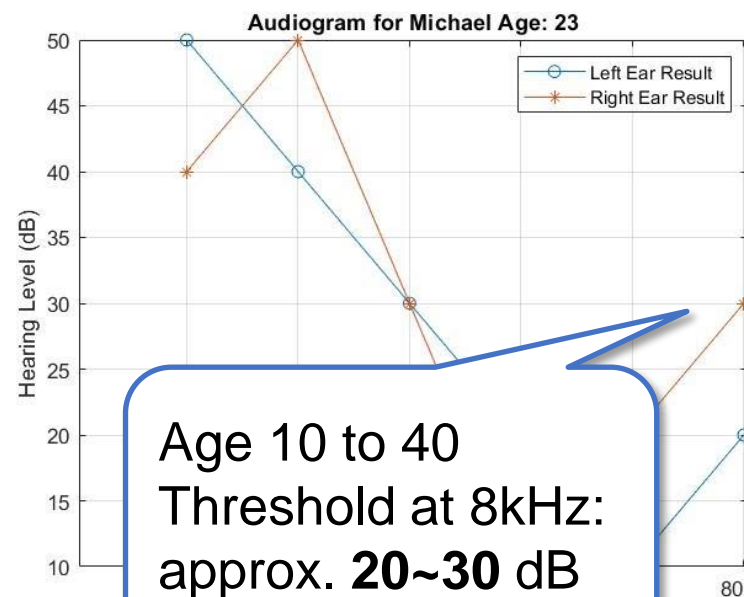
Results: Equal Loudness Contour



Results: Age-Related Hearing Loss



[3]



Methodology: Minimum Step-size in SPL

Pure tone for 1s

- 40dB, 1kHz

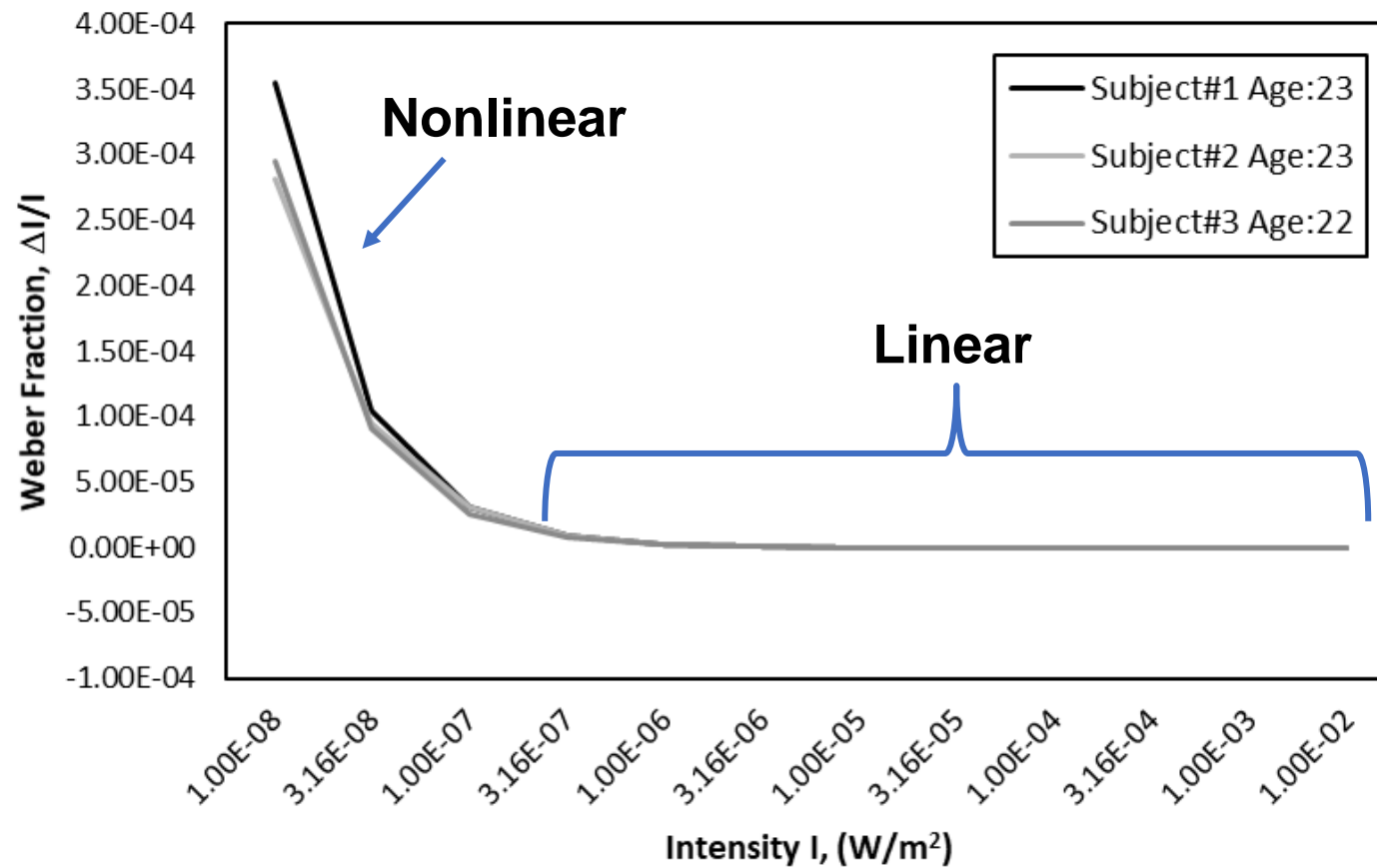
Pause for 1s

Pure tone for another 1s

- $(40 + \Delta_{dB})$ dB, 1kHz
- Δ_{dB} Selected by user

Repeat until difference is noticed

Results: Minimum Noticeable dB Change



Conclusion and Future Work

- Comparison with results from commercial and professional audiometers.
- Searching for possible solutions to optimize the result, such as masking technics.
- Make the application deployable to macOS users and further on cloud servers.

References

- [1] <file:///C:/Users/Yichun%20Zhang/Desktop/LoudnessItsDefinitionMeasurementandCalculation.pdf>
- [2] <https://southvalleyent.com/older-people-with-hearing-loss-at-risk-for-depression/>
- [3] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3606020/>