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Accuracy Testing of iPhone Application for Hearing Screening

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INTRODUCTION

Over 600 million people worldwide are affected by hearing loss (Martínez-Pérez et al., 2013). Research shows that many hearing aid users had difficulties with hearing for at least 10 years before getting a hearing aid (Ferguson, 2012).

The *Hearing Test with Audiogram* application measures an individual's hearing sensitivity using a mobile device. To provide accurate information about an individual's hearing sensitivity, the tones played on the app should reflect The American National Standards Institute (ANSI) guidelines, which specify a tolerance for the frequency and intensity of pure tones presented by audiometers (Gordon N. Stowe and Associates, Inc., 2012).

This research project assessed the effectiveness of the *Hearing Test with Audiogram* application for the iPhone 5S by testing the frequency and intensity of the six pure tones presented by the application (LouderTV, 2012).

Table 1: ANSI Tolerance Ranges for Frequency and Intensity

Tone	ANSI Frequency Range for Tolerances	ANSI Intensity Range for Tolerances
250 Hz	247 Hz to 253 Hz	+/-3.0 dB SPL
500 Hz	495 Hz to 505 Hz	+/-3.0 dB SPL
1000 Hz	990 Hz to 1010 Hz	+/-3.0 dB SPL
2000 Hz	1980 Hz to 2020 Hz	+/-3.0 dB SPL
4000 Hz	3960 Hz to 4040 Hz	+/-3.0 dB SPL
8000 Hz	7920 to 8080 Hz	+/-3.0 dB SPL

Images from *Hearing Test with Audiogram* app
Note: app is no longer available in iTunes App Store as of February 2016

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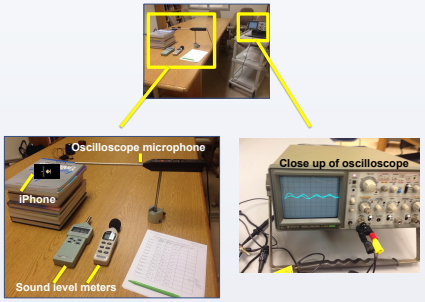
MATERIALS



- The iPhone 5S speaker was raised to the height of the microphone and placed three inches away.
- The microphone was attached to a Hitachi oscilloscope V-225 20mHz.
- Two Extech sound-level meters recorded tonal intensity.

This experiment took place in the Chichester Science Center laboratory at Longwood University in Farmville, Virginia.

METHODS

1. Before recording data, the *Hearing Test with Audiogram* application was calibrated.

2. Each pure tone was repeated 4 times total:
   - In left ear at intensity level 75*
   - In right ear at level 75*
   - In left ear at intensity level 100*
   - In right ear at level 100*

*The levels were labeled as 75 and 100, but the units for these values were not specified by the manufacturer. The research technician used dB SPL to measure intensity.

3. Actual intensities were recorded as the highest decibel reading over 5 seconds using a sound-level meter.

4. For each pure tone, the period was measured with the oscilloscope, and the frequency was calculated based on the measured period.

The procedure was repeated to find the period, frequency, and intensity of each pure tone.

RESULTS

At sound level 75, three of the six pure tones fell within ANSI tolerances for equipment calibration of frequencies. The same statement can be made for four of the six pure tones presented at level 100. Except for two values at level 75, all intensities fell outside of the accepted ANSI tolerance range.

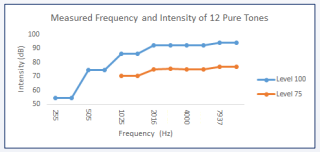
Table 2: Measure Frequency and Intensity of 12 Pure Tones Presented at Level 75

Tone	Recorded Intensity	Recorded Period	Calculated Frequency
Tone IA	70.4 dB SPL	0.976 ms	1024.50 Hz
Tone IB	70.2 dB SPL	0.976 ms	1024.59 Hz
Tone 2A	74.8 dB SPL*	0.496 ms	2016.13 Hz*
Tone 2B	75.2 dB SPL*	0.496 ms	2016.13 Hz*
Tone 3A	75.0 dB SPL*	0.25 ms	4000 Hz*
Tone 3B	76.6 dB SPL*	0.25 ms	4000 Hz*
Tone 4A	-	0.126 ms	7936.51 Hz*
Tone 4B	-	0.126 ms	7936.51 Hz*
Tone 5A	-	3.92 ms	255.10 Hz
Tone 5B	-	3.92 ms	255.10 Hz
Tone 6A	-	1.98 ms	505.05 Hz
Tone 6B	-	1.98 ms	505.05 Hz

Table 3: Measure Frequency and Intensity of 12 Pure Tones Presented at Level 100

Tone	Recorded Intensity	Recorded Period	Calculated Frequency
Tone IA	86.0 dB SPL	0.98 ms	1020.41 Hz
Tone IB	86.0 dB SPL	0.98 ms	1020.41 Hz
Tone 2A	92.1 dB SPL	0.504 ms	1984.13 Hz*
Tone 2B	92.1 dB SPL	0.504 ms	1984.13 Hz*
Tone 3A	92.1 dB SPL	0.252 ms	3968.26 Hz*
Tone 3B	92.1 dB SPL	0.252 ms	3968.26 Hz*
Tone 4A	94.0 dB SPL	0.126 ms	7936.51 Hz*
Tone 4B	94.0 dB SPL	0.126 ms	7936.51 Hz*
Tone 5A	54.5 dB SPL	4.0 ms	250 Hz*
Tone 5B	54.5 dB SPL	4.0 ms	250 Hz*
Tone 6A	74.6 dB SPL	1.96 ms	510.20 Hz
Tone 6B	74.6 dB SPL	1.96 ms	510.20 Hz

* Indicates value falls within ANSI tolerance range
- indicates the sound level meter did not read signal



CONCLUSION

Overall, the application was not an accurate measure for hearing sensitivity, as only two pure tones fell within ANSI's prescribed tolerance ranges for both frequency and intensity. As a result, the application should not be used to screen for hearing.

Further Research

Future research should improve upon the limitations of this experiment. Possible directions could include:

- Using more advanced equipment in a sound proof environment for more accurate results.
- Investigating how the use of ear buds influences the frequency and intensity of the tones.
- Comparing multiple iPhone applications designed as hearing screening tools.

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FURTHER INFORMATION

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