Reliability of the Home Hearing Test: Implications for Public Health

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Background

The United States Census Bureau projects that individuals over the age of 65 will comprise nearly a quarter of the population by the year 2050 [1 2]. This statistic suggests that more individuals are living with age-related chronic conditions, including hearing loss. In addition to population growth, recent workforce analyses indicate that the need for hearing healthcare (HHC) services will outweigh the capacity, with this gap continuing to grow over the next several decades [3 4]. Thus, there is a need to address access, uptake, and delivery of HHC services for this growing population.

One such need is the use of automated audiometry tools (self-tests or otherwise) to provide information about hearing thresholds. Previous research has shown consistent test-retest reliability for automated versus manual air-conduction audiometry [5]. What is **unknown**, however, is the accuracy of such measures for identifying degree of hearing loss in a larger sample of older adults.

Improving access to reliable, cost-efficient, objective hearing testing could increase patient education, action, and entry into the hearing healthcare system. Also, reliable, automated, tools for hearing testing could allow more time for audiologists to focus on more specialized diagnostic tests (e.g., speech in noise, aided speech tests).

Research Questions

When compared to manual audiometry (MA), how well does an automated hearing test measure:

1. Hearing thresholds from 500 – 8000 Hz?
2. Pure Tone Average (PTA) in the better-hearing ear?
3. Degree of hearing loss?

Etymotic Home Hearing Test (HHT)

- An automated hearing test that measures ear-specific, air-conduction thresholds at octave frequencies from 500-8000 Hz.
- Includes a soundcard that moderates the system's output up to 85 dBHL and ER-38 insert earphones.
- Employs a forced-choice adaptive psychophysical procedure [3].

Methods

Participants

- 60+ years of age
- No cerumen occlusion
- English-speaking

		Age in years					
n	Sex (% Female)	60-64	65-69	70-74	75-80	80-84	85+
112	63 (56.3%)	19 (19.6%)	37 (33%)	33 (29.5%)	15 (13.4%)	4 (3.6%)	1 (0.9%)

Table 1. Participant demographic information. *Information on age and sex for three participants was not available. Calculations based on n=109

Procedure

- Audiology students conducted otoscopic examinations, explained test procedures, and placed foam insert earphones in ear canals bilaterally.
- Participants were randomly assigned to 1 of 2 conditions: A- MA followed by HHT, H- HHT followed by MA. Test order was counterbalanced to control for order effects. Both tests were completed in the same session.
- Manual audiograms were obtained in sound-attenuating booths using standard clinic protocol in accordance with ASHA guidelines.

Completing the HHT

- HHT was completed in a quiet, carpeted classroom using Microsoft Surface Pro 4 tablets.

Figure 1. Patient instructions and results for the Etymotic Home Hearing Test

Results

1.

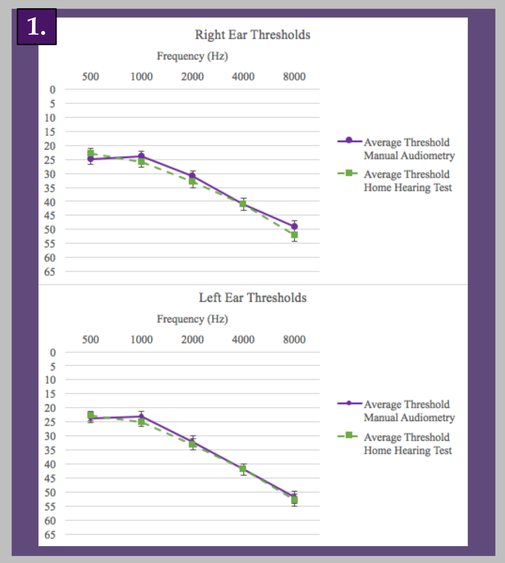


Figure 2. Comparison of average thresholds from 500 – 8000 Hz in the right (top) and left (bottom) ears with standard error bars.

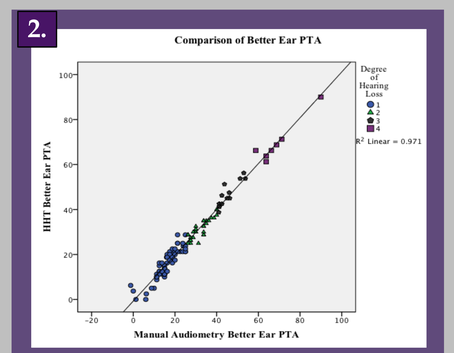
Table 2. Correlations between HHT and Manual audiometry thresholds by frequency in the right (top) and left (bottom) ears.

Pearson Correlations

Right Ear:						
Test		Audio				
	Hz	500	1000	2000	4000	8000
HHT	500	**.909**	.849	.684	.481	.414
	1000	.833	**.924**	.763	.569	.510
	2000	.662	.773	**.960**	.749	.655
	4000	.463	.575	.739	**.969**	.781
	8000	.366	.470	.634	.770	**.953**

Left Ear:						
Test		Audio				
	Hz	500	1000	2000	4000	8000
HHT	500	**.917**	.866	.659	.514	.423
	1000	.856	**.945**	.783	.561	.477
	2000	.671	.780	**.961**	.762	.626
	4000	.529	.570	.765	**.970**	.785
	8000	.405	.487	.644	.812	**.968**

2.



3.

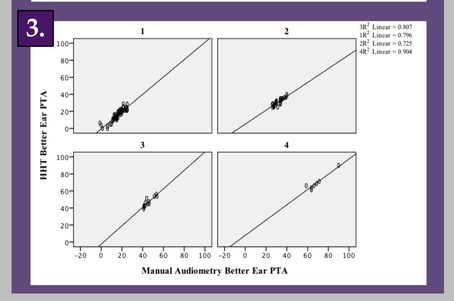


Figure 3. Comparison of 4-frequency pure-tone average (0.5 – 4 kHz) in the better-hearing ear as derived by manual audiometry vs. the HHT. Stratified by degree of hearing loss[6], where 1: 0-25 dBHL (n = 60), 2: 26-40 dBHL (n = 31), 3: 41-55 dBHL (n = 14), 4: > 55 dBHL (n = 7). Degrees of hearing loss are collapsed across one regression line based on Better Ear PTA (top; $p < 0.001$, $R^2_{adjusted} = 0.97$) and paneled with individual lines of best fit (bottom; 1: $p < 0.001$, $R^2_{adjusted} = 0.80$, 2: $p < 0.001$, $R^2_{adjusted} = 0.73$, 3: $p < 0.001$, $R^2_{adjusted} = 0.81$, 4: $p = 0.001$, $R^2_{adjusted} = 0.90$).

Discussion

Findings demonstrate that the Etymotic HHT:

- Is a reliable method of assessing pure-tone air conduction thresholds from 500 – 8000 Hz when compared to MA.
- Strongly correlates with 4-frequency PTA in the better-hearing ear as determined by MA.
- Strongly correlates with degree of hearing loss as determined by MA.
- Can be used to acquire hearing threshold information outside of audiology clinics.
- Is a viable tool for older adults when administered with basic instructions.

Our findings support those of Margolis et al. (2016) in that the HHT is a reliable measure of individual hearing thresholds. These results exhibit increased external validity through the use of a larger, distinct sample and a testing environment more similar to that of a community clinic or doctor's office waiting area. Findings also provide insight about the HHT's accuracy in determining degree of hearing loss[6].

Implications

Expanding hearing healthcare services into facilities such as primary care clinics, assisted living, and community centers could improve access to hearing healthcare and help identify individuals who could benefit from further audiological intervention. The HHT is a reliable measure for extending audiologic services beyond the bounds of the clinic.

Limitations & Future Work

- Degrees of hearing loss were not equally represented in this study. Implications based on predictability of degree of hearing loss are limited.
- Air conduction thresholds are not sufficient to provide diagnostic information regarding type of hearing loss.

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