

FUTURES AND POSSIBILITIES – Challenges and Opportunities

Enhancing Hearing Screening Accessibility through the Development of a Gamified Automatic Audiometer

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1. Continuous enhancements: learning and improvement AND/OR
2. Diversity and Inclusion

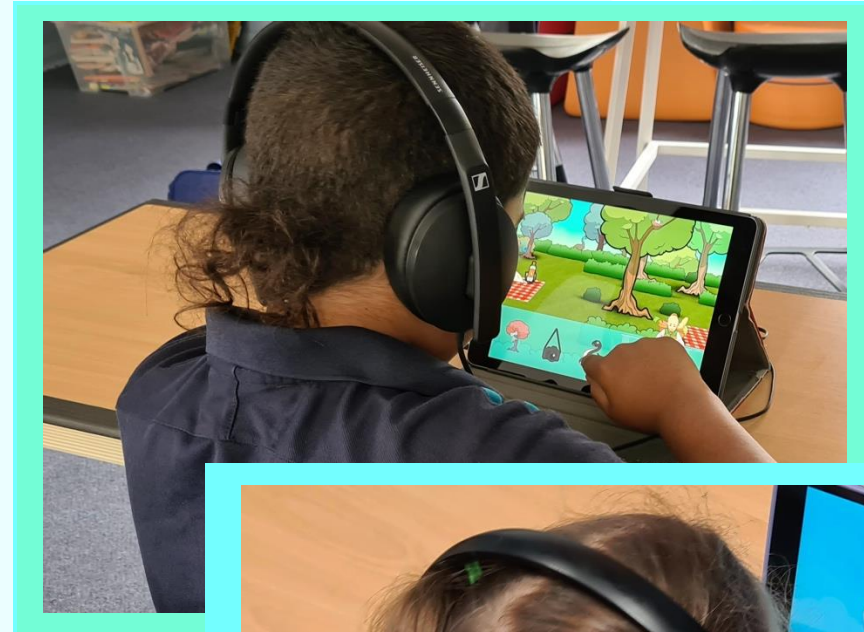
Introduction & Rationale:

Globally 430million people affected by hearing loss (WHO, 2023)

Estimated 1 in 10 children experience hearing issues at school start

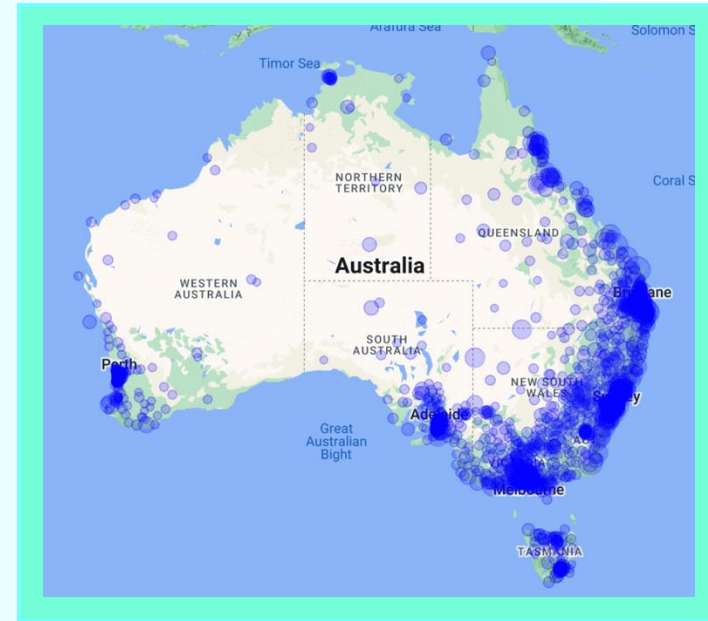
Current Screening Gap: cost and access

Goal: Provide equitable, hearing screening for diverse populations



Background: to improve access to screening Sound Scouts created the TFHS, using a combination of language and tone-based activities presented as games.

- **Evidence-based**
- **170,000+** children's hearing checks undertaken across Australia
- Acts as a **triage tool**
- Available in US & UK English, LATAM, Mandarin (Modern Arabic COMING SOON)



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Limitations: Language posed challenges for children with limited English proficiency

Solution:

- Addition of an **Automatic Audiometer**
- A cross-check for results outside normal range
- Self-administered, tone-based solution
- Maintain fun with a gamified interface

Objective: ALT to language-dependent solution

PLAY-BASED TEST OF HEARING

- Engagement
- Data Capture & Analytics
- Accessibility / scalability
- Listening in noise



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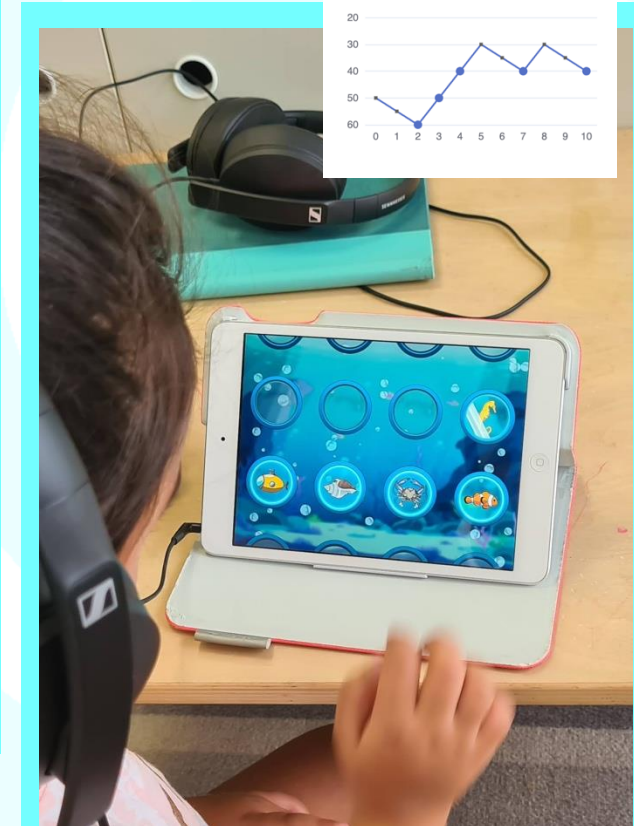
Development Phases: technical oversight provided by **Professor Harvey Dillon**.

Scope: accuracy + leverage gaming techniques

Design: accessibility on mobile device & to be visually engaging

Technical specifications:

- Hughson-Westlake procedure
- Automated adaptative procedures: test stimuli adjusted based on responses.



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Technical Challenges:

1. Delivery of AUDIO – the 'bits' that matter
2. Required a system to accommodate different headphones due to differences RETSPL values (to ensure the output in dB HL is accurate).

Solutions:

AUDIO issue was solved by replacing the audio engine with one with a wider dynamic range.
Headphone issue was solved by maintaining a table of measured values for each headphone and applying those into the calculations that set audio output volumes

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PROVING IT WORKS! A STUDY!!!

Research Project : Azza Al-Maskari^a, Vinayak Hulihalli^a, Reza Hoseinabadi^a, Harvey Dillon^{a,b}, Carolyn Mee^c, Kevin J. Munro^{a,d}

1. Validity
2. Reliability
3. Establish

- **Study Design:** Cross-sectional, within-subject
- **Participants:** 30 adults (23–78 years), normal to severe hearing loss
- **Procedures:**
 - Day 1: Conventional PTA (C-PTA) vs. Automatic PTA (A-PTA), repeated in counterbalanced order
 - Day 2: Retest using the opposite test order and different examiner
- Frequencies Tested:** 250, 500, 1000, 2000, 3000, 4000, 6000, 8000 Hz
- Environment:** Sound-treated booth to minimize ambient noise

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Key Findings Data obtained for 120 ears (averaged across left and right ears, and test-retest thresholds in eight frequencies), resulting in 960 thresholds.

30 participants = 20 normal hearing,
= 10 clinically relevant hearing loss.

- **Threshold Comparison:**

- Excellent agreement up to 4000 Hz (mean diff <2 dB)
- Larger discrepancies at 6000 and 8000 Hz due to initial reliance on different headphone RETSPLs

- **Correlation between automatic and conventional audiometry:**

- $r \geq 0.78$ from 500 to 8000 Hz

Implication: Sound Scouts Automatic Audiometer can accurately measure hearing thresholds across a wide range once properly calibrated

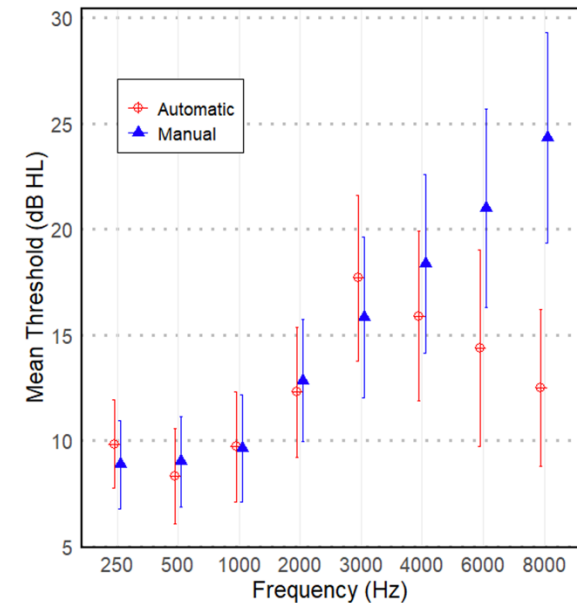


Figure 2. Mean thresholds for A-PTA (red circles) and C-PTA (blue triangles). Error bars show the 95% confidence interval of the mean.

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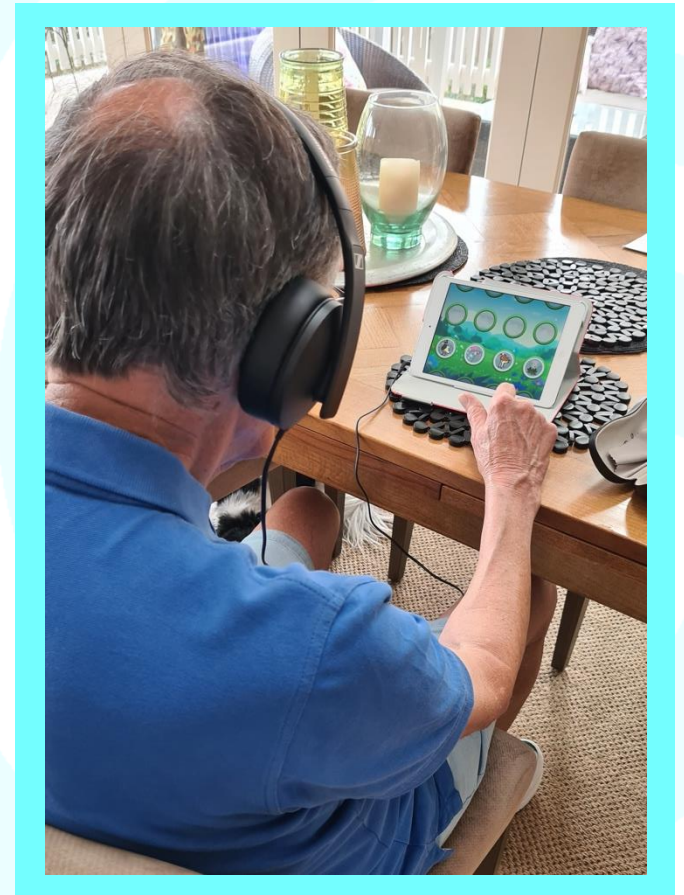
Key Findings – Reliability & RETSPLs

•Test - Retest Reliability:

- Automatic Audiometer was *equally reliable* as clinician-led tests (test-retest SD ~5.3 dB for both)

•RETSPL Development:

- New RETSPL values for Sennheiser HD300 headphones established
- Derived from mean threshold difference between A-PTA and C-PTA at each frequency
- Correct calibration critical for accurate high-frequency (6 kHz, 8 kHz) results



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Conclusion & Future Directions

- Self-administered Automatic Audiometer *valid* and *reliable*
- Hearing thresholds were easy to obtain and agreed closely with conventional audiometry (except at 6000 & 8000 Hz BUT new RETSPL values established and applied)
- Enables more inclusive hearing screening practices

The screenshot shows the 'Tone Selection' screen with the 'Standard' tab selected. Under 'Frequency Selection', four frequencies are listed: 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, each with a checked checkbox. Under 'Advanced Settings', the 'Screening Level' is set to '20 dB HL' and 'Ear Selection' has 'Left' and 'Right' both checked. A 'Reset to Default' button is at the bottom right, and a 'Continue' button is at the bottom center.

The screenshot shows the 'Tone Selection' screen with the 'Advanced Settings' tab selected. Under 'Frequency Selection', eight frequencies are listed in two columns: 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz, all with checked checkboxes. Under 'Advanced Settings', 'Screening Level' is 'Enabled' (radio button selected) and '-10 dB HL' is selected from a dropdown menu. 'Ear Selection' has 'Left' and 'Right' both checked. A 'Reset to Default' button is at the bottom right, and a 'Continue' button is at the bottom center.

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Additional Development - Adaptation for Older Populations & Mild Cognitive Decline

Expanded protocols to older populations, mild cognitive decline

- Challenges: user interface, test instructions, ensuring test validity.
- Simpler navigation and instructions.
- Slower pacing to account for dexterity & cognition
- Clear on-screen prompts

Future Work:

- Lower age application to include 3-4 yr old population
- Manual function for presentation of tones



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SUMMARY

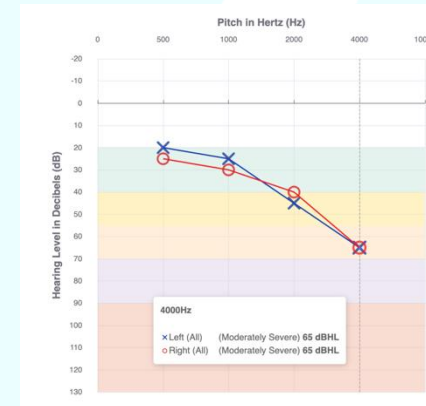
Accessibility & Inclusion: tone-based approach addresses language barriers

- Potential to reach children & adults with limited English or low-language skills

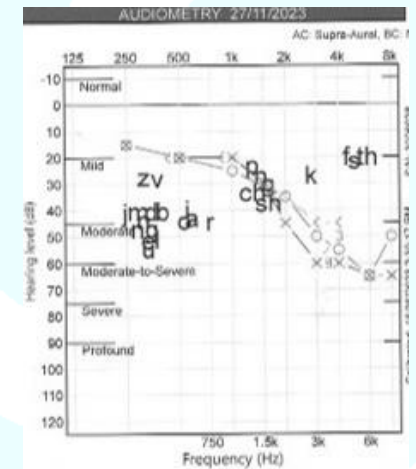
Scalability: Portable, cost-effective alternative to conventional audiometry

- Opportunities for remote or large-scale community screenings

Gamification Benefits: Higher engagement, reduced test anxiety, especially for younger user



Automatic Audiometer



Clinical Assessment