# The Effect of Sound Therapy on Auditory Brainstem Function and Loudness Perception

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## Introduction

- Hearing loss results in reduced input to the central auditory nervous system.
- The auditory system is plastic and *adapts* by altering and reorganizing responses in the central pathway.
- Homeostatic mechanisms help compensate for reduced input by *increasing central gain.*[1,2]

## Background

- Many ways to study auditory plasticity:
  - Use of *hearing aid amplification* to understand impact of restored peripheral input and audibility[3]
  - Use of *earplugs* to understand deprivation[4]
  - Use of *sound therapy* to understand enhanced sound input with or without amplification[4]

## Current study

- *Hypothesis*: Increased peripheral input via sound therapy in older adults with hearing loss will alter central gain in the brainstem and perceptual measures of loudness.
- *Relevance:* Improved understanding of plasticity will lead to improved targeted intervention for adults with hearing loss

## Methods

### Subjects

| | Treatment Group n=10 | Control Group n=11 |
|---|---|---|
| **Age:** mean (SD, range) | 70 (8.0, 56-78) | 69 (8.1, 55-86) |
| **Gender** | 5 men, 5 women | 4 men, 7 women |

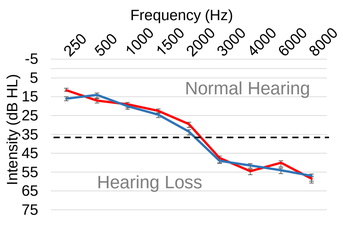


**Figure 1a.** Control group. Pure-tone hearing thresholds for the right (red) and left (blue) ears with standard error bars.

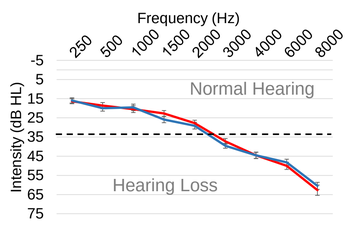


**Figure 1b.** Treatment group. Pure-tone hearing thresholds for the right (red) and left (blue) ears with standard error bars.

### Sound Therapy Treatment

- White noise delivered to both ears via hearing aids (Figure 2)
- Worn every day (12+hrs/day) for 2 weeks
- Adjusted for each participant
  - Provide maximum stimulation at 3 kHz
  - Subjective report of "comfortable"

**Figure 2.** Receiver-in-the canal hearing aid

### Groups

- Control: all study visits but no treatment
- Treatment: all study visits plus sound therapy

### Outcome Measures

- Physiological
  - Acoustic Reflexes: elicited ipsilaterally by broadband noise and measured in 1-dB steps.
- Behavioral
  - The Contour Test[5]: categorical loudness judgements measured as 3 kHz tonal stimulus intensity increased from near-threshold (Category 1) to uncomfortably loud (Category 7).

## Visit Timeline

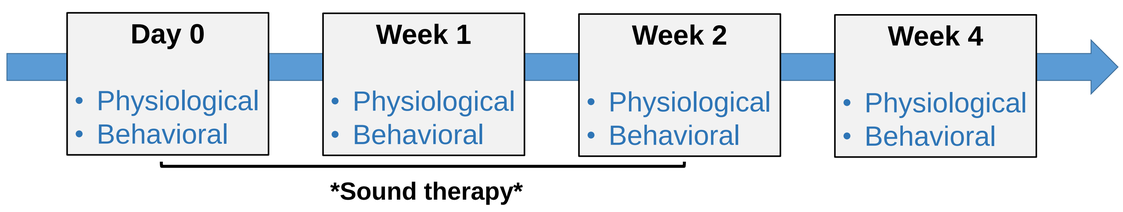


**Figure 3.** Timeline of participant visits from Day 0 (baseline) through Week 4. The treatment group uses sound therapy for two weeks beginning after the Day 0 visit and ending at the Week 2 visit.

## Acoustic Reflexes—What are they?

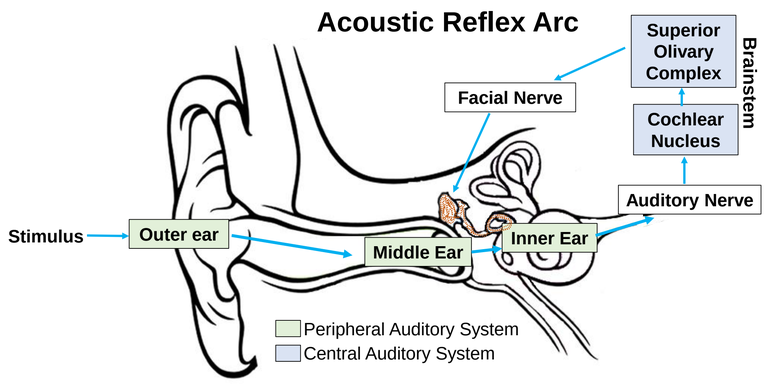


**Figure 4a.** The acoustic reflex arc involved in the generation of the acoustic reflex. Multiple structures in the auditory periphery and brainstem are involved.

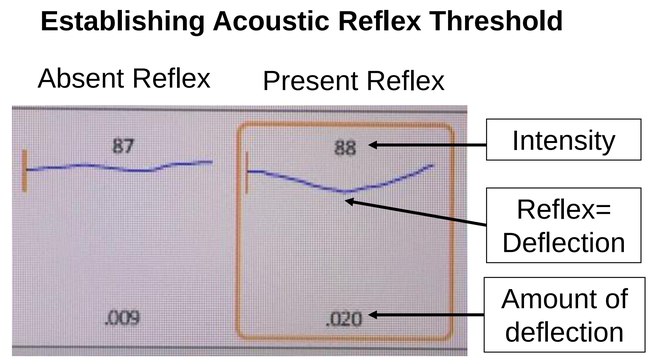


**Figure 4b.** Example of a present acoustic reflex at 88 dB HL and absent at 87 dB HL in the left ear.

## Results—Acoustic Reflex Thresholds (ARTs)

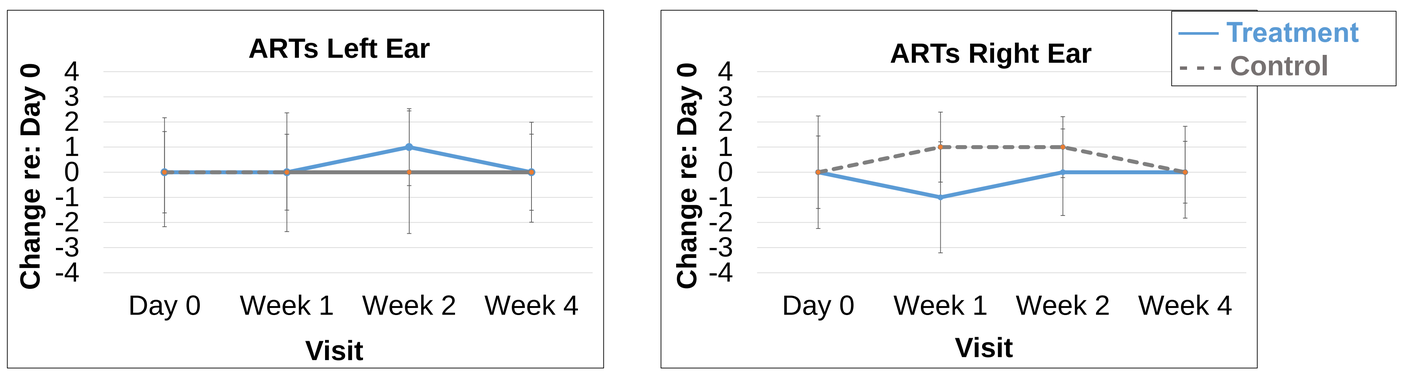


**Figure 5.** Change in mean acoustic reflex thresholds (ARTs) relative to Day 0 for the control and treatment group across visits. Reduced central gain should lead to increased ARTs following sound therapy. A repeated measures ANOVA on ARTs from Day 0 to Week 4 did not reveal a statistically significant between-subject effect of group ($F=2.26$, $p=.13$). Within-subject effects of time and ear were not statistically significant at alpha=0.05, and neither were any of the interactions between these and the between-subjects group factor.

## Results—Loudness Contour Test

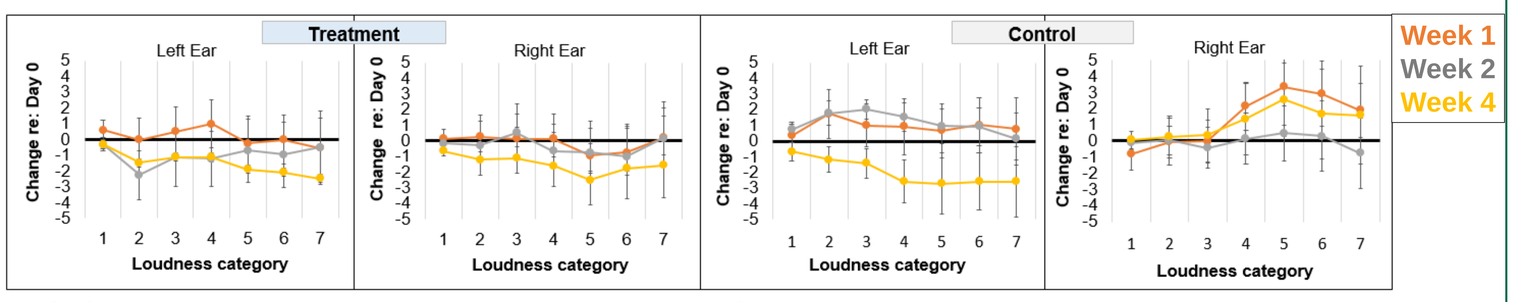


**Figure 6.** Change in mean loudness judgments relative to Day 0 for the control and treatment group across visits. Reduced central gain should lead to increased change in loudness judgements (expanded dynamic range) following sound therapy. A repeated measures ANOVA on loudness judgments from Day 0 to Week 4 revealed a statistically significant between-subject effect of group ($F=4.67$, $p=0.05$). Within-subject effects of time, ear, and contour category were not statistically significant at alpha=0.05, and neither were any of the interactions between these and the between-subjects group factor.

## Discussion

- Acoustic Reflex Thresholds: evidence of sound therapy affecting change at the level of the brainstem?
  - Unlike our previous study with older hearing-impaired adults using combined amplification and sound therapy, the present groups showed large variability in ART measures and no significant change with treatment or between groups.
- Loudness Contour Test: differences in how sound therapy affects normal and hard-of-hearing adults' loudness perception?
  - In previous work with normal-hearing adults, loudness judgments were adaptable (they changed) with use of sound therapy.[4] The present results show an overall difference in loudness judgements between groups, but no significant change with treatment for either group.

## References

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2. Schaette, R., and Kempter, R. (2006). Development of tinnitus-related neuronal hyperactivity through homeostatic plasticity after hearing loss: a computational model. Eur. J. Neurosci. 23, 3124–3138.
3. Munro, K.J., Walker, A.J., and Purdy, S.C. (2007). Evidence for adaptive plasticity in elderly monaural hearing aid users. Neuroreport 18, 1237–1240.
4. Formby C., Sherlock L.P., and Gold S.L. (2003). Adaptive plasticity of loudness induced by chronic attenuation and enhancement of the acoustic background. Journal of the Acoustic Society of America, 114(1):55-8.
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**QR Code**

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