Preference and Interaural Asymmetry

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ABSTRACT

Objectives: To define the relationship between ear preference strength and interaural asymmetry magnitude.

Study Design: Prospective, cross-sectional study.

Methods: 259 subjects completed standard audiometry and survey instruments. Ear preference was assessed using both a visual-analog scale and a 7-point categorical rating scheme (no preference and left or right somewhat, strong, or complete ear preference). Audiometric asymmetry was defined as an air conduction interaural threshold difference (ITD) of 15 dB or greater at any 2 frequencies between 0.25 and 4 kHz. Criterion for hearing loss was thresholds > 25 dB from 0.25 to 4 kHz and normal hearing was thresholds ≤ 25 dB. The maximum average ITD at two adjacent frequencies (ITD_{max2}) was calculated to quantify threshold asymmetry.

Results: The 3 study cohorts were normal hearing (NH, thresholds < 25 dB, n = 66 (25%)), symmetric hearing loss (SHL, any single threshold ≥ 25 dB, n = 81 (32%)), and asymmetric hearing (AS, n = 112 (43%)). NH and SHL cohorts had indistinguishable ear preference distributions (p = 0.57), while the AS cohort demonstrated greater preference for one ear (p < 0.05). Receiver operating characteristic (ROC) analysis for all ear preference categories showed very good diagnostic accuracy (all curves with area ≥ 0.84). The most likely ITD_{max2} range based on the largest odds ratio for each ear preference level was: no preference (≤ 15 dB), somewhat (15-29 dB), strongly (30-44 dB), and completely (≥ 45 dB).

Conclusions: Categorical ear preference can be used to identify the most likely range of interaural asymmetry.

INTRODUCTION

- Deficits in binaural hearing cause difficulty in localizing sound sources, assigning contextual meaning to sounds, and sharpening sound detection and discrimination in multisource environments.
- Patients with asymmetric hearing loss have inferior hearing function compared to those with symmetric hearing loss at comparable hearing threshold levels[1].
- In its most severe form, single-sided deafness, speech discrimination in noise is significantly impaired and dramatic reorganization of auditory cortex occurs[2,3].
- Binaural hearing deficits associated with asymmetric hearing have a considerable impact quality of hearing[4-6] but are often not well recognized.
- Current definitions of hearing asymmetry guide evaluation for vestibular schwannomas but are not based on binaural hearing deficits or the perception of hearing asymmetry[7].
- In this study, we investigate the relationship between ear preference perception and audiometric threshold asymmetry using a categorical measure of ear preference strength. We demonstrate that ear preference strength maps to degrees of audiometric asymmetry and is a very good classifier of interaural asymmetry magnitude. This finding enables practitioners to identify patients who are at risk for asymmetric hearing and may warrant detailed audiometric testing and treatment.

RESULTS

	Asymmetric ITD ≥ 15 dB (any 2 frequencies)	Symmetric HL > 25 dB (0.25 to 4 kHz)	Normal ≤ 25 dB (0.25 to 4 kHz)	P-Value
Total n (%)	112 (43%)	81 (32%)	66 (25%)	
Age (years)				
Mean (SD)	56.9 (16.8)	66.9 (13.3)	36.6 (15.6)	< 0.05*
Gender				
Male : Female	63:49	38:41	13:55	< 0.05*
Past or current hearing aid use (%)	42 (38%)	35 (43%)	0 (0%)	< 0.05†
ITD_{max2}				
Mean (SD)	39.7 (25.5)	4.7 (3.8)	4.5 (3.8)	< 0.05◊

Table I. Study Demographics

* p < 0.05 for all post-hoc comparisons; † p < 0.05 for Normal vs. Asymmetric and Symmetric HL; ◊ p < 0.05 for Asymmetric vs. Symmetric HL and Normal

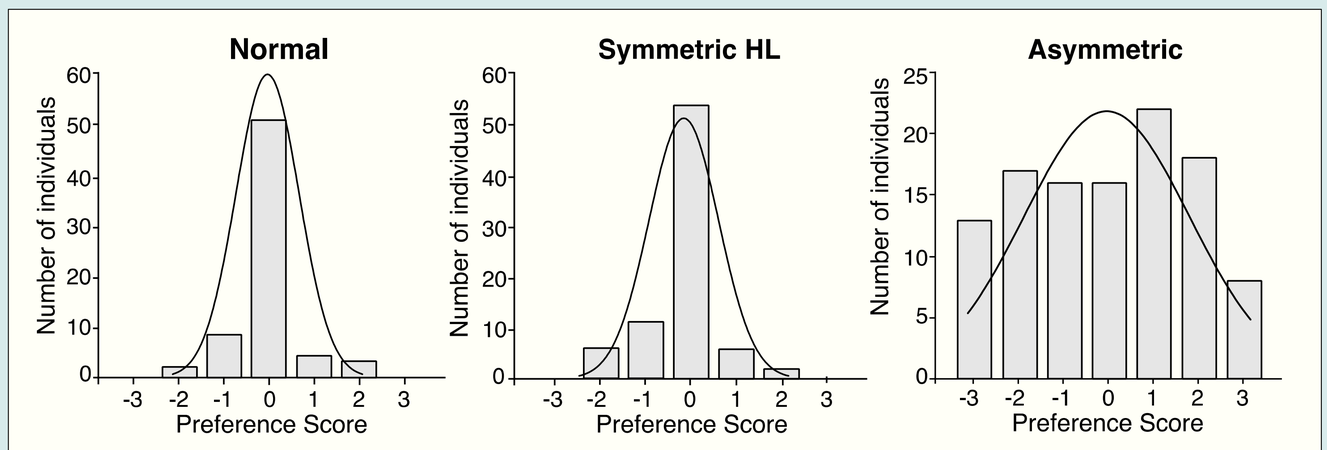

Fig. 1. Frequency distribution curves are similar between symmetric hearing loss and normal hearing cohorts (p = 0.57) while the asymmetric hearing cohort shows a broad range of preference categories (p < 0.05).

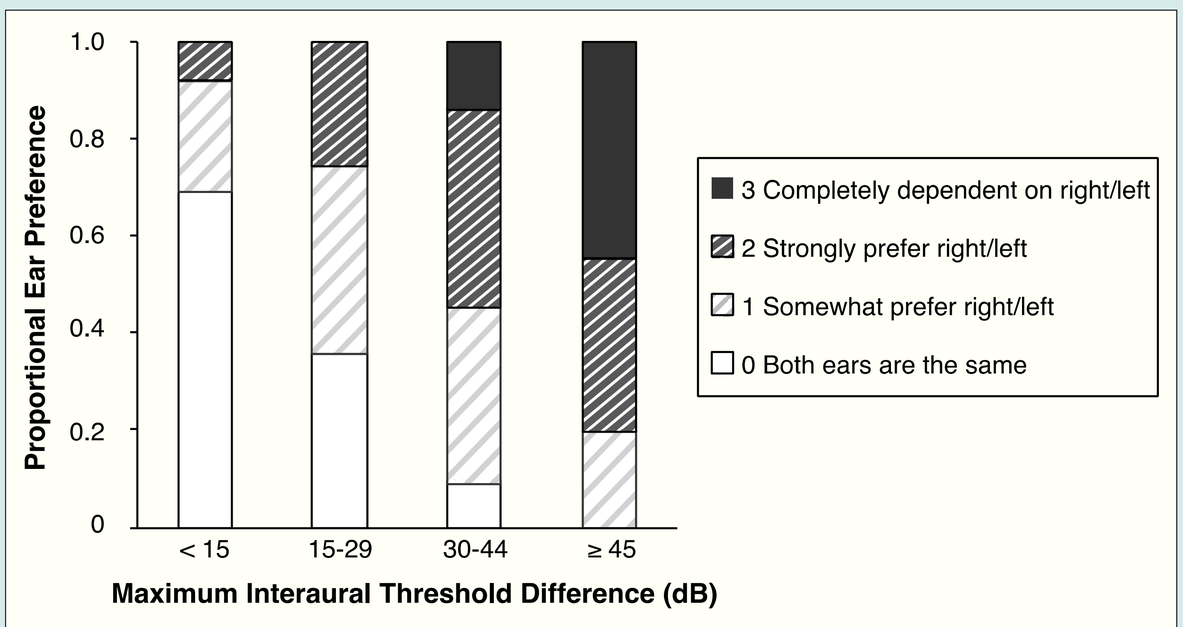

Fig. 2. The proportion of subjects reporting stronger ear preference increases as interaural asymmetry increases (p < 0.05 for all comparisons).

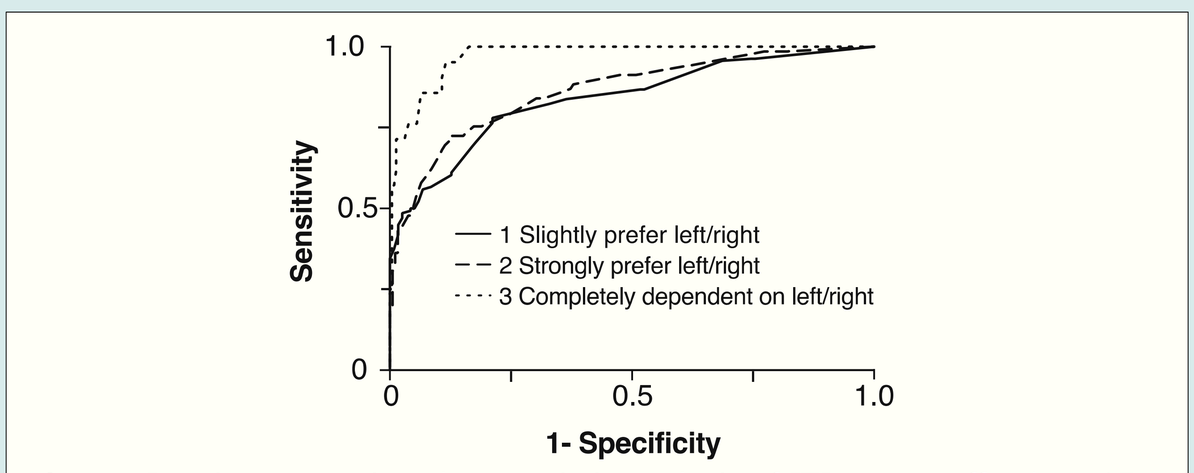

Fig. 3. Receiver operating characteristic analysis of ITD_{max2} cutoff values 15 dB, 30 dB, and 45 dB indicates good to excellent diagnostic accuracy (A' ≥ 0.84) at each ear preference strength category.

Preference Score	ITD_{max2} (dB) < 15	15-29	30-44	≥ 45
0 No preference	**11.0** [6.0-20.0]	0.6 [0.3-1.0]	0.1 [0.02-0.4]	0
1 Somewhat prefer	0.6 [0.4-1.1]	**2.1** [1.1-4.1]	1.7 [0.7-4.2]	0.6 [0.3-1.5]
2 Strongly prefer	0.2 [0.9-0.4]	1.6 [0.8-3.4]	**3.4** [1.4-8.6]	3.1 [1.5-6.6]
3 Completely dependent	0	0	1.9 [0.5-7.0]	**54.8** [15.0-200.2]

Table II. Odds ratios (OR) with [95% confidence intervals] for lateralized ear strength and maximum average interaural threshold difference at two adjacent frequencies (ITD_{max2}) range pairs. The maximum OR for each ear preference score is marked in orange.

METHODS

Which best describes your hearing (choose best description)?

- ☐ Completely dependent on LEFT ear
- ☐ Strongly prefer LEFT ear
- ☐ Somewhat prefer LEFT ear
- ☐ Both ears are the same
- ☐ Somewhat prefer RIGHT ear
- ☐ Strongly Prefer RIGHT ear
- ☐ Completely dependent on RIGHT ear

Please indicate how you use your two ears

LEFT Exclusively | LEFT and RIGHT Equally Useful | RIGHT Exclusively

Survey Instruments

- Subjects recruited from UCSF outpatient Audiology clinics completed standard audiometry and a questionnaire evaluating ear preference (shown above)
- The visual analog scale was scored from -50 (exclusive left ear use) to 0 (no preference) to +50 (exclusive right ear use). The 7-point categorical rating scheme was scored as follows: no ear preference = 0; left or right somewhat = -1, 1; left or right strongly = -2, 2; and left or right completely = -3, 3

Audiometric Testing

- Audiometric testing performed at 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz.
- Definitions:
  - **Audiometric asymmetry:** air conduction interaural threshold difference (ITD) of 15 dB or greater at any 2 frequencies between 0.25 and 8 kHz [8-10].
  - **ITD_{max2}:** the maximum average ITD at two adjacent frequencies was calculated to quantify threshold asymmetry[11].
  - **Hearing loss:** any threshold greater than 25 dB from 0.25 to 4 kHz and normal hearing represented thresholds less than or equal to 25 dB across those frequencies.

CONCLUSIONS

- Patient-reported ear preference is a good to excellent classifier of interaural asymmetry.
- Increasing ear preference strength is associated with increasing odds of greater hearing asymmetry.
- Ear preference strength maps to the best estimate audiometric asymmetry magnitudes:
  - No preference to ITD_{max2} < 15 dB
  - Somewhat/strongly prefer to ITD_{max2} ≤ 15-44 dB
  - Completely dependent to ITD_{max2} ≥45 dB
- A single question about ear preference strength can be used to identify patients with asymmetric hearing expeditiously and promptly to guide evaluation and treatment.

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