A New Method To Quantify Horizontal Localization Performance

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INTRODUCTION

Horizontal sound localization performance is often descriptively displayed by plotting presentation azimuths against response azimuths. With this descriptive method, error patterns are difficult to interpret and difficult to compare across listening conditions. The purpose of this poster is to introduce a new method for quantifying horizontal localization performance which facilitates descriptive comparison across listening conditions for hearing aid research. With the new method, the localization performance is quantified using Area of Angular Error (AAE), which is the area of the polygon formed by connecting the mean absolute angular errors for adjacent azimuths on a polar plot.

A TRADITIONAL APPROACH

This method is based on angular differences between presentation and response azimuths for all stimuli. Descriptively, performance is displayed by plotting presentation azimuths against response azimuths for all participants (see bubble charts in the 3rd column of this poster). Performance is quantified using RMS error across azimuths:

$$RMS(°) = \sqrt{\frac{\sum_{i=1}^{n}(Presentation_i - Response_i)^2}{n}}$$

where n is the total number of presented stimuli.

Disadvantage: error patterns between two conditions are difficult to compare.

THE AAE APPROACH

This method is based on a polar plot of angular errors for all tested azimuths. Descriptively, performance is quantified using a visual representation of the polar pattern.

Advantages:

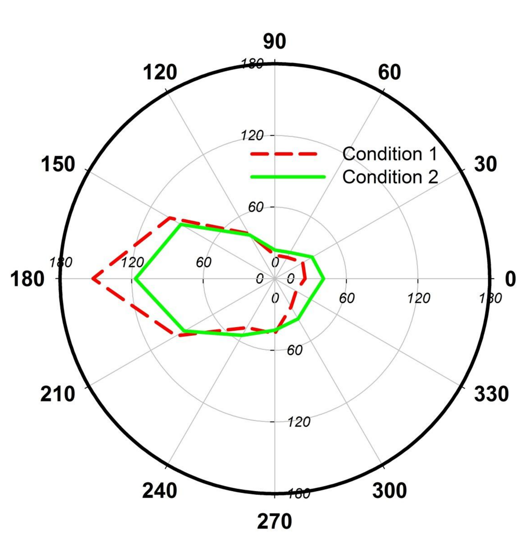
- The error patterns between two conditions are easy to observe.
- Descriptive display of the performance and data for analysis are based on the same polar plots.

How to use the AAE approach?

Step 1: Calculate mean absolute angular error for each azimuth

Step 2: Mark the angular errors on a polar plot and connect the adjacent azimuths to form a polygon

Step 3: Calculate the area of the polygon to quantify localization performance for statistical analysis
- Matlab function ***polyarea*** (Mathworks, Inc.)

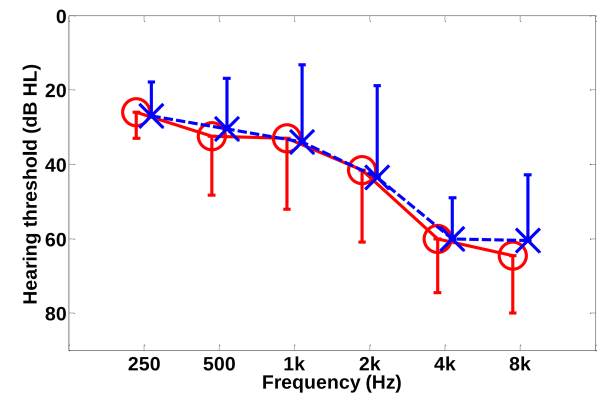


Does AAE approach give same answers as traditional approach?

Localization performance in masking noises was evaluated in three listening conditions. Performance in these conditions was compared using the AAE approach and a traditional approach using RMS errors across azimuth (e.g., Van den Bogaert, et al., 2011).

Subjects

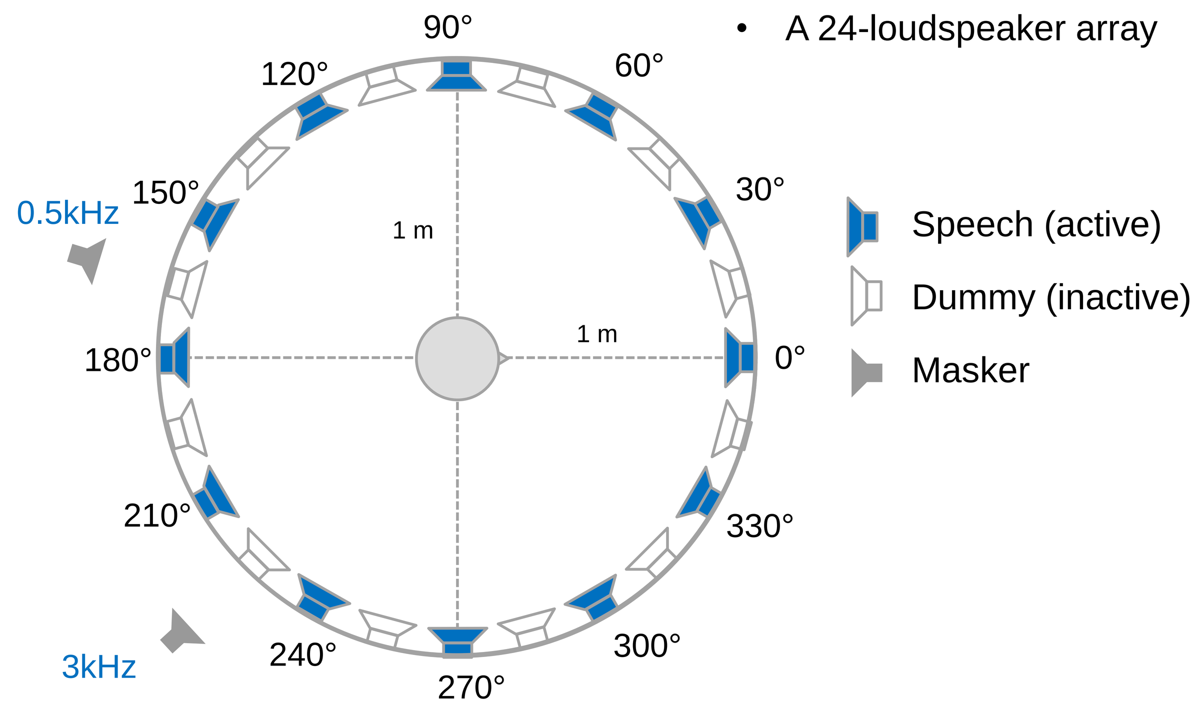
- Participants: 10 adults with symmetrical sensorineural hearing loss
- HA: Two pairs of BTEs (HA1 and HA2). HAs were bilaterally fitted using the NAL-NL1 method



Methods

A. Experimental Setup

- In a sound-treated room
- A 24-loudspeaker array



B. Stimuli

- Speech: filtered speech utterances (200-600Hz); average duration 1.33 seconds (from 1.3 to 1.4 seconds)
- Maskers: octave band steady-state noise centered at 0.5 kHz and 3 kHz

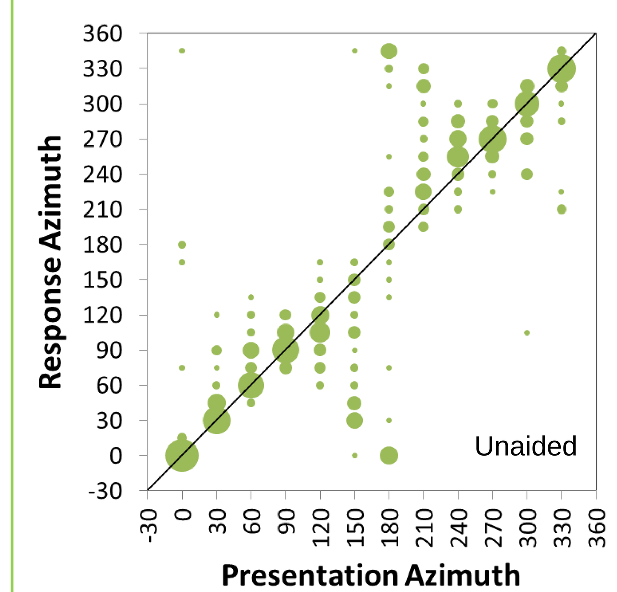
C. Test Administration

- There were 4 speech utterances for each active loudspeaker (azimuth) and the presentation level was 70 dB SPL.
- The 0.5 kHz noise was presented at 55 dB SPL and the 3 kHz noise was presented at 65 dB SPL.
- Speech stimuli were presented from each active loudspeaker in random order. The two noises were presented continuously.
- Listening conditions: unaided (UN) and aided (HA1 and HA2)
- For the two aided conditions, participants were tested after a 4-week clinical trial.

Results

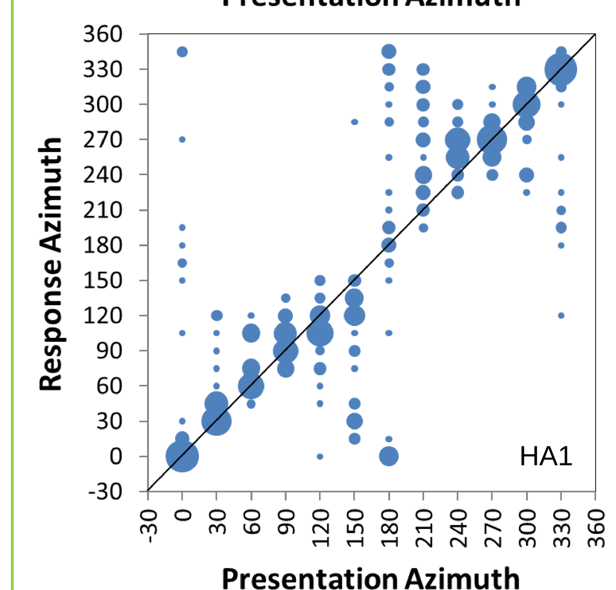
A. With The Traditional Approach

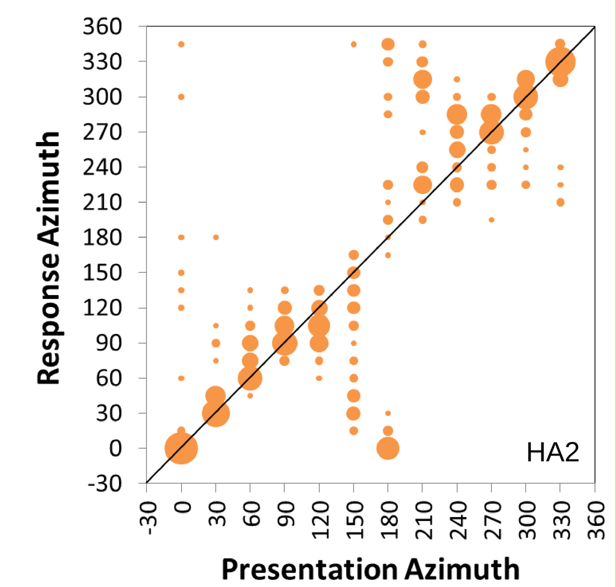
The bubble charts show performance-response patterns for all participants. In each chart, bubbles located on the main diagonal indicate perfect localization performance. The larger the bubble, the greater the number of responses for a particular azimuth.



Mean RMS errors:

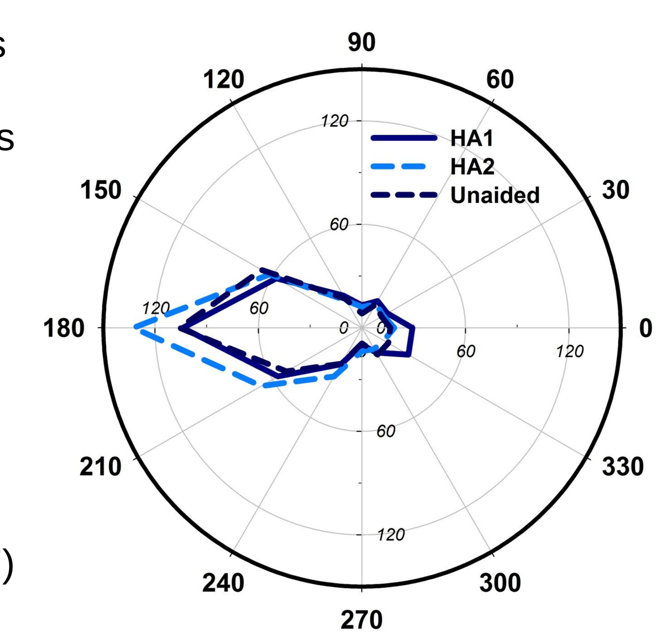
- Unaided: 52.26 (SD = 16.95)
- HA1: 53.57 (SD = 19.50)
- HA2: 57.44 (SD = 16.18)
(Greater scores correspond to more errors)





B. With the AAE Approach

Each of the polygons depicts the mean angular error pattern across all participants for each listening condition.



Mean AAE:

- Unaided: 5337 (SD = 4077)
- HA1: 6129 (SD = 5018)
- HA2: 7046 (SD = 4728)

(Greater scores correspond to more errors)

C. Statistical Analyses

Paired t-tests, * significant effect at 0.05 level

	RMS error		AAE	
	t (9)	*p*	*t* (9)	*p*
Unaided vs. HA1	-.345	.738	-1.006	.341
Unaided vs. HA2	-3.444	.007*	-2.696	.025*
HA1 vs. HA2	.919	.382	1.041	.325

Discussion

- Statistically, the two approaches produce the same results.
- The advantage of using the RMS approach is that the spread of individual data can be descriptively displayed in a bubble chart.
- With the RMS approach, difference among the three conditions is difficult to observe by using bubble charts.
- With the AAE approach, the difference between the three conditions is readily visualized by comparing the polygons displayed in polar plots.
- The AAE method is especially useful for comparing different hearing aid technologies

CONCLUSION

The AAE method provides a new way to display horizontal localization data that facilitates intuitive comparisons of performance in different listening conditions, such as different hearing aids.

REFERENCES

Van den Bogaert T, Carette E, Wouters J. (2011). Sound source localization using hearing aids with microphones placed behind-the-ear, in-the-canal, and in-the-pinna. Int J Audiol. 50(3):164-76.

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