T32a

WAISMAN CENTER

The effect of a cochlear implant processing strategy on auditory motion tracking in NH listeners

Keng Moua, Alan Kan, & Ruth Y. Litovsky
University of Wisconsin-Madison, USA
e-mail: kmoua8@wisc.edu

Binaural Hearing and Speech Laboratory

Conference on Implantable Auditory Prostheses
Lake Tahoe, CA.
July 16-21, 2017

1. Introduction

- A previous experiment conducted in our lab assessed auditory motion perception in adults with normal hearing (NH) and bilateral cochlear implants (BiCIs). The results of the study showed, BiCI users were poorer than NH adults at identifying a moving sound from a stationary sound and identifying the direction of a moving sound [1].
- Most of our BiCI participants use the Advanced Combinational Encoder (ACE) clinical strategy, which selects frequency channels with the highest energy, and does so separately for each ear, thereby minimizing binaural coordination across channels [2,3,4].
- To better understand the contribution the ACE strategy has on poor auditory motion-tracking performance in BiCI users, we conducted this auditory motion experiment in NH adults listening with an ACE processed stimuli.

2. Stimulus

Binaural Recordings

- White noise tokens (100-6000 Hz bandwidth, 500 ms duration) were recorded using binaural microphones placed in the ears of a KEMAR manikin.
- Angular ranges of motion: 0° (stationary), 10°, 20°, and 40°.

Figure 1 shows the binaural recording setup.

- 19 target locations, spanning -90° to +90° in 10° intervals, across azimuth.
- Moving sound sources were simulated using Vector Base Amplitude Panning [5] across an array of loudspeakers (Fig. 1).
- Binaural recordings were processed using the Nucleus MATLAB Toolbox (NMT) to simulate ACE processing and the resultant channel envelopes were used to modulate sine tones.

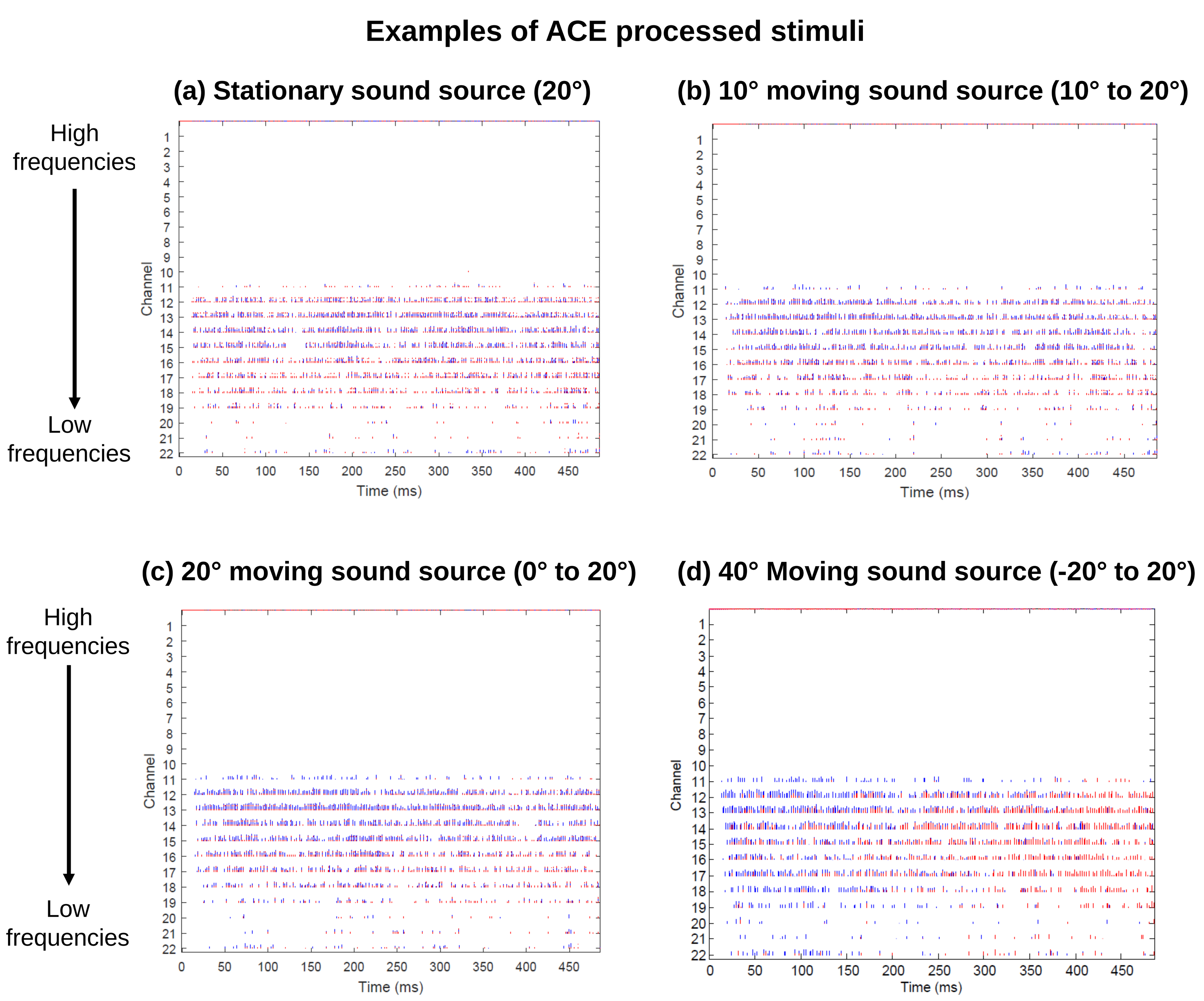

Figure 2 shows the output of the peak-picking stage of the NMT when simulating the ACE strategy. Examples are shown for: (a) stationary sound source at 20°; (b) 10° moving sound source (10° to 20°); (c) 20° moving sound source (0° to 20°); & (d) 40° moving sound source (-20° to 20°). Blue pulses = left ear & red pulses = right ear. Note, that the ACE strategy appears to only pick peaks within the mid-to-low frequency ranges and that changes in the interaural level differences are most prevalent when the sound source traverses a 40° angular range.

3. Methods

Testing

- 10 NH listeners; ACE-processed stimuli (NH-ACEsim) via Sennheiser HD 600 circumaural headphones.
- 10 NH listeners tested with normal acoustic stimuli (NH-Acoustic) from a prior study [1].
- 9 BiCI users listened with the ACE strategy (BiCI-ACE) from a prior study [1].

Task

- Stationary and moving sounds were presented randomly within a single block.
- Participants were asked to report the perceived trajectory of the stimuli on a graphical user interface (Fig. 3). Stationary responses were reported by a single dot and moving responses were reported by a line indicating the perceived trajectory.

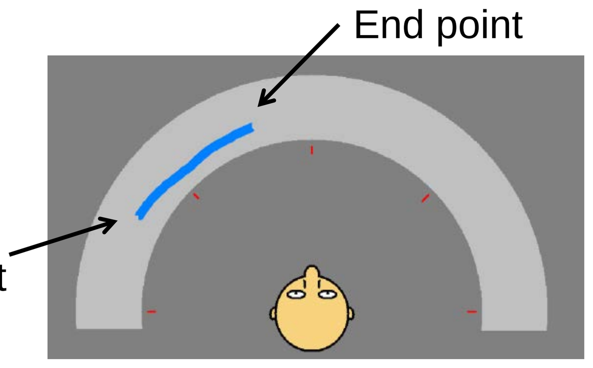

Figure 3 shows the graphical user interface used to capture listener responses. The perceived sound source trajectory is shown as a blue line.

4. Results

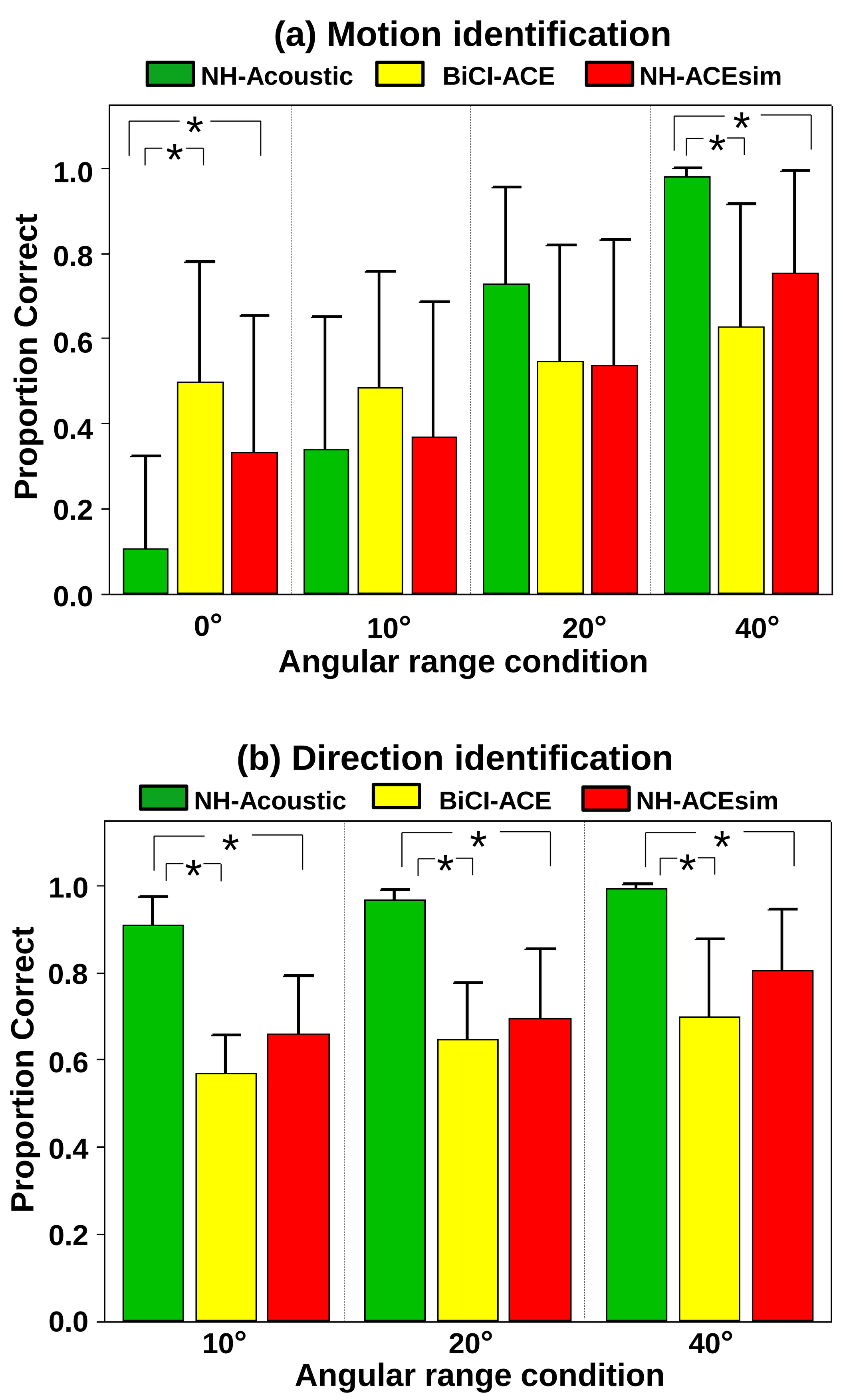

Figure. 4 shows the means (±SD) for each group (green bar = NH-Acoustic, yellow bar = BiCI-ACE, & red bar = NH-ACEsim) plotted for **(a)** proportion of moving trials identified as a moving sound and **(b)** proportion of moving trials identified as moving and moving in the correct direction. The NH-Acoustic and BiCI-ACE data shown are from previous work [1].

- NH-ACEsim listeners showed statistically similar performance to the BiCI-ACE listeners, but remained poorer than the NH-Acoustic listeners in determining whether a sound was stationary or moving, in the 0° and 40° conditions, respectively (Fig. 4(a); Table 1).
- Similarly, the NH-ACEsim listeners remained poorer than the NH-Acoustic listeners when identifying the direction of motion at all angular ranges tested (Fig. 4(b); Table 1).
- These results suggest that the peak-picking process of the ACE strategy may be distorting the cues necessary for good auditory motion tracking performance. This could be due to different peaks being chosen independently, therefore, channels are not temporally aligned across the ears (see Fig. 2).

Table 1. Statistical Analysis
A 2-way mixed effects analysis of variance with Bonferroni Correction (α = 0.012)

Groups	Measure	Conditions			
		0°	10°	20°	40°
NH-Acoustic vs BiCI-ACE	Motion Identification	*p<.003	P=.301	p=.13	*p=.001
NH-Acoustic vs NH-ACEsim	Motion Identification	*p=.011	p=.83	p=.11	*p<.008
NH-Acoustic vs BiCI-ACE	Direction Identification	n/a	*p=.001	*p<.001	*p<.001
NH-Acoustic vs NH-ACEsim	Direction Identification	n/a	*p<.001	*p<.001	*p=.001

5. Summary

- NH adults listening to an ACE processed stimuli, resulted in similar performance when identifying the motion and direction of a moving sound source as BiCI users.
- Future studies will need to understand which aspect of the ACE strategy is contributing to the poor performance in auditory motion tracking abilities.

6. References

[1]. Moua, K., Kan, A., & Litovsky, R. Y. (2017, Feb.). *Auditory motion perception of individuals with single sided deafness*. Poster sessions presented and the Association for Research in Otolaryngology, Baltimore, MD.
[2]. Loizou, P. C. (1998). Mimicking the Human Ear, *IEEE Signal Processing Magazine*, 15 (5), 101-130
[3]. Zeng, F. G., Rebscher, S., Harrison, W., Sun, X., & Feng, H. (2008). Cochlear Implants: System Design, Integration, and Evaluation, IEEE Reviews in Biomedical Engineering, 1, 115-142.
[4]. Kan, A. & Litovsky, R. Y. (2015). Binaural hearing with electrical stimulation. Hearing Research, 322, 127-137
[5]. Pulkki, V. (1997). Virtual Sound Source Positioning Using Vector Base Amplitude Panning. *Journal of Audio Engineering Society*, 45(6), 456-466.

7. Acknowledgements

We would like to thank our listeners for their participation. This work was supported by NIH-NIDCD (R01 DC003083 & R01 DC008365 to RYL, R03 DC015321 to AK), and NIH-NICHD (U54 HD090256 to the Waisman Center).

WAISMAN CENTER
UNIVERSITY OF WISCONSIN-MADISON
Printing courtesy of the Friends of the Waisman Center