



The impact of asymmetric rates on interaural time difference lateralization and auditory object formation in bilateral cochlear implant and normal hearing listeners

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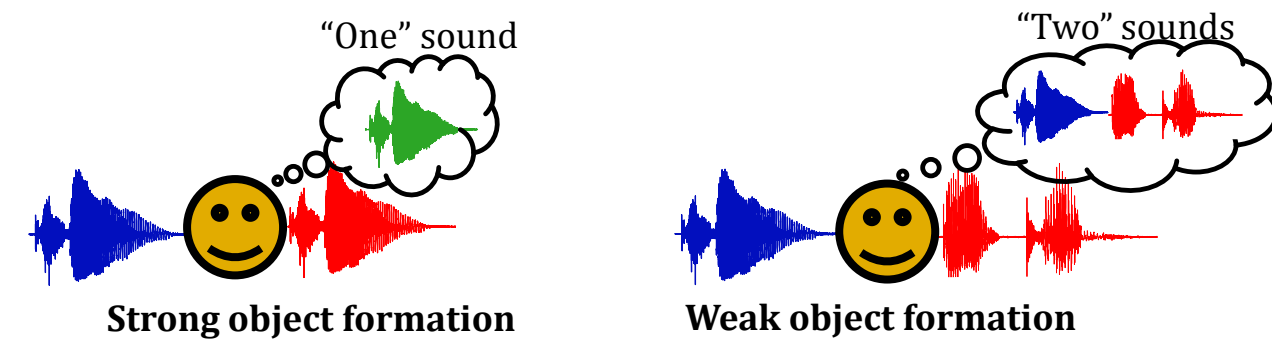


Binaural Hearing and Speech Laboratory

INTRODUCTION

Components that may influence a listener's ability to successfully attend to a signal in noise include:

Auditory Object Formation

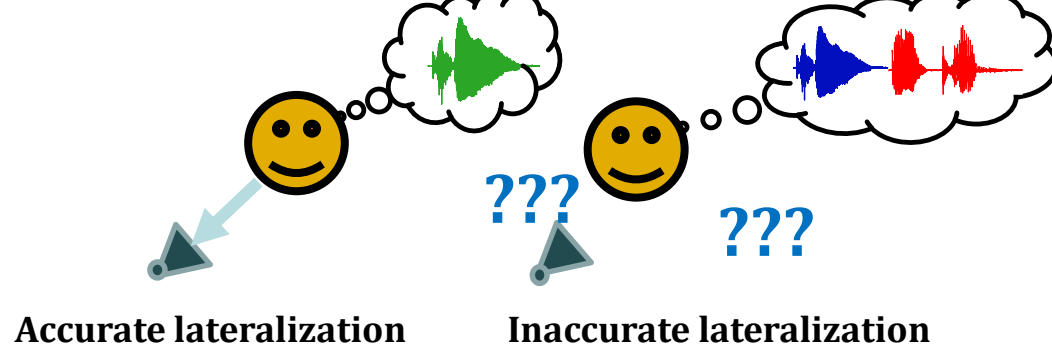


Auditory object formation occurs when pieces of information within and across ears are bound together to perceive one coherent object

Normal hearing (NH) listeners

- ❖ Have good binaural sensitivity that leads to good lateralization of interaural time differences (ITDs)¹.
- ❖ When provided with symmetric or identical across-ear information, listeners perceive a coherent auditory object³.
- ❖ Lack of auditory object formation (AOF) may lead to poor lateralization of ITDs.

Binaural Sensitivity



Having good sensitivity to binaural cues can help with locating the direction of a coherent object

Bilateral cochlear implant (BiCI) listeners

- ❖ Binaural sensitivity is limited in clinical processors from poor representation of the ITD in the signal. However, listeners demonstrate ITD sensitivity when listening with research processors².
- ❖ Sound processors operate independently and may encode the same signal differently between the two ears⁴.
- ❖ It is unknown whether poor ITD sensitivity with sound processors is due to poor AOF.

Hypothesis: If stimulation rate is a major component of lateralization and auditory object formation...

1. Asymmetric across-ear rates will *weaken object formation* and yield *poor lateralization*.
2. Symmetric across-ear rates will *strengthen object formation* and yield *good lateralization*.

METHODS

- ❖ **BiCI listeners (N=8):** Presented with biphasic electrical pulse trains using synchronized research processors (Cochlear RF Generator) at a single pitch-matched pair of electrodes (Fig. 1).
- ❖ **NH listeners (N=12):** Presented with a Gaussian enveloped tone (GET) acoustic pulse train centered at 4 KHz.
- ❖ Experiment: single-interval task with 6 response options (Fig 2).
- ❖ **ITDs (in μ s):** randomized trial-by-trial.
 - ❖ BiCI: 0 (all), ± 500 (5 listeners), ± 800 (2 listeners), ± 1000 (1 listener).
 - ❖ NH: 0, ± 700 .
- ❖ **Rate conditions (pulses per second, pps):**
 - ❖ Left: always 100 pps.
 - ❖ Right: 75, 85, 99, 100, 101, 125, 150, 175, 200, 250, 300 pps, interleaved.
- ❖ 20 repetitions for each ITD and rate combination.

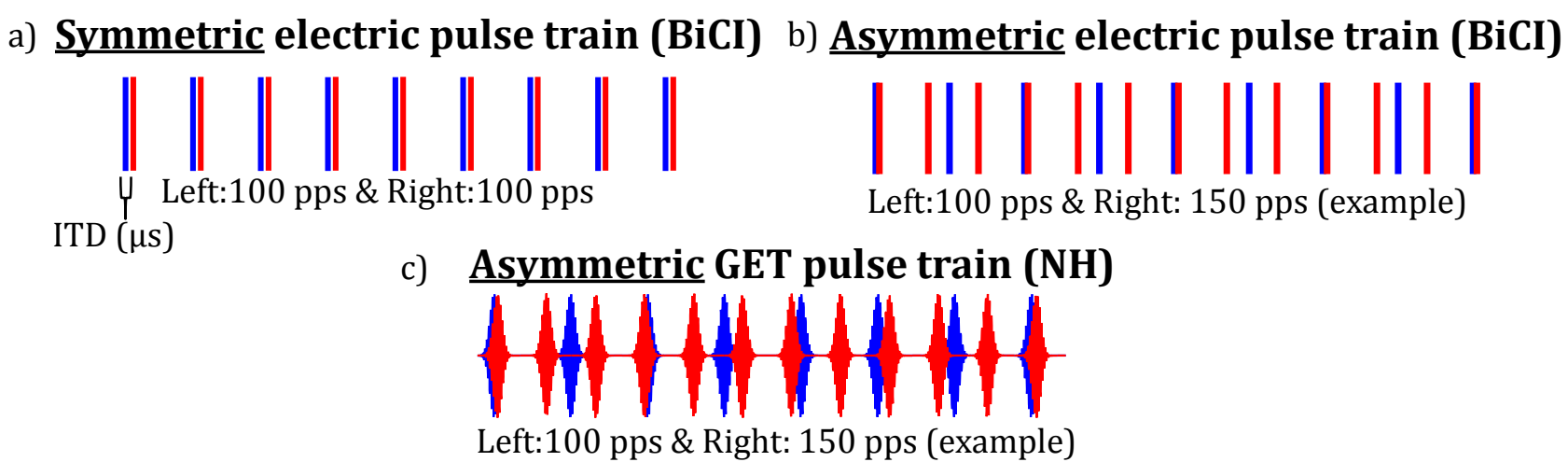


Figure 1: Stimulus examples of BiCI (a,b) and NH (c) pulse-rate conditions.

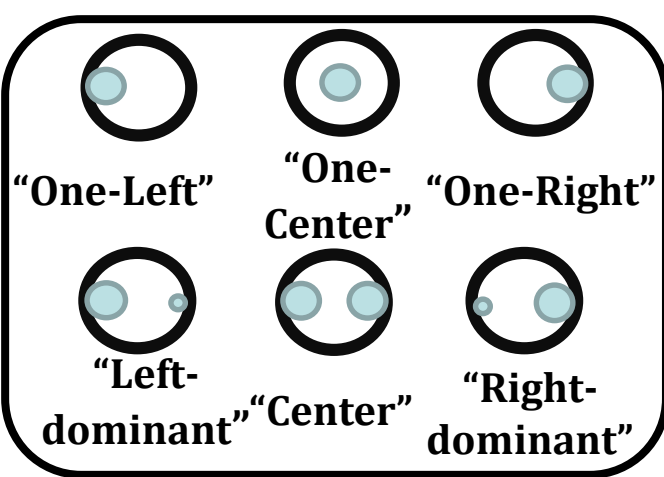


Figure 2: Response options

RESULTS I: How many sounds were reported as a single auditory object?

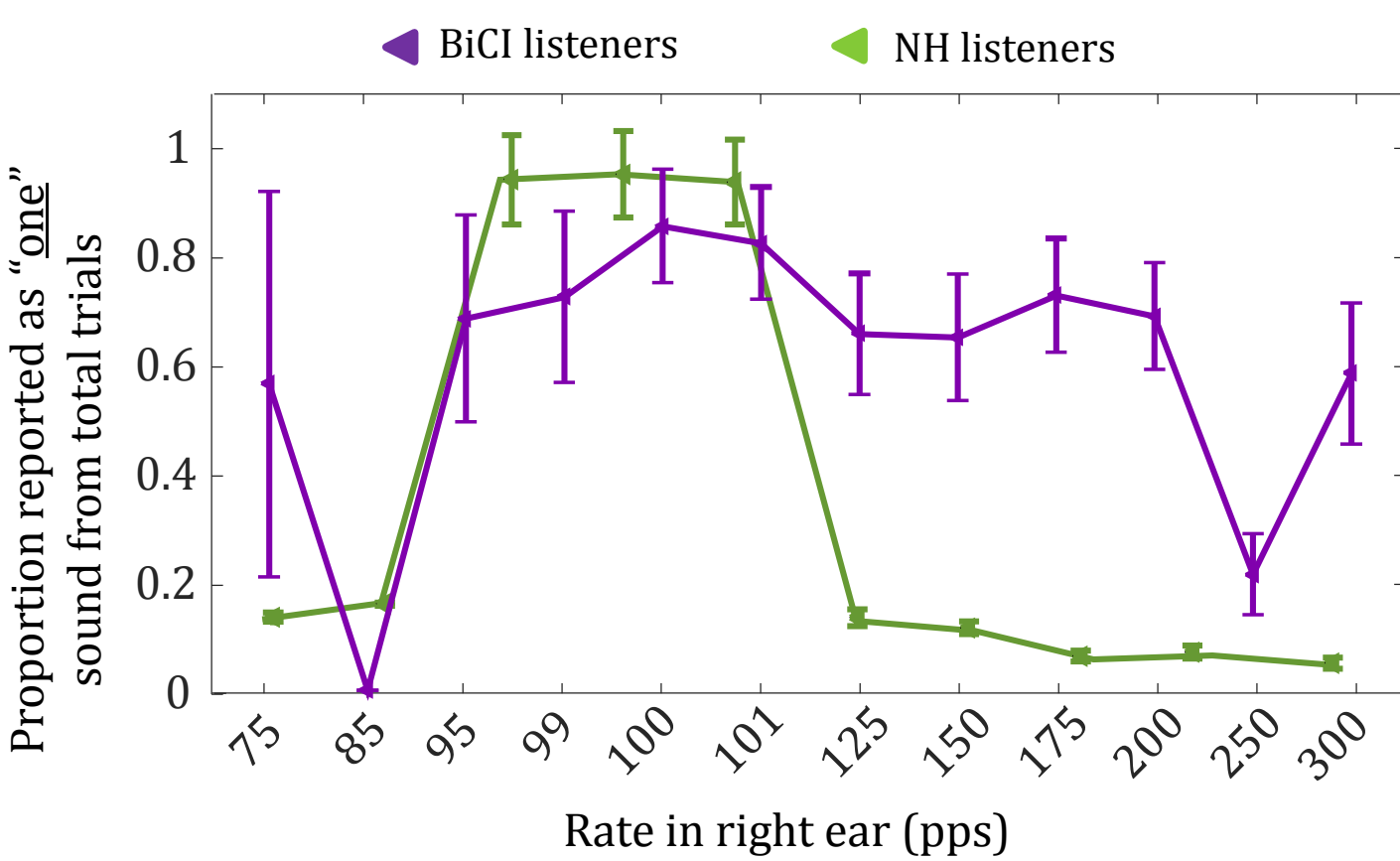


Figure 3: Proportion of 'One' sound responses ("One-Left", "One-Center", or "One-Right") averaged across listeners. Error bars represent standard error.

- ❖ NH listeners show AOF for a narrow range of asymmetric rates across the ears.
- ❖ NH listeners never report hearing one sounds when rates differ more than -15% and +25%.
- ❖ BiCI listeners show AOF for a broader range of asymmetric rates across the ears.

RESULTS II: How many responses were correctly lateralized (NH Listeners)?

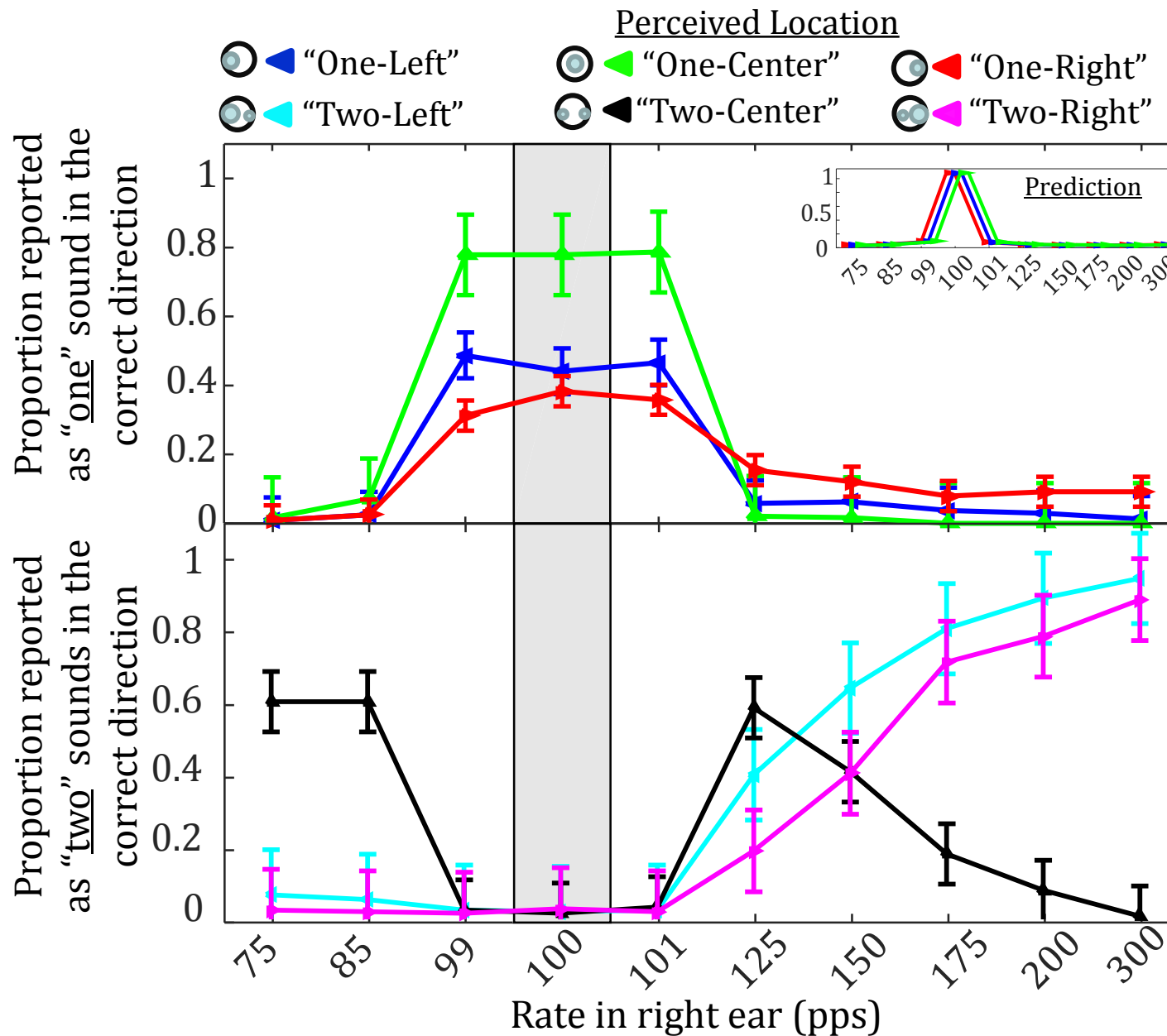


Figure 4: Proportion of correctly lateralized responses per target ITD presented, averaged across the group of NH listeners. Predicted results shown in inset. Error bars represent standard error.

- ❖ NH listeners appear to show some, yet weaker lateralization when rates are symmetric even in the presence of AOF.
- ❖ However, NH listeners poorly lateralize when rates are completely asymmetric and AOF is lacking.

RESULTS III: How many responses were correctly lateralized (BiCI Listeners)?

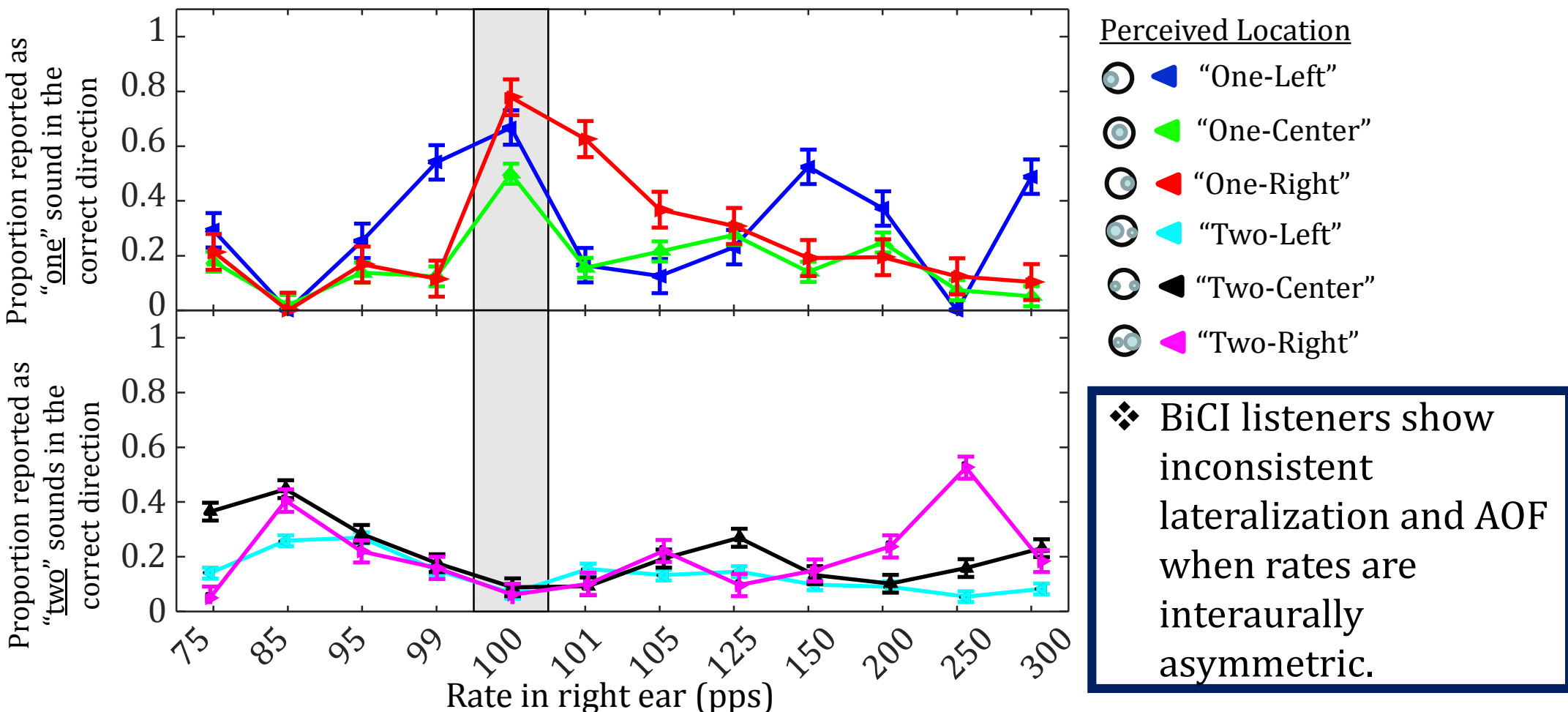


Figure 5: Proportion of correctly lateralized responses per target ITD presented, averaged across the group of BiCI listeners. Error bars represent standard error.

- ❖ Response patterns across listeners appear to differ:
 1. IBK, IBF, and IBK no longer lateralize the ITD of the perceived single fused image with the introduction of dichotic pulse rates
 2. ICD, ICJ, ICP, IBQ, and IAU, lateralize by making more "left" and "right" decisions in the dichotic pulse-rate conditions.
- ❖ BiCI listeners with poorer ITD sensitivity appear to show poor lateralization and greater AOF regardless of rate symmetry.

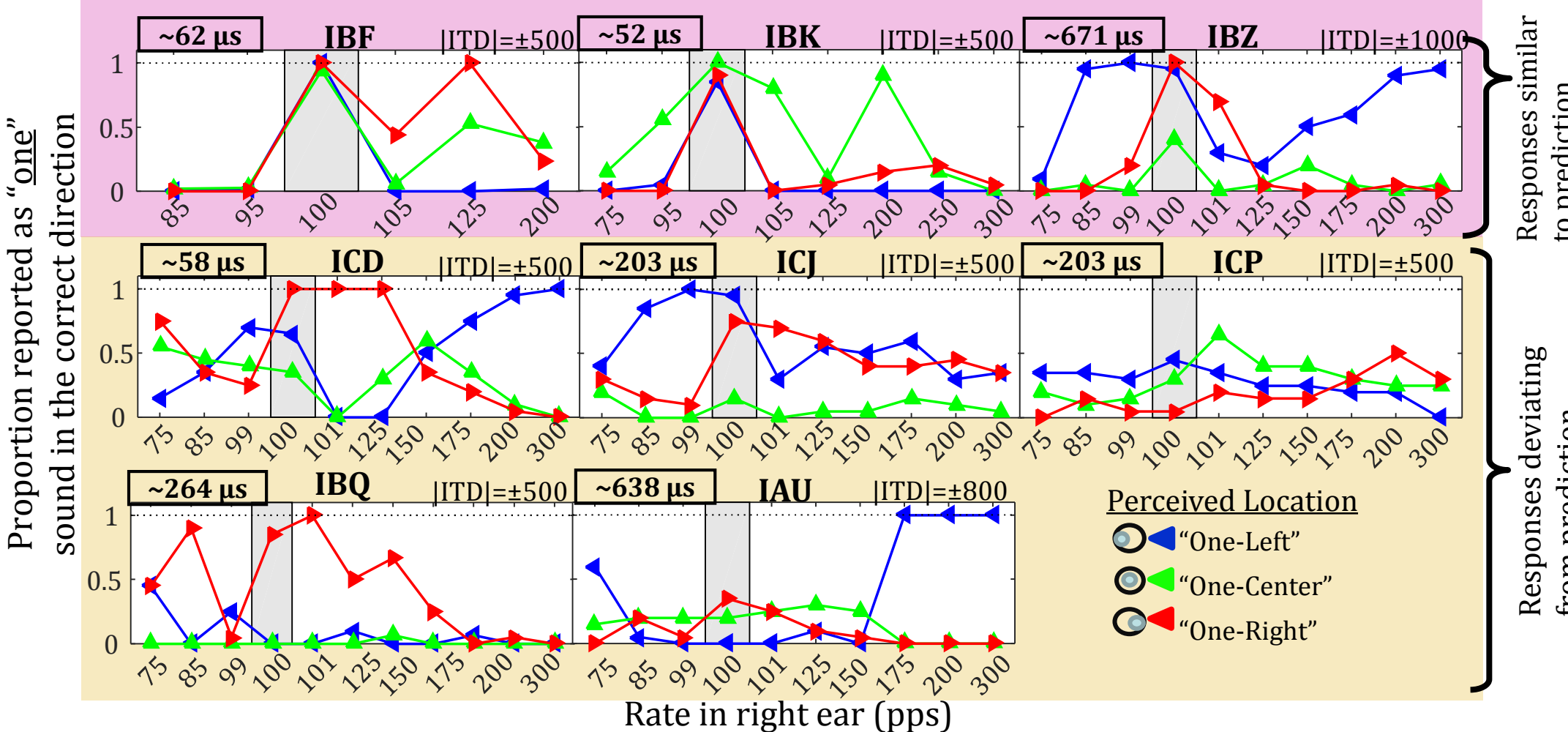


Figure 6: Proportion of lateralized responses reported as "one" sound per target ITD for each individual BiCI listener; ITDs tested shown in top right of each panel; each BiCI listener's sensitivity to ITDs of symmetric rates is shown in the top left.

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DISCUSSION

- ❖ As expected, BiCI and NH listeners have a high degree of AOF when information across the ears is the same. However, when information is different across the ears, range of AOF differs between BiCI and NH listeners suggesting that detection of rate differences with simultaneous presentation across the ear is more difficult with electrical stimulation (Fig. 3) .
- ❖ As expected, when AOF is poor, ITD lateralization is also poor. However, a high degree of AOF did not guarantee good ITD lateralization in both NH and BiCI listeners (Fig. 3, 4 & 6).
- ❖ Overall, our results suggest that having AOF even when information is different across the ears is insufficient for good lateralization for both populations of listeners.