

Lateralization of dynamic interaural time and level differences in high-frequency click trains

G. Christopher Stecker

Department of Speech & Hearing Sciences, University of Washington

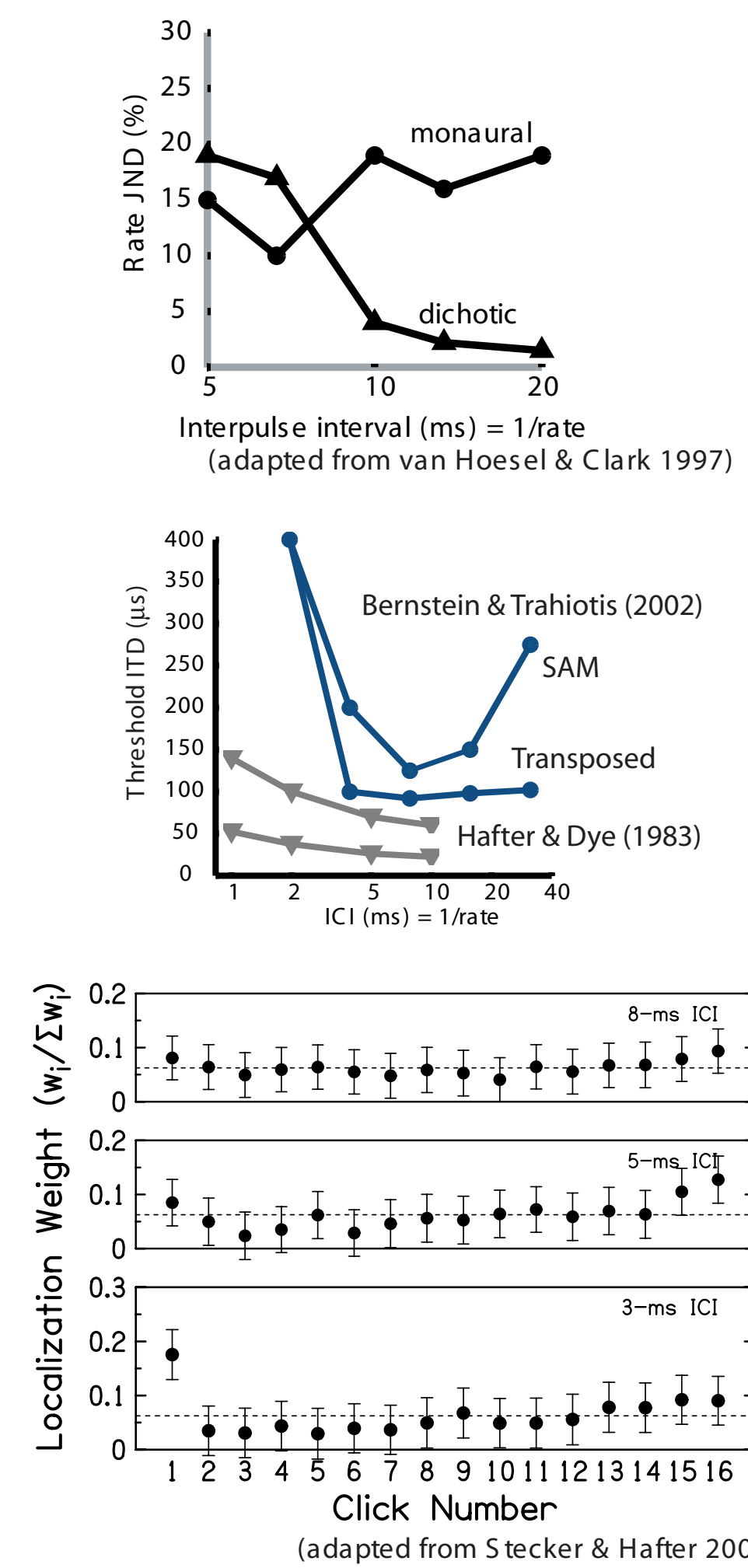


Background

ITD discrimination with bilateral cochlear implants
van Hoesel & Clark (1997)
-ITD thresholds of bilateral CI users profoundly impaired at pulse rates above ~200 pps (5 ms IPI)
-dichotic rate discrimination exceeds monaural discrimination only for slow pulse rates <~200 pps.

Binaural adaptation
Hafer & Dye (1983) - minimal improvement of ITD thresholds with duration of high-rate band-limited click trains (<2 ms ICI = 500 pps).
Bernstein & Trahiotis (2002) - poor ITD thresholds for high-frequency transposed tones (~click trains) at AM rates above ~250 Hz (4 ms ICI).
Hafer, Dye, & Wenzel (1983) - rate-limitation for ILD.
Hafer, Dye, Wenzel, & Knecht (1990) - rate limitation affects ITD and ILD together, not independently.

Temporal weighting in sound localization
Shift to "pure onset" strategy for high-rate click trains
Saberi (1996) - ITD discrimination
Stecker & Hafer (2002) - freefield localization

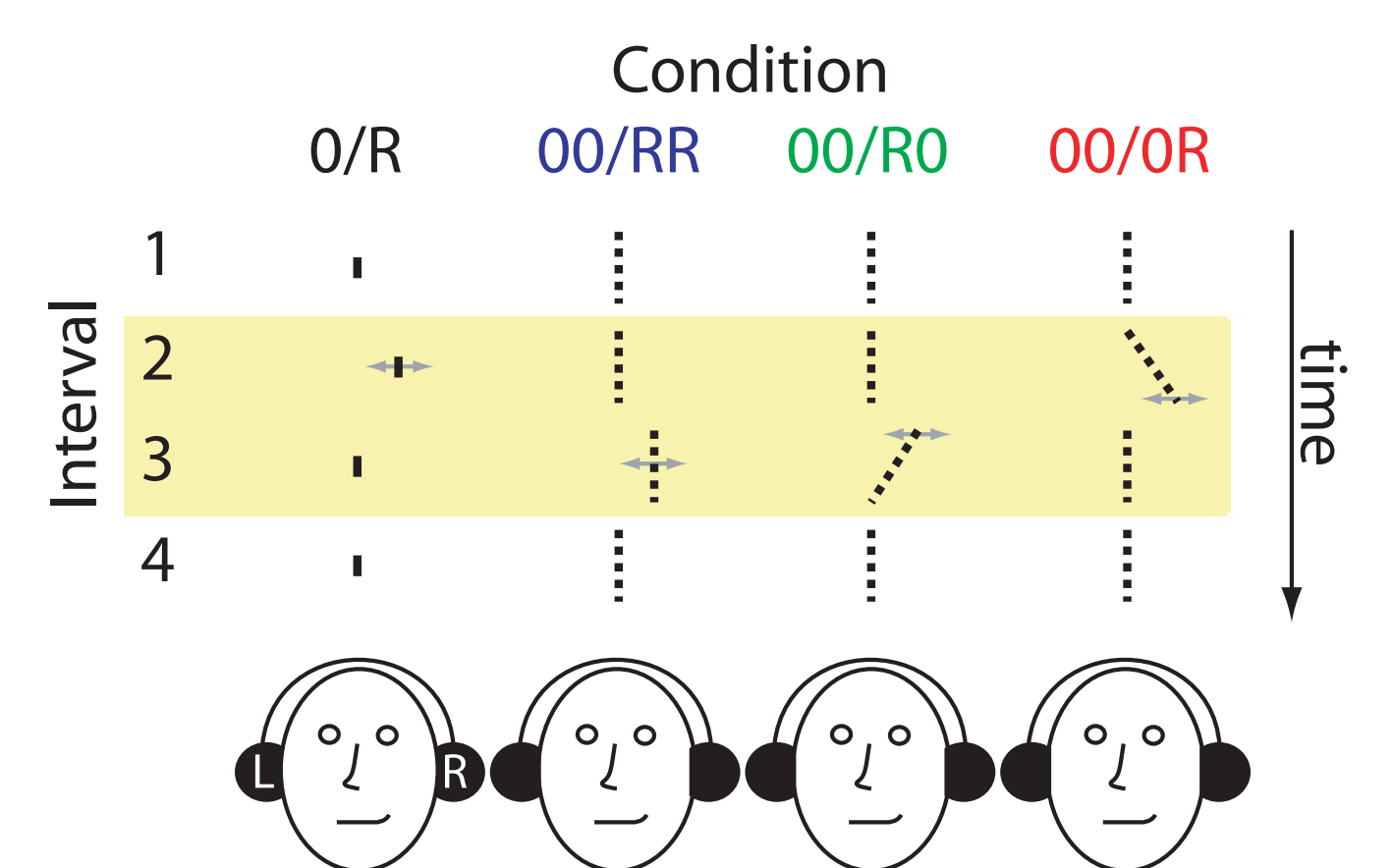


Questions

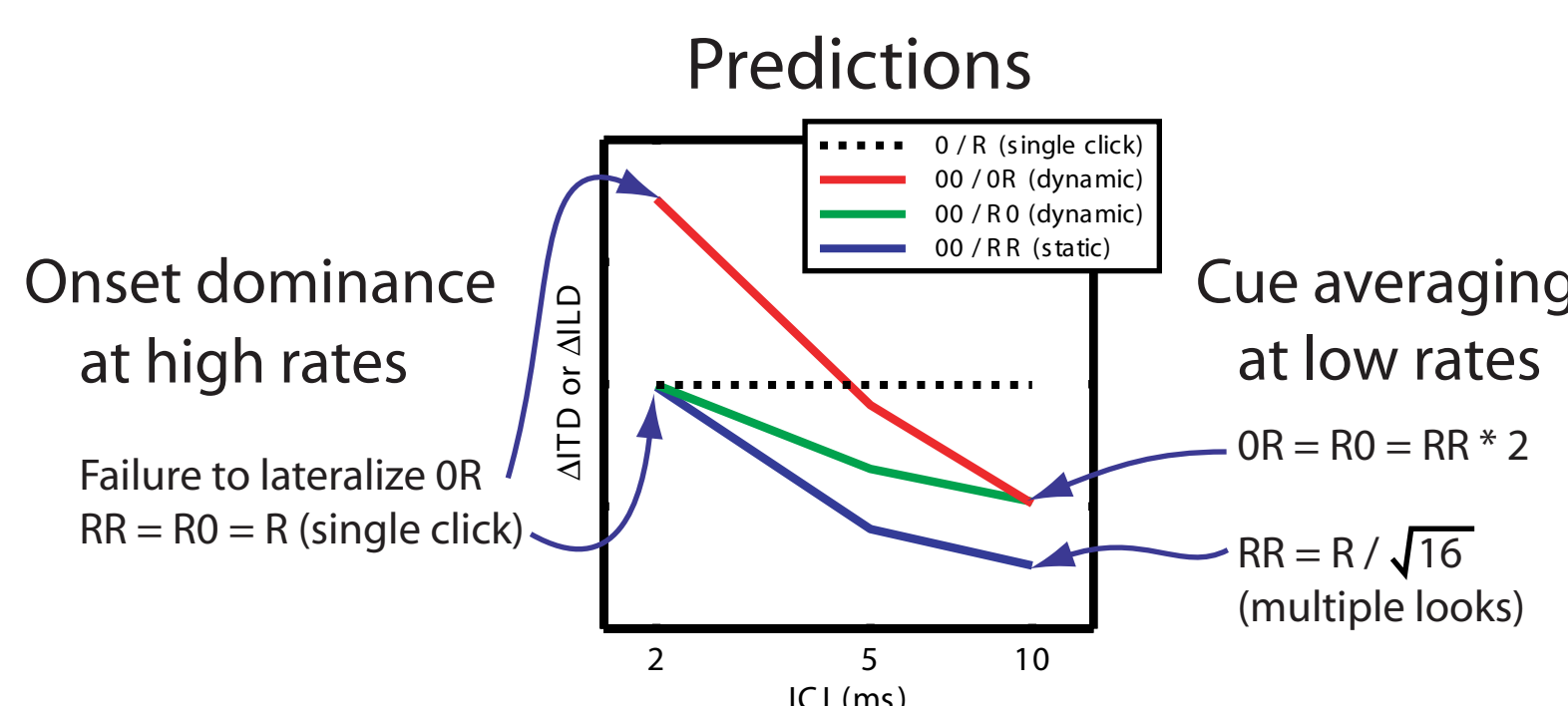
Is failure of dichotic rate discrimination in bilateral CI users due to dominance of onset?
Is dominance of onset similar for ITD- and ILD-based discrimination?

Stimuli & Task

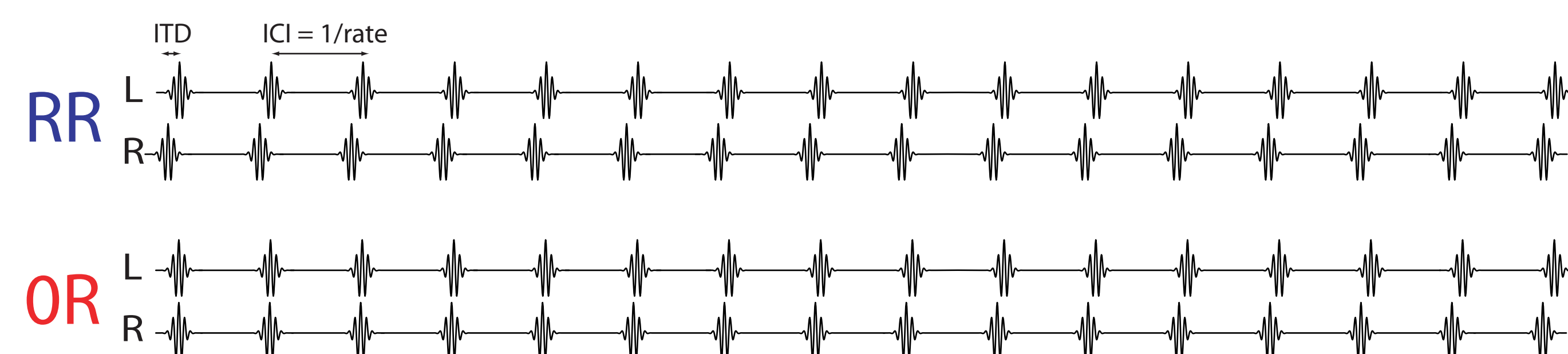
Normal-hearing listeners
Gaussian impulses ("clicks")
4 kHz carrier frequency
2ms nominal duration (BW ~900 Hz)



Single dichotic clicks or 16-click trains
Fixed diotic (0- μ s ITD, 0 dB ILD) standard
Static right-leading target ITD or ILD (R, RR)
Dynamic right-leading target ITD or ILD increasing (OR) or decreasing (RO)
Inter-click interval (ICI) = {2, 5, 10 ms} aka pulse rate = {500, 200, 100 pps}
Stimulus level: 65dBA (single) or 71-74 dBA (trains) SPL

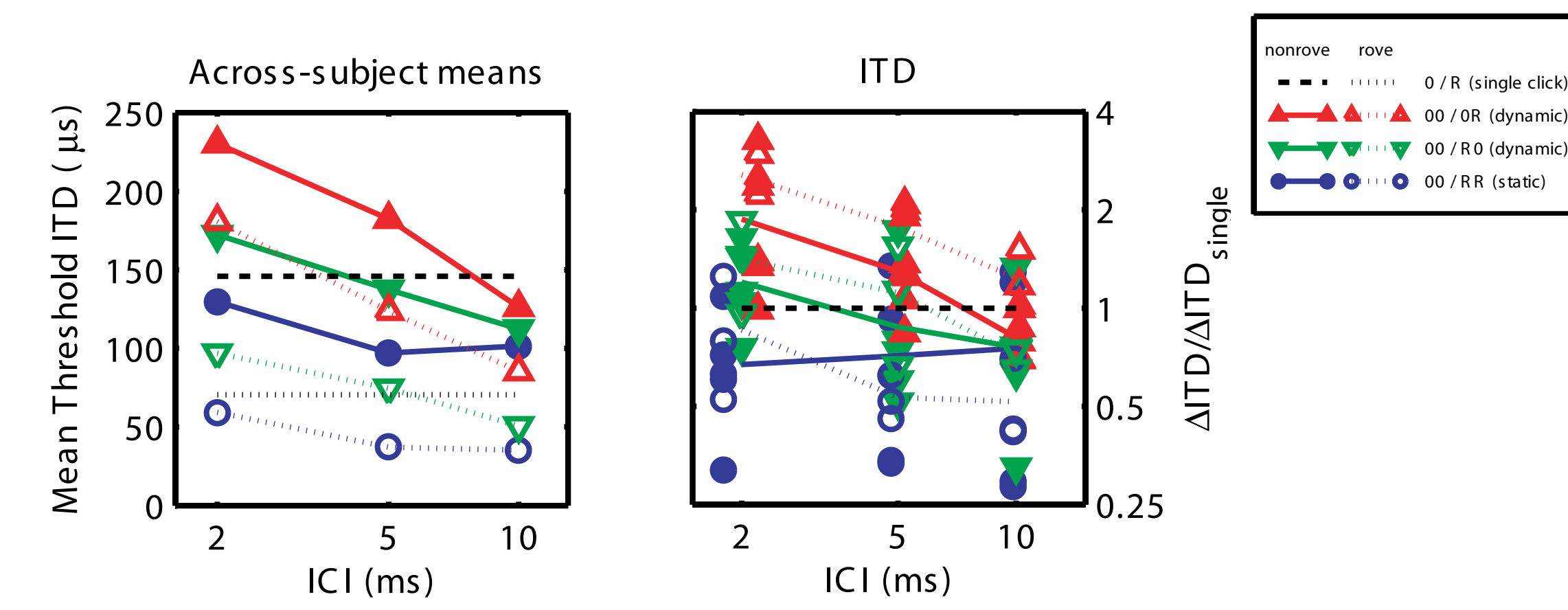


Roving conditions:
+/- 6 dB level rove
+/- 10% ICI rove
Task: 4I2AFC, target interval 2 or 3 (-XX-) 2 down / 1 up adaptive procedure

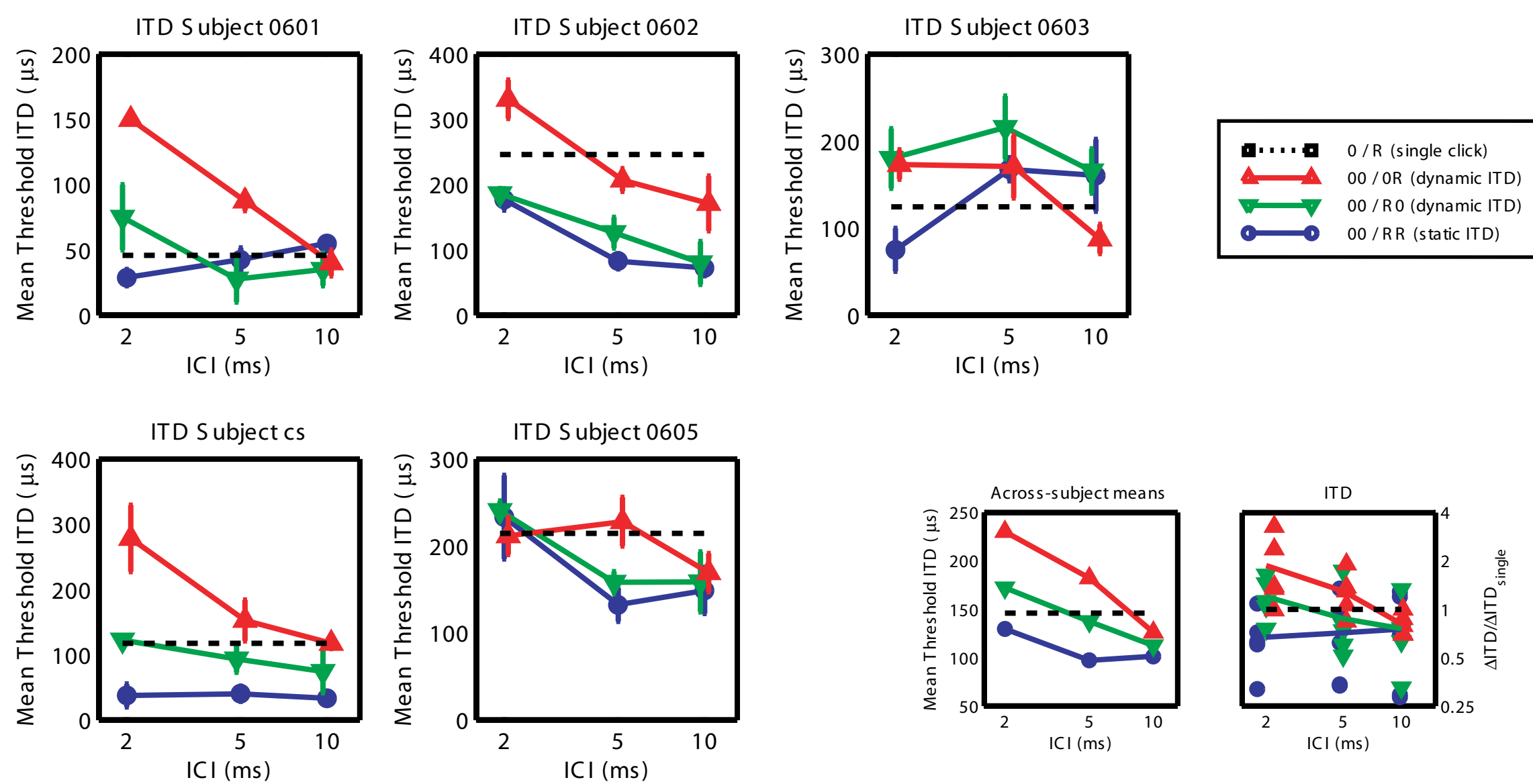


Discrimination of dynamic ITD

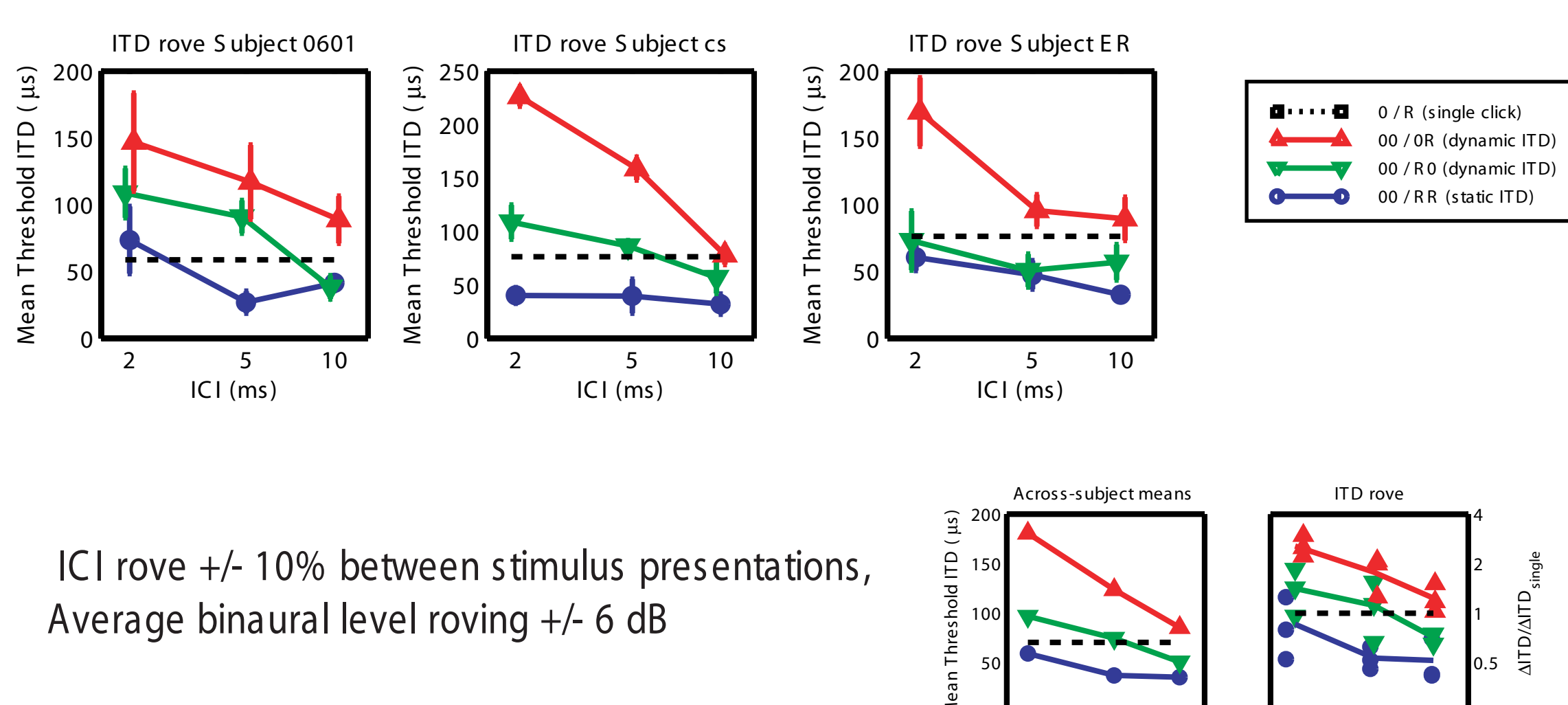
Summary



No Rove



Roving ICI, ABL



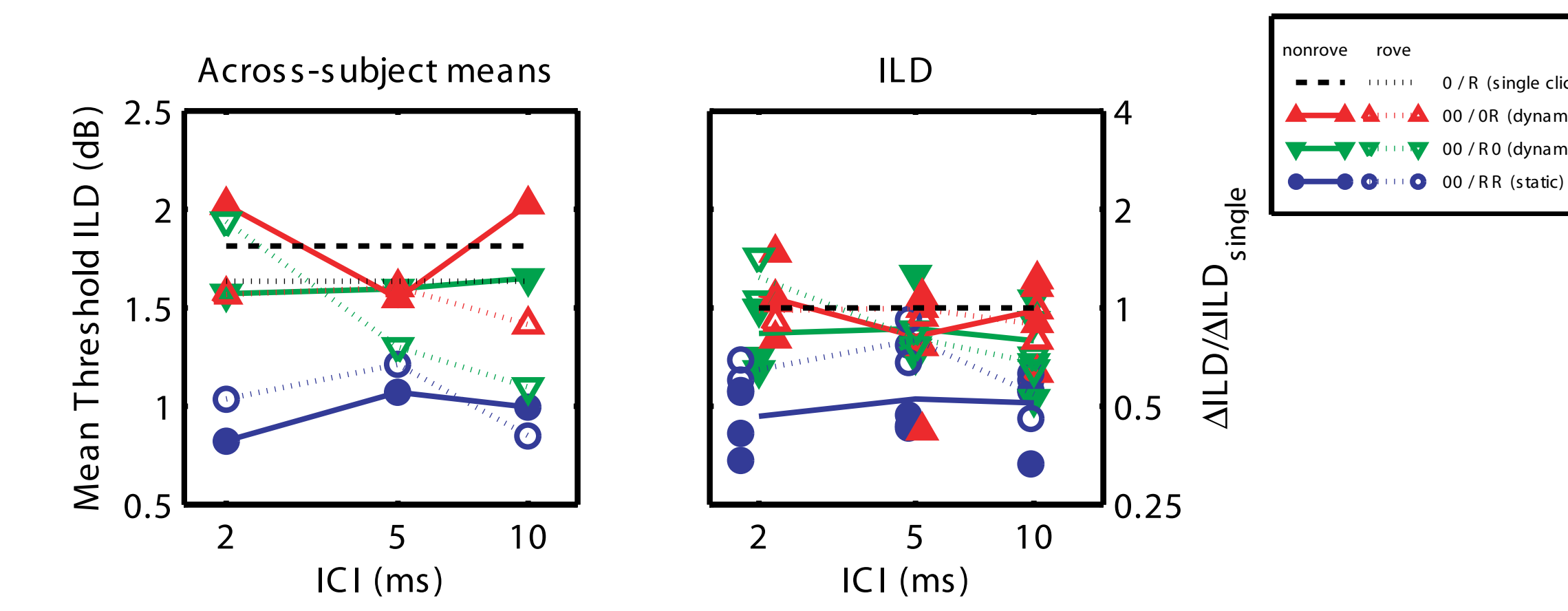
ITD thresholds were elevated for high-rate (2-ms ICI) click trains, especially in absence of onset ITD (condition OR).

High-rate stimuli with onset ITD (conditions OR and RR) produced thresholds similar to single click, although RR thresholds were lower than single clicks overall. The pattern suggests that onset-dominance is not complete even at 2 ms ICI or 500 pps.

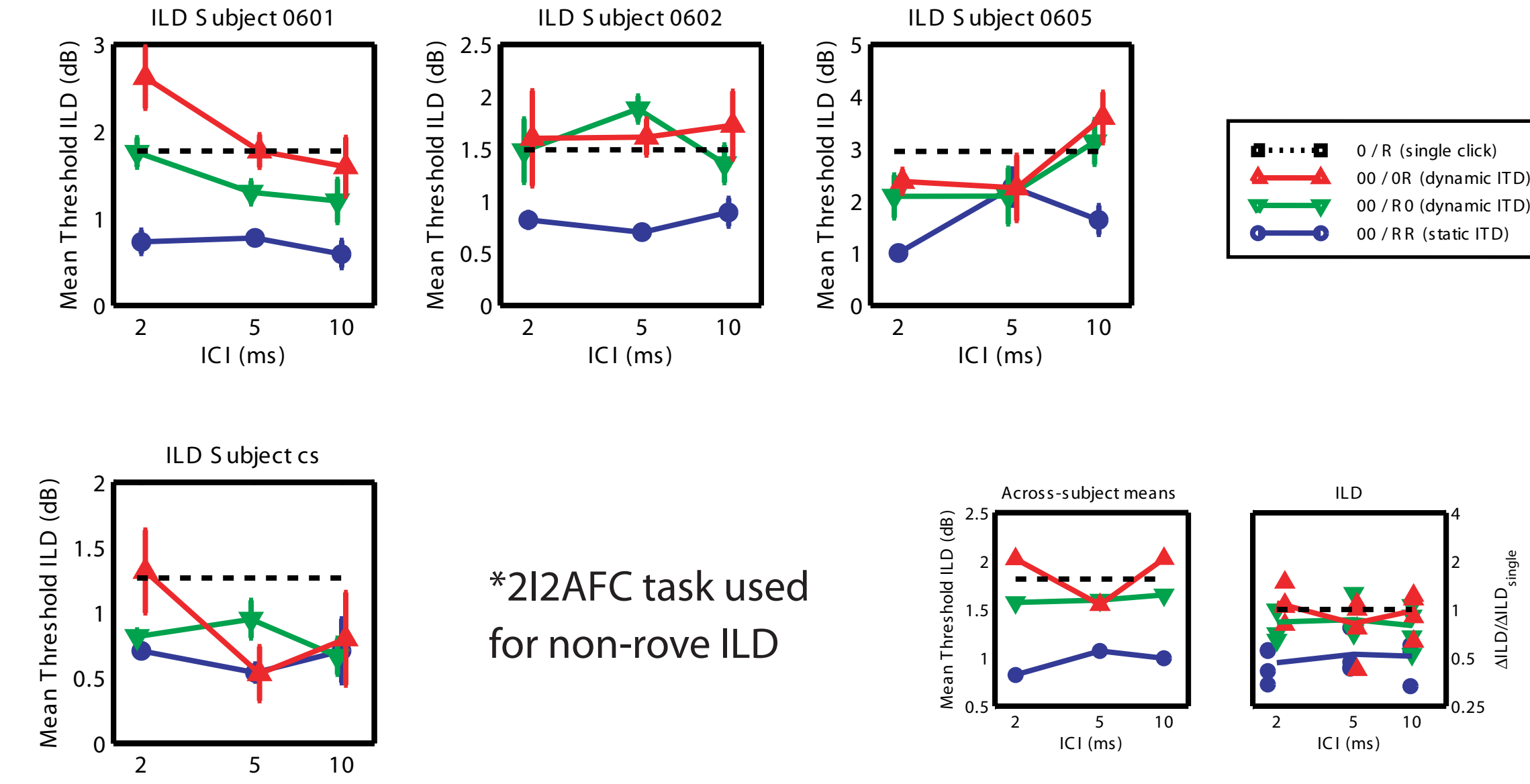
Thresholds for low-rate stimuli (10 ms) generally improved relative to high rates. However, with few exceptions, R0 and OR thresholds failed to converge as predicted by averaging of multiple looks.

Discrimination of dynamic ILD

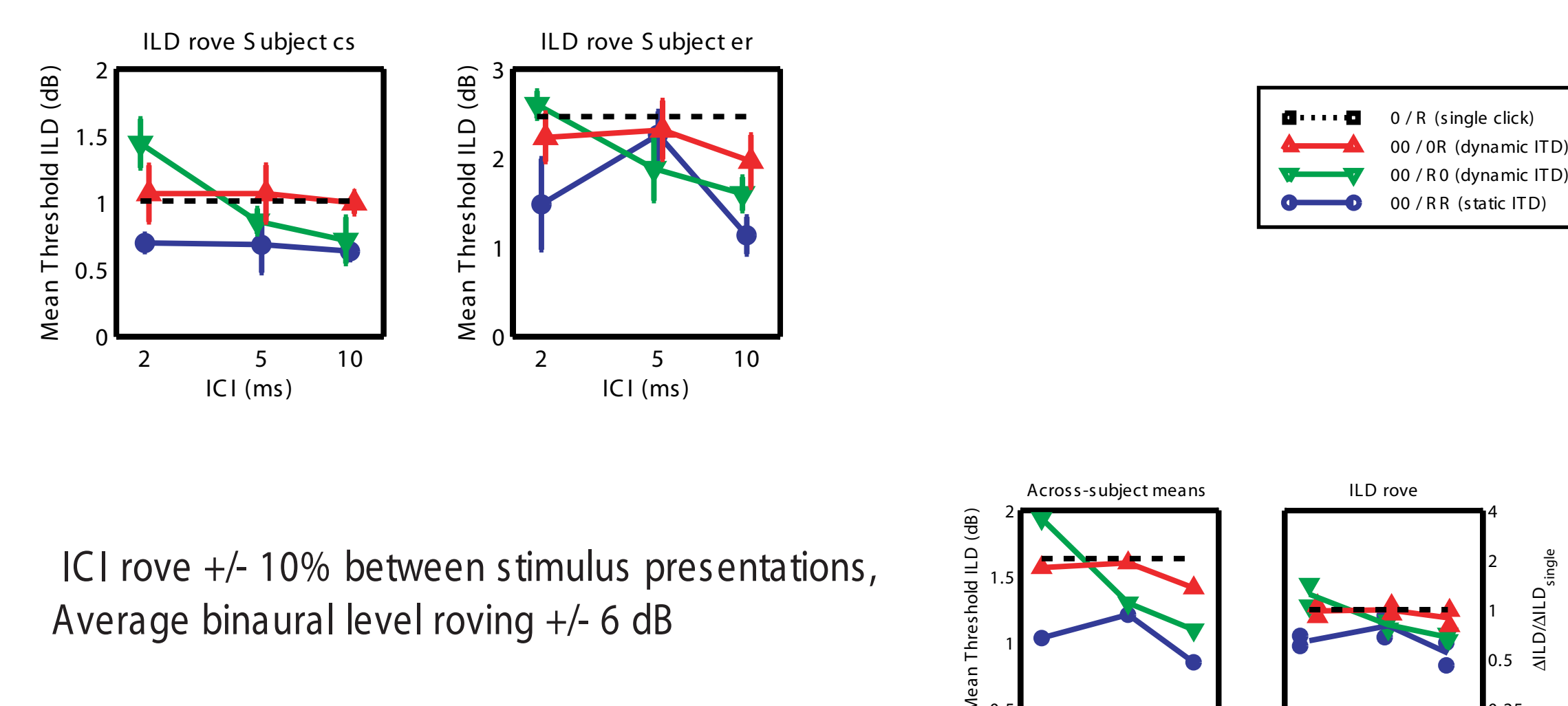
Summary



No Rove



Roving ICI, ABL



ILD thresholds were not elevated for high-rate (2-ms ICI) click trains lacking onset ILD (one exception).

Dynamic-ILD stimuli (R0, OR) thresholds were similar to single click regardless of ICI.

RR thresholds were lower than single click thresholds overall.

Little or no systematic change in ILD threshold with click rate (but possible trend for R0).

Discussion

Onset dominance for ITD at high rate?
+ ITD thresholds were especially elevated without onset cues (condition OR)
+ R0 thresholds were similar to single click
- RR thresholds lower than single click (onset dominance was incomplete)

Averaging of ongoing ITD at low rates?
+ Thresholds improved with ICI
- R0, OR thresholds failed to converge in some listeners (due to late-arriving sound?)

Onset dominance for ILD at high rate?
- ILD thresholds were not elevated by lack of onset cues (condition OR)
+ R0 thresholds were similar to single click (but so were OR thresholds)
- RR thresholds lower than single click, did not vary with ICI

Averaging of ongoing ILD at low rates?
- Thresholds mainly did not depend on ICI
? R0 thresholds improved with ICI for some listeners. Why?

More questions

What about very high rates (several thousand pps) that may be used in clinical CI devices?
What role do late-arriving cues (Stecker & Hafer 2002) play in lateralization with ITD, ILD?
What about stimuli with combined ITD and ILD cues in consonance or dissonance?

Acknowledgments

The author thanks Shiboney Dumo, Andrew Brown, and Erin Reddish for assistance running this study and interpreting its results. Also, Richard van Hoesel, whose inquiry initially stimulated this research, Julie Bierer and Katie Faulkner provided helpful discussion regarding studies related to performance with binaural cochlear implants. Supported by the University of Washington and NSF SGER IOB-0630338.

References

Bernstein LR & Trahiotis C (2002). Enhancing sensitivity to interaural delays at high frequencies using "transposed stimuli." *JASA* **112**:1026-1036.
Hafer ER & Dye RHJ (1983). Detection of interaural differences of time in trains of high-frequency clicks as a function of interclick interval and number. *JASA* **72**:644-651.
Hafer ER, Dye RHJ, & Wenzel E (1983). Detection of interaural differences of intensity in trains of high-frequency clicks as a function of interclick interval and number. *JASA* **73**:1708-1713.
Hafer ER, Dye RHJ, Wenzel E, & Knecht K (1990). The combination of interaural time and intensity in the lateralization of high-frequency complex signals. *JASA* **87**:1702-1708.
Saberi K (1996). Observer weighting of interaural delays in filtered impulses. *Percept. Psychophys.* **58**:1037-1046.
Stecker GC & Hafer ER (2002). Temporal weighting in sound localization. *JASA* **112**:1046-1057.
van Hoesel RJM & Clark GM (1997). Psychophysical studies with two binaural cochlear implant subjects. *JASA* **102**:495-507.

e-mail: cstecker@u.washington.edu