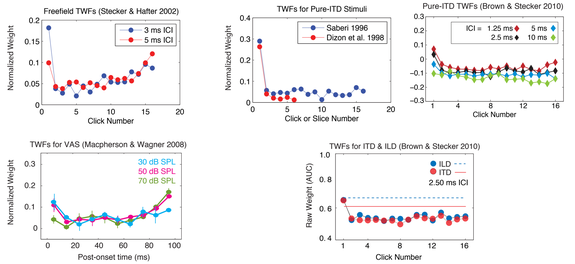
Temporal weighting functions for lateralization by interaural time and level differences

G. Christopher Stecker, Jennifer D. Ostreicher, Andrew D. Brown, and Julie M. S. Stecker

Dept. of Speech and Hearing Sciences, University of Washington

Background: Temporal weighting functions (TWFs) in sound localization



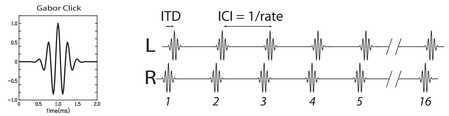
-Onset dominance at short ICI
-Upweighting of late sound (Stecker & Hafter 2009)
  -only for localization (open loop)? multiple cues?
-Greater contribution of ongoing ILD than ITD in discrimination (Brown & Stecker 2010, van Hoesel 2008)
-Temporal irregularity enhances ongoing cues (Brown & Stecker 2011)

Current study: measure TWFs for individual cues (ITD, ILD) with open-loop (lateralization) tasks.

Methods

Stimuli:

Trains of 16 Gabor clicks (cos*Gaussian)
-4 kHz carrier frequency, click duration 221 μs/σ (-3 dB BW 1.25 kHz)
-Inter-click interval (ICI) of 2, 5, or 10 ms
-"Base" ITD and/or ILD varies across trials
  (+/- 100, 300, 500 μs; +/- 1, 3, 5 dB)
-Per-click variation of ITD and/or ILD: uniform distribution
  (+/-100 μs ITD, +/- 2 dB ILD) about the base value



Subjects

-13 normal hearing listeners (including 2nd & 4th authors)
-8-9 subjects per condition

Conditions:

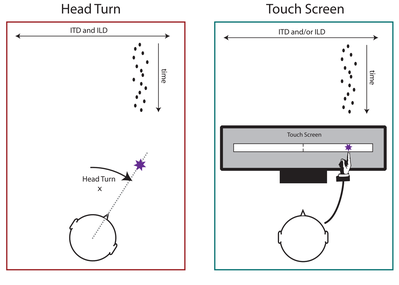
1) ITD and ILD in "agreement" for each click ← head turn

2) ITD and ILD in "agreement"
3) Pure ITD
4) Pure ILD
5) Independent ITD and ILD. (Base values in agreement)

} touch screen

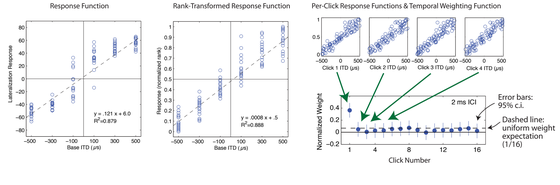
Tasks:

Single-interval open-loop lateralization
-Head position monitored during both stimulus and response
-(Method 1) Lateral-position scaling with head turn
-(Method 2) Lateral-position scaling with touch-sensitive display
-90 trials/run , 8 runs/condition (720 trials/condition/ICI/subject)



Analysis

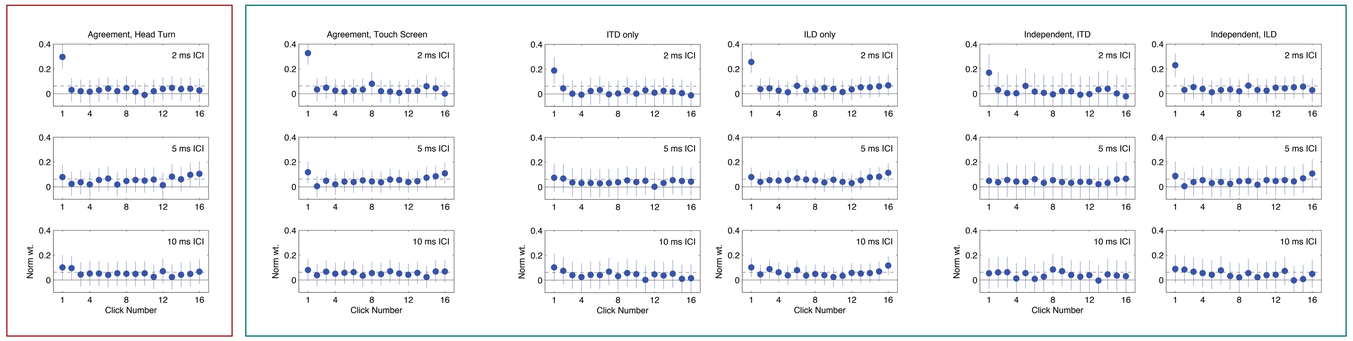
-Responses normalized via rank transform per run
-Temporal weighting functions (TWF)
-Multiple linear regression of response rank *x* onto click ITD/ILD
  $x = \Sigma(w_i \theta_i) + \varepsilon$, where θ_i = ITD or ILD of *i*th click, and $\Sigma w_i = 1$
-Summary measure: Average Ratio (Saberi 1996; Stecker & Hafter 2009)
  $AR_{on} = w_1 / \text{mean}(w_2 ... w_{n-1})$ $AR_{off} = w_n / \text{mean}(w_2 ... w_{n-1})$



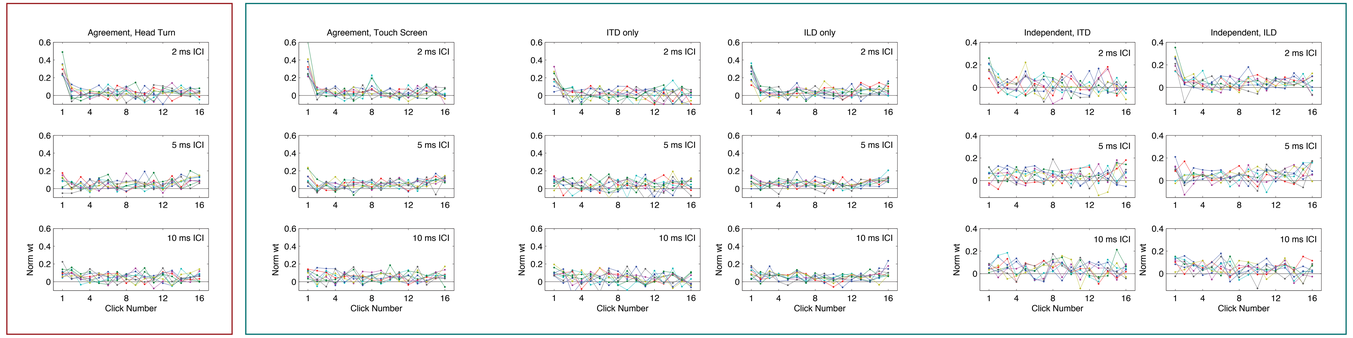
Contact: cstecker@uw.edu http://faculty.washington.edu/cstecker

Results and Discussion

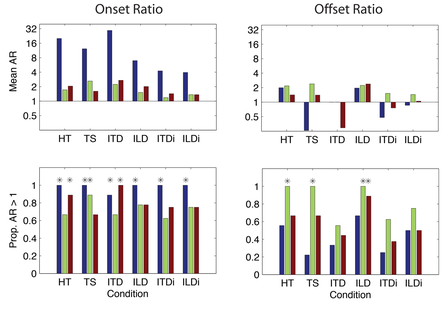
1. Subject-averaged TWFs



2. Individual data



3. Summary measures of onset dominance, upweighting



4. Summary

-Onset dominance at short ICI across conditions
-Modest upweighting, strongest at 5ms ICI
  Primarily conditions including ILD as a cue
-No difference between head turn and touch screen tasks

5. Conclusions

-Upweighting affects mainly open-loop tasks
  Role of sensory memory?
  Other conditions requiring temporal integration?
-Greater upweighting for ILD than ITD
  Different integration mechanism (time constant)?
  Different contribution to lateralization vs discrimination?

Acknowledgments

Anna Mamiya, Jackie Bibee, and Leah Anderson assisted with data collection.
Work supported by the University of Washington and NIDCD: R03-DC009482 (GCS), F31-DC010543 (ADB).

References

Akeroyd MA & Bernstein LR (2001). *J. Acoust. Soc. Am.* **110**:2516-2526.
Bernstein C & Trahiotis LR (2002). *J. Acoust. Soc. Am.* **112**:1026-1036.
Brown AD & Stecker GC (2010). *J. Acoust. Soc. Am.* **128**:332-341.
Brown AD & Stecker GC (2011). *J. Acoust. Soc. Am.* **129**:293-.
Dizon RM, Culling JF, Litovsky RY, Shinn-Cunningham BG, & Colburn HS (1998). *Assoc Res. Otolaryngol. Abs.* **21**:42.
Macpherson EA & Wagner ML (2008). *Assoc Res. Otolaryngol. Abs.* **31**:882.
Saberi K (1996). *Percept. Psychophys.* **38**:1037-1046.
Stecker GC & Brown AD (2010). *J. Acoust. Soc. Am.* **127**:3092-3103.
Stecker GC & Hafter ER (2002). *J. Acoust. Soc. Am.* **112**:1046-1057.
Stecker GC & Hafter ER (2009). *J. Acoust. Soc. Am.* **125**:3914-3924.
van Hoesel RJM (2008). *J. Acoust. Soc. Am.* **124**:3861-3872.
Zurek PM (1980). *J. Acoust. Soc. Am.* **67**:952-964.