Temporal weighting of interaural time differences in low frequency noise presented at low signal-to-noise ratio

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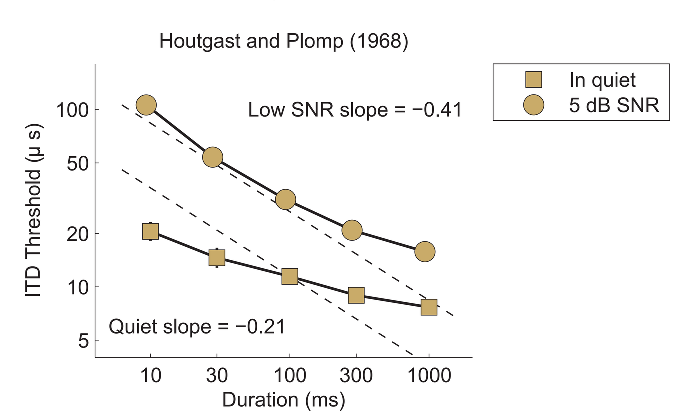
Background

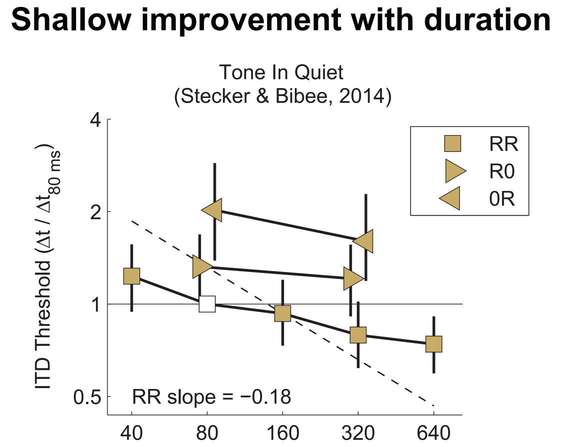
ITD discrimination thresholds improve with increased duration, but suboptimally for 500 Hz noise bands (Houtgast & Plomp 1968), high-frequency click trains (Hafter & Dye 1983), and 500 Hz pure tones (Stecker & Bibee 2014) suggests that *cues at sound onset dominate ITD processing.*

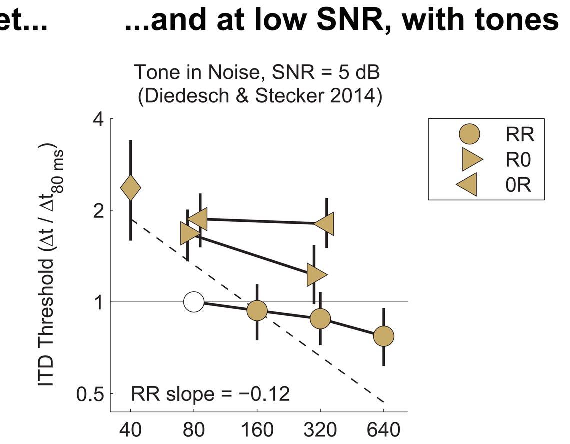
Presence of continuous masking noise (5 dB SNR) altered this pattern to reveal optimal threshold-duration slopes for noise-band targets (Houtgast & Plomp 1968) but not for pure-tone targets (Diedesch & Stecker 2014). Optimal slopes would suggest *strong ongoing ITD cues at low SNR.*

In this study, we investigated presented noise-band targets to determine if target (tones vs noise) or masker type (diotic vs. noise -400us) had an effect on threshold-duration slopes. Conditions with time-varying ITD were also tested to explicitly *asses the role of cues occuring early or late in the sound* (Stecker and Brown 2010; Stecker & Bibee 2014).



Shallow improvement with duration in quiet... **...and at low SNR, with tones**





Guide to figures: All data figures plot ITD threshold values in μs or geometric means of thresholds normalized to each subject's threshold at 80 ms duration (condition RR). Symbols plot thresholds for various stimulus configurations, and error bars indicate two-level bootstrapped 95% confidence intervals. Dashed lines represent threshold expectations based on optimal integration of ITD across duration (a slope of $1/\sqrt{T}$, or -0.5 on these log-log plots). Slope estimates indicated on each figure obtained by linear regression across durations.

Methods

Task:

- **2 interval, 2 alternative forced choice (2I2AFC)**
- **Target in either the 1st or 2nd interval**
- **Right leading ITD**
- **Headphones used to measure lateralization thresholds**
- **2 down, 1 up Levitt tracker**

Target Stimulus:

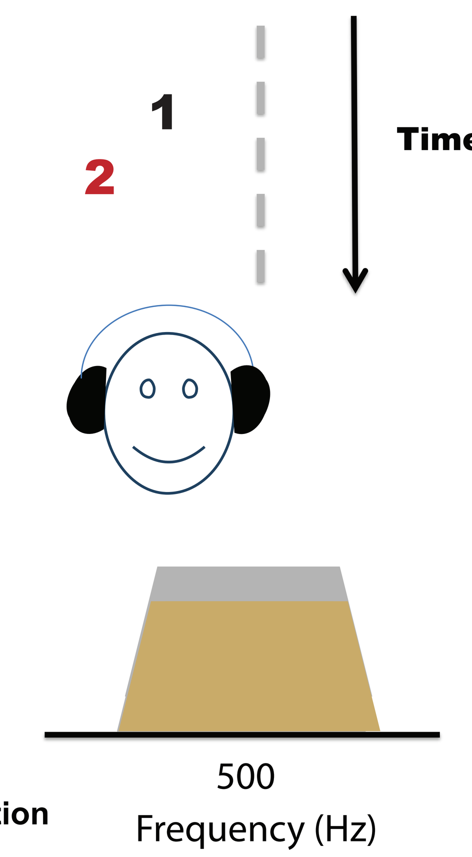
- **Frequency:** **500 Hz octave band noise**
- **Intensity:** **60 dB SPL**
- **Duration:** **40 – 640 msec (RR)**
  80 & 320 msec (R0 & 0R)
- **Ramp:** **20 msec, diotic**
- **Freq. Rove:** **± 10%**
- **Int. Rove:** **± 5dB (noise in quiet)**

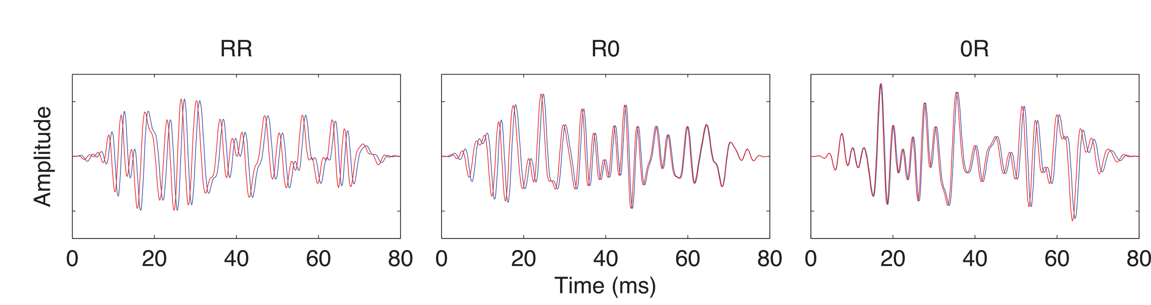
Masker:

- **Frequency:** **500 Hz**
- **Bandwidth:** **Octave**
- **Intensity:** **55 dB SPL (5 dB SNR)**
- **Duration:** **Absent or Continuous**
- **Type:** **400us left ITD, or diotic**

Target ITD Configurations:

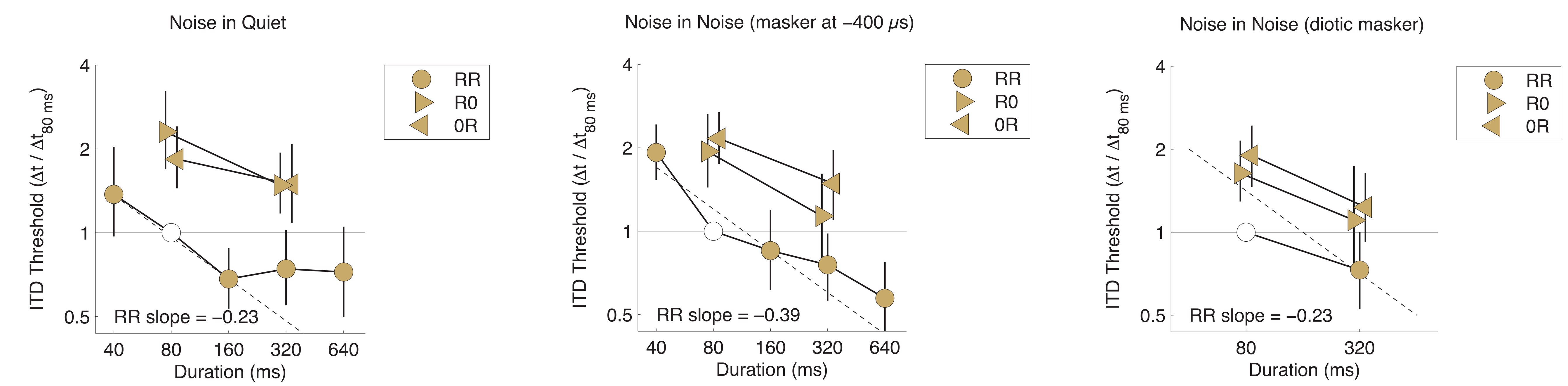
1. **"RR" - Constant ITD throughout the duration**
2. **"R0" - No offset ITD**
3. **"0R" - No onset ITD**



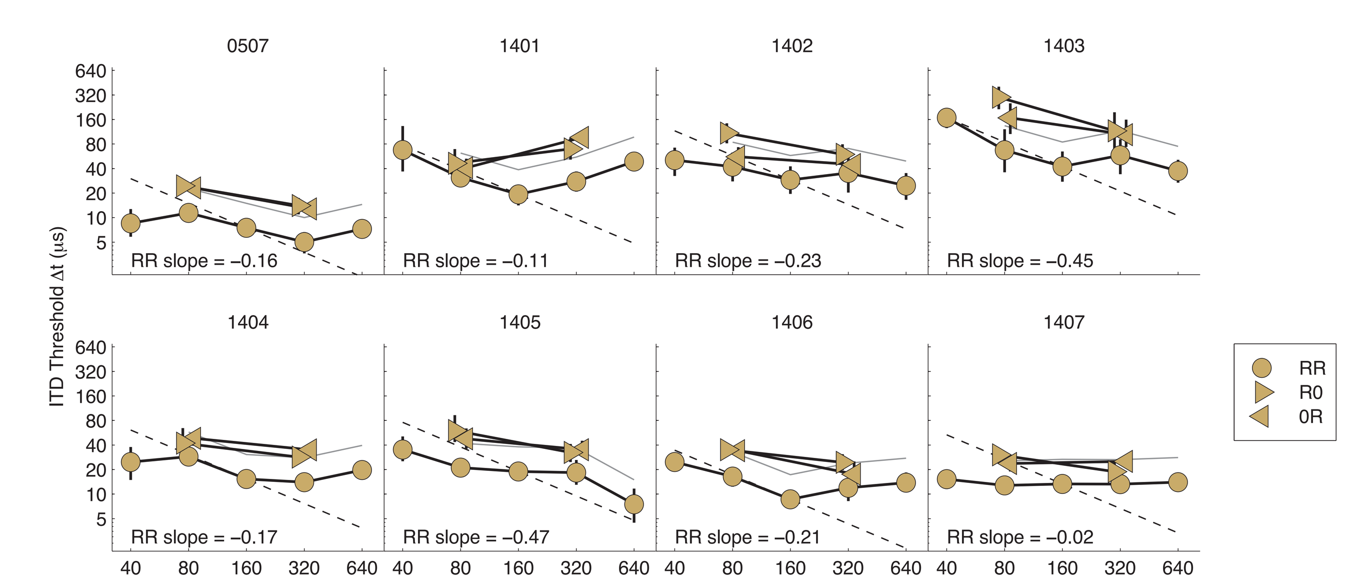


Results

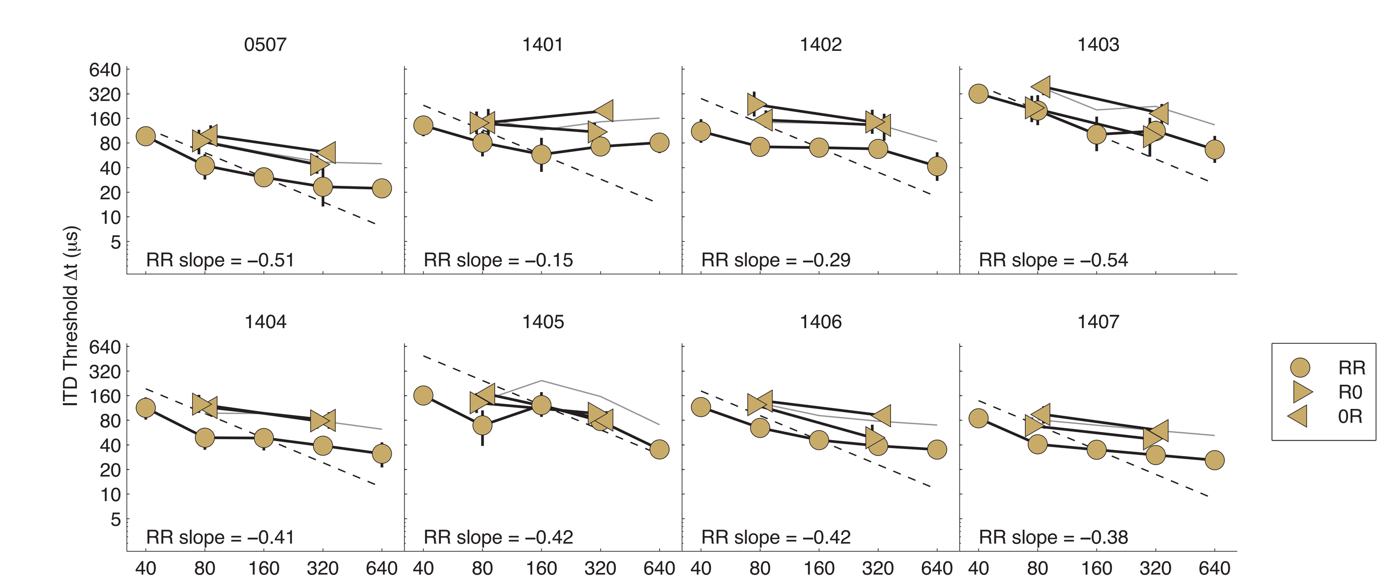
Suboptimal improvement with duration in quiet (?)... **...and nearly optimal at low SNR**



Individual data in quiet



Individual data with continuous masker at -400us



Summary & Discussion

Noise targets produced steeper (near optimal) ITD threshold-duration slopes than tonal targets, especially at low SNR. Result is roughly consistent with Houtgast & Plomp (1968) and suggests *greater influence of ongoing ITD in noise targets.*

For noise targets, dynamic-ITD thresholds did not strongly differ between R0 and 0R, and improved with duration. Further onsistent with *greater influence of ongoing ITD in noise targets* compared to tonal targets.

Nonlinear threshold-duration functions - steeper slopes at short (40-160ms) versus long durations (160-640 ms) suggest temporal limits of windowed integration (Buell & Hafter 1988) and/or floor effects on ITD thresholds.

Acknowledgements

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