Measuring sensitivity to envelope interaural time differences by adapting modulation depth

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BACKGROUND

Listeners are sensitive to interaural time differences carried in the envelope of high-frequency sounds (ITD_{ENV}), but the salience of this cue depends on the envelope properties [1]. For example, ITD_{ENV} varies systematically with the depth of modulation of sinusoidally amplitude-modulated (SAM) tones [2,3].

Listeners with sensorineural hearing loss show enhanced sensitivity to amplitude modulation under certain conditions [4-7], often attributed to loss of cochlear compression. Here we tested the hypothesis that this translates into superior ITD_{ENV} sensitivity under similar conditions.

We implemented a task in which modulation depth is varied adaptively to measure ITD_{ENV} sensitivity. This task provides a convenient means for comparing ITD_{ENV} sensitivity across listeners using a large (suprathreshold) value of ITD.

METHODS

Stimuli

The target was a 4-kHz SAM tone, modulated at 32/64/128 Hz, with a fixed ITD of 500 µs. It was presented with an interaurally uncorrelated 1300-Hz low-pass masking noise. Target sensation level was set individually to 30 dB. A subset of NH listeners repeated the experiment at sensation levels of 50 and 70 dB.

Tasks

1) Absolute detection thresholds: two-interval forced choice task, two-down one-up adaptive track.
2) AM detection thresholds: two-interval forced choice task, two-down one-up adaptive track.
3) ITD training: single-interval left-right task with diotic reference, full modulation depth, max 5 blocks of 20 trials.
4) ITD thresholds: single-interval left-right task with diotic reference, two-down one-up adaptive track.

Participants

10 listeners with normal hearing (NH; 18-44 years) and 10 listeners with bilateral, symmetric, sensorineural hearing impairment (HI; 19-60 years).

4 NH and 2 HI did not pass ITD training and thus ITD thresholds could not be obtained.

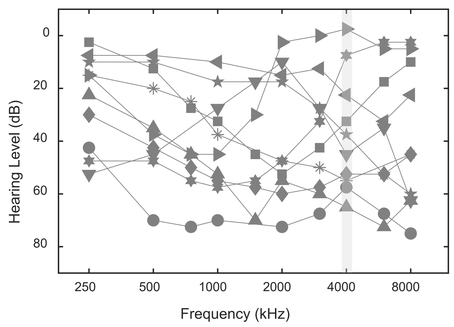


Figure 1. Individual HI audiograms (across-ear average).

RESULTS: NH AND HI AT EQUAL SENSATION LEVEL

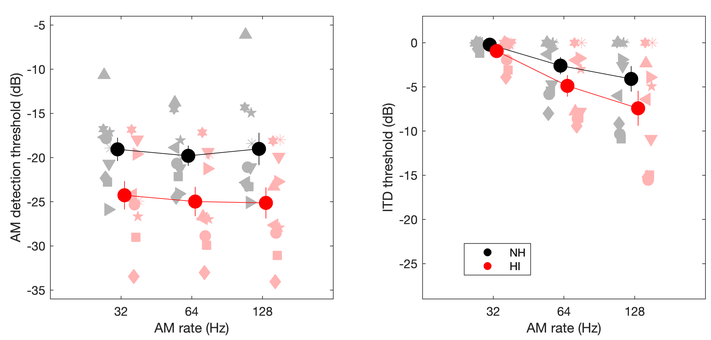
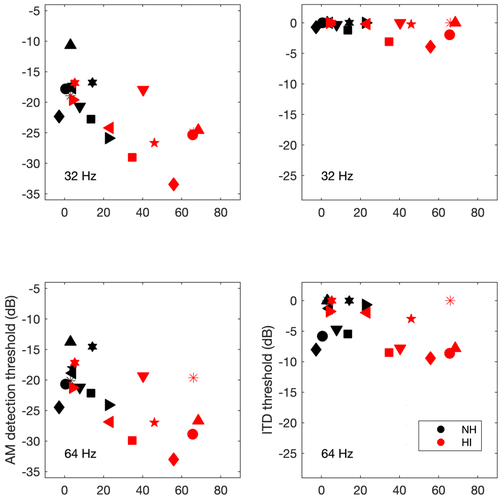


Figure 2. AM detection thresholds (left) and ITD thresholds (right). Shown are individual NH (black) and HI (red) participants and group means. Values at 0 dB represent unmeasurable thresholds. Error bars here and elsewhere are standard errors of the mean.

Figure 3. Normalized ITD thresholds as a function of normalized AM detection thresholds for each AM rate. Shown are individual NH (black) and HI (red) participants and group means.



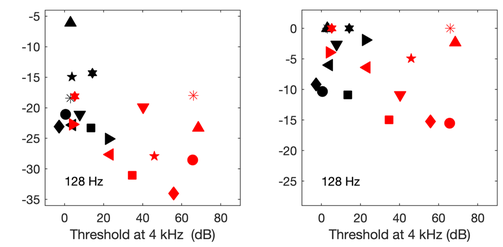


Figure 4. AM detection thresholds (left) and ITD thresholds (right) as a function of absolute detection thresholds for different AM rates (rows). Shown are individual NH (black) and HI (red) participants.

RESULTS: NH LEVEL EFFECTS

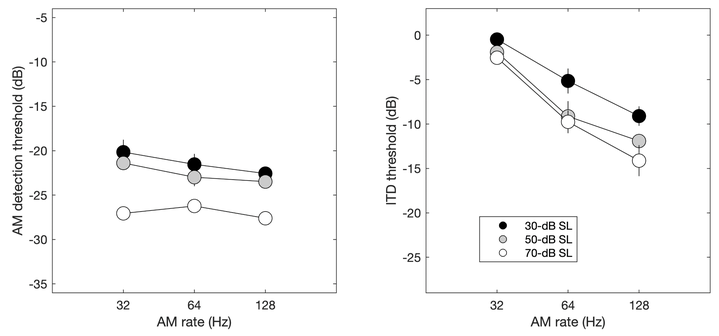


Figure 5. AM detection thresholds (left) and ITD thresholds (right) for a subset of NH listeners (n=4) at 3 different levels.

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