

A Physiologically-Based Model of ITD Discrimination in Bilateral Cochlear Implant Subjects

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Principal cells of the medial superior olive are sensitive to the relative arrival times of inputs originating at each ear, and hence encode interaural time differences (ITDs). The net internal interaural delay determines the best ITD (BD) of each neuron, and consists of mechanical and neural components. The mechanical component is the net cochlear traveling wave delay resulting from mismatches in characteristic frequency between the ears. The neural component comprises axonal propagation delays and the influence of inhibitory synapses.

Mean BD decreases with increasing best frequency (BF), such that the rising slopes of neural rate-ITD curves tend to occur on the midline. As a consequence, ITD acuity is finest on the midline and systematically worsens as reference ITD increases (moves away from the midline). It is uncertain to what extent mechanical and neural delays each contribute to this system of organization. Bilateral cochlear implants bypass the mechanical delays and thus provide insight to the relative importance of the neural component.

ITD acuity was measured as a function of ITD in a bilaterally-implanted human subject using low-rate pulse trains and a two-alternative forced choice procedure. Just noticeable differences in ITD increased with reference ITD in a similar manner to the normal hearing condition. To account for these data quantitatively, a model of ITD discrimination was derived from published physiological recordings of ITD-sensitive neurons in inferior colliculus of bilaterally-implanted cats. The model predicts the data only if the rising slopes of the rate-ITD curves tend to occur on the midline irrespective of rate-ITD curve halfwidth. Together, the results show that normal ITD coding is at least partially the result of systematic biases in the neural delay component, and emphasize that alignment of rate-ITD slopes on the midline is a fundamental feature of the ITD code.

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