

## The neural representation of an auditory spatial cue adapts to stimulus statistics

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Recently it has been shown that neurons in the auditory midbrain nucleus of the inferior colliculus (IC) can quickly adapt to local stimulus statistics so as to improve the neural representation of the most commonly-presented sound intensities [1]. The neural mechanisms behind this effect could arise at multiple levels of the auditory pathway, from the periphery to the IC. Here, we demonstrate that a similar adaptive phenomenon also occurs in the coding of the interaural (between ears) time difference (ITD) in the IC, suggesting that it may be a more general phenomenon. ITD is a major cue for sound localization, and is first represented by the neurons of the medial superior olive (MSO), where the information from the two ears is brought together. MSO neurons directly excite ipsilateral IC neurons and are three synapses downstream of the sensory hair cells of the cochlea. Thus for ITD coding, this adaptive phenomenon must originate entirely in non-peripheral neurons.

To examine the effect of stimulus statistics on IC neuron responses, we presented a ~7 min continuous binaural broadband noise to anaesthetized guinea pigs whilst recording extracellularly from single IC neurons. The ITD of the noise was randomly selected every 50 ms from a probability distribution that spanned the range of ITDs that can naturally occur for the guinea pig head size ( $\pm 325 \mu\text{s}$ ) and had a 130  $\mu\text{s}$  wide high-probability region from which ITDs were chosen 80% of the time. The ITDs of each noise stimulus were divided into 100 equal bins, and rate-ITD functions were constructed from the mean spike rate over all the 50ms instances in each ITD bin. Figure 1a shows the rate-ITD functions (smoothed with a 3-point average) of a typical IC neuron, for noise stimuli with different high probability regions denoted by the colored bars on the abscissa. Figure 1b shows the corresponding Fisher information, a measure of accuracy of representation, for each rate-ITD function. Observe that the peak Fisher information (over the rate-ITD function slope) moves with the high probability region when that region lies in the range of ITDs that lead at the ipsilateral ear (negative ITDs). Figure 2 shows the population Fisher information curve for each position of the high probability region. This was constructed as the sum of the Fisher information of all neurons ( $n=10$ ), with the added assumption, from brainstem symmetry, that each neuron has a partner whose attributes were identical but reflected about 0 ITD. We can see that the neural population appears to adapt to stimulus statistics so as to crudely move its region of highest coding accuracy (its peak population Fisher information) towards the most probable ITDs.

### References

[1] Neural population coding of sound level adapts to stimulus statistics. I. Dean, N. S. Harper, and D. McAlpine. *Nature Neuroscience* 4(12): 1684-1689, November 2005.

Figure 1

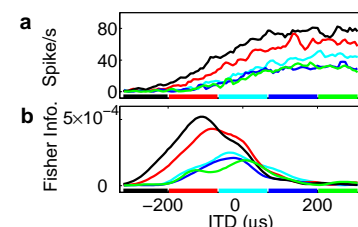


Figure 2

