HW5

1. Notches are a monoaural cue used to locate sound sources in terms of elevation. A “notch” is set apart as a significant drop in magnitude in the sound spectrum. As the source of sound becomes lower, the frequency at which the notch occurs shifts to higher frequencies. There are two types of binaural cues; ILDs and ITDs. ILD, or interaural level difference, relies on your head absorbing some of the energy from sound waves, resulting in one ear receiving a sound wave with less magnitude. Because lower frequencies travel well through solid objects, this is more effective to differentiate sources of higher frequencies. The second type of binaural cue is the ITD, or interaural time difference. This examines the difference in times in which each ear receives a sound wave. Lower frequency sounds have a longer wavelength, which means that they’re easier to identify via ITD than ILD. For short, abrupt stimuli, the ITD can rely on comparing onset times for the sound waves. However, for continuing stimuli, the ITD would have to rely on the IPD, or interaural phase difference. This examines the difference in waveforms received by the ears. At extremely high frequencies, the periods of the wavelengths are too small to reliably differentiate, and IPD isn’t as useful anymore.

2. Both ILD and ITD functions best when the sound source is perfectly to one side. By maximizing the distance between ears, we ensure the most amount of energy lost (for ILD), as well as the most amount of difference in time (for ITD).

3. As mentioned before, ILD is optimal for higher frequencies, as they lose more energy when traveling through the human head, while ITD is more optimal for lower frequencies. This is because at lower frequencies, IPD is more pronounced. Thompson and Rayleigh first proposed this, with Rayleigh later proposing the duplex theory of sound localization.

4. Jeffress’ delay line model dictates that there is an internal map for the azimuth plane. This map is composed of a line of neurons, with each corresponding to a discrete angle in the azimuth plane. Signals are routed to this line from both ears. In the middle of the line, which is equidistant from both ears, signals should take roughly the same amount of time to reach the corresponding neuron. As we go down the line, either towards the left or right of the organism, the difference in time signals take to travel increases. In birds, the amount of BITDs (the ITD that results in maximum spiking) lie within the physiological range of ITDs, which is consistent with what the Jeffress’ model requires. However, this is not true in mammalian species, which suggests it is unlikely that we employ such a system.

5. IPD is interaural phase difference, which relies on calculating how “in phase” or “out of phase” the two sound signatures received by the ears are. ITD relies on the time difference in initial onset of the wavelengths. For ongoing, periodic stimuli, ITD actually relies on IPD. In figure 10, the LSO neuron can be better described as IPD sensitive.

6. If a sound wave were to originate from two areas 180 degrees from each other in the azimuth plane, ITD and ILD by themselves would be unable to differentiate the two sound sources.