Demonstration 37. Binaural Lateralization (3:14)

The most important benefit we derive from binaural hearing is the sense of localization of the sound source. Although some degree of localization is possible in monaural listening, binaural listening greatly enhances our ability to sense the direction of the sound source.

Although localization also includes up-down and front-back discrimination, most attention is focussed on side-to-side discrimination or *lateralization.* When we listen with headphones, we lose front-back information, so that lateralization becomes exaggerated; the image of the source appears to switch from one side of the head to the other by moving "through the head", or the sound source appears to be "in the head."

Lord Rayleigh (1907) was one of the first to recognize the importance of time and intensity cues at low frequency and high frequency, respectively. Low-frequency sounds are lateralized mainly on the basis of interaural time difference, whereas high-frequency sounds are localized mainly on the basis of interaural intensity differences.

In the first example, tones of 500 Hz and then 2000 Hz are heard with alternating interaural phases of plus and minus 45 degrees. At 500 Hz, the image switches from side to side as the phase changes. At 2000 Hz, on the other hand, no such movement is perceived. (The interaural time difference varies from $\Delta t = \Delta\phi/2\pi f = 250$ to -250 μs in the first case, but only 62.5 to -62.5 μs at 2000 Hz).

In the second example, a 100-μs pulse (heard as a "click") is presented with an interaural time difference that cycles from 5 ms to -5 ms, so that the source of the click appears to move between left and right

The third example uses tones of 250 and 4000 Hz to illustrate the effects of interaural intensity difference at low and high frequency. The interaural intensity changes (in 1.25 s) from 32 dB to -32 dB. In both cases, the image moves from side to side. Although the auditory system processes interaural intensity cues at both low and high frequency, the head does not cast much of an acoustic shadow at low frequency (due to diffraction), and hence there is little intensity difference even when the source is located to one side of the head.

Commentary

"Tones of 500 and 2000 Hz are heard with alternating interaural phases of plus and minus 45 degrees."
"Next the interaural arrival time of a click is varied. The apparent location of the click appears to move."
"Finally, the interaural intensity differences of a 250-Hz and a 4000-Hz tone are varied."

References

- J.Blauert (1983), *Spatial Hearing* (MIT Press, Cambridge, MA).

- W.M.Hartmann (1983), "Localization of sound in rooms," J. Acoust. Soc. Am. *74*, 1380-91.

- E.R.Hafter and R.H.Dye (1983), "Detection of interaural differences of time in trains of high-frequency clicks as a function of interclick interval and number," J. Acoust. Soc. Am. *73*, 644-51.

- Lord Rayleigh (J.W.Strutt) (1907), "On our perception of sound direction," Phil. Mag. *13*, 214-32.

- H.Wallach, E.B.Newman and M.R.Rosenweig (1949), "The precedence effect in sound localization," Am. J. Psych. *62*, 315-36.