

Demonstration 7. Loudness Scaling (2:58)

Establishing a scale of subjective loudness requires careful psychoacoustical experimentation involving large numbers of subjects. A scale of *sones*, established on the basis of work by Stevens (1956) and others, has been widely used to describe subjective loudness. On this scale, the loudness in sones S is proportional to sound pressure p raised to the 0.6 power:

$$S = Cp^{0.6},$$

where C depends on the frequency. In other words, the loudness doubles for about a 10-dB increase in sound pressure level. Other investigators have found that the exponent varies with tone frequency (generally increasing at low frequency and low level) and spectral content. Some investigators find the exponent to be as great as one (loudness proportional to sound pressure p), which leads to a loudness doubling for a 6-dB increase in sound pressure level (Warren, 1970).

In this demonstration, a reference sound of broadband noise alternates with similar sounds having levels of $0, \pm 5, \pm 10, \pm 15$ or ± 20 dB with respect to the reference tone. The tones are 1 s long, separated by 250 ms of quiet, and the trials are separated by 2.25 s of quiet. To help establish a scale, the reference tone is first presented along with the strongest and weakest sounds that will be heard. It is suggested that the reference tone be assigned a loudness of 100, although some teachers may prefer to use 30, or 50 or some other number.

The test tones at each level are as follows:

+15, -5, -20, 0, -10, +20, +5, +10, -15, 0, -10, +15, +20, -5, +10, -15, -5, -20, +5, +15 dB.

You may wish to plot all the student responses on a graph of subjective loudness (log scale) versus sound level (linear scale) to establish an average loudness scale. In this case, it would be advantageous to have each listener designate a test tone that sounds "twice as loud" as the reference tone by 200, and one that sounds "half as loud" by 50.

Commentary

"In this experiment you will rate the loudness of 20 noise samples which are preceded by a fixed reference. First you hear the reference sound, followed by the strongest and weakest noise samples."

"Now the twenty samples. For each sample, write down a number reflecting its loudness relative to the reference."

References

- G.Canévet, R.Hellman and B.Scharf (1986), "Group estimation of loudness in sound fields," *Acustica* 60, 277-82.
- R.M.Warren (1970), "Elimination of biases in loudness judgements for tones," *J. Acoust. Soc. Am.* 48, 1397-1403.
- D.W.Robinson (1957), "The subjective loudness scale," *Acustica* 3, 344-58.
- S.S.Stevens (1956), "The direct estimation of sensory magnitudes-loudness," *Am. J. Psych.* 69, 1-25.