Psychology of Perception
Psychology 4165-100
Summer 2007

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MUEN D156, 09:15–10:50 M–F

Homework 3: Amplitude vs. Loudness
20 Points: Due at the beginning of class, Friday, 29 June 2007

There are two parts to this homework assignment. Each part counts 10 points. Late homework will receive a grade of zero.

Part 1:

We must always keep in mind the distinction between the physical nature of a stimulus and the psychological nature of the experience. Sound amplitude is expressed in RMS pressure units or in decibels relative to a standard pressure (usually 0.00002 N/m^2). A psychological unit of loudness is the **sone**.

By definition, 1 sone is the loudness of a 1000 Hz tone 40 dB above detection threshold. Assuming that the detection threshold for such a tone is 0 dB, then by definition 1 sone is the loudness of a 1000 Hz tone with a sound pressure level of 0.002 N/m^2. As you already know, the relationship between perceived loudness and sound pressure level is nonlinear. This relationship is usually a power function:

$$L = k \cdot SPL^{0.6}$$

where L is loudness, SPL is the sound pressure level in Newton per square meter, and k is a scaling constant. To compute loudness in sones, use a scaling constant k = 41.6:

$$Sones = 41.6 \cdot SPL_{N/m^2}^{0.6}$$

Using the above relationships, compute the loudness of a 1000 Hz sine wave tone having the following intensities: 40, 50, 60, 70, 80, 90, 100, and 110 dB and put the results in a table. Don't forget to first convert decibels into Newtons per square meter. Examining your table, what do you have to do to the pressure of a sound to double its loudness?

Part 2:

The critical band is an extremely important concept in hearing. It influences our ability to discriminate tones, the loudness of sounds, the ability to hear sounds in the presence of masking sounds and so forth. For example, if two tones fall into separate critical bands, they will be treated (approximately) independently of each other.

You are given two 60 dB sounds. The first sound is a simple sine wave tone having a frequency of 1000 Hz and an amplitude of 60 dB. The second sound has four components: a 1st harmonic (the fundamental frequency) of 1000 Hz and a 2nd, 3rd, and 4th harmonic. The intensity of each of the four components is 0.01 N/m^2 (remember that the intensity of the complex sound is equal to the square root of the sum of the component's squared intensities). Assuming that the components of the complex sound all fall in separate critical bands, and that loudness in separate critical bands simply add together, what is the loudness (in sones) of the simple tone and what is the loudness (in sones) of the complex tone? Are they equal? Why or why not?