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9:30–10:45 TR

Homework 4: Amplitude vs. Loudness
10 Points: Due at the beginning of class, Thursday, 5 March 2015

There are two parts to this homework assignment. Each part counts 5 points. Late homework will receive a grade of zero.

Part 1:

We must distinguish between the physical stimulus on the one hand and the psychological experience on the other. Sound amplitude is expressed in RMS pressure units or in decibels relative to a standard pressure (P_0= 0.00002 N/m^2).

$$dB = 20\log_{10}\left(\frac{P}{P_0}\right)$$

The psychological unit of loudness is the **sone**. By definition, 1 sone is the loudness of a 1000 Hz tone 40 dB above its detection threshold. Assuming that a normal listener's detection threshold for a 1000 Hz tone is 0 dB, then 1 sone is the loudness of a 1000 Hz tone with a sound pressure level of 0.002 N/m^2. The relationship between perceived loudness and sound pressure level is nonlinear: a power function:

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

where L is loudness, SPL is the sound pressure level in Newtons per square meter, and k is a scaling constant. The scaling constant for a normal listener is 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 rounding to the nearest whole number: in R you can use the `round()` function. Don't forget to convert decibels into Newtons per square meter before computing the loudness in sones:

```
db2spl <- function(db) {0.00002 * 10^(db/20)}
```

dB	40	50	60	70	80	90	100	110
SPL								
Sones								

Make two graphs:
1) Sones on the ordinate; SPL on the abscissa and
2) Sones on the ordinate; dB on the abscissa (make the sones axis a logarithmic scale by including `log="y"` as an argument to the plot command; eg, `plot(…, log="y")`

What do you have to do to the pressure of a sound to double its loudness?

Part 2:

The five pairs of tones given in the table below have the same intensity (70 dB). Using the principles derived from the Plomp and Levelt (1965) experiment which of the five tone pairs would have the maximum amount of dissonance (minimum amount of consonance)? Why? Hint: compute critical band estimate using 15% of the mean frequency of the two tones in each pair and compare it with the frequency separation of the pair.

Pair	Tone 1	Tone 2	Mean Frequency	Critical Band	Frequency Difference
1	498 Hz	502 Hz			
2	490 Hz	510 Hz			
3	481 Hz	519 Hz			
4	465 Hz	535 Hz			
5	450 Hz	550 Hz			

Which of the tone pairs will sound most dissonant? Why?

Which of the tone pairs will sound the loudest? Why?