LING 151 Lab: Audition

November 12th, 2008

1 Acoustic vs. Auditory Representations

- So far in class, we've worked with scales that reflect the physical properties of sound waves (more or less) directly: Hz, dB.
- The human ear doesn't necessarily perceive sound in a way that corresponds to these scales.
- Researchers have devised alternative scales that better reflect how humans actually hear sounds.
- Today, we'll see how sounds look different when we examine them using auditory scales rather than acoustic scales.
- In particular, we're used to looking at spectra where the frequency is measured in Hz and the amplitude in dB.

  ⇒ Today, we'll look at spectra where the frequency is measured in Bark and the amplitude in phones.

2 Viewing Spectra on Acoustic and Auditory Scales

- At `http://people.ucsc.edu/~kaplanas/labs`, you will find ten sound files named `A.wav` – `J.wav`. Each of these files contains a recording of one fricative. Sounds `A` through `E` are voiceless; sounds `F` through `J` are voiced. Download these files, but don't listen to them.
- For each sound, complete the following procedure:

  1. Read the sound into the Praat objects window.
  2. Create a spectrum of the sound:
     - Highlight the `Sound` object.

   - Go to `Spectrum -` → `To Spectrum...` and click `OK`.
3. In the Praat picture window, select the top half of the drawing area (the pink box shows you what part of the window you've selected).
4. Draw the spectrum of the sound in the picture window.
   - Highlight the `Spectrum` object.
   - Go to `Draw -` → `Draw...` and click `OK`.
5. Create an `Excitation` object from the `Spectrum` object. The `Excitation` object will represent the same information as is contained in the spectrum, but it uses Bark and phone scales rather than Hz and dB. In other words, it will give you an *auditory* spectrum.
   - Highlight the `Spectrum` object.
   - Go to `To Excitation...` and click `OK`.
6. Select the bottom half of the Praat picture window.
7. Draw the auditory-scaled spectrum of the sound.
   - Highlight the `Excitation` object.
   - Go to `Draw...` and click `OK`.
8. Save the picture with the two spectra of the sound.
   - Go to `File` → `Write to EPS file...`, change the filename (and possibly the directory) appropriately, and click `OK`.
   - Be sure to highlight the entire picture window (or at least the part containing the images you want to save) before creating an `.eps` file. I find that not doing this leads to weird results.

- You probably won't be able to open your saved `.eps` files directly, but you can easily import them into a Word document. Within Word, go to `Insert` → `Picture` → `From file...` and choose the `.eps` file you want.

3 Analyzing the Mystery Fricatives

- The ten fricatives you have just analyzed are listed below. Without listening to the recordings, you will use the spectral properties of the fricatives to try to identify them.

s	ʃ	ʂ	ç	x
z	ʒ	ʐ	ʝ	ɣ

- Recall that we expect that the further forward in the mouth a fricative is articulated, the more high-frequency energy we will see in its spectrum. In addition, we expect voiced fricatives to differ from their voiceless counterparts mainly by the addition of some low-frequency noise (the voicing component). Today, we will test both of these predictions using acoustic and auditory spectra.

- Look first at the *acoustic* spectra of the voiceless fricatives (`A` – `E`). Many of these spectra have a distinct peak corresponding to the frequency components with the greatest amplitude. Using this peak, order the fricatives from the one with the highest-frequency energy to the one with the lowest-frequency energy.
  - For example, if sound `A` has a peak at around 2000 Hz and sound `B` has a peak at around 3000 Hz, order sound `B` before sound `A`. If there isn't enough detail on the graphs to tell exactly what Hz a peak corresponds to, just estimate (or compare the two graphs directly). If it isn't clear where the peak is or whether there's a peak at all, just make your best guess.
  - If fricatives that are further front really do have higher-frequency components than fricatives that are further back, then your list should order the fricatives from front to back. In other words, the first fricative in your ordered list should be [s], the second one [ʃ], and so on. Later we'll check to see if this is true.
  - Record your proposed order in the table in figure 1 below.
- Repeat this process for the voiced fricatives (`F` – `J`) and record your results in figure 1.
- Now look at the *auditory* spectra for the voiceless fricatives. Note that the Bark scale stretches out the low end of the frequency scale and compresses the high end. Following the same procedure as above, order the voiceless fricatives from highest-frequency to lowest-frequency, this time using information from the auditory spectra. Record your results in figure 2.
- Repeat the process for the voiced fricatives, again using the auditory spectra. Record your results in figure 2.

4 Questions to Consider

- When you're finished, ask me for the key to the true identity of these fricatives. (You can also just listen to the files, but I find that some of these fricatives are surprisingly hard to identify out of context.)
- Consider the following questions:
  1. How well did you predict the identity of the fricatives? Were any fricatives particularly difficult to identify?
  2. Which spectra gave you better information about the fricatives, the acoustic spectra or the auditory spectra?
  3. How similar do the acoustic spectra of corresponding voiced and voiceless fricatives look? The auditory spectra? What does this tell us about the production/perception of voiced vs. voiceless fricatives?

Figure 1: Proposed identification of the mystery fricatives based on acoustic spectra

POA		**Voiceless**	**Voiced**
Alveolar	([s], [z])		
Postalveolar	([ʃ], [ʒ])		
Retroflex	([ʂ], [ʐ])		
Palatal	([ç], [ʝ])		
Velar	([x], [ɣ])		

Figure 2: Proposed identification of the mystery fricatives based on auditory spectra

POA		**Voiceless**	**Voiced**
Alveolar	([s], [z])		
Postalveolar	([ʃ], [ʒ])		
Retroflex	([ʂ], [ʐ])		
Palatal	([ç], [ʝ])		
Velar	([x], [ɣ])		