LING 151 Lab: Measuring Vocal Tracts

October 22nd, 2008

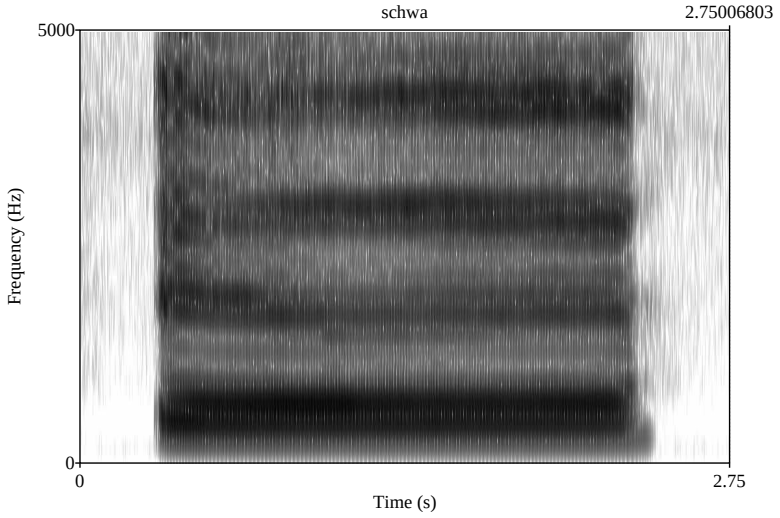
1 Background

- We know how to use the length of a tube to calculate its resonant frequencies.
- Today, you will use the resonant frequencies of your vocal tract to calculate its length.

2 Instructions

- Record yourself saying the vowel [ə].
  - We use [ə] because it is the one for which the vocal tract comes the closest to having the shape of a simple tube.
  - I found that I got the best results when I made a conscious effort to keep my tongue and lips completely relaxed and my jaw very high, almost closed. My tongue was close to the roof of my mouth, and the resulting vowel was actually closer to [ɨ]. You can listen to my production of this vowel in the file `schwa.wav`, which can be downloaded at `http://people.ucsc.edu/~kaplanas/labs`.
- Look at the spectrogram of the vowel. Hopefully, the formants will be approximantly equally spaced. (This is what we expect from the resonant frequencies of a single tube.)
  - Recall from class that *formants* are just another term for the resonant frequencies of the vocal tract during a vowel.
  - Figure 1 shows how my vowel turned out. I measured the formants in the middle of the vowel, since this is where they seem to be most evenly spaced.
  - Praat has a function that automatically marks the formants. You can turn this on (and off) by going to `Formant` → `Show formants`.

Figure 1: Spectrogram of Abby's [ə]



- The vocal tract behaves like a tube open at one end and closed at the other. The formula for the nth resonant frequency f_n of this kind of tube is

$$f_n = \frac{nc}{4L}, \tag{1}$$

where n is an odd number, c is the speed of sound in air (34,300 $\frac{cm}{s}$), and L is the length of the tube.

  ⇒ Confusingly, the numbering system for formants and for f_n is different; this is because n has to be an odd number when the tube is closed at one end. Thus, F1 (the first formant) corresponds to $n = 1$ in the equation above, but F2 (the second formant) corresponds to $n = 3$, F3 corresponds to $n = 5$, and so on.

- Find the value of each of the first four resonant frequencies (= the first four formants) of your vowel (in Hz) and record them in the table in figure 2.

  ⇒ You can query the values of the formants in Praat by going to `Formant` → `Get first formant`, `Formant` → `Get second formant`, and so on. Handy shortcuts are the keys `F1` – `F4`, which do the same thing.

  ⇒ Alternatively, you can click directly on the formant in the spectrogram; red crosshairs will appear that give you the coordinates of the point you clicked on. This means that you can click on the formant directly to determine its frequency. This method isn't as precise as using the built-in queries, but it's useful if you

believe Praat is having difficulty calculating a formant accurately. For example, my F4 was very wide, and Praat's automatic calculations of the formant frequencies showed a lot of scatter, so I found the value of this formant using this second method.

- For each formant, plug in the appropriate values for f_n, n, and c into equation (1) and solve for L. Record the results in the table.
- If your vocal tract was a perfect tube when you recorded the vowel, then each formant should give you the same length for your vocal tract. Probably, though, the four values are slightly different. Estimate the true length of your vocal tract by averaging them.
- When you're done, record your estimated vocal tract length on the pad in the front of the room. Also record your height. At the end of class, we'll graph everyone's results and test the hypothesis that vocal tract length is correlated with height.

3 Measurements

Figure 2: Resonant frequencies of your vocal tract

n	**Formant**	**Frequency (Hz)**	**Length (cm)**
1	F1		
3	F2		
5	F3		
7	F4		
Average Length			

Figure 3: Example: Resonant frequencies of Abby's vocal tract

n	**Formant**	**Frequency (Hz)**	**Length (cm)**
1	F1	606	14.2
3	F2	1766	14.6
5	F3	2781	15.4
7	F4	4039	14.9
Average Length			14.8