

**Homework 9: Speech Perception**  
**10 Points: Due at the beginning of class, Thursday, 16 April 2009**

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

**Part 1:**

Vowel sounds are characterized by regions of the frequency spectrum that have relatively more energy than neighboring frequencies. These local maxima are called *formants*. Each vowel can have up to about six formants but the first two are usually sufficient to allow a listener to distinguish one vowel from another. Below is a table modified from Wikipedia that gives the frequencies of the first and second formants of nine vowels (<http://en.wikipedia.org/wiki/Formant>)

	Vowel	Formant $f_1$	Formant $f_2$
1	<b>u</b>	<b>320 Hz</b>	<b>800 Hz</b>
2	o	500 Hz	1000 Hz
3	<b>œ</b>	<b>700 Hz</b>	<b>1150 Hz</b>
4	<b>a</b>	<b>850 Hz</b>	<b>1400 Hz</b>
5	ø	500 Hz	1500 Hz
6	y	320 Hz	1650 Hz
7	<b>æ</b>	<b>700 Hz</b>	<b>1800 Hz</b>
8	<b>e</b>	<b>500 Hz</b>	<b>2300 Hz</b>
9	<b>i</b>	<b>320 Hz</b>	<b>2500 Hz</b>

Plot the position of each vowel in a graph with  $f_1$  on the horizontal axis and  $f_2$  on the vertical. Use these limits for the x- and y-axes:  $xlim = c(250, 900)$ ,  $ylim = c(600, 2800)$ . Label each point with the corresponding vowel. Hint: the `text()` command draws a series of characters in a character vector. For example if `lab <- c("a", "b", "c")` then `text(x, y, lab)` will plot a, b, and c in succession at the x- and y-coordinates given in x and y. Draw an enclosing polygon using the six vowels that are in bold (the `polygon()` command is useful here).

**Part 2:**

If you consider the vowel plot a perceptual space, which two vowels would be easiest to discriminate and which would be the most difficult? Explain your reasoning.