Formants

For the purposes of distinguishing vowels from each other, we are more interested in the frequency response curves (indicating the preferred resonating frequencies of the vocal tract) rather than in the raw spectrum of the wave.

Each of the preferred resonanting frequencies of the vocal tract (each bump in the frequency response curve) is known as a **formant** . They are usually referred to as F1, F2, F3, etc. For example, the formants for a schwa as spoken by an adult male whose vocal tract is 17 centimetres long:

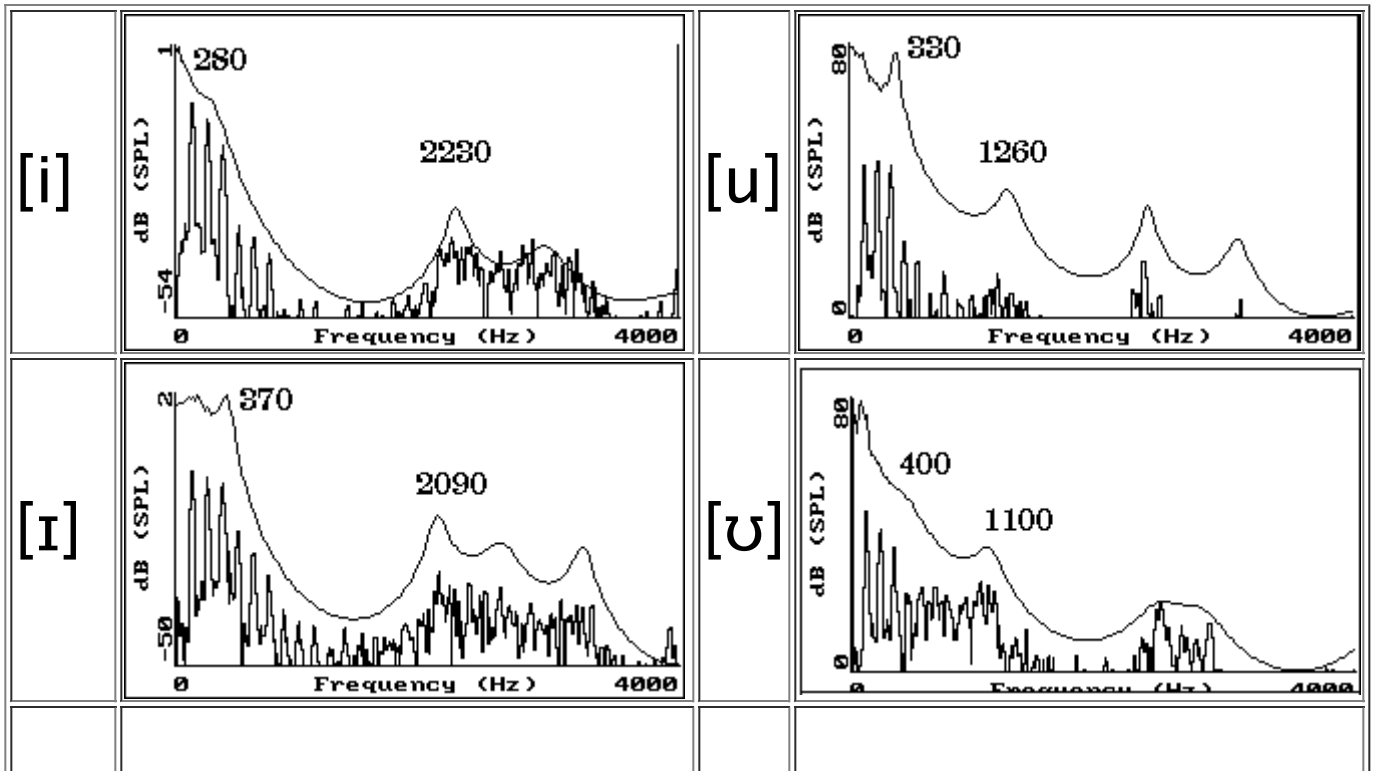
F1	first formant	500 Hz
F2	second formant	1500 Hz
F3	third formant	2500 Hz
	...	

(People whose vocal tracts are longer or shorter than 17 cm will have different frequencies for these formants, but the pattern of 1x-3x-5x will be the same.)

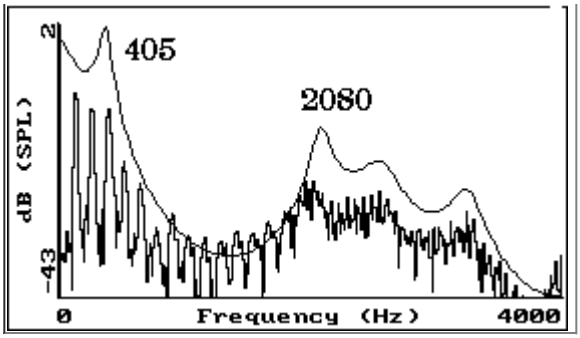
By changing the vocal tract away from a perfect tube, you can change the frequencies that it prefers to vibrate at. That is, by moving around your tongue body and your lips, you can change the position of the formants.

Some vowel formants for Canadian English

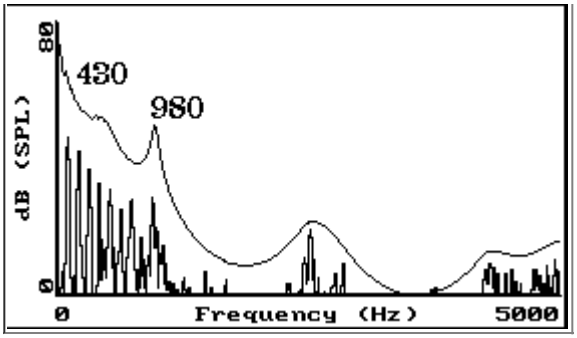
Each of the following figures shows a computer-generated spectrum and response curve for a particular utterance of a Canadian English vowel by an adult male (namely, me). The jagged lines show the harmonics. The curved line is the computer's guess as to what the frequency response curve of the vocal tract must have been. The frequencies of the first two formants (as guessed by the computer) have been given for each vowel.



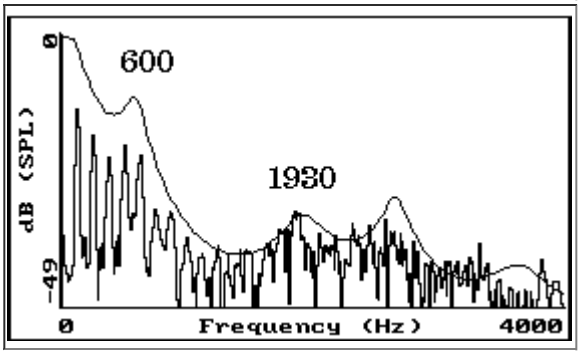
[e]



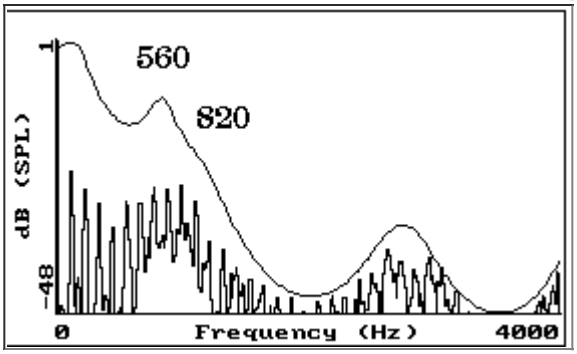
[o]



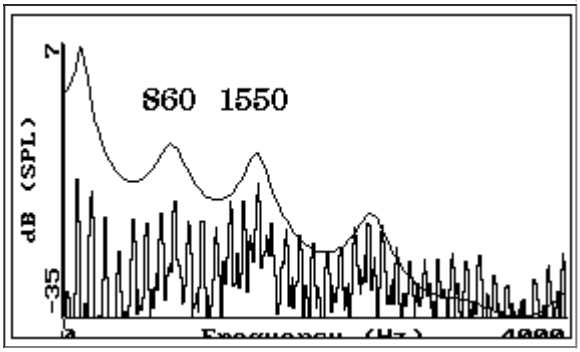
[ɛ]



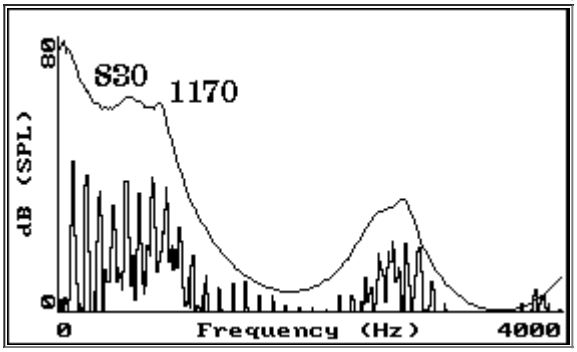
[ɔ]



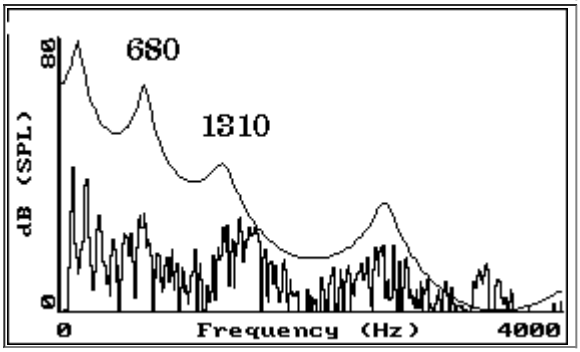
[æ]



[ɑ]



[ʌ]

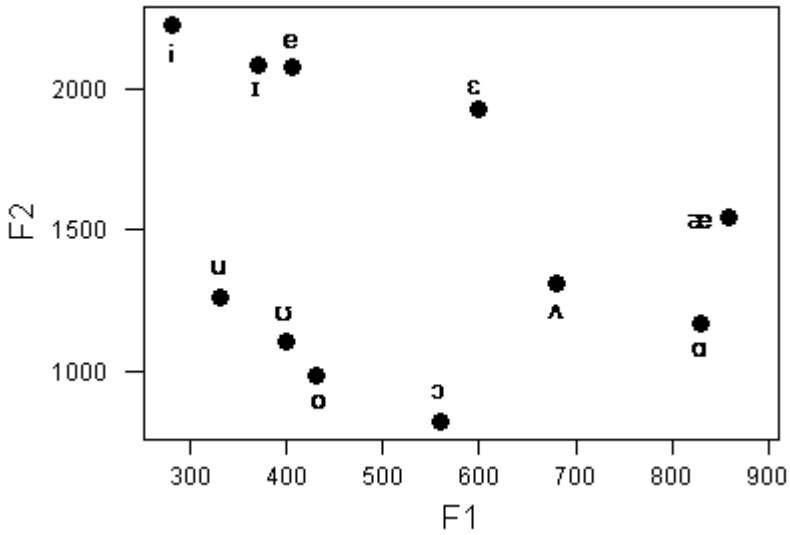


Relating formants to articulation

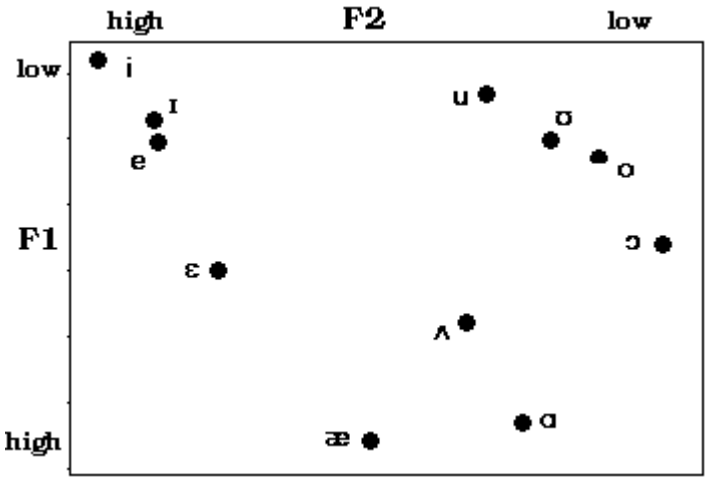
The positions for the first two formants of a vowel aren't random. Let's look more closely at the formants we saw for Canadian English vowels:

Vowel	[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
F1	280	370	405	600	860	830	560	430	400	330	680
F2	2230	2090	2080	1930	1550	1170	820	980	1100	1260	1310

We can place each vowel on a graph, where the horizontal dimension represents the frequency of the first formant (F1) and the vertical dimension represents the frequency of the second formant (F2):



This is just a mirror image of our familiar vowel chart! If we change the axes of the graph so that the horizontal dimension shows (decreasing) F2 and the vertical dimension shows (decreasing) F1, we get something almost exactly like our vowel chart:



The frequency of the first formant is mostly determined by the height of the tongue body:

- high F1 = low vowel (i.e., high frequency F1 = low tongue body)
- low F1 = high vowel (i.e., low frequency F1 = high tongue body)

The frequency of the second formant is mostly determined by the frontness/backness of the tongue body:

- high F2 = front vowel
- low F2 = back vowel

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