

Experiment 4: Measuring formants
As information about consonant place and vowel quality

1. Introduction

Despite the fact that we can transcribe speech with a string of discrete alphabetic symbols, speech sounds are not in fact pronounced one at a time, with the speaker finishing the current one before going on to the next. Instead the speaker is still saying the previous sound while saying the current one and is also starting to say the next one, all at the same time. This overlap of the pronunciation of one speech sound with the sounds before and after it is called “coarticulation.” Because sounds coarticulate with one another, they affect one another’s acoustics, too. The purpose of this experiment is to examine the acoustic effects of coarticulation between a consonant and a following vowel.

2. Method

You will once again work in groups; in this case consisting of 3 members.

Each group records three speakers pronouncing CVC syllables (one per experimenter). For one speaker, the final C is [b] in all the syllables, for the second it is [d], and for the third it is [g]. All three speakers produce syllables with [b], [d], or [g] as the initial consonant, and the vowels [i], [ɪ], [e], [ɛ], [æ], [u], [ʊ], [o], [ɔ], or [a].¹ That is, you record 30 different syllables (3 consonants x 10 vowels) from each speaker. Each syllable should be recorded 6 times, for a total of 180 syllables from each speaker; only five repetitions will be analyzed. The syllables should be pronounced in the sentence, “I want a ___ again,” in the place of the blank.

Once the syllables are recorded, you label the beginning and end of each vowel using the labeling facility in PRAAT. Labels are composed from the following elements:

Element	Meaning
{b, d, g}	initial consonant
{ii, ih, ee, eh, ae, uu, uh, oo, oh, aa}	vowel
{b, d, g}	final consonant and speaker
{1, 2, 3, 4, 5}	repetition

¹ These are the vowels in *heed*, *hid*, *hayed*, *head*, *had*, *who’d*, *hood*, *hoed*, *hawed*, and *hod*, respectively. Before you decide to record a speaker, make sure they distinguish the last two vowels by asking them to pronounce the shibboleths, *cot* and *caught*.

For example, the label "bihg2" refers to the second repetition of the syllable [big] by the speaker whose final consonant is [g].

Labeling will be demonstrated in class on Wednesday, 3 October 2007. Once the labeling is done, the measurements can be automated by using a script. This will also be demonstrated on Wednesday.

The script extracts the times corresponding to the beginning, middle, and end of each labeled interval, the frequencies of the second formant (F2) at five locations in each vowel, the beginning, the one-quarter point, the middle, the three-quarters point, and the end, and the values of F1 and F2 at the midpoint of the vowel. The script automatically writes all these values for each vowel to a separate line in a text file, together with the label attached to that syllable, which can be used to identify the syllable. The values in this file can then be analyzed to determine how coarticulation with the consonant influences the acoustics of the vowel, and vice versa.

To use the script, put all the sound files and the associated TextGrid files into a directory of their own and copy the script to that directory, too. Then run Praat and open the script from the Praat menu. To run the script, all you need to do is select Run from its Run menu, and then fill in the values in the box that opens up. Use the following values:

Directory:	The complete path to the directory where the sound and TextGrid files may be found. As indicated, in the window, this can be pasted in before the "\". Make sure that the entry in that box ends with this backslash.
Voicing threshold:	Do not change this value.
Offset from first marker.	0.005 These values shift the point where you actually take the formant values 5 ms away from the very edges of the vowel and make it easier to get sensible values.
Offset from second marker.	0.005
Formant:	2
Mean_interval:	0.01 The values extracted are the averages of all values with an interval of this duration. By averaging a series of values, we also reduce the likelihood of artifacts.

Output_file_name: The name you want to give to the file in which the data will be stored. This can be whatever you want.

3. Reporting results

We want to know two basic things about how the consonants and vowels affect the frequency of the second formant (F2):

- (1) How does F2 vary at the beginning of the vowel after each consonant as a function of the following vowel?
- (2) How does F2 vary at the one-quarter, one half, and three quarters points as a function of the preceding consonant.

To answer the first of these questions, you need to sort the data in the data file so that all the values for each place of articulation are on adjacent rows, and then all the values for each vowel are on adjacent rows within the rows corresponding to a particular place of articulation, as sketched below:

Consonant	Vowel
b	i
b	i
b	i
...	
b	I
b	I
...	
d	i
d	i
...	
d	I
...	

This is easy to do, because you can use the labels as a sort key. Open the data file in Excel, and select all the data. Then select sort from the Data menu and enter the column containing the labels as the Sort key.

Once you have all the data sorted by consonant and vowel in this way, you can then calculate the average values for F2 for each consonant next to each vowel. This is accomplished by using the *average* function in Excel. To use this function, you type:

=average(X2:X6)

where X2:X6 is the range of cells containing the data for a particular consonant-vowel combination, where "X" refers to the column where the data are found and "2" and "6" identify the first and last rows. Then repeat this calculation for each consonant-vowel combination. The result will be 30 means (3 consonants x 10 vowels).

To answer the second question, you simply repeat this process for the measurements taken at the one quarter, midpoint, and three quarters points in the vowel. The result will be 90 means (3 consonants x 10 vowels x 3 measurement locations).

So, you might ask: what do I do with these means, once I have obtained them? The answer to this question is simple, and has two parts in each case.

First, for the measurements at the beginning of the vowel, we want to know whether the means for a consonant at a particular place of articulation differ as a function of the vowel that follows and if they do differ, in what way. Second, we want to know whether these differences, if they exist, are similar for all three places of articulation. For example, if F2 is higher at the beginning of the vowel when it is [e] rather than [o], and the consonant is bilabial [b], is this formant also higher when the vowel is [e] rather than [o] and the consonant is [d] or [g]?

Similarly for the measurements inside the vowel, we want to know first whether and how the measurements differ for each vowel as a function of what consonant precedes it, and second whether these differences are similar for all vowels. For example, if F2 is higher when the consonant is [d] than when it is [b] for the vowel [i], is this also the case when the vowel is [ɪ]? These comparisons should be carried out separately for each of the three locations inside the vowel, to see how far into it the consonant's influence persists.

Variation in the consonants' values as a function of the following vowel tells us about how the vowel coarticulates with the consonant, while variation in the vowels' values tell us how the consonant coarticulates with the vowel.

Finally, you want to combine the data from all three speakers analyzed by your group to compare the F2 values at the beginning of the vowel and at the three points inside it see whether differences in place of articulation in the final consonant affect the measurements.

You should turn in the spreadsheets with all your sorted data along with your write-up of this experiment.