SSC 0158: The Science of Talking

Laboratory for week 2

Analysis of Natural Vowels

Introduction

The acoustic structure of vowels can be conveniently characterised by measuring their *formant frequencies*. These are the frequencies of the first few resonances in the vocal tract which make significant changes to the spectrum of the sound generated by vocal fold vibration as that sound passes through.

We can measure formant frequencies fairly accurately by investigating the *estimated vocal tract filter response* calculated from the short-time spectrum of the signal in the centre of a vowel. In this experiment you will measure the formant frequencies of vowels embedded in a sentence of your own speech, and compare the frequencies to your classmates.

Scientific Objectives

- To investigate how formant frequencies vary for different vowels.
- To investigate how much formant frequencies vary for the same vowel across speakers.

Learning Objectives

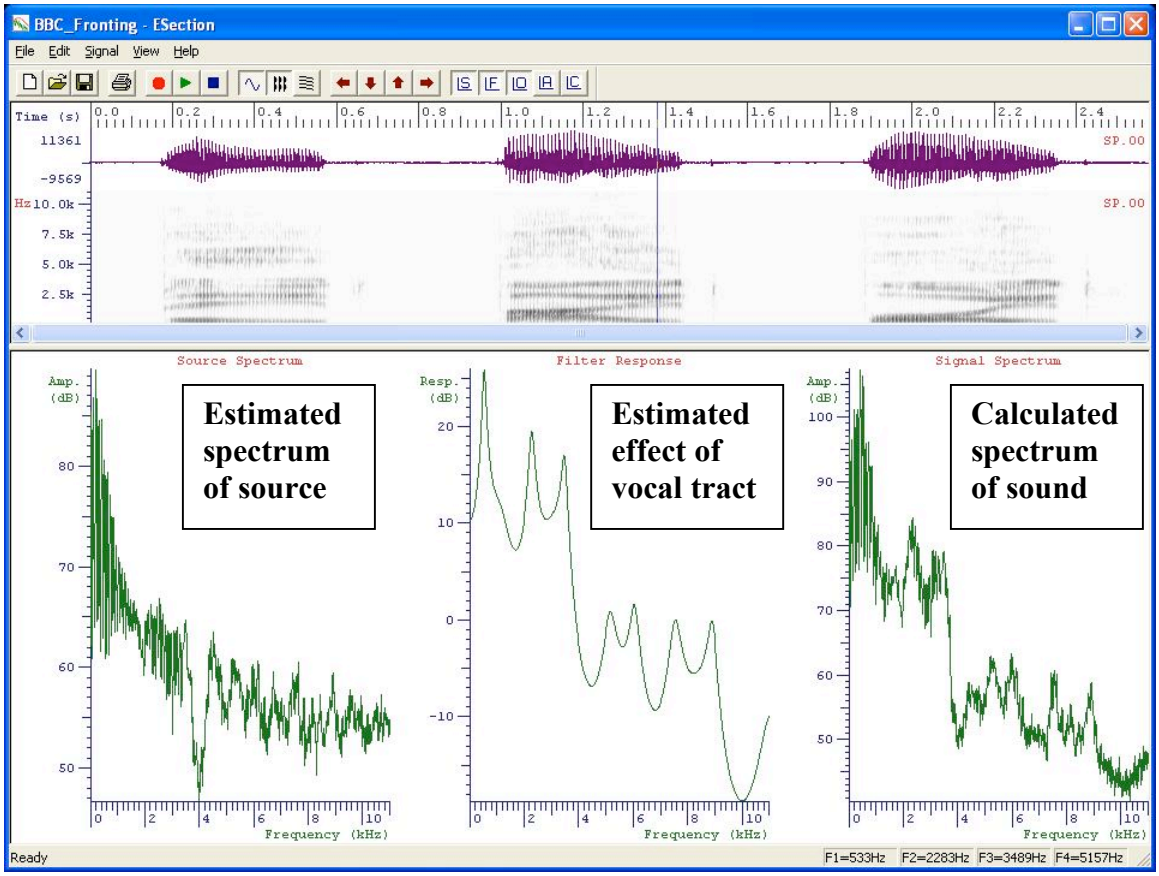
- To gain a better understanding of the source-filter model of vowel sound production.
- To gain experience in studying the spectra of vowels.
- To practise making measurements from live speech, to better appreciate the difficulties that can arise.

Method

The SFS program ESection (Location: Desktop\LabPrograms\ESection) is used to record a sentence ('Record Signal'), to display an analysis of the vowel sounds ('Display Waveform', 'Display Wide-band', 'Source Spectrum', 'Filter Response', 'Output Spectrum'), and to allow the measurement of the formant frequencies ('F1=…Hz', shown at bottom right).

You can select a portion of the signal using the left (left click the mouse) and right cursor (right click the mouse). You can use the program's facility to zoom and to replay selected portions of the signal to relate parts of the signal to parts of the utterance. Then you can measure formant frequencies by investigating the *estimated vocal tract filter response* calculated from the short-time spectrum of the signal *in the centre of a vowel*. You can print out any display, but be sure to use your name as a title.

Observations ('bayed, bide, Boyd' by Peter Ladefoged)

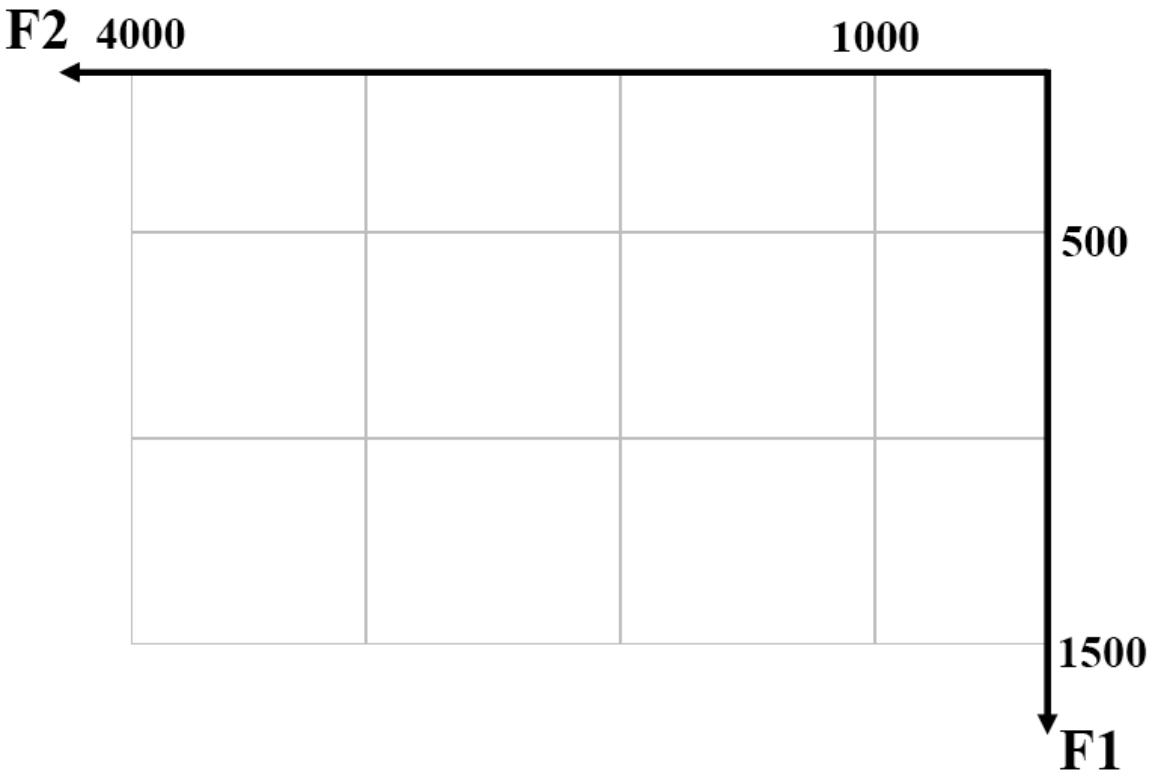


1. Each student should record and analyse the sentence:
   1) "Gene had thirty-four smart boots."
   2) "The boy went to buy a bowl."

2. Using the estimated filter response display, measure the first two formant frequencies for the four vowels, writing your results in this table.

Vowel	F1 (Hz)	F2 (Hz)
/i:/ in 'Gene'		
/ɜ:/ in 'thir-'		
/ɔ:/ in 'four'		
/a:/ in 'smart'		
/u:/ in 'boots'		

3. Plot your vowels and those of your group roughly on the F1-F2 graph below. Plot F1 going from top to bottom on the *right* side of the paper, and F2 going from right to left across the *top* of the paper. Also plot your vowels on the class F1-F2 diagram (men in blue, women in red). Why is there so much variation?



4. Measure the diphthongs in sentence 2. You will need to measure the formant frequencies *at the beginning and at the end*. Plot this line on your F1-F2 diagram. Explain how it relates to your other measured vowels.

Diphthong	F1 (Hz)	F2 (Hz)
/ɔɪ/ in 'boy'	from: to:	from: to:
/aɪ/ in 'buy'	from: to:	from: to:
/aʊ/ in 'bowl'	from: to:	from: to:

5. Look at the diphthongs in a spectrogram (e.g., in SFS/ESection). Where do you see the formant frequencies here? What is the big advantage of a spectrogram over a spectrum for the analysis of diphthongs?