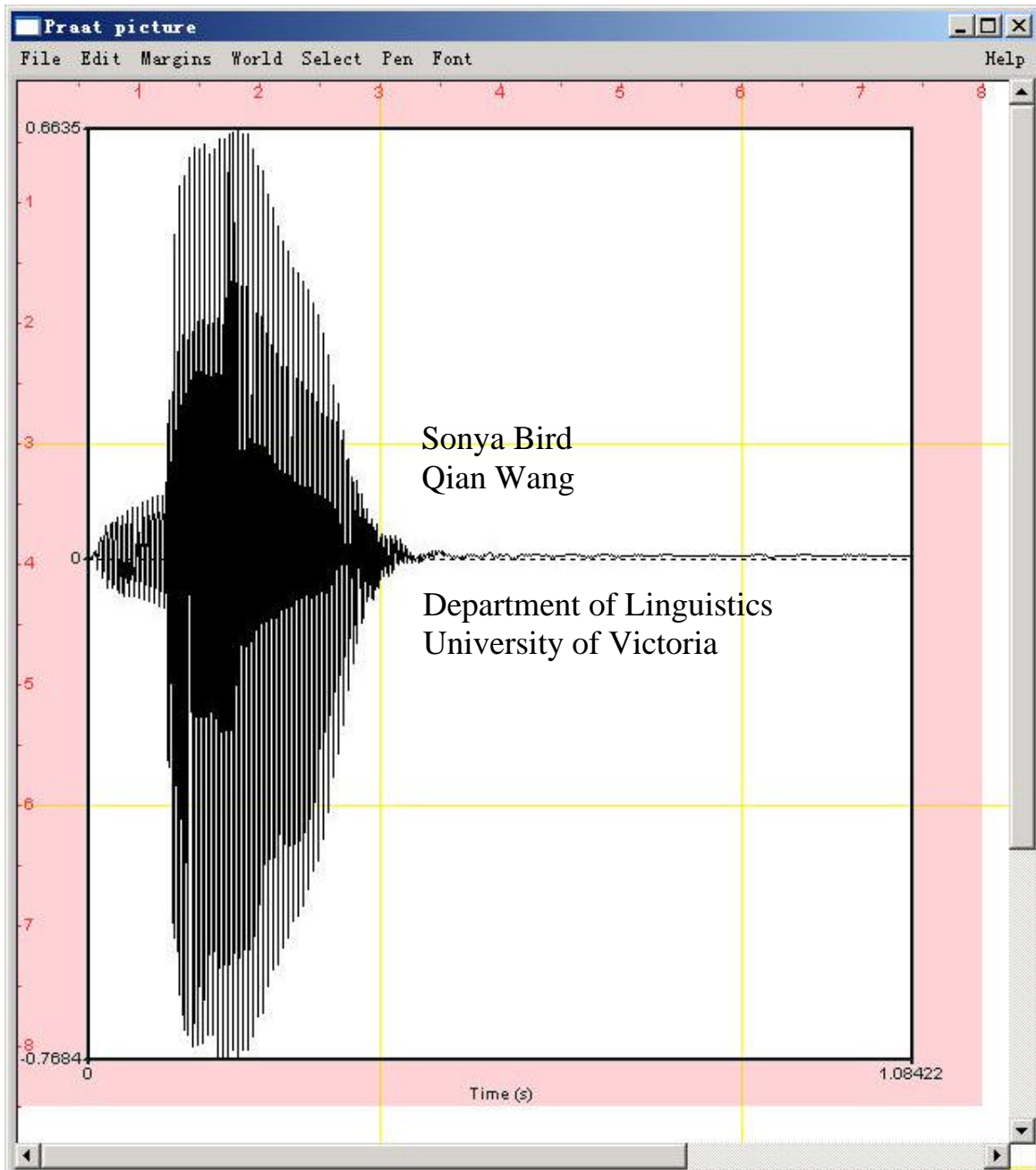


LING 380: Acoustic Phonetics Lab Manual



INTRODUCTION

This lab manual is designed to be used in the context of an introductory course in Acoustic Phonetics. It is based on the software Praat, created by Paul Boersma and David Weenink (www.praat.org), and covers measurement techniques useful for basic acoustic analysis of speech. LAB 1 is an introduction to Praat: the layout of various displays and the basic functions. LAB 2 focuses on fundamental frequency, harmonics and formants, and on how to measure these using different displays. The next three labs guide students through taking acoustic measurements typically relevant for vowels (LAB 3), sonorants (LAB 4) and obstruents (LAB 5). LAB 6 discusses ways of measuring phonation. LAB 7 focuses on stress, pitch-accent, and tone. Labs 8 and 9 bring together the material from previous labs in an exploration of cross-dialectal (LAB 8) and cross-linguistic (LAB 9) differences in speech. Finally, LAB 10 introduces speech manipulation and synthesis techniques. Each lab includes a set of questions designed to ensure that the user understands the measurements taken as well as the values obtained for these measurements. These questions are repeated in the worksheet at the end of the lab, which can serve as a way of recapitulating the content of the lab.

The lab manual is a work in progress, and the authors, Sonya Bird and Qian Wang, would appreciate any feedback you may have on it. Thank you!

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LAB 1 – EXPLORING PRAAT

GOAL OF LAB 1

The goal of this first lab is to explore some of the basic features of PRAAT (www.praat.org), which we will be using for speech analysis throughout the term. You will learn to make recordings, bring up visual displays of these recordings (waveforms and spectrograms), segment and label various components of these recordings, and export the visual displays into a word document. The skills you learn today will be useful for your lab work throughout the remainder of this course and beyond...

1. Open Praat: double click on the following icon (Fig. 1.1):



Figure 1.1 Praat icon

2. Get to know the Praat layout (Fig. 1.2)

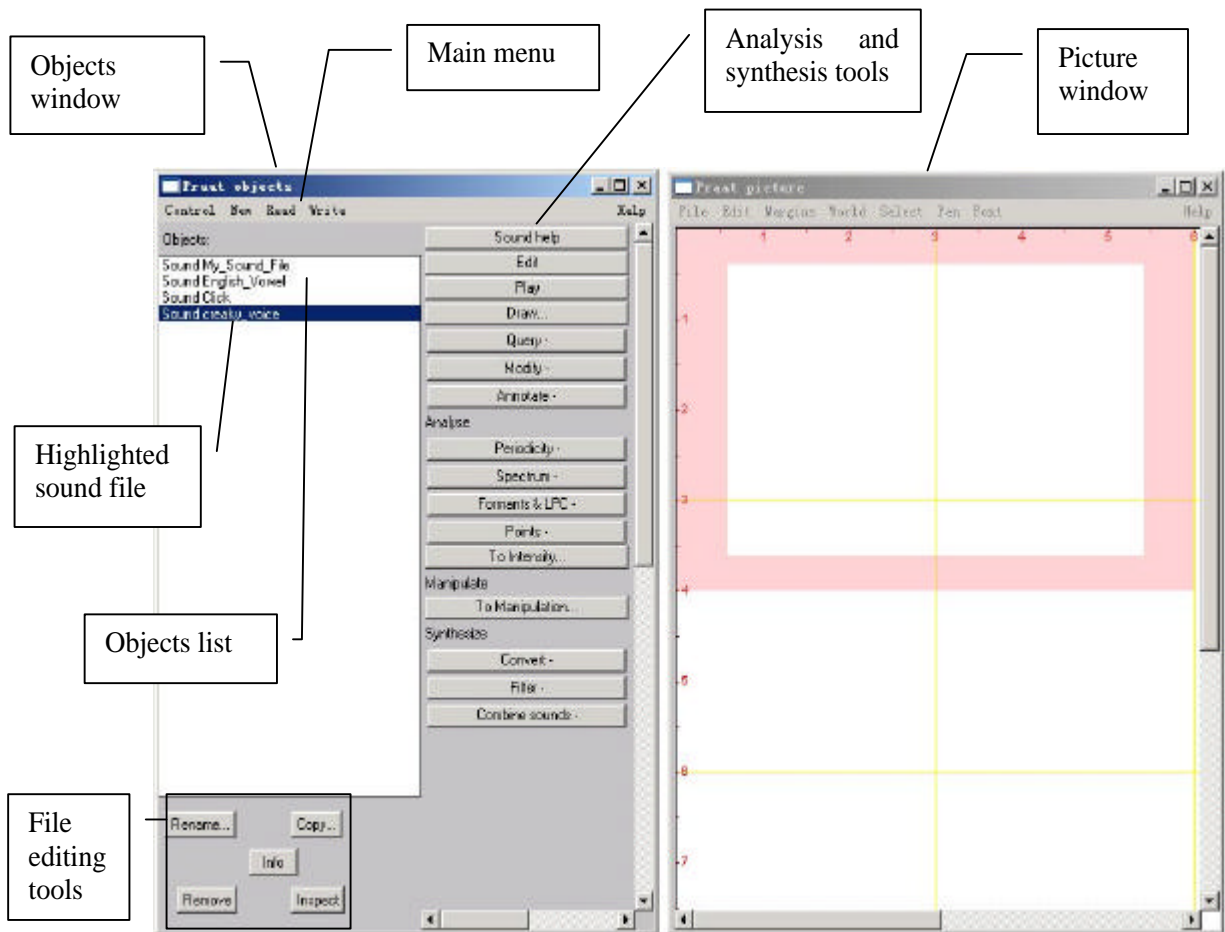


Figure 1.2 Praat layout

TIP The tools you see in the Analysis and Synthesis Tool Panel (see Fig. 1.2 above) are specific to the highlighted object(s) in the list. For example, the tools that are listed for a sound object are different from that for a Textgrid object¹. When you first open Praat, there will be nothing in your object list. As a result, nothing will show up in your Analysis and Synthesis Tool Panel.

3. Record the sentence: “My name is [first-name] [last-name]”
 - o In the main menu of the Objects window (see Fig. 1.2):
 - o **New > Record mono Sound** (sampling rate: 44 100 Hz) (Fig. 1.3)
 - o Make sure the volume bar is fluctuating as you record – if it isn’t, you’re not recording; if you don’t see the volume bar at all, you’re not speaking loudly enough.
 - o Watch out for clipping (Fig. 1.4): if your recording level is too high and you go into the red on the volume bar, you’ll end up with what is called a “clipped” signal – this is very bad for speech analysis!
 - o Give the recording a name (in the box below “Save to list”)
 - o Save to list

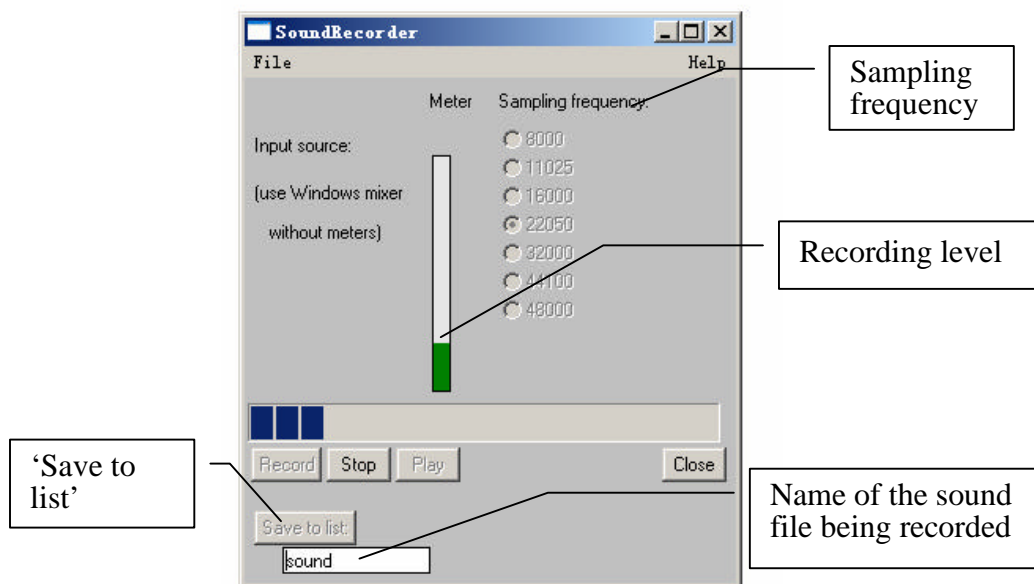
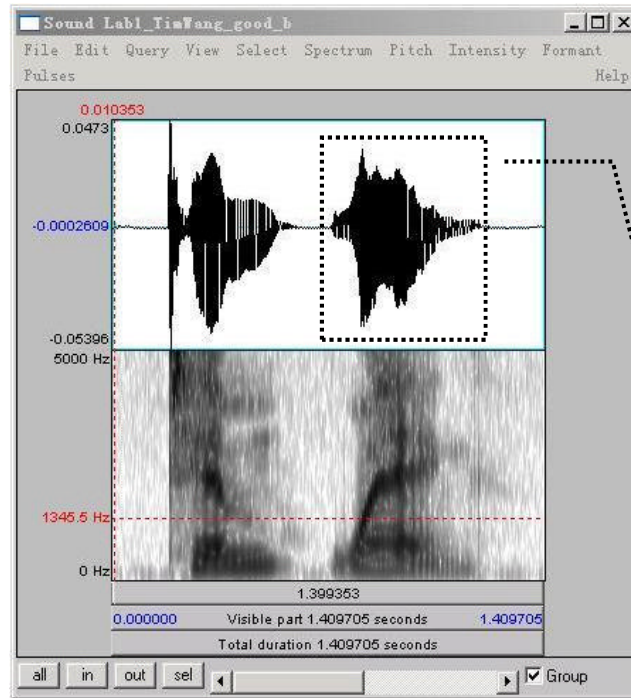


Figure 1.3 Recording a mono Sound

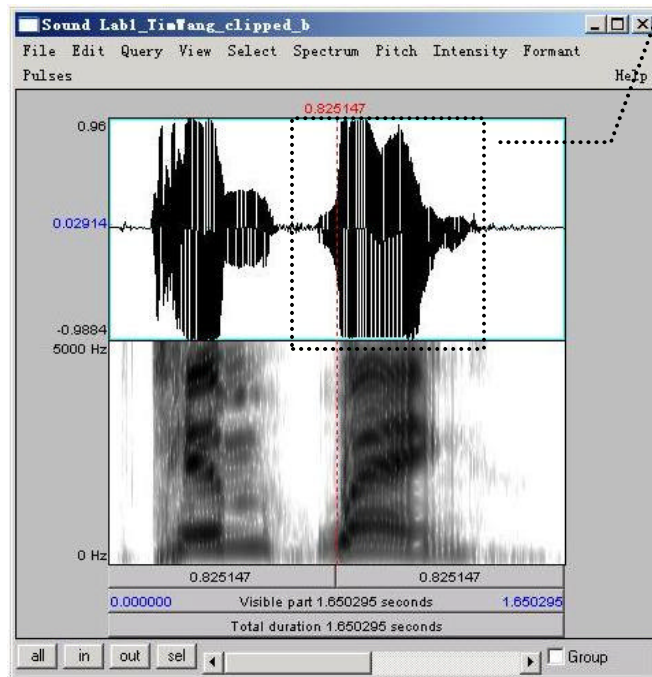
¹ What is a Textgrid object? See step 8 below.

LAB 1 – EXPLORING PRAAT



Good Recording

Compare the waveform in these two cases. The one in the clipped recording has a square-like form.



Clipped Recording

Figure 1.4 Clipped signal

4. Open the sound file in the Edit window:

- o In the Objects window (see Fig. 1.2), highlight the sound file you've just recorded.
- o Click **Edit** on the “**Analysis and synthesis tools**” panel (see Fig. 1.2).

When you first open a sound file in the Edit window, it may seem a bit of a mess. You can see blue vertical lines in the waveform, and lines of red dots and a blue line in the spectrogram (see Fig. 1.5). You can tidy up the visual display by doing the following: in the menu of the Edit window:

- o **Pulses > Show pulses** (click on this to unselect it)
- o **Formants > Show formants** (click on this to unselect it)
- o **Pitch > Show pitch** (click on this to unselect it)

Two things are being displayed now in the Edit window: the **waveform** on the upper level and the **spectrogram** on the lower level.

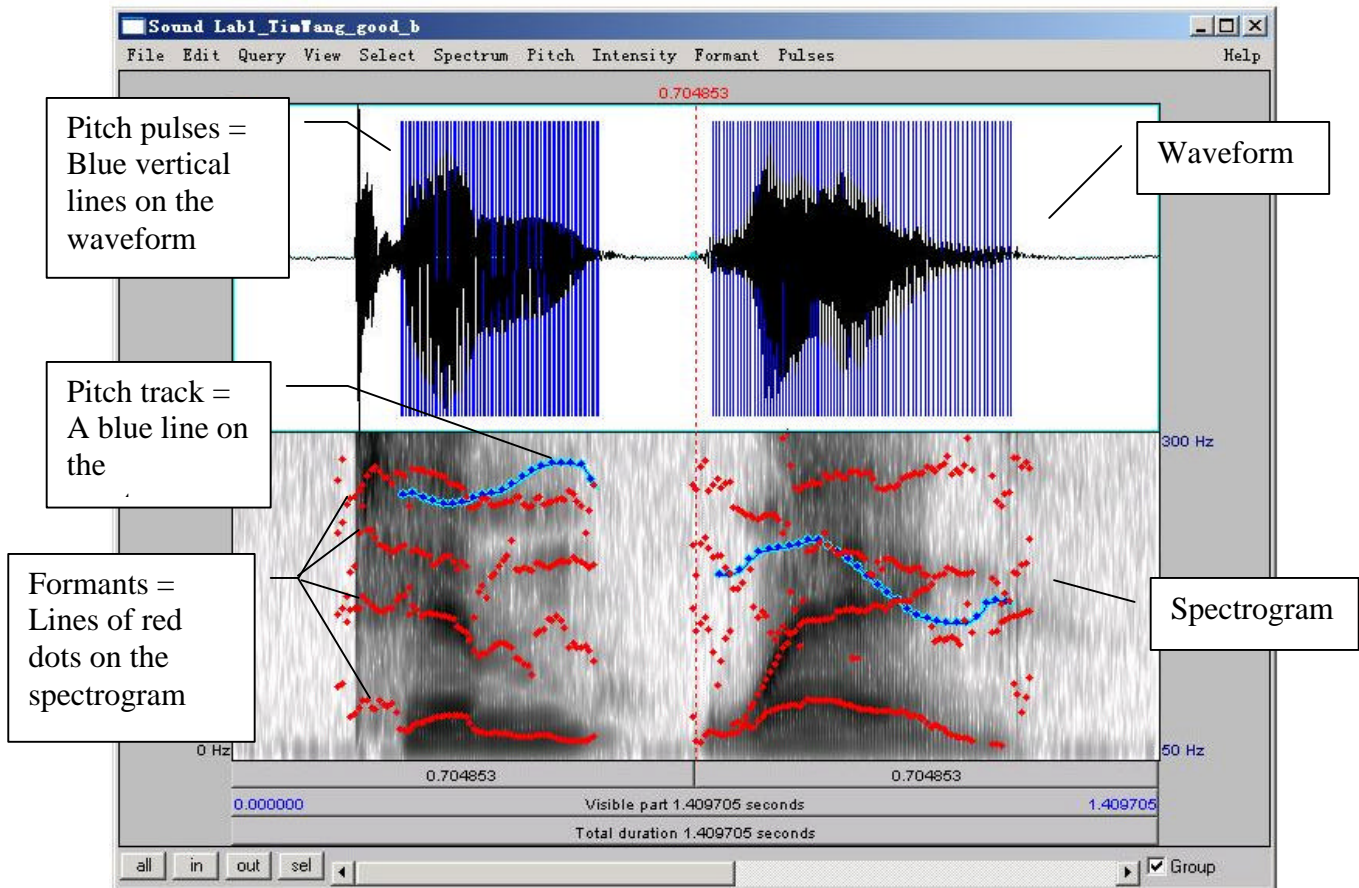


Figure 1.5 A crowded edit window

TIP Here are some common manipulations you will find useful:

Selecting a portion of the sound file and measure the duration of the portion

- o To select a portion of the sound file, place the cursor on the starting point on the waveform or spectrogram and drag the mouse over the portion you are interested in.
- o The number in black at the top and bottom of the display indicates the duration of the selection. The two red numbers on each side of the selection (on the top only) indicate the starting and ending time of the selection (see Fig.1.6).

Zooming into a portion of the sound file

- o To zoom into a specific portion of the sound file, select it first and click “sel” in the zoom options panel (see Fig. 1.6).
- o You can also use the “in” and “out” buttons in the zoom options panel to zoom in or zoom out within the sound file. This will zoom the file around the center point of the window display, regardless of where your cursor is.

Listening to a sound file

- o In the Edit Window, you can listen to the sound file or a portion thereof by clicking on one of the panels at the bottom of the display (Fig. 1.6).

5. Extract [first-name last-name]

- o Select the portion that corresponds only to your first and last name (see Fig. 1.6)
- o **File > Extract Selection** (The extracted selection will show up as a entry (‘sound untitled’) in the Praat objects window)
- o Close Edit window

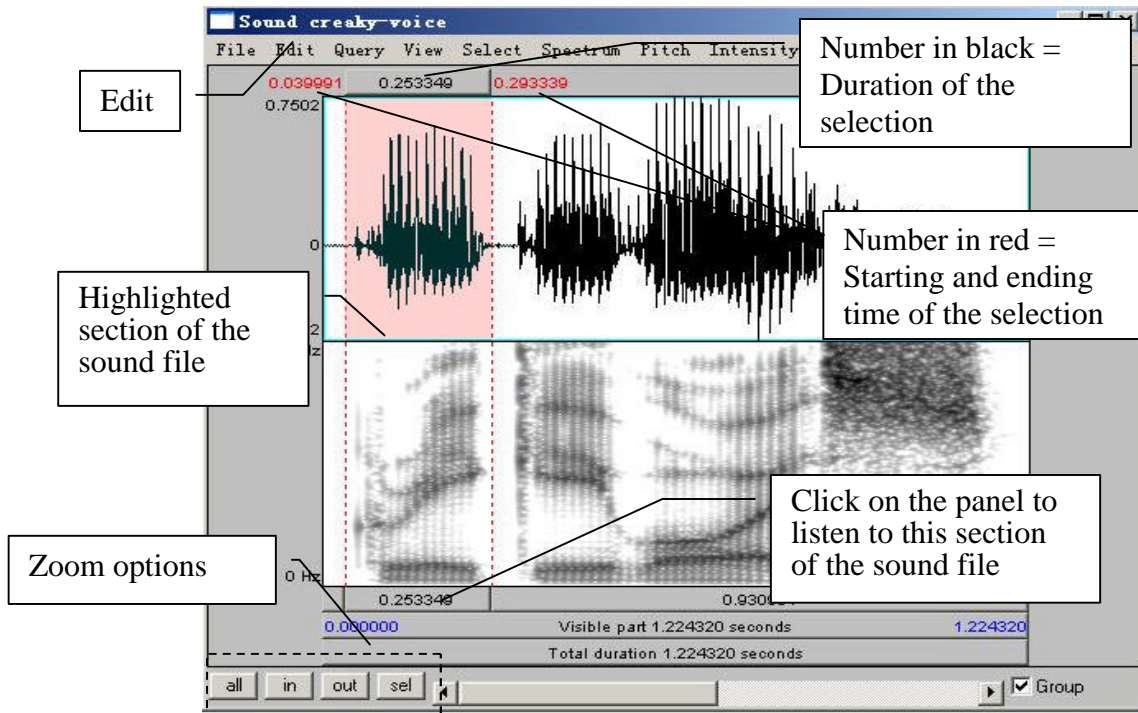


Figure 1.6 Editing a sound file

6. Rename the extracted file ('sound untitled' in the Praat objects window)
 - o In the Objects window, highlight 'sound untitled'
 - o Click **Rename** below the object list

Q1: What information should you include when giving your sound file a name?

7. Save the new sound file on the desktop:
 - o Highlight the file in the object list
 - o **Write > Write to WAV file...** (this is the most widely acceptable extension)
 - o Select the desktop as the save-to location
8. Create a textgrid

Textgrids let you label or annotate the spectrogram (and sound file) – they are particularly helpful for acoustic analysis, to keep track of where you've taken measurements, etc.

- o In the Praat Objects window, highlight the newly renamed file (see step 6)
- o **Annotate > To TextGrid...** (see Fig. 1.7)
- o Create two tiers (this will be enough for our purposes): All Tier names: **word segment**²

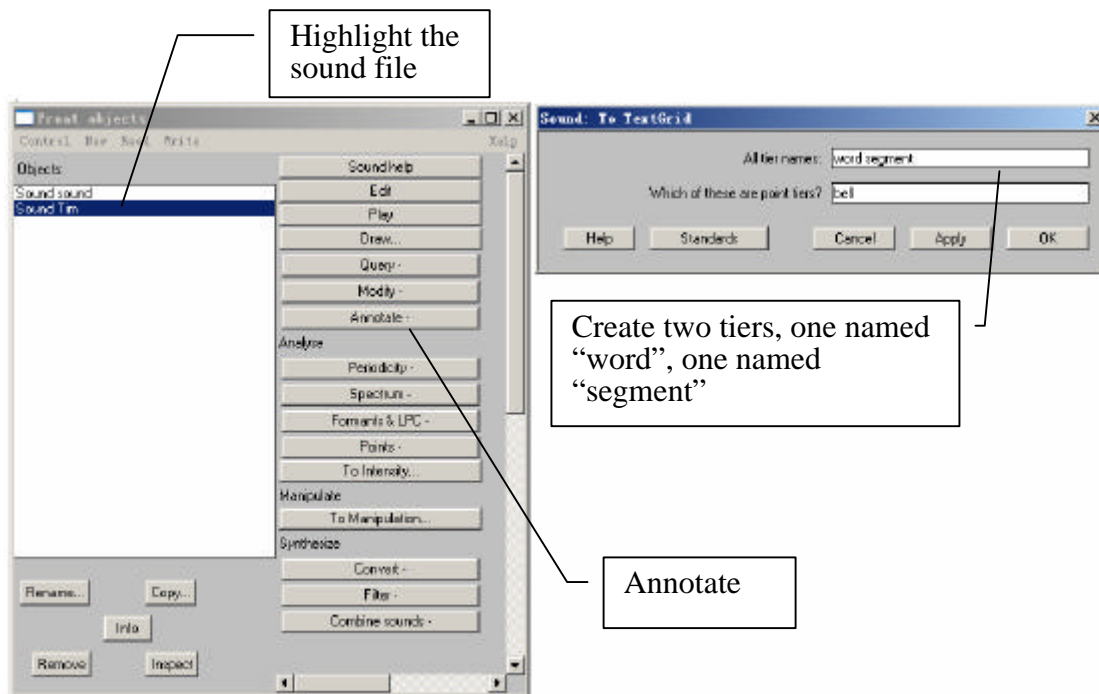


Figure 1.7 Creating a textgrid

² This creates 2 tiers, one with the name of 'word' and the other with the name of 'segment'. Ignore the second line in the TextGrid naming window "Which of these are point tiers". This is irrelevant at the present stage.

9. Open the sound file and textgrid together: (see Fig. 1.8)

In order to segment and/or label a sound file, you have to open the sound file TOGETHER with its textgrid file.

- o Hold down Ctrl and click on each file to highlight them both
- o **Edit**

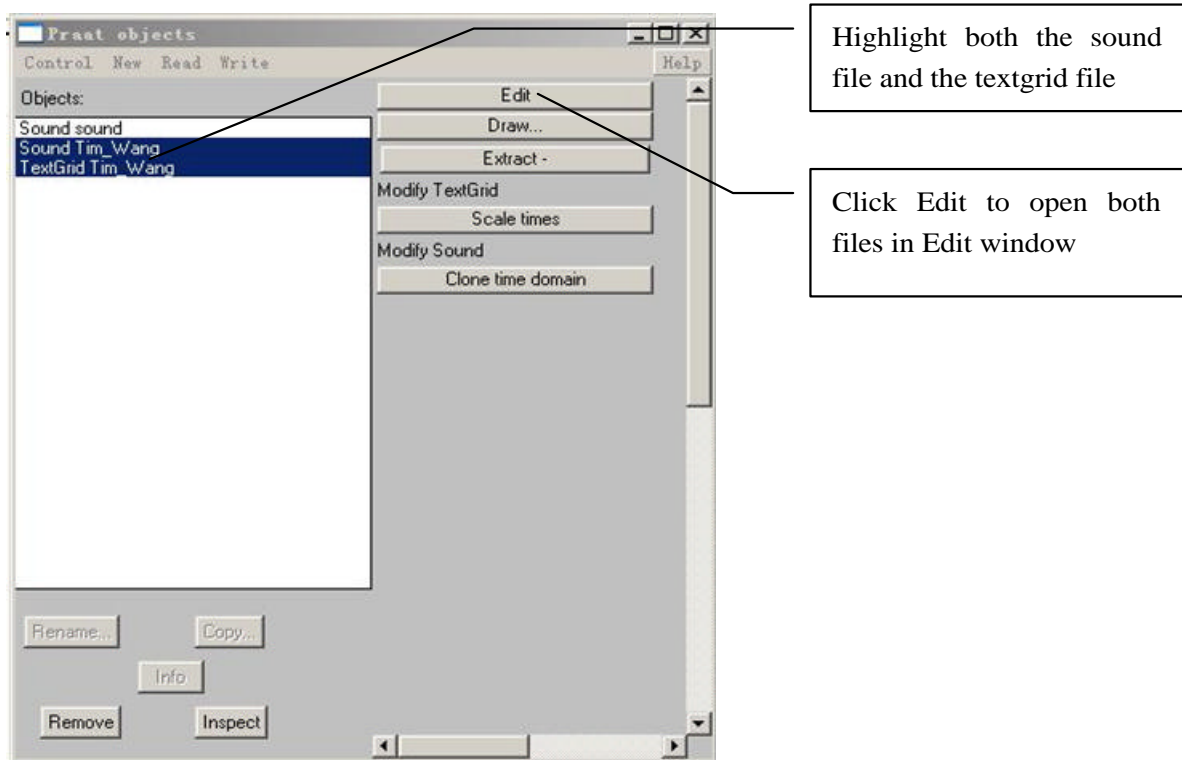


Figure 1.8 Opening a textgrid file with its corresponding sound file

In your display you should now see the waveform (top), the spectrogram (middle) and the textgrid (bottom) corresponding to your sound file (see Fig. 1.9). We will talk about waveforms and spectrograms in detail later on.

10. Segment the file (see Fig. 1.9)

In the sound file, identify your first name and last name. Use the following steps to segment each:

- o To find each name on the spectrogram, listen to the sound file and look at the spectrogram – these should give you hints as to where each name starts and ends. It may help to zoom into small chunks of the sound file and listen those.
- o Place the cursor at the beginning of the name on the spectrogram/waveform (not on the Textgrid tier). A boundary line will show up.
- o Click in the little circle at the top of the word tier in the Textgrid to create a boundary (Fig.1.9).

- o To remove a boundary that you have made,
 - o Highlight the boundary
 - o Go to **Boundary > Remove** OR click Alt+backspace
- o To move a boundary,
 - o Highlight the boundary by clicking on it (it should go red) and drag it.

11. Label the intervals (see Fig. 1.9)

- o Select/highlight the target interval by clicking between two boundaries, the selected interval should go yellow.
- o To input or change the text in an interval, edit in the Textbox above the spectrogram (See Fig 1.9).
- o Give each interval you create a name ([first name] or [last name])

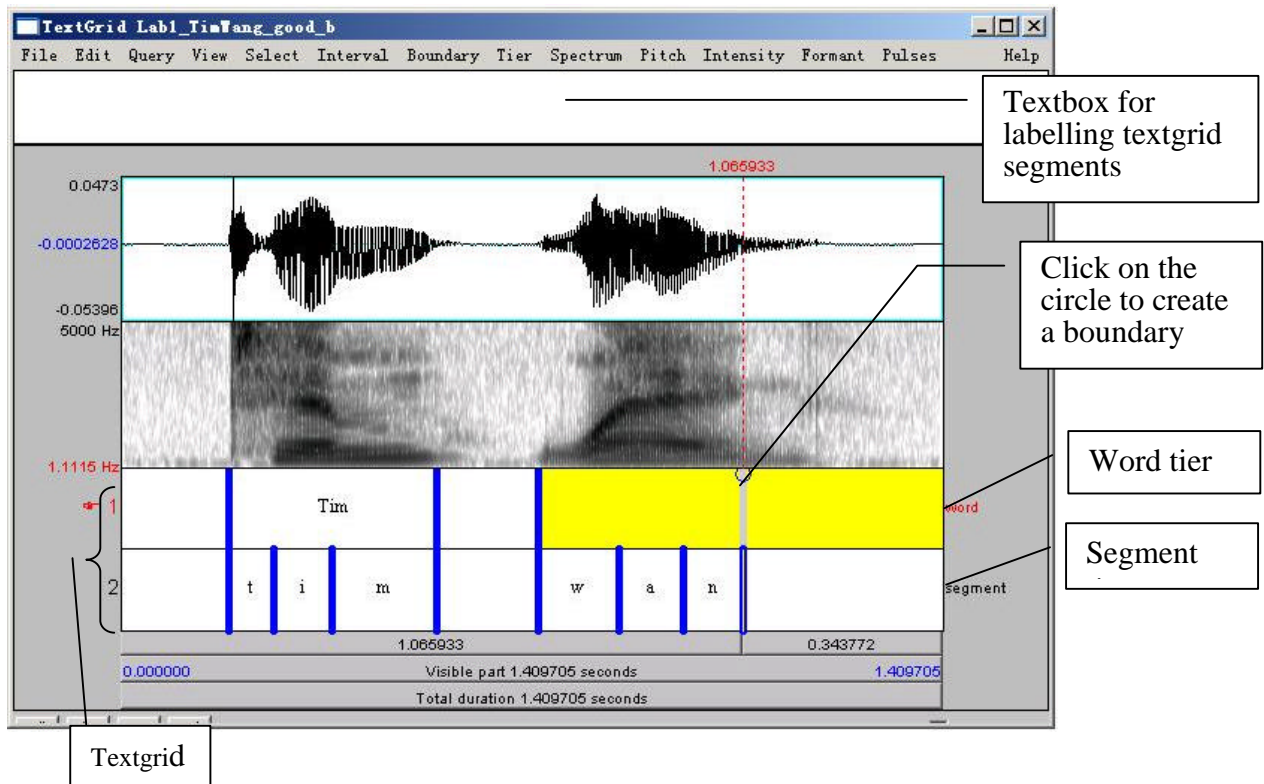


Figure 1.9 Segmenting and labeling

12. Follow steps (10) and (11) to segment your [first name + last name] into segments.

- TIP** To use phonetic symbols in your segment tiers,
- o In the TextGrid editing window, go to **Help > Phonetic symbols**
 - o From here you can see what keystrokes you need to create special fonts (using them is not recommended because they end up looking a bit wonky...)

Q2: How can you tell where one word ends and another word begins?

Q3: Do you notice any patterns in terms of how different sounds look visually, on either the waveform or the spectrogram?

- a. Which sounds have the highest amplitude and how can you tell?
- b. How do sounds of different sonority (e.g. stop vs. fricative) look on the spectrogram?

13. Save your textgrid onto the desktop:

- o **File > Write TextGrid to textfile...**

14. Export your labeled waveform and spectrogram to Word (see Fig. 1.10):

- o Maximize the Edit window: click on the little square at the top right of your Edit window
- o Hit **PrtSc** (“Print Screen”) on your keyboard³. Nothing would happen on your screen at this point.
- o Open Word, and provide a prose introduction to the image you are about to paste in: e.g. “Figure 1 is a waveform and spectrogram of my name”
- o Hit **Ctrl+V** to paste the Praat image into your word document.
- o Give your Figure a number and title below the image (see Fig. 1.10)

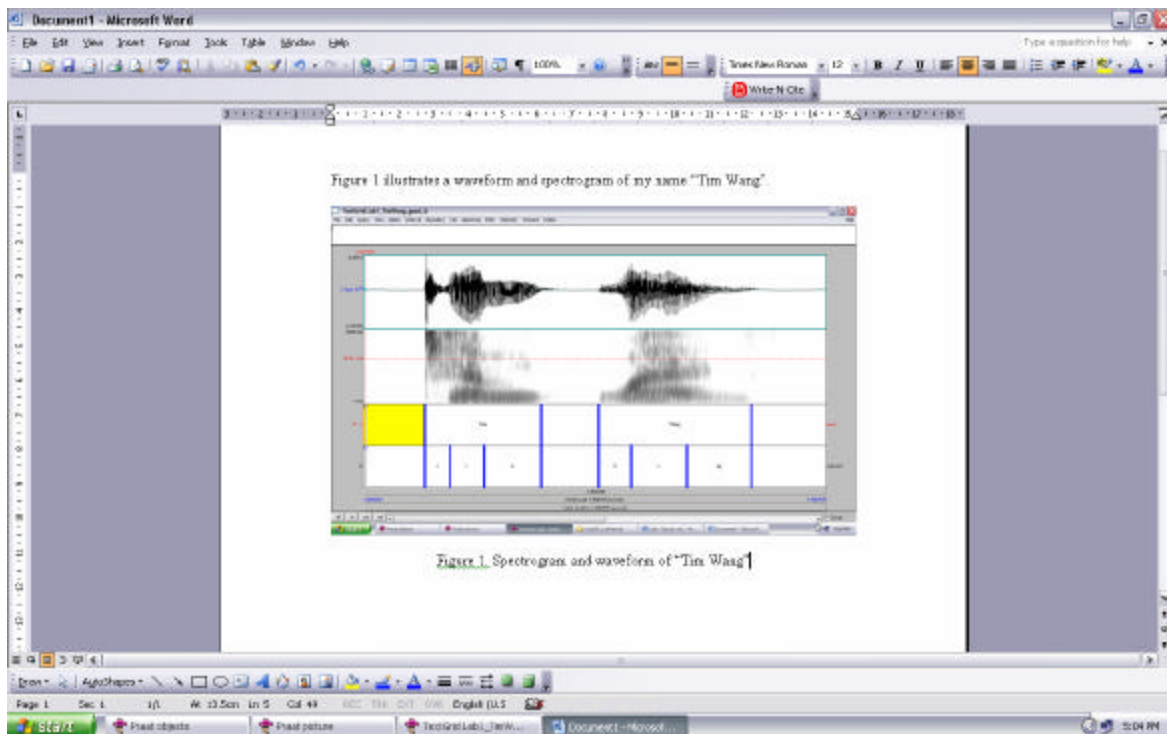


Figure 1.10 Example of Word output

³ Note: this works on a PC. On a MAC: command-shift-3. By doing this, you are actually copying what you see on the screen to a clipboard, although it seems that nothing has happened.

15. Save the file: you must print it out and bring it to the next class.

If you complete all of these steps, you should end up with a word file with an image of the labeled waveform/spectrogram corresponding to your name, as in Fig. 1.10. You can save this file, and your Praat files (sound and textgrid) by e-mailing them to yourself or copying them onto a flash drive (memory stick).

You must hand in your worksheet at the end of the lab.

LAB 1 – EXPLORING PRAAT – WORKSHEET

Don't forget – You must hand in the word document you created in the next class.

Q1: What information should you include when giving your sound file a name?

Q2: How can you tell where one word ends and another word begins?

Q3: Do you notice any patterns in terms of how different sounds look visually, on either the waveform or the spectrogram?

- a. Which sounds have the highest amplitude and how can you tell?
- b. How do sounds of different sonority (e.g. stop vs. fricative) look on the spectrogram?

**LAB 2 – THE SOURCE-FILTER MODEL OF SPEECH:
FUNDAMENTAL FREQUENCY, HARMONICS AND FORMANTS**

GOAL OF LAB 2

The goal of this lab is to explore the basic acoustic components of (sonorous) speech sounds: FUNDAMENTAL FREQUENCY, HARMONICS, and FORMANTS. These components create the acoustic signal associated with speech – understanding them is crucial to understanding what we actually hear, when we hear speech.

RECORDING

- Record yourself saying the vowel [æ] at three different pitches: low, mid, high – try to get the biggest range in pitch you can ((if you can't remember how to do this, refer to LAB1, p.2)
- Open the recording in Praat's Edit window

IMPORTANT NOTES

- Use the worksheet to note down all measurements, and to answer the questions asked throughout the lab.
- Do not use decimals for any of your measurements (good: 90 Hz; bad: 90.75 Hz)

SECTION I. FUNDAMENTAL FREQUENCY (F_0) OR PITCH

1. Measure the fundamental frequency (pitch) in the middle of each [æ] using the three techniques below and fill out Table 2.1.

Q1: Which method do you prefer and why?

Three ways to measure fundamental frequency:

- a. By displaying the pitch track and having Praat measure the pitch automatically (see Fig. 2.1):
 - Display the pitch track: **Pitch > Show pitch**
 - Place your cursor in the middle, stable portion of the vowel
 - Go to **Pitch > Get pitch**: a box will appear with the pitch value in it.

TIP If the blue pitch contour (blue line) doesn't appear clearly, it is because Praat's default pitch range is not appropriate for the file you're listening to:

- go to **Pitch > Pitch settings...**
- adjust the pitch range so you can see the pitch contour clearly:
 - If you have a very high voice you may need to adjust the range upwards.
 - If you have a very low voice you may need to adjust the range downwards.

LAB 2 – THE SOURCE-FILTER MODEL OF SPEECH

b. By displaying the pitch track and measuring pitch manually (see Fig. 2.1):

- Display the pitch track: **Pitch > Show pitch**
- Click on the blue pitch track in the middle of the vowel
- A red horizontal bar should appear, with the pitch value (in dark blue) on the right side of the window.

TIP The Fundamental frequency value is always displayed on the right side of the window in dark blue; formant frequencies are displayed on the left side in red – be careful not to get these two confused!

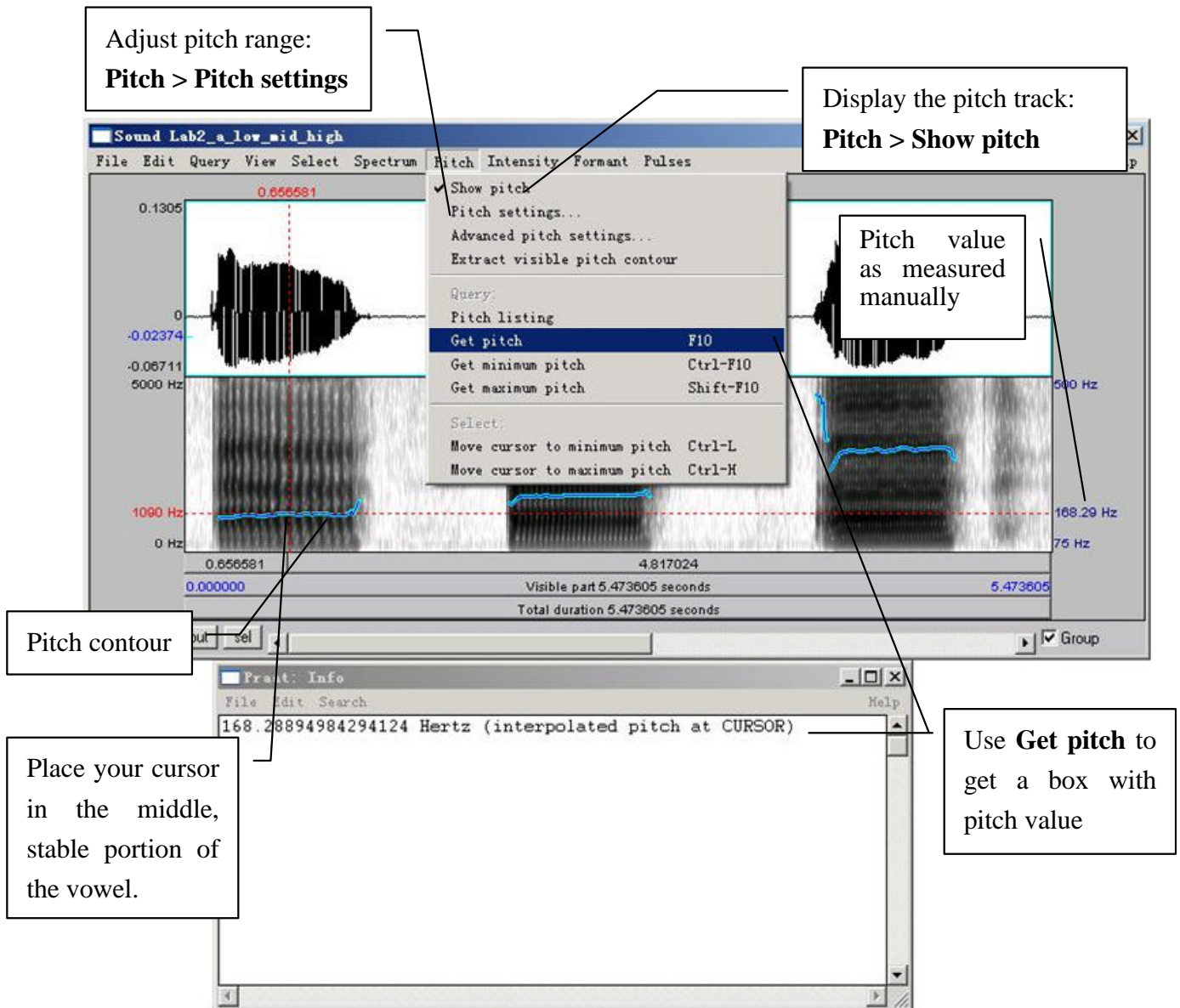


Figure 2.1 Getting a pitch value in Praat

- c. By looking at the waveform (top of the display) (see Fig. 2.2)
 - o Zoom into a small piece of the waveform in the middle of the vowel and measure the period by highlighting one complete cycle and noting the time associated with it (in the panel above the waveform)
 - o To get the frequency (**f**) from the period (**T**): $f = 1/T$

TIP If you zoom in enough, the panel above the waveform will include both the period and the frequency (in parentheses), so you don't have to do any calculations.

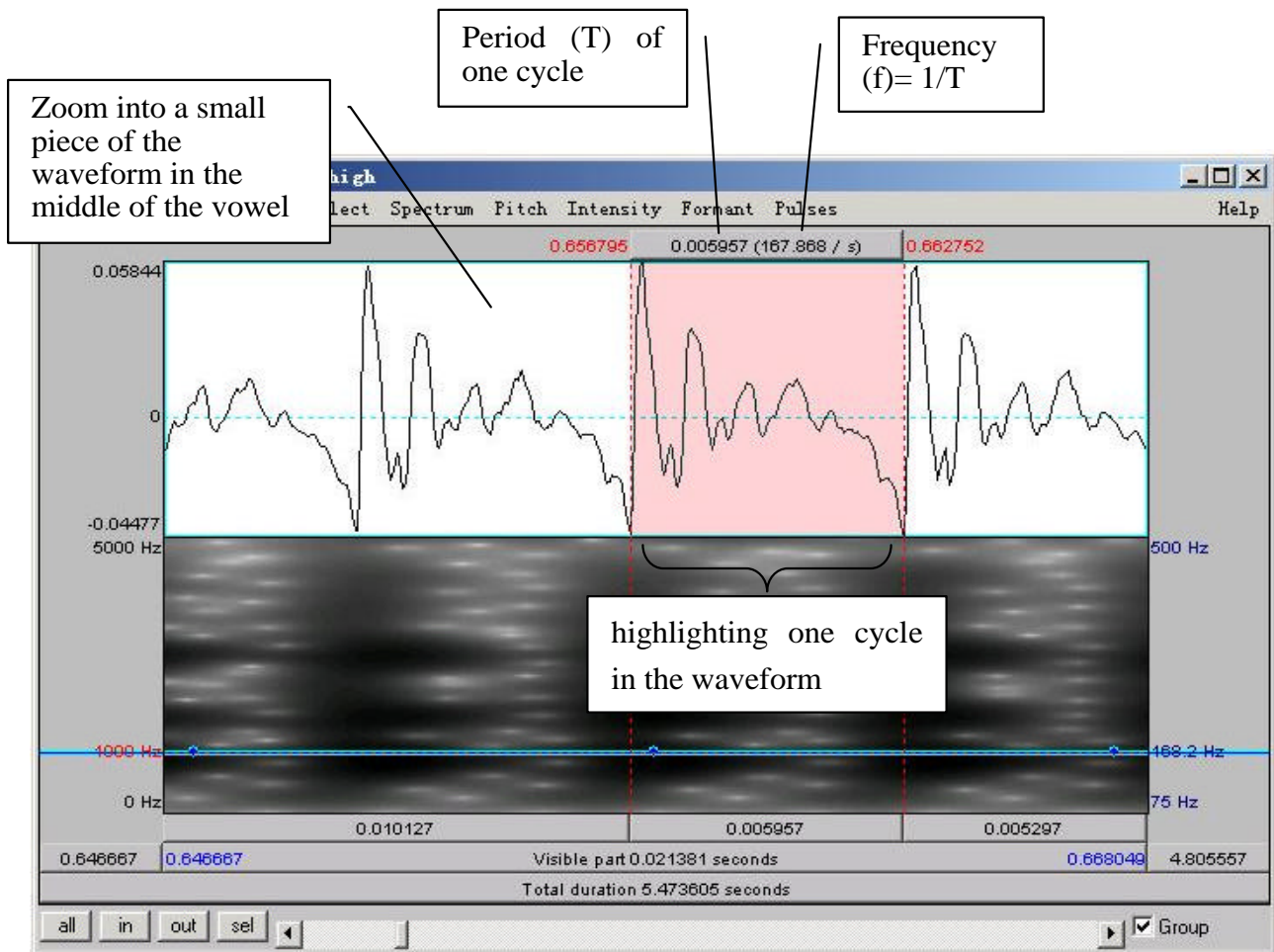


Figure 2.2 Calculating pitch by waveform

SECTION II. HARMONICS

When our vocal folds vibrate, the result is a complex wave, consisting of the fundamental frequency (which you just measured) plus other higher frequencies, called HARMONICS. To see these, we need to look at a NARROW-BAND spectrogram, which is more precise along the frequency domain than the default WIDE-BAND spectrogram.

2. Display a narrow-band spectrogram:

- o Go to: **Spectrum > Spectrogram settings...** (see Fig. 2.3)
- o Change the window length to 0.025s (see Fig. 2.3)
(The default is window length is 0.005s, which displays a wide-band spectrogram)

→ This changes the spectrogram dramatically!

Q2: What is the tradeoff that is apparent when comparing a wide-band to a narrow-band spectrogram?

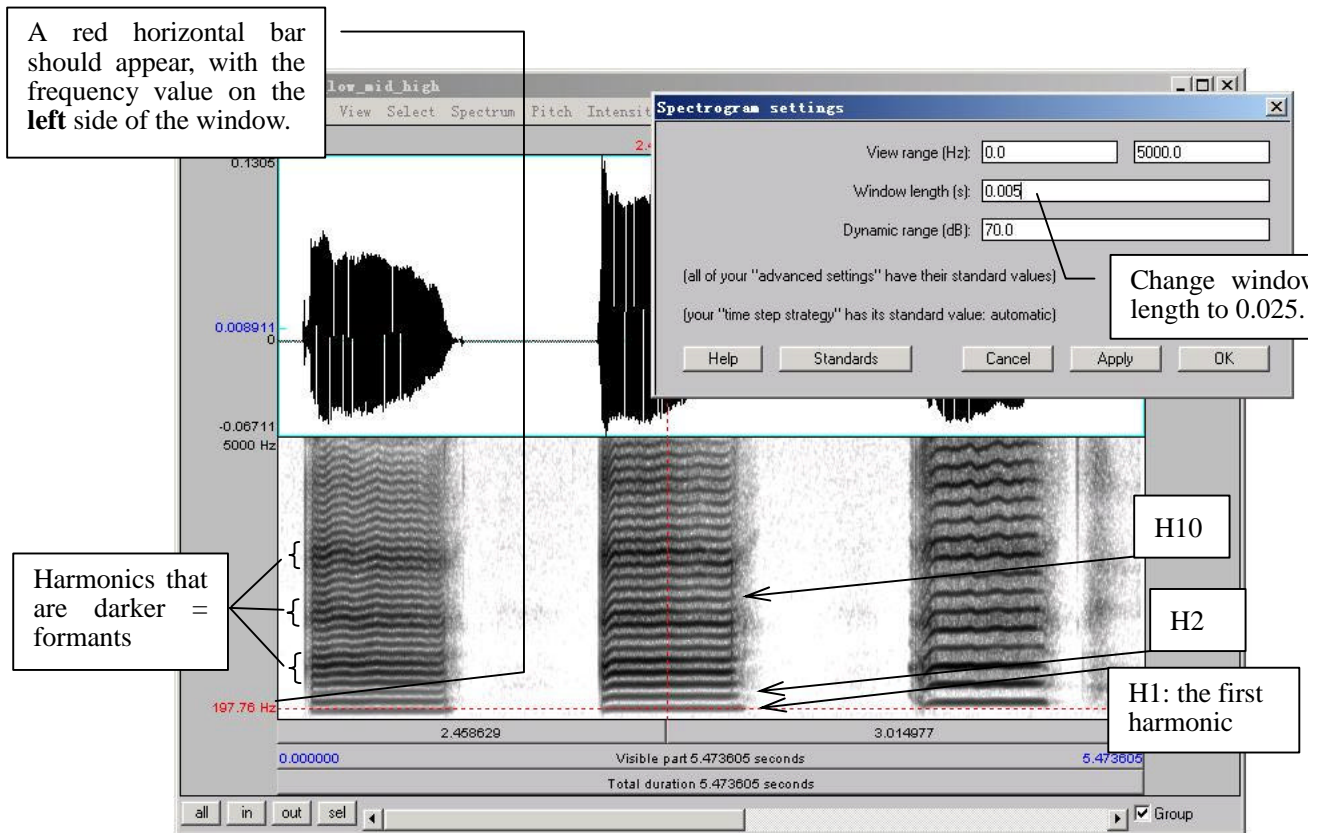


Figure 2.3 Harmonics

3. Looking at each [æ], notice the grey horizontal bands: these correspond to harmonics (see Fig. 2.3). For each [æ], measure the frequency of the first 3 harmonics (H1-H3), plus of the 10th harmonic (H10). Use Table 2.2 to note down your measurements.
 - Click on the centre (horizontally) of each harmonic, in the centre (vertically) of each [æ]
 - A red horizontal bar should appear, with the frequency value on the left side of the window, in red.

Q3: Compare the frequency of H1 with the fundamental frequencies measured in 1 above. Based on this comparison, what does the first harmonic (H1) correspond to?

TIP If you have a very low voice, the first dark line you see may be H2, instead of H1. Ask your instructor if you are not sure.

Q4: What is the relationship between the first and subsequent harmonics? (the relationship should be the same across [æ]s)

TIP Keep in mind there will be measurement error here, so various relationships may not be as clear as they would be in an ideal world...

SECTION III. FORMANTS

Looking at the narrow-band spectrogram, you should notice that some harmonics are darker than others (see Fig. 2.3). Darkness corresponds to loudness, i.e. the darkest harmonics are the ones that are the most amplified. These amplified harmonics form the FORMANTS that are characteristic of sonorant speech sounds.

4. Now, go back to the wide-band spectrogram:
 - Go to: **Spectrum > Spectrogram settings...**
 - Change the window length back to 0.005 ms (the default)

You will see that the formants appear on the wide-band spectrogram as thick dark bands.

5. Measure the first and second formants (F1 and F2) in the middle of each [æ] using the three techniques outlined below and note down your measurements in Table 2.3.

Q5: Which method do you prefer and why?

Three ways to measure formants:

- a. By displaying the formants (red dots) and having Praat measure the frequency of each one automatically (see Fig. 2.4):

LAB 2 – THE SOURCE-FILTER MODEL OF SPEECH

- Display the formant track: **Formant > Show formants**
 - Place your cursor in the middle, stable portion of the vowel
 - Go to **Formant > Formant listing**: a box will appear with the time point at which the measurement was taken, and the first four formants (F1 and F2 are the important ones now).
- b. By displaying the formants and measuring the frequency of each one manually:
- Display the pitch track: **Formant > Show formants**
 - Place your cursor in the center of each formant, in the middle of the vowel
 - A red horizontal bar should appear, with the frequency value on the left side of the window, in red (see Fig. 2.4).
- c. By measuring the frequency without displaying Praat's formants – this is sometimes easiest if Praat's formant tracking goes wonky.
- Get rid of Praat's formant tracking: **Formant > Show formants** (unclick)
 - Place your cursor in the center of each formant, in the middle of the vowel
 - A red horizontal bar should appear, with the frequency value on the left side of the window, in red.

Q6: Would you say the formant frequencies are the same or different across [æ]s?
 (Be sure to take measurement error into account when answering this question.)

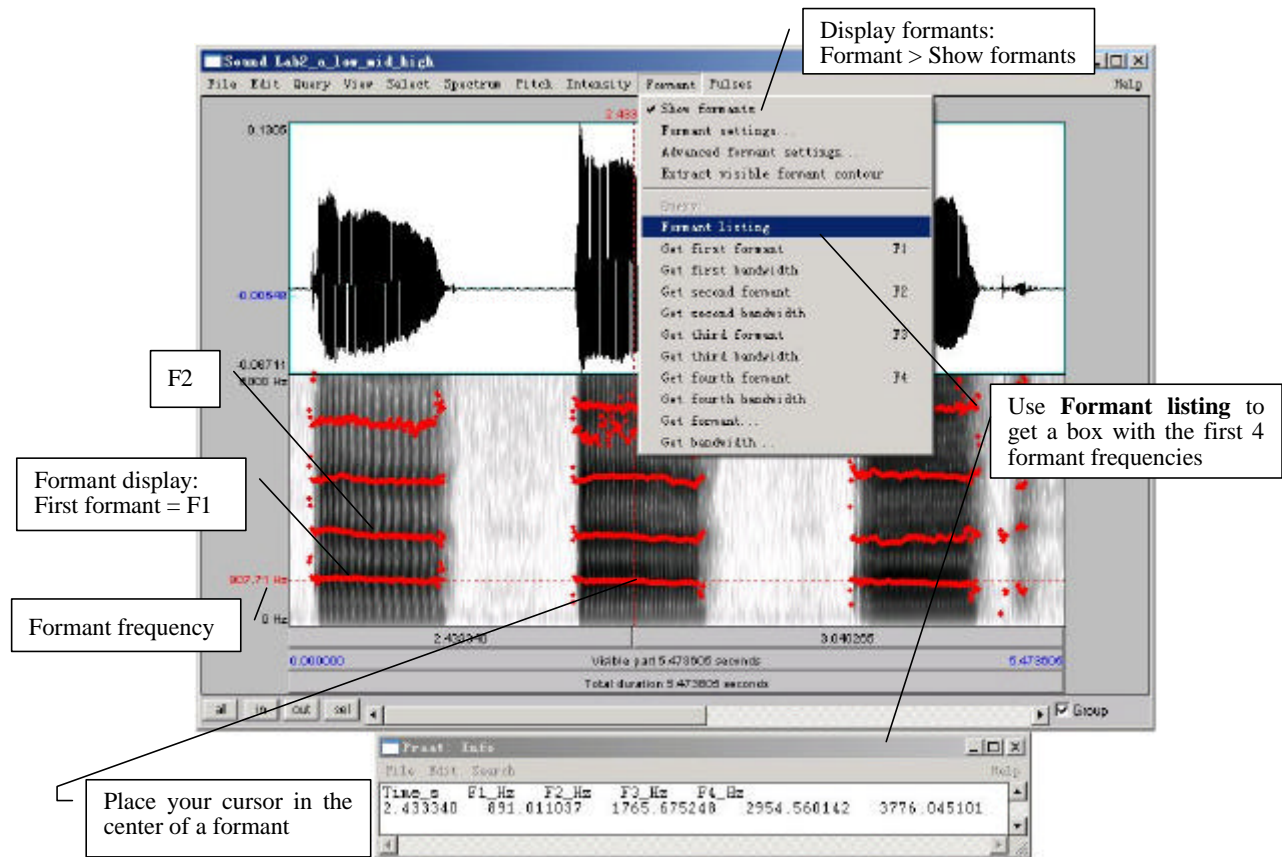


Figure 2.4 Formants

SECTION IV. THE RELATIONSHIP BETWEEN HARMONICS AND FORMANTS

The relationship between the harmonics and the formants is captured in the SOURCE-FILTER MODEL of speech production. In this last section of the lab, think about what the source and filter might be in this model.

- Go back to the narrow-band spectrogram (refer back to Section II, p.15).
 - Get rid of the pitch contour: **Pitch > Show pitch** (unclick)
6. What is the ordinal number of the harmonic (H2, H5, H8, etc.) that is at the centre of the first formant, for each [æ]? Use Table 2.4 to note down your answer.

Q7: Does the harmonic you noted Table 2.4 have the same number across [æ]s?

Q8: What explanation is there for the pattern observed in Tables 2.3 and 2.4: why would the harmonic number be different across [æ]s (Table 2.4), but the frequency of this harmonic (approximately = F1) be (approximately) the same across [æ]s (Table 2.3)?

⇒ To answer this question, think about what creates harmonics vs. formants...

LAB 2 – THE SOURCE-FILTER MODEL OF SPEECH – WORKSHEET

SECTION I. FUNDAMENTAL FREQUENCY (F₀) OR PITCH

Table 2.1 Fundamental frequency measurements

<i>Recording</i>	Pitch contour (automatic)	Pitch contour (manual)	Waveform (one cycle)
[æ] low pitch			
[æ] mid pitch			
[æ] high pitch			

Q1: Which method do you prefer and why?

SECTION II. HARMONICS

Q2: What is the tradeoff that is apparent when comparing a wide-band to a narrow-band spectrogram?

Table 2.2 Harmonics measurements

[æ] pitch	H1	H2	H3	H10
Low				
Mid				
High				

Q3: Compare the frequency of H1 with the fundamental frequencies measured in 1 above. Based on this comparison, what does the first harmonic (H1) correspond to?

Q4: What is the relationship between the first and subsequent harmonics? (the relationship should be the same across [æ]s)

SECTION III. FORMANTS

Table 2.3 Formants measurements

<i>Recording</i>	With formant tracking (automatic)	With formant tracking (manual)	Without formant tracking (manual)
[æ] low pitch	F1: F2:	F1: F2:	F1: F2:
[æ] mid pitch	F1: F2:	F1: F2:	F1: F2:
[æ] high pitch	F1: F2:	F1: F2:	F1: F2:

Q5: Which method do you prefer and why?

Q6: Would you say the formant frequencies are the same or different across [æ]s? (Be sure to take measurement error into account when answering this question.)

SECTION IV. THE RELATIONSHIP BETWEEN HARMONICS AND FORMANTS

Table 2.4

<i>Recording</i>	Number of the harmonic corresponding to first dark band in narrow-band spectrogram (e.g. H1, H4)
[æ] low pitch	
[æ] mid pitch	
[æ] high pitch	

LAB 2 – THE SOURCE-FILTER MODEL OF SPEECH

Q7: What is the ordinal number of the harmonic (H2, H5, H8, etc.) that is at the centre of the first formant, for each [æ]? Does this harmonic have the same number across [æ]s? Use Table 2.4 to note down your answer.

Q8: What explanation is there for the pattern observed in Tables 2.3 and 2.4: why would the harmonic number be different across [æ]s (Table 2.4), but the frequency of this harmonic be (approximately) the same across [æ]s (Table 2.3)?

⇒ To answer this question, think about what creates harmonics vs. formants...

LAB 3 – VOWEL PROPERTIES

GOAL OF LAB 3

In this lab, we are going to explore vowel properties: INTRINSIC PITCH and SPECTRAL MAKE-UP (FORMANT STRUCTURE).

RECORDING

- o Record yourself saying the words beat, bit, bait, bet, bat, boat, but, boot (see LAB1, p.2)

Take a quick look at your vowels in the Edit window, and make sure you can clearly see the vowel formants (see LAB1 on formant display, p.4). If you have trouble seeing them, you can download the file LAB3_EnglishVowels.wav and take your measurements on this file. If you do this, please make a note of it on your worksheet.

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
 - o Follow the instructions on the webpage to download Lab3_EnglishVowels.wav onto the desktop.
1. Which vowels are contained in these words? Fill in the appropriate IPA symbols on the top row in Tables 3.1, 3.2 and 3.3 and the bottom line of Figure 3.3 on the worksheet.

Q1: In this lab, you should take all of your measurements in approximately the same spot: what spot is this and why?

SECTION I. INTRINSIC PITCH

2. Measure the pitch (F_0) in each of the vowels (see LAB2, p.12). If your pitch values seem strange, try using another measurement method as confirmation (the waveform, using the pitch contour). Remember that measuring off the waveform is the safest, since it avoids counting on Praat's automated pitch tracker. Note down your measurements in Table 3.1:
3. You can also confirm your pitch measurement by looking at the spectral slice, which gives the component frequencies and their amplitudes (see Fig. 3.1).
 - o Select a portion of the vowel (70-80ms)
 - o **Spectrum > View spectral slice**
 - o Click on the first (big) peak = $H_1 = F_0$ (Ignore any small spikes at the beginning, this might just be noise.)
 - o Note down the frequency of this peak (at the top of the vertical bar)
4. Use the confirmed pitch values from Table 3.1 and plot the pitch of each vowel on Figure 3.3 on your answer sheet, Make sure you label your y-axis, using a scale that allows you to spread out your measurements as much as you can.

LAB 3 – VOWEL PROPERTIES

Q2: Is pitch the same across all vowels? Do you notice any patterns with it?

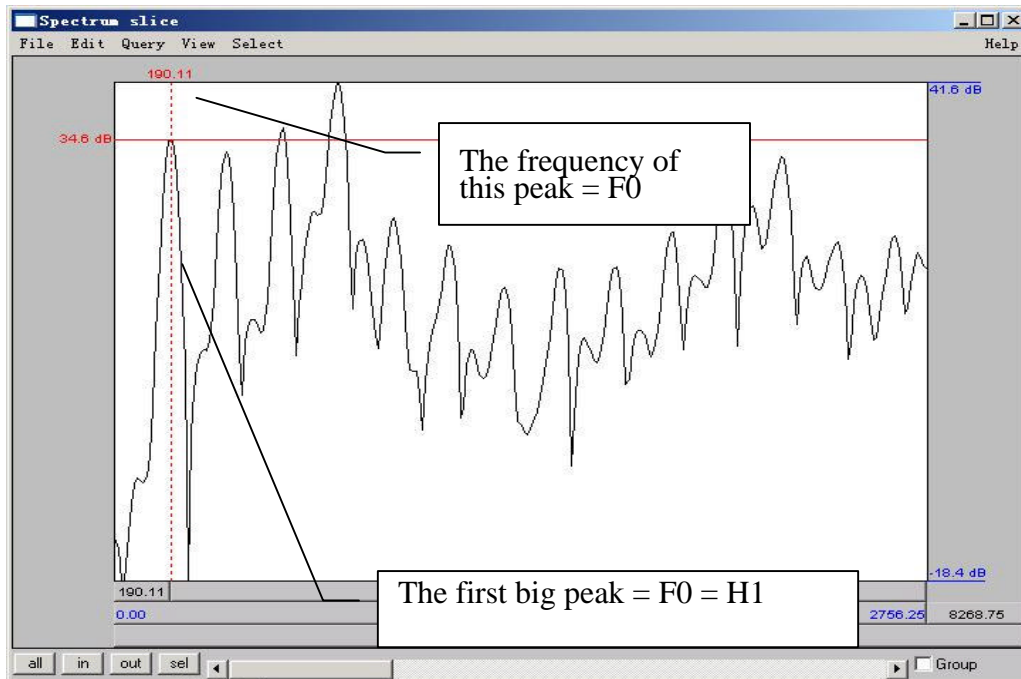
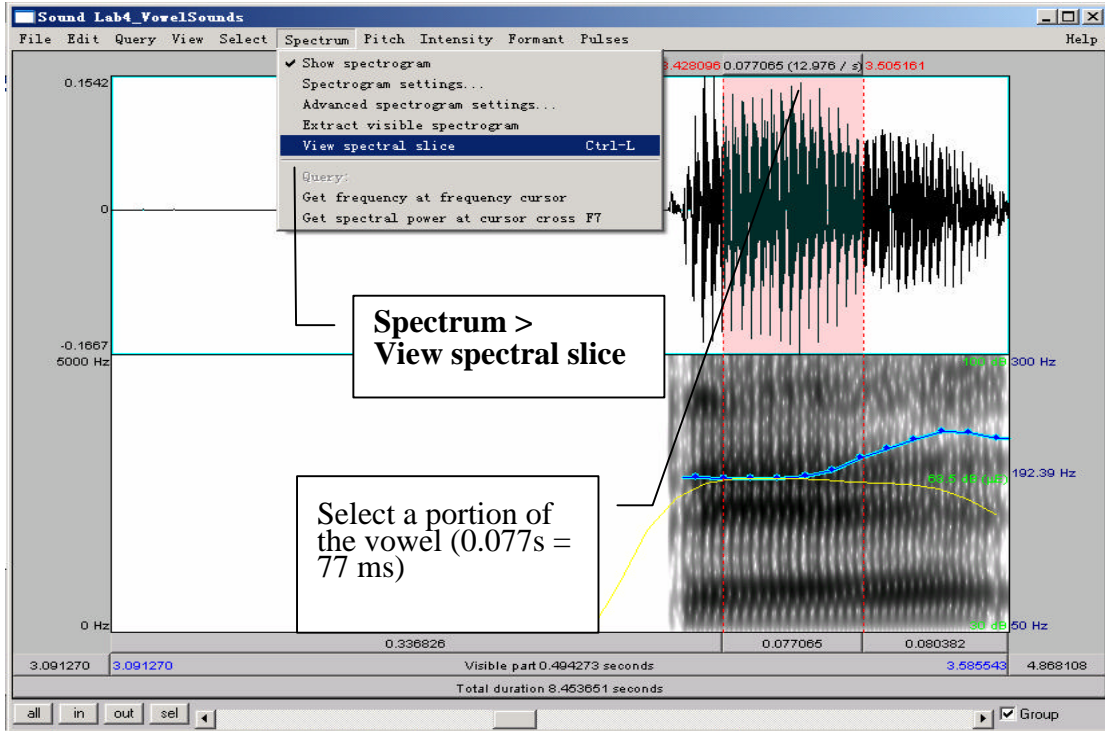


Figure 3.1 Using a spectral slice to measure F0

SECTION II. SPECTRAL MAKE-UP (FORMANT VALUES)

5. On the default wide-band spectrogram, measure the first and second formants (F1 and F2) of each vowel (see LAB2, p.16). Enter the obtained values in Table3.2, and use them for plotting your vowel space in Figure 3.4 on the worksheet

- TIP** 1. You can use Praat’s automatic Formant tracking to help you if you want, just remember to use your judgment: trust yourself more than you trust Praat!
2. It’s not always easy locating formants. Don’t get discouraged, just do the best you can!

Q3: Look at the formants values associated with different vowels:

- Why do formants differ across vowels?
- What does F1 seem to correspond to, in terms of articulation?
- What about F2?

Now go to a narrow-band spectrogram (see LAB2, p.15)

6. Optional step, for extra practice with harmonics: Count up from H1 (the first dark band on the spectrogram, see LAB2 if you can’t remember how to do this, p.15) and note down in Table 3.3 which harmonic contributes most to F1 and F2 for each vowel (see Fig. 3.2a or see LAB2, p.18). You can use formant track if it helps you to identify F1 and F2.
7. Also optional: Confirm your answer by looking at the spectral slice (see Fig. 3.2b):
- o Select approximately 70-80ms in the middle portion of each vowel
 - o **Spectrum > View spectral slice**
 - o Zoom in a bit on the spectral slice
 - o Select the target portion of the spectral slice
 - o On the Zoom panel: Sel
 - o Locate the approximate frequency of F1 (or F2). You can do this in two ways:
 - o By moving the cursor around until you find the right frequency value at the top of the window, *or*
 - o By using the Select menu in the spectrum slice window
 - o Go to Select > Move cursor to...
 - o Input the value of F1 (or F2) measured in (5) above; The cursor will automatically move to the right location
 - o Identify the harmonic that corresponds most closely to F1 (or F2).

LAB 3 – VOWEL PROPERTIES

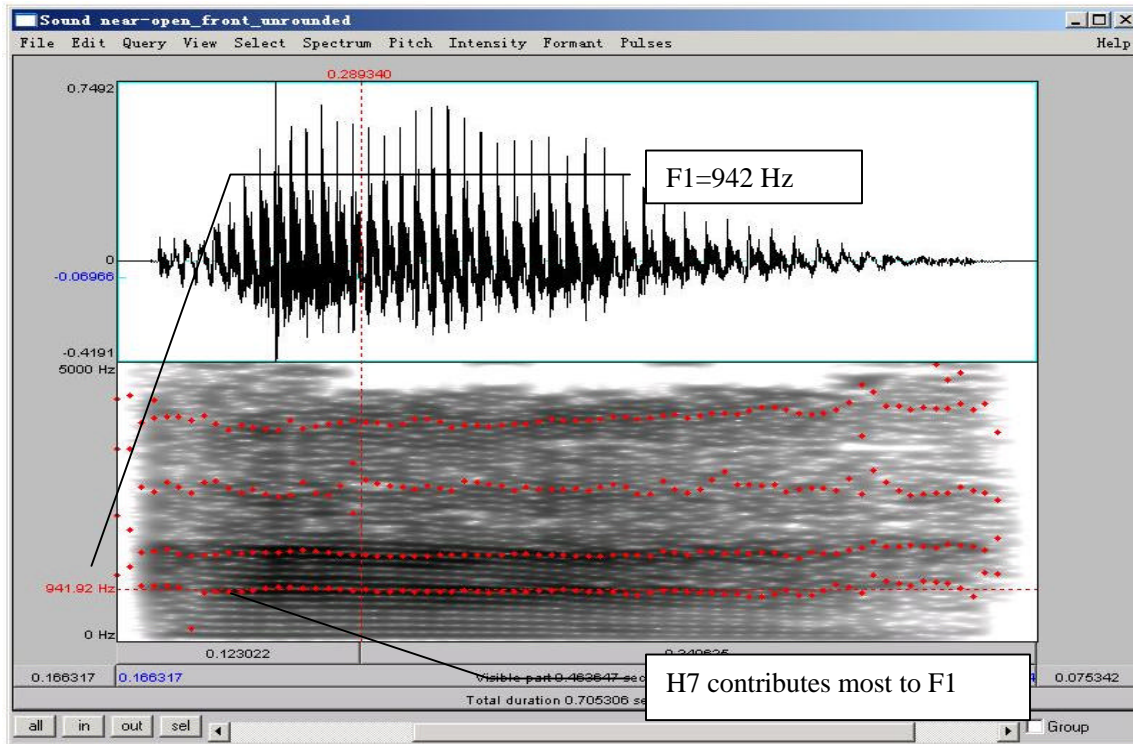


Figure 3.2a. Determining the harmonics in a narrow-band spectrogram

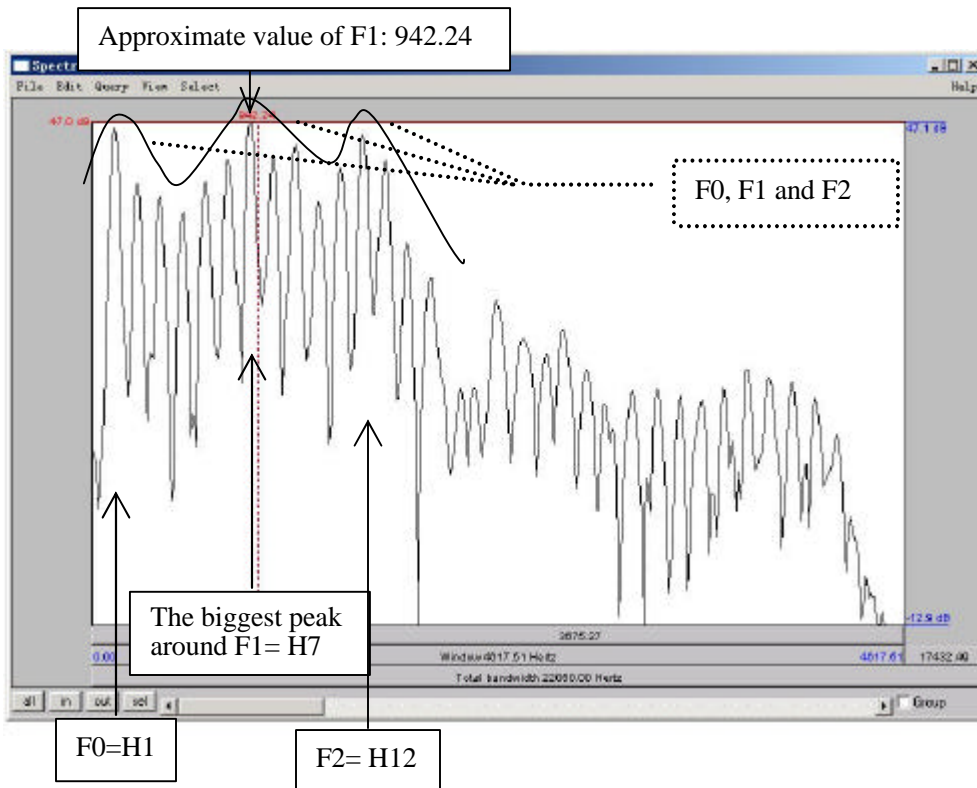


Figure 3.2b. Determining the harmonics by spectral slice

SECTION III. SUMMARY SO FAR

You should now be fairly comfortable with the different displays that are regularly used in acoustic analysis: THE WAVEFORM, THE SPECTROGRAM (wide- vs. narrow-band), and THE SPECTRAL SLICE, plus – OVERLAID ON THE SPECTROGRAM – pitch pulses, fundamental frequency, formant contours, and amplitude (for a more detailed discussion of amplitude, see LAB6, C. ACOUSTIC INTENSITY, p.53).

To be sure you've understood these displays and how to use them, answer the following questions:

Q4: In each of the main displays – waveform, spectrogram, and spectral slice – what is displayed on the horizontal axis and on the vertical axis?

Q5: What display(s) would you use if you're interested measuring acoustically the following phenomena:

- Tonal contrasts in Chinese
- Stress in English
- Co-articulatory effects of consonants on adjacent vowels
- The pronunciation of voiced vs. voiceless stops across languages (e.g. in French vs. English)
- Phrase-final glottalisation (creakiness)

To answer these questions, think about what the acoustic cues are of these phenomena – that will lead you to think about which display best shows these acoustic cues.

Q6: What other phenomena of speech can you think of that you could measure acoustically? Which display would you use to measure these?

LAB 3 – VOWEL PROPERTIES – WORKSHEET

SECTION I. INTRINSIC PITCH

Q1: In this lab, you should take all of your measurements in approximately the same spot: what spot is this and why?

Table 3.1 Intrinsic vowel pitches (F0)

<i>Formant</i>	[]	[]	[]	[]	[]	[]	[]	[]
Waveform								
Pitch contour (manual)								
Spectral slice								

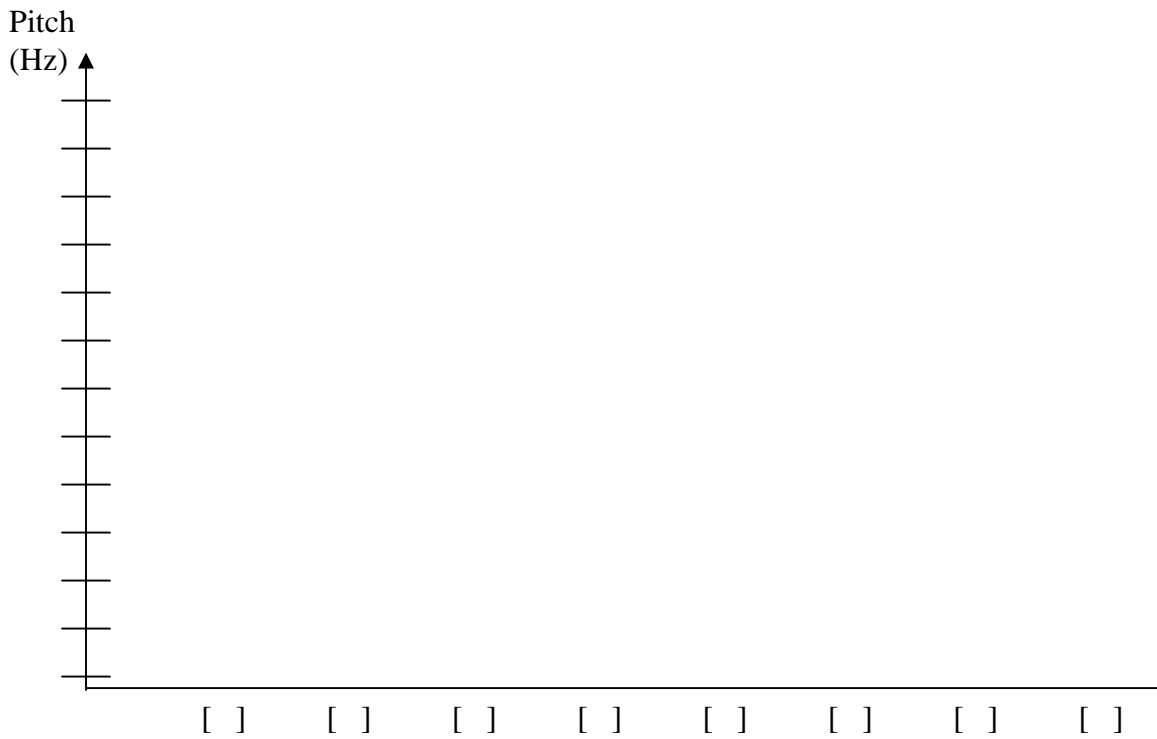


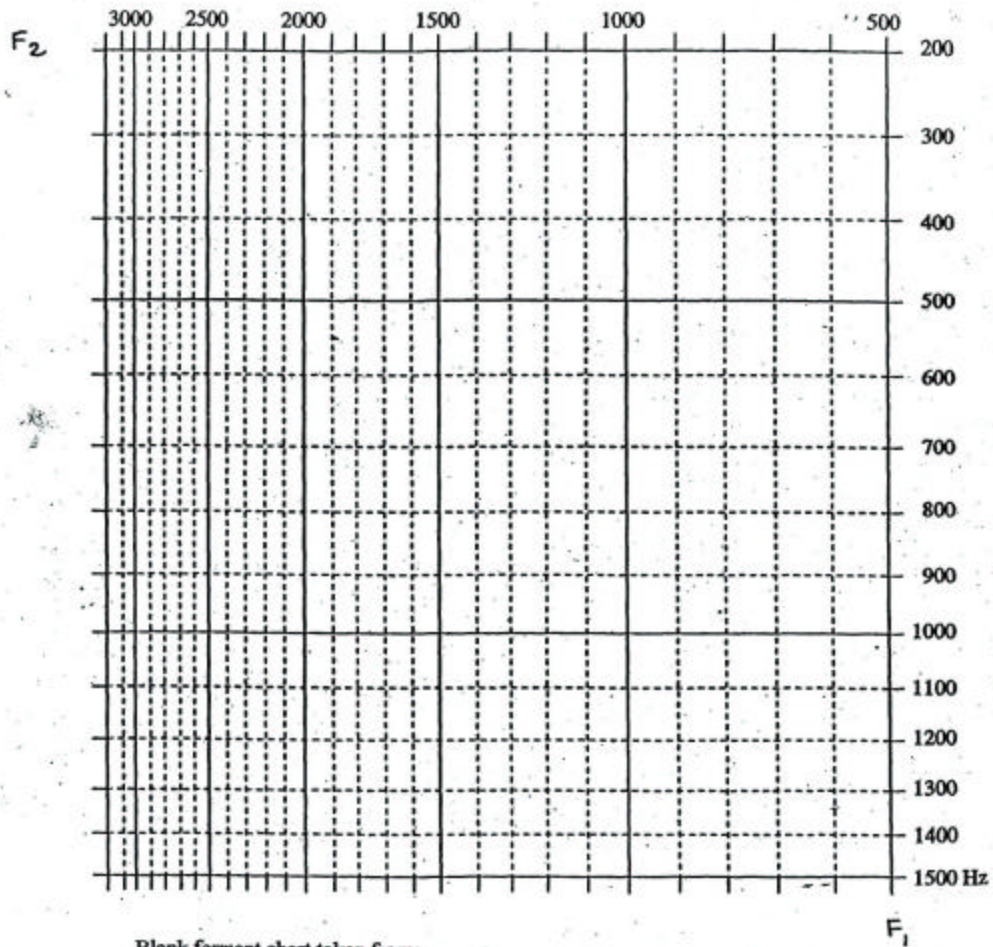
Figure 3.3 Intrinsic vowel pitches.
Please label your y axis with appropriate frequency intervals

Q2: Is pitch the same across all vowels? Do you notice any patterns with it?

SECTION II. SPECTRAL MAKE-UP (FORMANT VALUES)

Table 3.2 Vowel formants

Formant	[]	[]	[]	[]	[]	[]	[]	[]
F1 (Hz)								
F2 (Hz)								



Blank formant chart taken from:
 Ladefoged, P. 2001. *A course in Phonetics, fourth edition*. Boston, MA: Heinle & Heinle.
 p. 178.

Figure 3.4 Plotting your vowel space

LAB 3 – VOWEL PROPERTIES

- Q3: Look at the formants values associated with different vowels:
- Why do formants differ across vowels?
 - What does F1 seem to correspond to, in terms of articulation?
 - What about F2?

Table 3.3 Contributing harmonics to vowel formants

<i>Formant</i>	[]	[]	[]	[]	[]	[]	[]	[]
# of H contributing to F1								
# of H contributing to F2								

SECTION III. SUMMARY SO FAR

Q4: In each of the main displays – waveform, spectrogram, and spectral slice – what is displayed on the horizontal axis and on the vertical axis?

Q5: What display(s) would you use if you're interested measuring acoustically the following phenomena:

- Tonal contrasts in Chinese
- Stress in English
- Co-articulatory effects of consonants on adjacent vowels
- The pronunciation of voiced vs. voiceless stops across languages (e.g. in French vs. English)
- Phrase-final glottalisation (creakiness)

To answer these questions, think about what the acoustic cues are of these phenomena – that will lead you to think about which display best shows these acoustic cues.

Q6: What other phenomena of speech can you think of that you could measure acoustically? Which display would you use to measure these?

LAB 4 – SONORANTS

GOAL OF LAB 4

Sonorants are:

- o similar to vowels in that they have formants
- o different from vowels in that they are generally lower amplitude (and behave as consonants phonologically)

In this lab, we are going to explore the acoustic correlates of different sonorants: NASALS [m n ŋ], GLIDES [w j] and LIQUIDS [l ɹ].

RECORDING

For this lab, you will need to download the following files onto the Desktop:

<i>File name</i>	<i>Sounds included</i>
a_N_a.wav	ama, ana, aŋa
WiJu.wav	wi, ju
Ri_iR.wav	.ii, li, iɹ, il

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
- o Download the sound files: Right click > Save target as...

SECTION I. NASALS

In this section, you should focus on what is common between all three nasals.

- o Open the file **a_N_a.wav**. Follow the instructions below and to fill in Table 1 on the acoustic correlates of different nasals. You don't have to complete both A and B. Choose one to proceed.

A. Nasal formants

If you can't remember how to measure formants, refer back to LAB2 (p.16).

1. In Table 4.1, note down F1, F2 and F3 for each nasal, as measured in the middle of the nasal .

Q1: Look at your measurements of F1, F2 and F3: are there any systematic patterns across nasals? (Relate your answer to Q2 and Q3 below)

- a. Is there one formant with a similar frequency for all places of articulation?
- b. Is there one formant that has a much higher amplitude than the others, across nasals?

B. Spectral slice

2. Create spectral slices for each nasal and for one example of [a] (see LAB3, p.22).

LAB 4 – SONORANTS

3. In Table 4.1, note down the overall shape of the spectrum of each nasal, as well as the shape of [a] (one example of [a] is enough).

Q2: Compare the spectral slices of the nasals vs. [a] – do you see any overall differences between the nasals on the one hand and [a] on the other? (Relate this to your answer to Q1 and Q3)

C. Waveform

4. Nasals have very distinctive waveforms. To see this, zoom in on 10 or so cycles.
5. For each nasal, note down in Table 4.1 the shape of one cycle (see Fig. 4.1). Also note down the shape of one cycle of one example of the vowel [a].

Q3: Do you notice a systematic pattern across nasals, that is missing in [a]? What causes this pattern? (Relate this to Q1 and Q2 above)

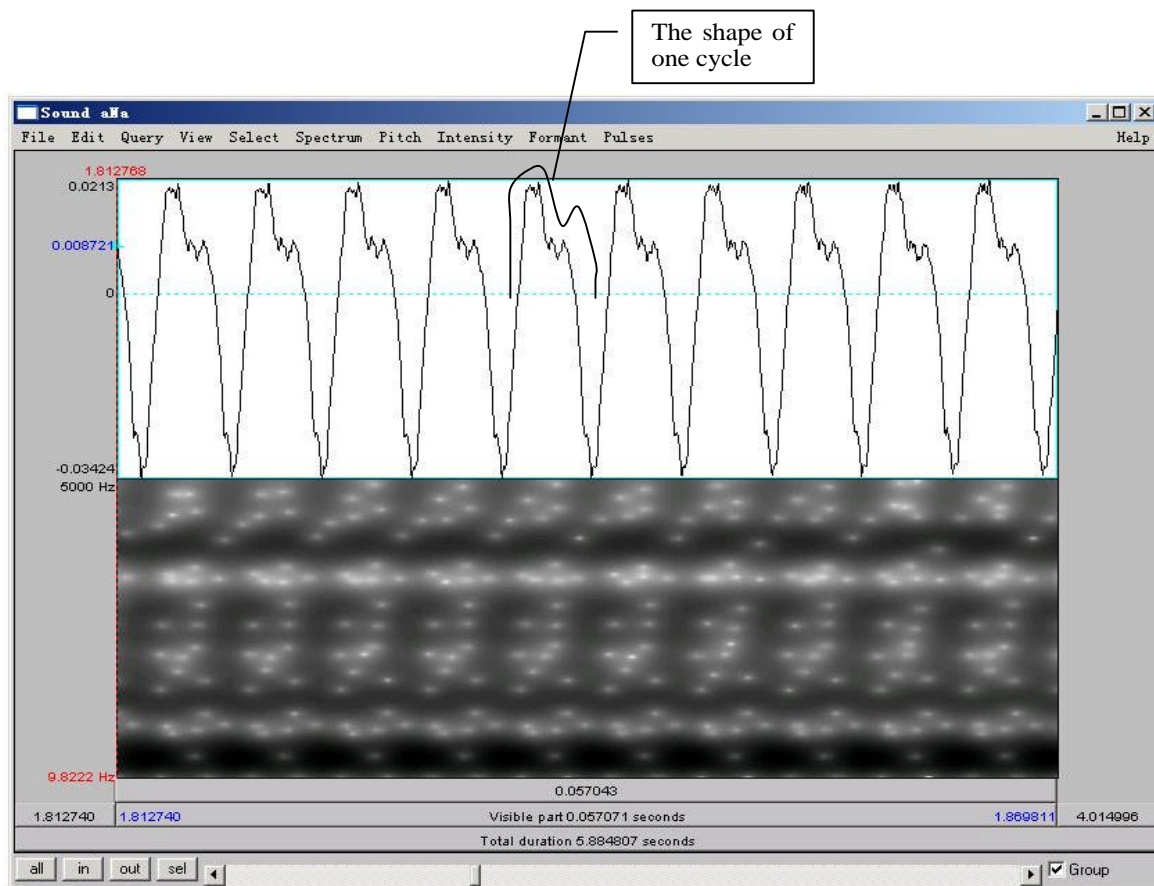


Figure 4.1. Nasal waveform

D. Antiformants

Antiformants are the opposite of formants – they're bands of frequencies that are actively *damped* rather than amplified (we'll talk about this in class). They show up on the spectrogram

as bands of white, i.e. bands of ‘silence’ at particular frequencies (see Fig. 4.2). They can be hard to see, so don’t worry if their measurement seems hard. For finding antiformants, you may find it easier to get rid of the formant tracking.

- Again in Table 4.1, note down the frequency of A1 (Antiformant 1), A2 and A3 for each nasal, as measured in the middle of the nasal.

Q4: Are there any systematic patterns across nasals: is there one antiformant with a similar frequency for all places of articulation?

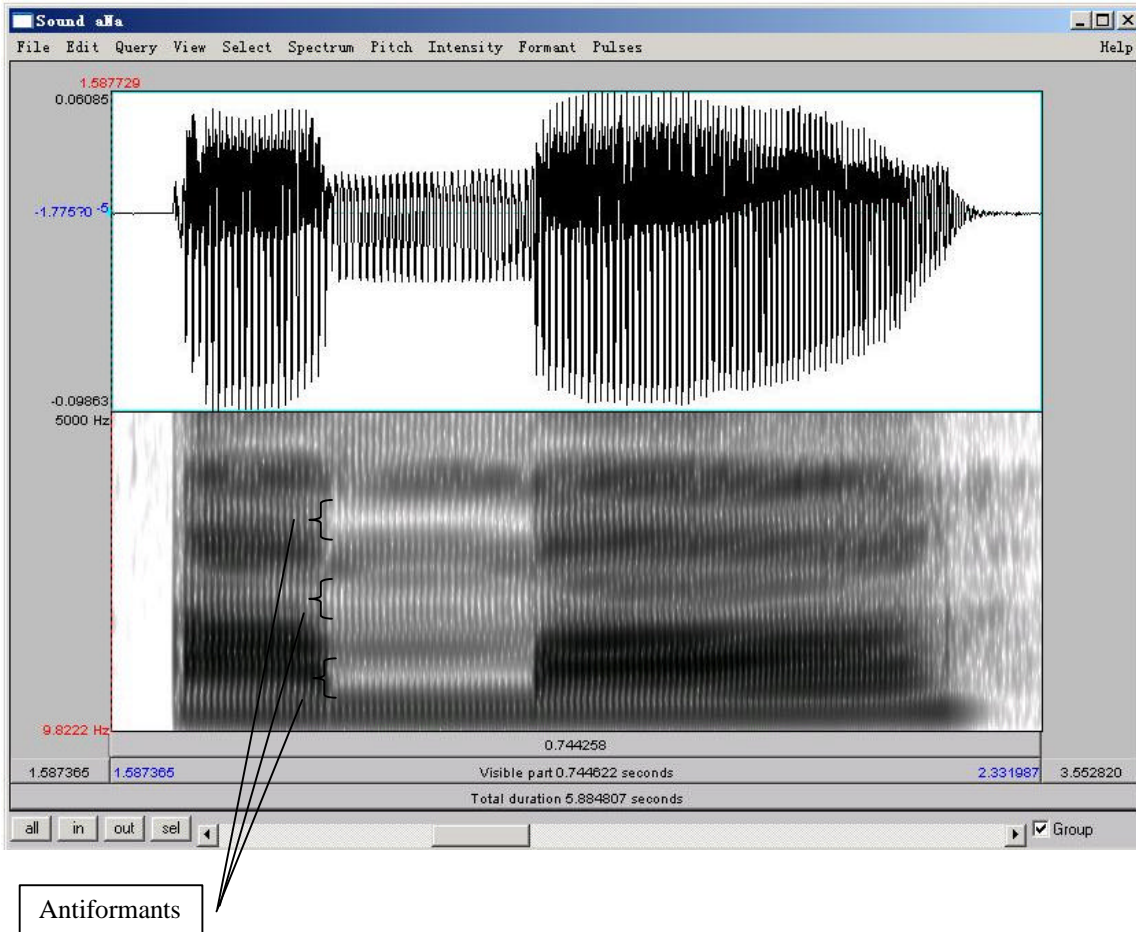


Figure 6.2. Antiformants

E. Formant transitions (correlates of place of articulation)

This section is optional. Focus on the difference between the three nasals in this part. The easiest way to see the formant transitions is by displaying the formant tracking:

- In Table 4.1, draw lines to indicate the shape of the F1, F2 and F3 contours throughout each V_1NV_2 sequence.

Q5: Do you notice any differences between the contours, i.e. between the transitions into and out of nasals with different places of articulation? We'll re-visit this question in future labs...

SECTION II. GLIDES

8. Open the files **Wi.wav** and **Ju.wav**. Follow the instructions below and fill in Table 2 on the acoustic correlates of different glides.

A. Formants

9. In Table 4.2, note down the frequency of F1, F2 and F3 for each glide, as measured around the mid point of the glide.

TIP The mid point of [w] should be at about: 3.19s and the midpoint of [j] should be at about 2.85s.

Q6: Look at the formant structure of the glides: which vowel does each glide resemble?

B. Formant transitions

10. In Table 4.2, draw lines to indicate the F1, F2 and F3 contours throughout each GV sequence.

Q7: Are any differences between the contours, i.e. between the transitions out of the two glides? What do you think may cause these differences (in terms of articulation).

SECTION III. LIQUIDS

11. Open the file **Ri_iR.wav**. Follow the instructions below and fill in Table 4.3 on the acoustic correlates of different glides.

A. Formants

Use only the coda [ɹ] and [l] (the 3rd word [iɹ] and the 4th word [il] in the sound file) for these measurements: formants are easier to see in coda position because they are more “stretched out”.

12. In Table 4.3, note down the frequency of F1, F2 and F3 for each liquid, as measured around the mid point of the liquid

TIP The mid point of [ɹ] should be at about: 4.39s and the midpoint of [l] should be at about 5.78s.

Q8: Make note of the differences between each liquid – which formant is most different between the two?

B. Formant transitions

Again, use only the **coda** [ɹ] and [l] ([iɹ] and [il]) for these measurements.

13. In Table 4.3, draw lines to indicate the F1, F2 and F3 contours throughout each VL sequence.

Q9: Do you notice any differences between the contours, i.e. between the transitions into the two liquids? What do you think causes these differences?

C. Formant transition durations: Onsets vs. Codas

Certain sounds are pronounced differently in onset vs. coda position, including liquids. In this last part of the lab, you will compare one acoustic correlate of liquids across syllabic positions: duration.

14. *Onset*: Use [ɹi] [li] for the measurement of onset liquids. Measure the duration from the beginning of the L-V transition (where the formants start to move) to the point at which the formants stabilize in the following vowel (see Fig.4.3). Note down your measurement in Table 4.3

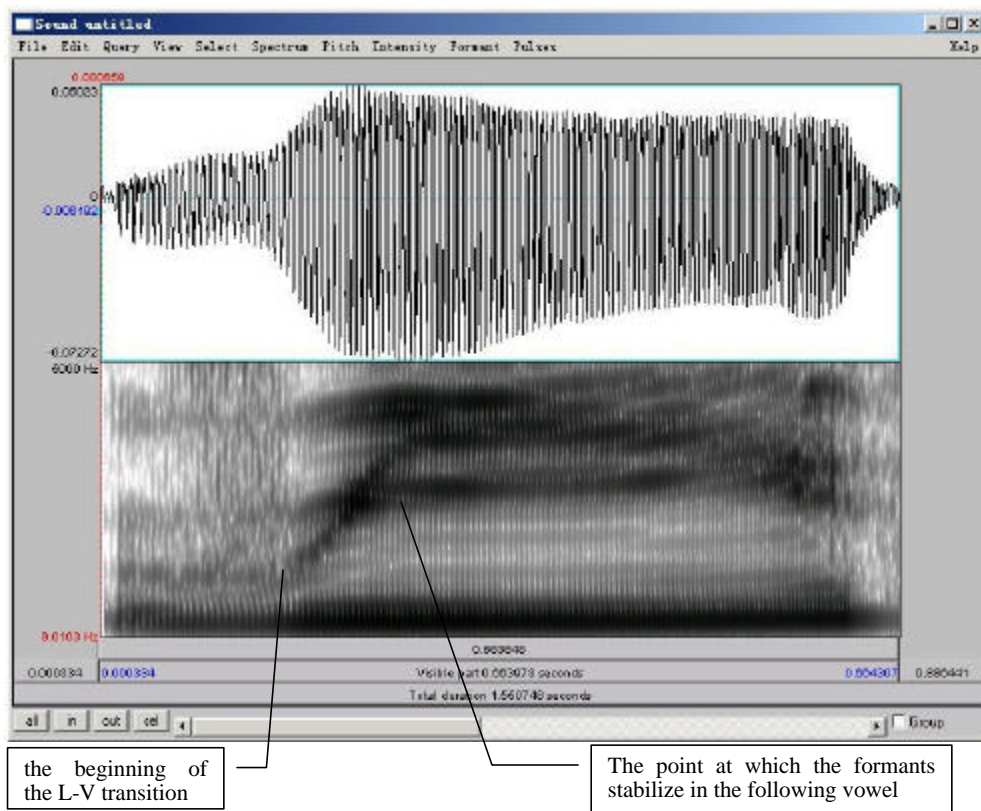


Figure 4.3. Formant transition in onset position

15. *Coda*: Use [iɪ] [il] for the measurement of onset liquids. Measure the duration between the beginning of the V-L transition (where the formants start to move) to the point at which the formants stabilize in the following liquid (see Fig. 4.4). Note down your measurement in Table 4.3.

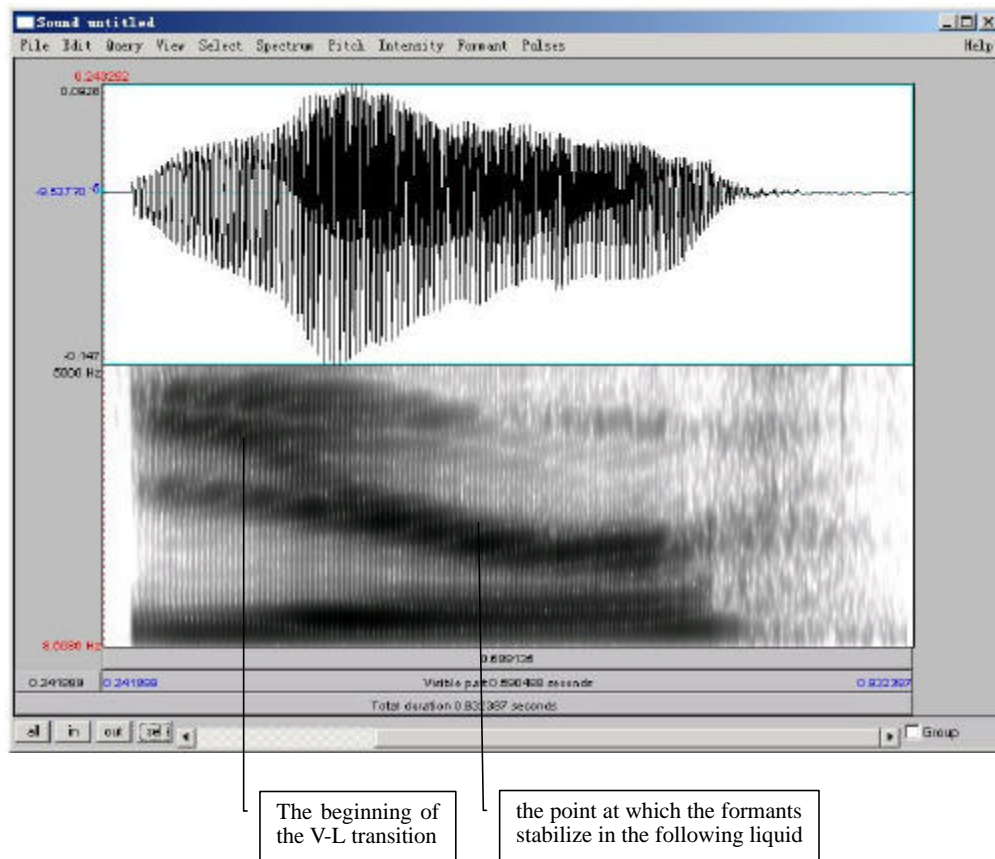


Figure 4.4. Formant transition in coda position

Q10: Compare the transition durations in onset vs. coda position ([ɹi vs. iɹ and li vs. il) : which are longer?

Q11: Can you think of any other differences between /l ɹ/ in onset vs. coda position? (think about their articulations...)

LAB 4 – SONORANTS – WORKSHEET

SECTION I. NASALS

Table 4.1 Acoustic correlates of nasals

Correlates		[m]	[n]	[ŋ]
A. Nasal Formants		F1 F2 F3	F1 F2 F3	F1 F2 F3
B. Spectral slice comparison	Nasal spectral slice			
	Spectral slice for [a]			
C. Waveform comparison	Nasal waveform			
	Waveform for [a]			
D. Antiformants		A1 A2 A3	A1 A2 A3	A1 A2 A3
E. Formant transitions				

- Q1: Look at your measurements of F1, F2 and F3: are there any systematic patterns across nasals? (Relate your answer to Q2 and Q3 below)
- a. Is there one formant with a similar frequency for all places of articulation?
 - b. Is there one formant that has a much higher amplitude than the others, across nasals?

LAB 4 – SONORANTS

Q2: Compare the spectral slices of the nasals vs. [a] – do you see any overall differences between the nasals on the one hand and [a] on the other? (Relate this to your answer to Q1 and Q3)

Q3: Do you notice a systematic pattern across nasals, that is missing in [a]? What causes this pattern? (Relate this to Q1 and Q2 above)

Q4: Are there any systematic patterns across nasals: is there one antiformant with a similar frequency for all places of articulation?

Q5: Do you notice any differences between the contours, i.e. between the transitions into and out of nasals with different places of articulation? We'll re-visit this question in future labs...

SECTION II. GLIDES

Table 4.2 Acoustic correlates of glides

	[w]	[j]
Formants (GV)	F1 F2 F3	F1 F2 F3
Formant transitions (GV)		

Q6: Look at the formant structure of the glides: which vowel does each glide resemble?

Q7: Are any differences between the contours, i.e. between the transitions out of the two glides?
 What do you think may cause these differences (in terms of articulation).

SECTION III. LIQUIDS

Table 4.3 Acoustic correlates of liquids

	ɹ	l
Formants (VL)	F1 F2 F3	F1 F2 F3
Formant transitions (VL)		
Formant transition duration	onset coda	onset coda

LAB 4 – SONORANTS

Q8: Make note of the differences between each liquid – which formant is most different between the two?

Q9: Do you notice any differences between the contours, i.e. between the transitions into the two liquids? What do you think causes these differences?

Q10: Compare the transition durations in onset vs. coda position (ɹi vs. iɹ and li vs. il) : which are longer?

Q11: Can you think of any other differences between /l ɹ/ in onset vs. coda position? (think about their articulations...)

LAB 5 – OBSTRUENTS

GOAL OF LAB 5

In this lab, we are going to explore the acoustic correlates of different obstruents in terms of two parameters: VOICING and PLACE OF ARTICULATION.

RECORDING

Download the 5 files you'll be using onto the Desktop:

<i>File name</i>	<i>Sounds included</i>
Lab5_a_stop_a.wav	(ap ^h a, aba, at ^h a, ada, ak ^h a, aga)
Lab5_a_stop.wav	(lap, lab, bat, bad, rack, rag)
Lab5_i_stop_i.wav	(ip ^h i ibi, it ^h i, idi ik ^h i, igi)
Lab5_a_fricative_a.wav	(afa, aθa, asa, aʃa, aha)
Lab5_shoe_chew.wav	(shoe, chew)

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
- o Download the sound files.

SECTION I. STOP CONSONANTS

A. Voicing

Three important acoustic correlates of VOICING in stops are: THE VOICE BAR, VOT, and THE DURATION OF THE PRECEDING VOWEL. For each of the stops in the file, take the three measurements according to the instructions below. Use Table 1 to fill in the measurements you take on voicing. Answer the related questions by comparing across all stops after you complete the table.

1. Open the following sound file in Praat: **a_stop_a.wav**. Note down the presence vs. absence of the voice bar (see Fig. 5.1) during the stop closure of each consonants in Table 5.1 on the worksheet.

Q1: If the voice bar is present at all, does it last through the duration of the closure? Why do you think it might go away?

2. Still using the sound file **a_stop_a.wav**, measure the VOT of each stop and fill in Table 5.1. Compare voiced/voiceless counterparts (p/b, t/d, k/g):

- o Zoom in so that you can clearly see the stop closure followed by the beginning of the vowel.
- o Measure the time between the end of the stop closure (= the beginning of the release burst) and the onset of voicing in the following vowel (= the onset of regular pitch pulses in the waveform). This is *voice onset time*, or VOT.

LAB 5 – OBSTRUENTS

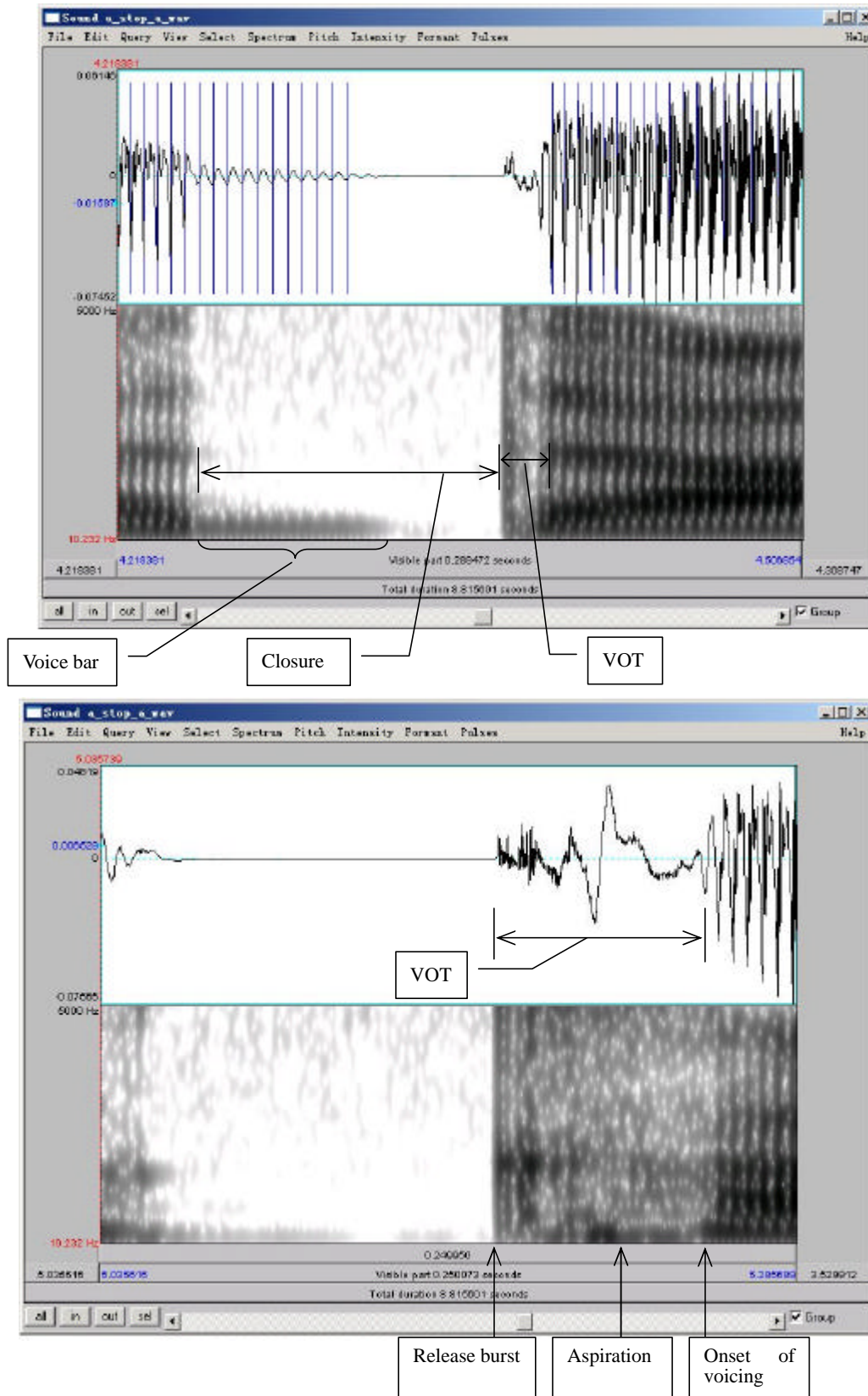


Figure 5.1 Voice bar and VOT measurement

Q2: How does VOT differ in voiced vs. voiceless stops and what articulatory explanation can you come up with for this?

- Now open a different sound file **a_stop.wav** in Praat. Measure the duration of the vowel preceding each stop, and fill in Table 5.1 on the worksheet. Compare vowel durations in the voiced vs. voiceless series.

Q3: How does the duration of the preceding vowel differ depending on the voicing of the following consonant?

B. Place of Articulation

Several acoustic correlates distinguish between different PLACES OF ARTICULATION in stops. The main ones are VOT, spectral pattern during aspiration (voiceless stops), and transition into the adjacent vowels. We will focus on formant transitions in this section; THE SECTIONS ON MEASURING VOT AND SPECTRAL PATTERN ARE OPTIONAL. Focus on the differences associated with place of articulation (i.e. the differences between /p b/, /t d/ and /k g/).

- Open the following sound files in Praat: **a_stop_a.wav** and **i_stop_i.wav**
 - Focus on the voiced stops for now
- In Table 5.2, note down the formant transition shape (particularly F2) between each voiced stop and the following [a] or [i] vowel (see Fig. 5.2).
 - Zoom in so that you can clearly see the formant transition from the stop into the following vowel.
 - Note down the movement contour of **F2** (and **F1** if you can see it) into the following vowel.

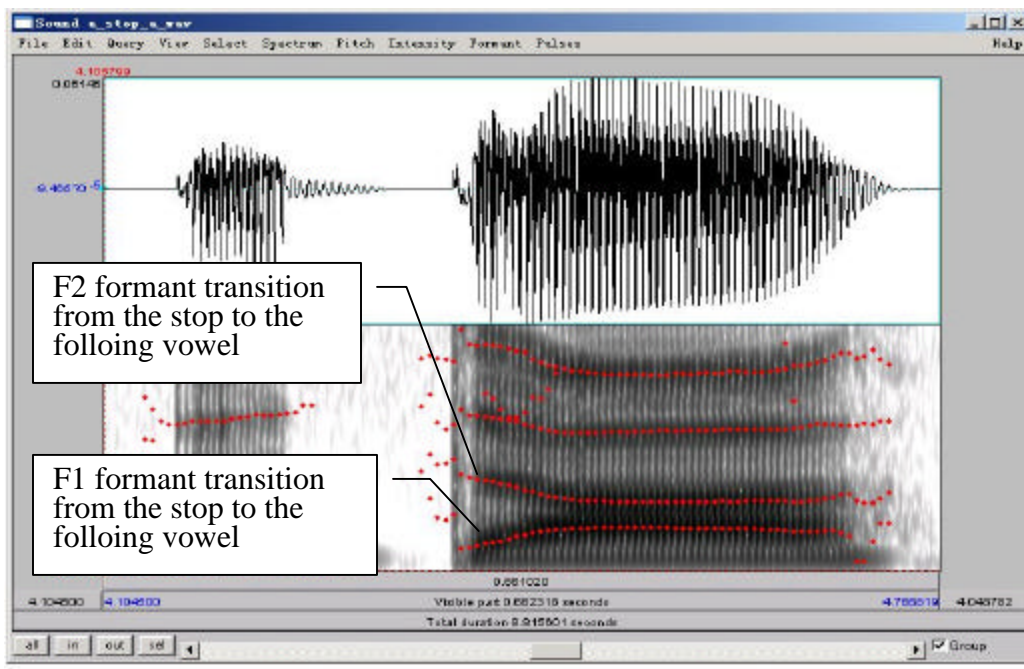


Figure 5.2 Formant transition from the stop to the following vowel

Q4: How do the different places of articulation differ with respect to the F2 transitions into the following vowels? What causes these differences?

Q5: Looking specifically at [ada] and [idi], do you notice a difference in the formant transitions? What do you think causes this difference?

Optional Questions on VOT and Spectral Patterns

5. **VOT:** In Table 5.3, note down the **VOT** for each of the voiceless stops in the [a] and [i] contexts (see Figure 5.1; note: you should already have the VOTs for the voiceless stops in the [a] context in Table 5.1 – you can measure them again to confirm your measurements if you want to).

Q6: How does the VOT differ depending on POA, and why?

Q7: Are there any overall differences in VOT between stops preceding [a] vs. [i]? If so, why might this be the case?

6. **Spectral Pattern:** In Table 5.3, note down the overall spectral pattern during the aspiration of each voiceless stop in the [a] context: what frequencies seem most amplified, i.e. where is most of the aspiration noise?

There are two ways to look at overall **spectral pattern during the aspiration**. Choose one of these to complete 6 above.

a. By looking at the spectrogram

- o Zoom in on the spectrogram so you can clearly see the aspiration.
- o Observe the overall distribution of frequencies and amplitudes by looking at the spectrogram.

b. By looking at the spectrum

It might help here to also take a look at the spectrum during aspiration (see Fig. 5.3 for an example using a fricative, which is similar to aspiration):

- o Zoom in on the aspiration portion of the stop.
- o Select approximately 25ms during the aspiration portion of the stop.
- o **Spectrum > View spectral slice.**
- o Note down the overall shape of the spectrum – again, look at which frequency ranges are most amplified?

Q8: How does the spectral pattern differ depending on POA, and why?

(This question is tricky. Don't worry too much if you can't see a pattern here. We'll talk about what you should see and why in class!)

SECTION II. FRICATIVES

Different PLACES OF ARTICULATION in fricatives are correlated with two main properties: spectral content and relative amplitude. By examining the OVERALL SPECTRAL CONTOUR, PEAK FREQUENCY and the AMPLITUDE OF PEAK FREQUENCY, we can have an idea of the properties of a fricative.

- Use Table 5.4 to fill in the measurements you take on these three dimensions and compare between fricatives of different POA.

For this portion of the lab, make sure that the spectrogram is set to display frequencies up to **9000 Hz**:

- o **Spectrum > Spectrogram settings...**
- o View range: up to 9,000Hz

- o Open the following sound file in Praat: **a_fricative_a.wav**
- o Select approximately **80ms** in the middle of each fricative
- o **Spectrum > View spectral slice**
- o For each fricative, note down:
 - o The overall shape of the spectral contour
 - o The spectral peak: the frequency or frequencies around which most of the energy is centered, i.e. the highest amplitude frequencies (the highest peaks)
 - o The amplitude of the peak frequency or frequencies (that you noted down above) – note: the positive dB values are louder than the negative dB values.

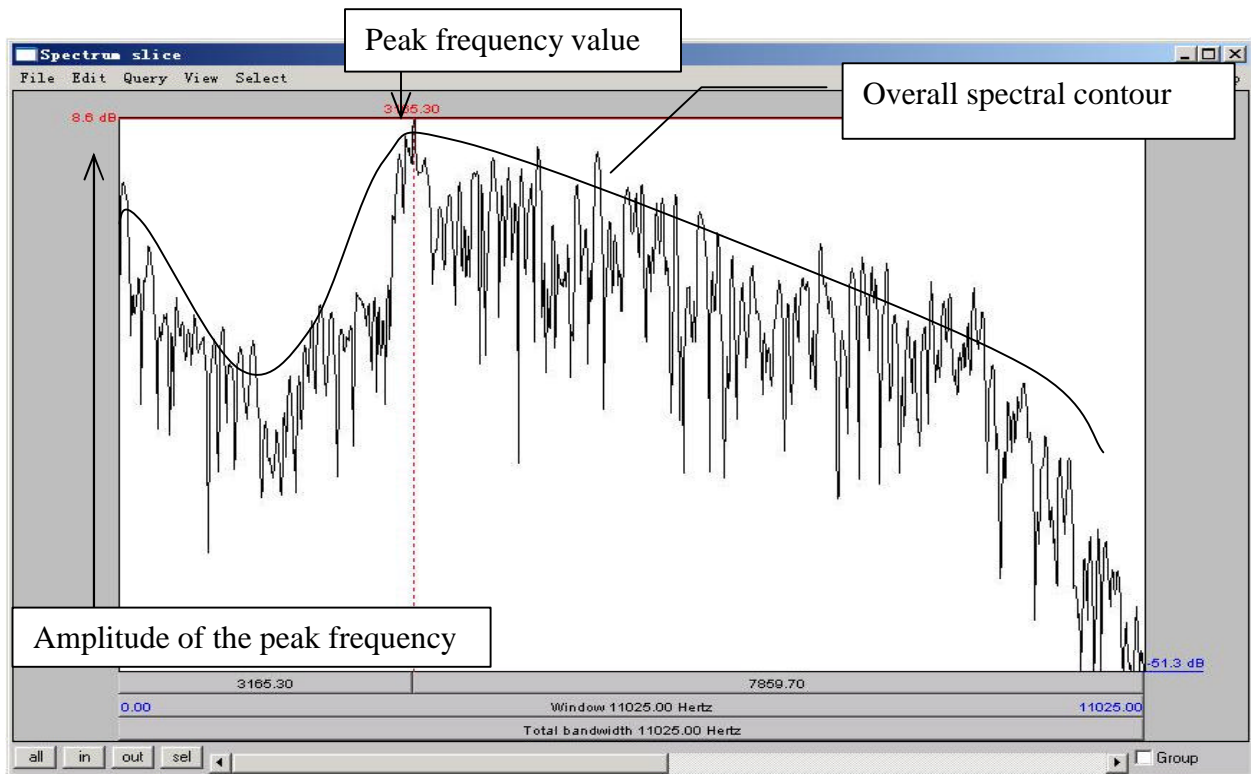


Figure 5.3 Fricative spectral analysis

TIP You can also get a good idea of the frequency ranges and their relative amplitudes by looking at the spectrogram.

Q9: Among the fricatives you measured, which ones are highest/lowest in amplitude? What do you think is the reason for this (think about articulation)?

Q10: Compare the spectral peaks of [s] vs. [ʃ]. What do you think causes the difference between these two fricatives?

SECTION III. AFFRICATES VS. FRICATIVES

The main difference between affricates and fricatives is RISE TIME, i.e. the time it takes between the onset of the consonant and the point where the amplitude is stable and high.

8. Use Table 5.5 to note down your measurements of rise time in [ʃu] ‘shoe’ vs. [tʃu] ‘chew’:
 - o Open the sound file in Praat: **shoe_chew.wav**
 - o Zoom in so you can clearly see the whole of the fricative/affricate, including its onset.
 - o On the waveform, measure the duration between the onset of the frication and the point where the amplitude reaches a stable high intensity

Q11: Which has a longer rise-time, the fricative or the affricate?

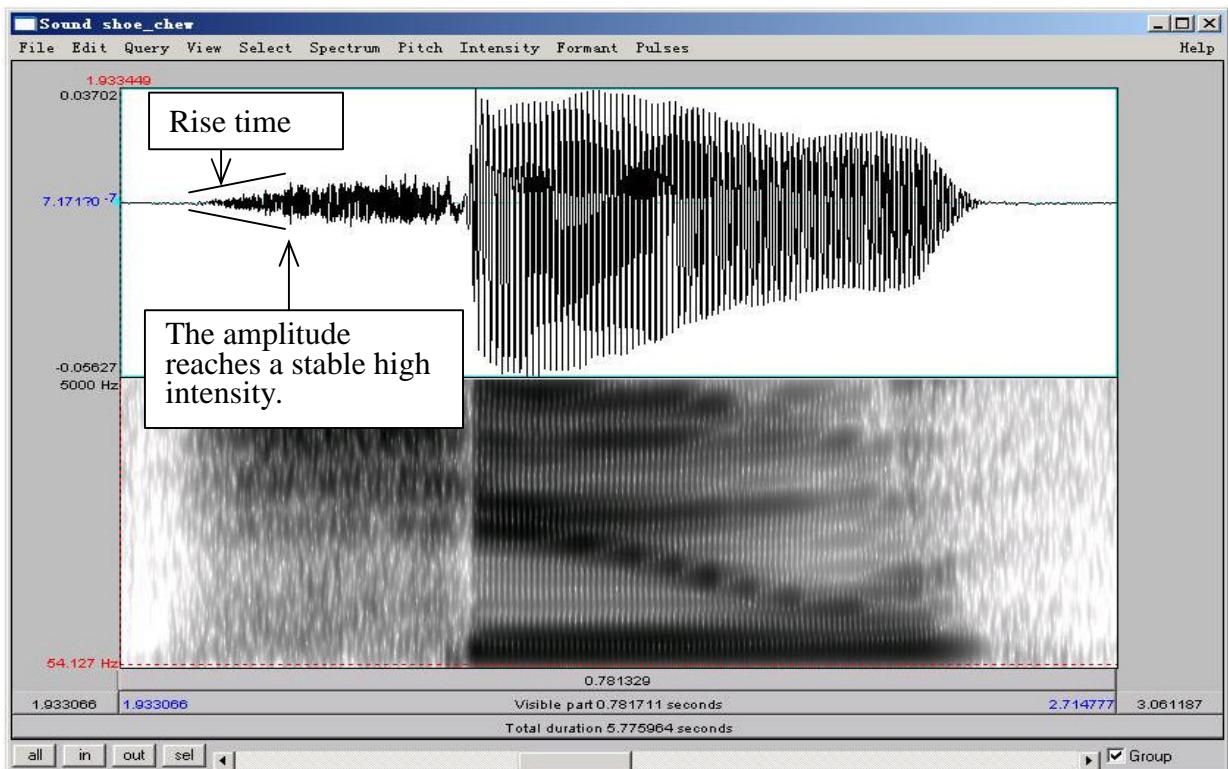


Figure 5.4 Measuring rise time in fricatives and affricates

LAB 5 – OBSTRUENTS – WORKSHEET

SECTION I. STOPS

Table 5.1. Acoustic correlates of **VOICING** in stops

Correlates		Stops					
		p ^h	b	t ^h	d	k ^h	g
1. Voice bar (a_stop_a.wav)	Is it there?						
	How long does it last?						
2. VOT (ms) (a_stop_a.wav)							
3. Preceding V duration (ms) (a_stop.wav)							

Q1: If the voice bar is present at all, does it last through the duration of the closure? Why do you think it might go away?

Q2: How does VOT differ in voiced vs. voiceless stops and what explanation can you come up with for this?

Q3: How does the duration of the preceding vowel differ depending on the voicing of the following consonant?

LAB 5 – OBSTRUENTS

Table 5.2. Acoustic correlates of PLACE OF ARTICULATION in stops: formant transitions

Correlate \ Stops		b	d	g
4. Formant transitions	[i] context			
	[a] context			

Q4: How do the different places of articulation differ with respect to the F2 transitions into the following vowels? What causes these differences?

Q5: Looking specifically at [ada] and [idi], do you notice a difference in the formant transitions? What do you think causes this difference?

Table 5.3. Acoustic correlates of PLACE OF ARTICULATION in stops: **VOT** and **Spectral Pattern**

Correlates \ Stops		p ^h	t ^h	k ^h
5. VOT	[i] context			
	[a] context			
6. Overall spectral pattern during aspiration				

Q6: How does the VOT differ depending on POA, and why?

Q7: Are there any overall differences in VOT between stops preceding [a] vs. [i]? If so, why might this be the case?

Q8: How does the spectral pattern differ depending on POA, and why?
 (This question is tricky. Don't worry too much if you can't see a pattern here. We'll talk about what you should see and why in class!)

SECTION II. FRICATIVES

Table 5.4 Acoustic correlates of **PLACE OF ARTICULATION** in fricatives.

7.	Overall spectral contour	Peak frequency (Hz)	Amplitude of peak frequency
[f]			
[θ]			
[s]			
[ʃ]			
[h]			

Q9: Among the fricatives you measured, which ones are highest/lowest in amplitude? What do you think is the reason for this (think about articulation)?

Q10: Compare the spectral peaks of [s] vs. [ʃ]. What do you think causes the difference between these two fricatives?

SECTION III. AFFRICATES VS. FRICATIVES

Table 5.5 Acoustic correlates of fricatives vs. affricates: rise time

8.	[ʃ]	[tʃ]
Rise time (ms)		

Q11: Which has a longer rise-time, the fricative or the affricate?

LAB 6 – PHONATION TYPES

GOAL OF LAB 6

In this lab we are going to explore the three main phonation types used across languages: MODAL VOICING, CREAKY VOICING, AND BREATHY VOICING.

RECORDING

Go to <http://web.uvic.ca/ling/coursework/ling380/index.html> and download the 3 files:

Lab6_Breathy Voice.wav

Lab6_Modal Voice.wav

Lab6_Creaky Voice.wav

- o Open the sound files in Praat
- o Fill in the cells of Table 6.1 on the worksheet to compare voicing types in terms of different parameters. Follow the instructions below for taking the appropriate measurements.

TIP Since the word “voice” occurs in all three recordings, this is a good word to use for comparing across phonation types. Unless otherwise noted, measurements should be taken **around** the transition point between [o] and [i] in [oi] of *voice*, i.e. where the formants start spreading out. Here are approximate transition points in each file:

- o Modal voicing: 0.590s (see Fig. 6.1)
- o Creaky voicing: 0.703s
- o Breathy voicing: 0.654s

TIP Always keep in mind that what matters in comparing measurements are *relative* values rather than *absolute* values. E.g. in measuring jitter, what matters is which phonation type has the most jitter, not what the exact measurement is.

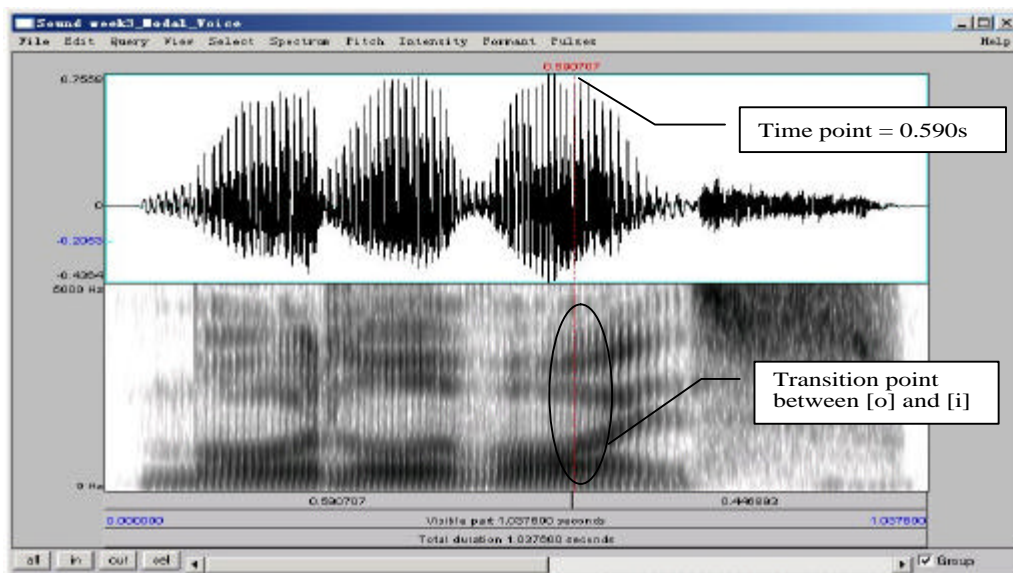


Figure 6.1 Measurement point

A. Fundamental frequency (F0)

1. Fundamental frequency can be a good indication of phonation type. Note down F0 at the measuring point of the three phonation types in Table 6.1 (if you can't remember how to do this, see LAB2, p.12).

B. Periodicity

There are two things to consider here:

- a. How regularly the pitch pulses occur = degree of periodicity in the waveform
 - b. How many higher-frequency components there are in the waveform = spectral noise
2. The degree of periodicity can be quantified by measuring the **jitter**: the variation in the duration of successive F₀ cycles (see Fig. 6.2). Follow the instructions below and note down your jitter measurements.

high jitter value = high degree of aperiodicity in the glottal source

TIP You will not be able to get a jitter value unless the pitch pulses are showing up correctly in the waveform (the blue vertical lines on the waveform, see Fig. 6.2). If at the suggested point of measurement (see above), there are no pitch pulses, measure jitter at some other point where you *do* see the pitch pulses.

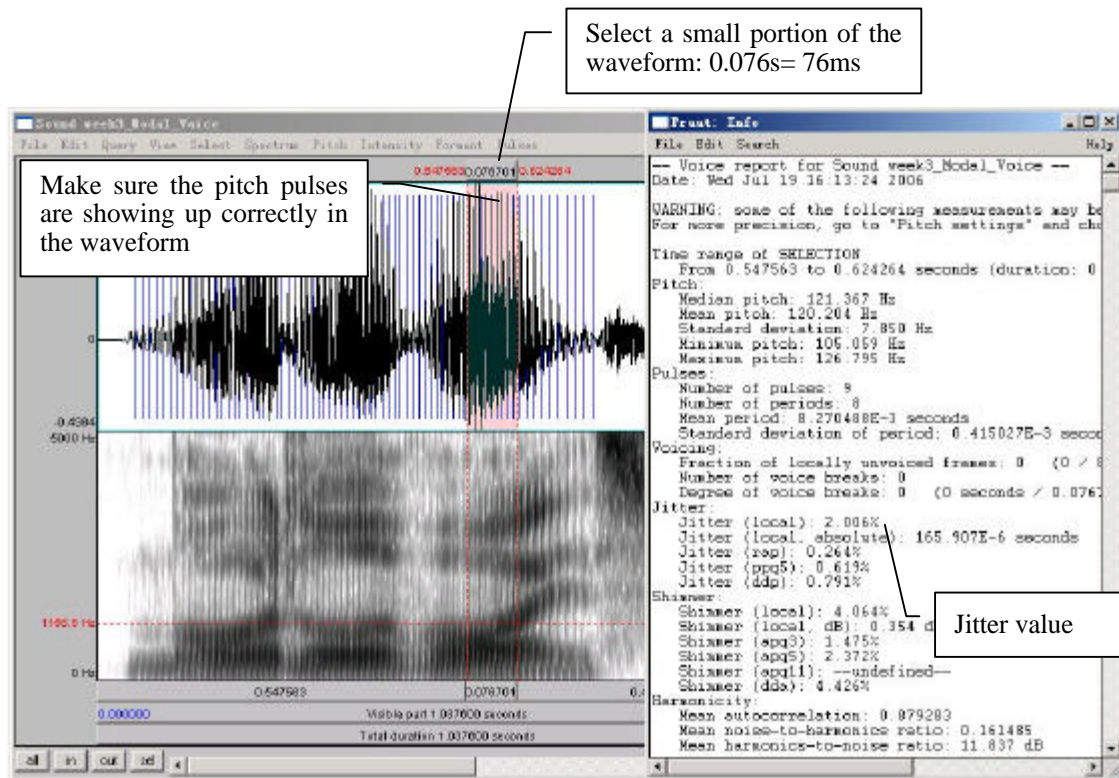


Figure 6.2 Jitter measurement

- o Measure Jitter value
 - o Pulses > Show pulses
 - o Select a small portion (70-80 ms) of the waveform around the measurement point OR where where you see pitch pulses clearly.
 - o Pulses > Voice report
 - o In the report window, get value for **Jitter (local)**, and note this down in Table 6.1

- 3. Also on the waveform you can see how much spectral noise there is in the signal by how complex the waveform looks (see Fig. 6.3). Note down your judgment on how much noise you observe.

lots of little jagged peaks = lots of spectral noise in the higher frequencies

- o Zoom in on the waveform until you can clearly see a few cycles (Fig. 6.3)

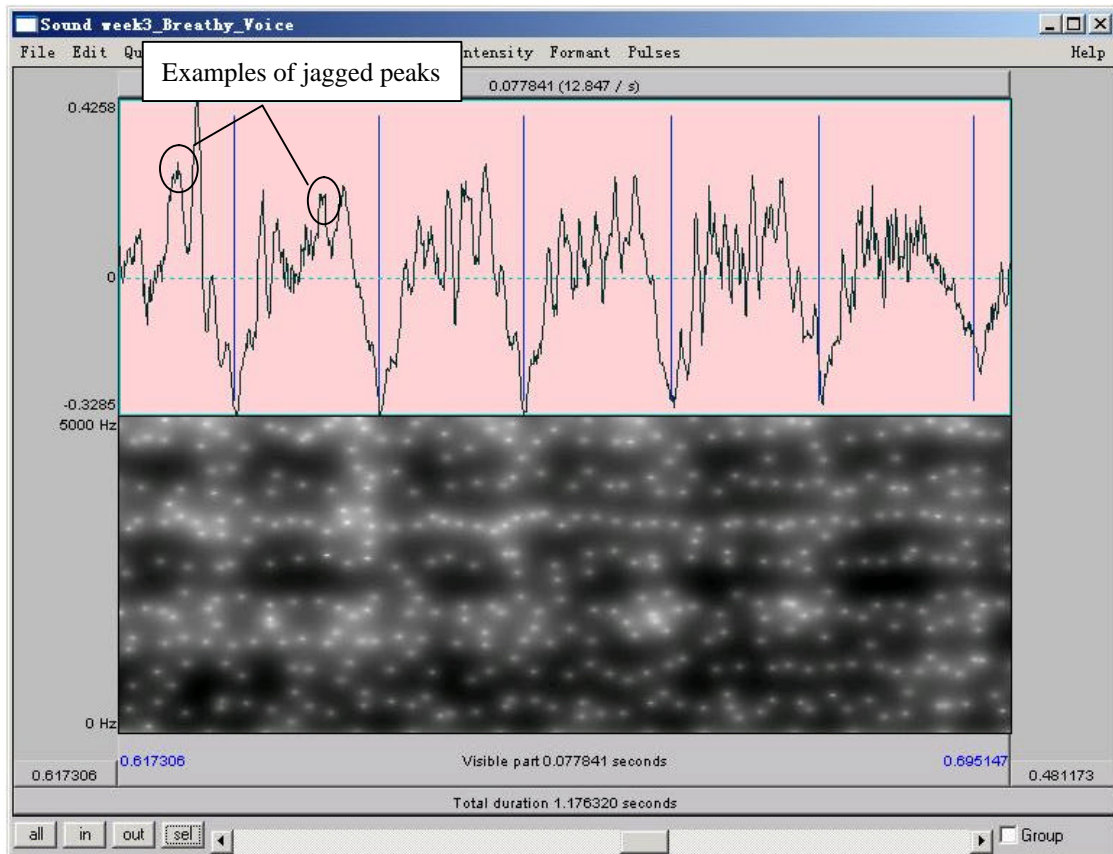


Figure 6.3 Jagged peaks

C. Acoustic intensity

The three phonation types also differ in intensity. There are two ways to consider the intensity difference, introduced below.

4. Acoustic intensity can be 'eyeballed' by viewing the waveform or spectrogram directly. Note down the relative darkness on spectrogram and the relative size of deviations from zero waveform for different phonation types in Table 6.1.

relative darkness = loudness (spectrogram)
relative size of deviations from zero waveform = loudness (waveform)

5. Amplitude can also be quantified by viewing the amplitude envelope (yellow contour) on the spectrogram display (see Fig. 6.4). Note down the green amplitude value (in dB) on the right of the screen for different phonation types.

- o **Intensity > Show intensity**
- o Find the peak intensity (highest point on yellow amplitude contour) during the vowel [oi]
- o Click on the amplitude contour at this point.
- o Note the green amplitude value (in dB) on the right of the screen

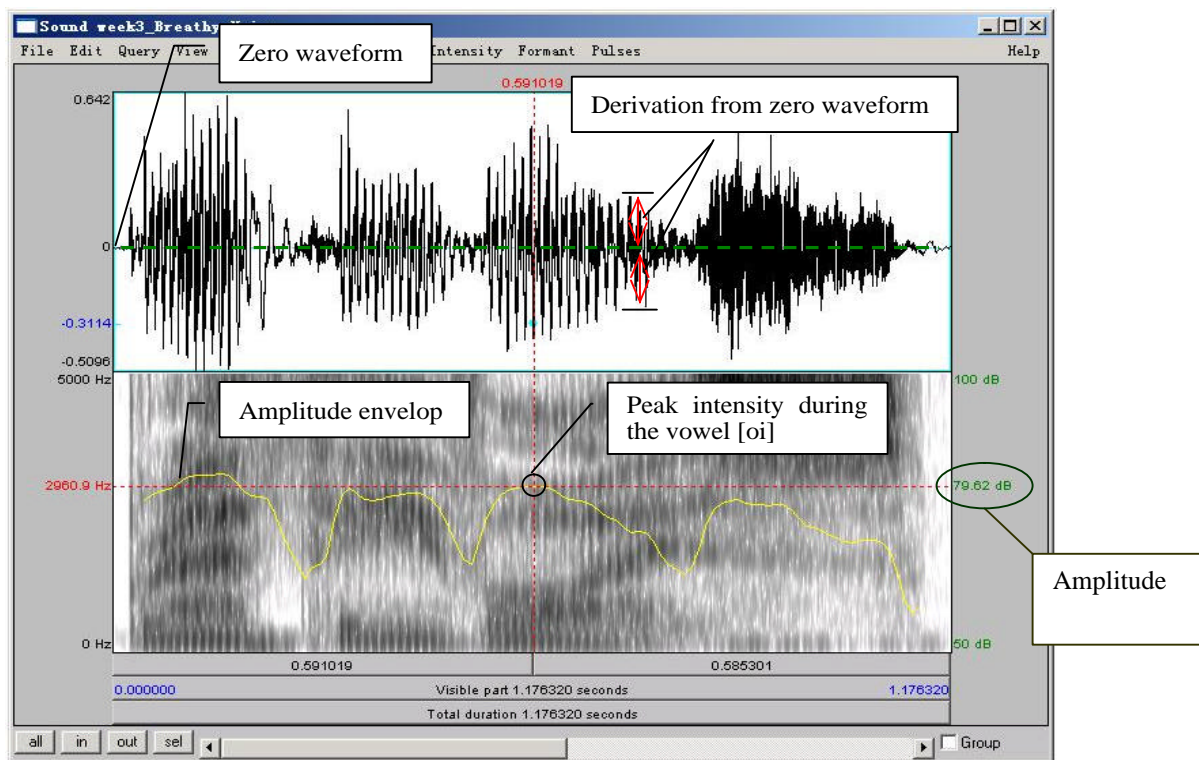


Figure 6.4 Acoustic intensity

D. Spectral tilt

Spectral tilt is the degree to which intensity drops off as frequency increases

6. Spectral tilt can be eyeballed by looking at a spectral slice of the waveform, which gives the component frequencies and their amplitudes (see Fig. 6.5 a). Note down the overall slope of the spectrum for different phonation types in Table 6.1.
 - o Select a portion (70-80 ms) of the waveform around the measurement point (given above).
 - o **Spectrum > View spectral slice**
 - o The overall slope of the spectrum (= how quickly the amplitude drops off in the higher frequencies) is an indication of spectral tilt:

Step slope = highly negative spectral tilt = rapid drop off in A of higher frequencies

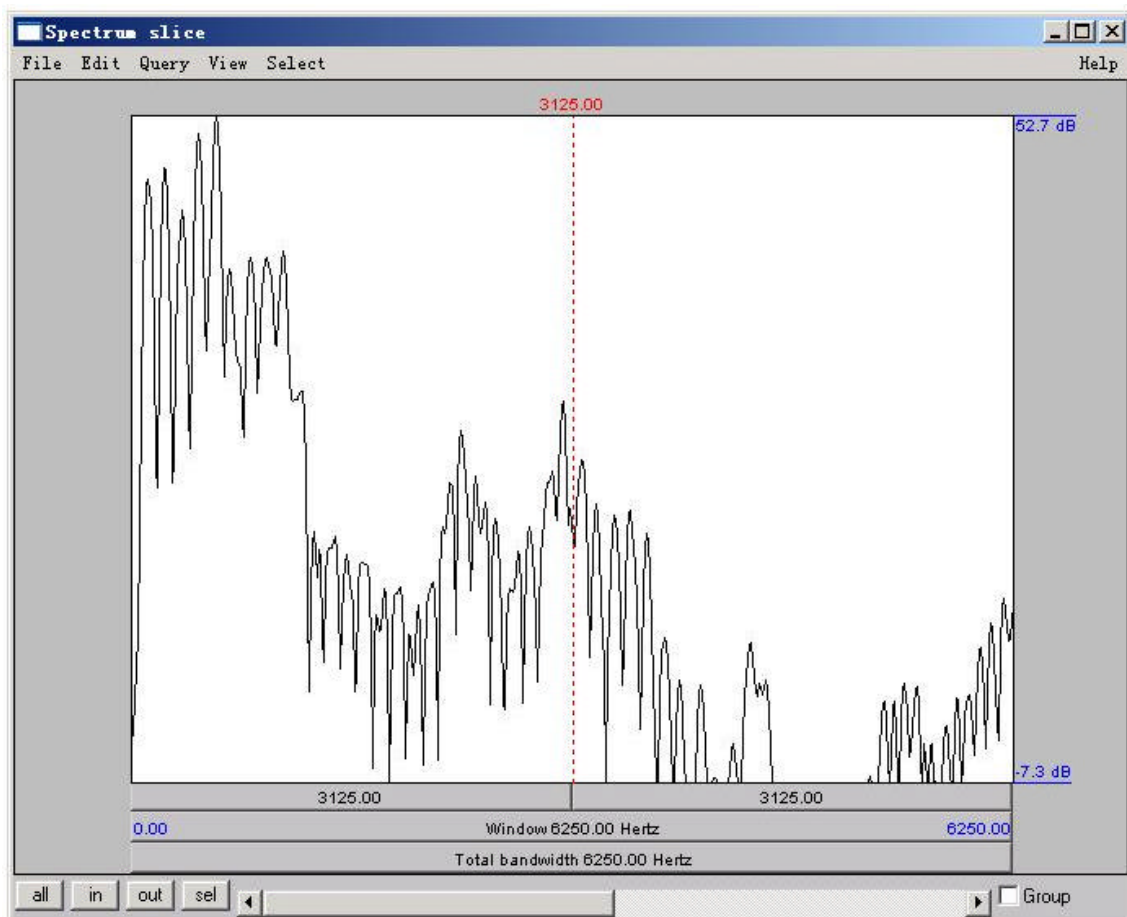


Figure 6.5a Measuring spectral tilt – zoomed-out view

LAB 6 - PHONATION TYPES

7. Spectral tilt can be quantified by comparing the amplitude of F0 to that of higher frequency harmonics, e.g. the second harmonic, the harmonic closest to the first formant, or the harmonic closest to the second formant. The easiest way to measure spectral tilt is by subtracting the amplitude of F0 (H1) from the amplitude of the second harmonic (H2) (see Fig. 6.5b). Fill in Table 6.1 with the spectral tilt value of the three phonation types.
 - o Select the first few peaks (around 10 peaks) and zoom in so that you can see H1 and H2 clearly
 - o In the spectral slice, click on the peak of H1 and get its amplitude
 - o (The number on the left of the screen corresponds to the amplitude; the number at the top of the screen corresponds to the frequency)
 - o Click on the peak of H2 and get its amplitude
 - o Calculate spectral tilt by this formula: Spectral tilt = A(H2)-A(H1)

TIP H1 is the first big-sized peak; H2 is the second one. There may often be one or two lower amplitude peaks before H1, so make sure you're measuring the right peaks. If you click on the first big peak (H1), the value at the top of the vertical red bar gives you its frequency. Make sure this frequency corresponds to F_0 (as verified by some other measurement technique – see LAB2, p.12). Also make sure that the frequency of H2 is approximately twice the frequency of H1 (again, see LAB2 for the reasoning here, p.16).

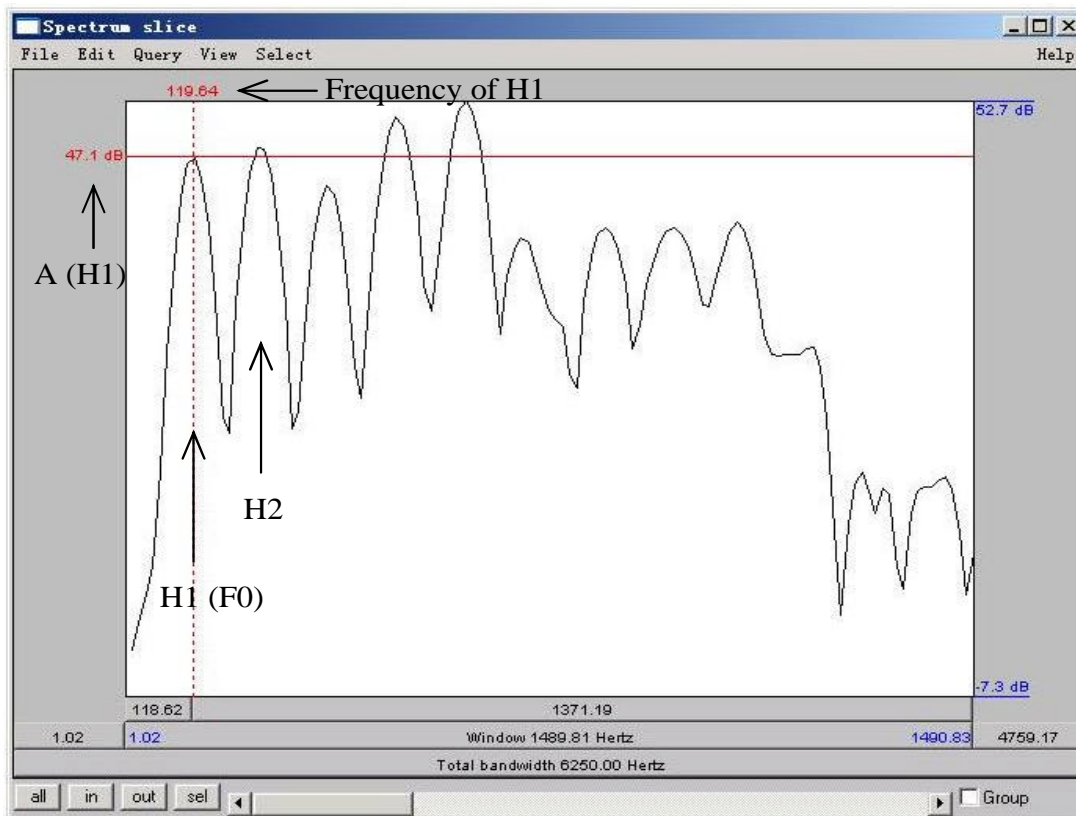


Figure 6.5b Measuring spectral tilt – zoomed-in view

E. Formant frequency

8. Non-modal phonation can affect the formant frequencies, particularly the first formant (F1). Note down F1 for each phonation type.
 - o For this measurement, consider the stable (middle) part of the [o] portion of the [oi] diphthong, not the transition point between [o] and [i].
 - o On the spectrogram, click in the centre (vertical) of the first formant (F1)
 - o The number at the left of the screen, at the end of the red horizontal bar gives you the frequency (in Hz)

TIP You can use the formant tracings if they help: **Formant > Show formants**

F. Duration of [oi]

9. Duration can also be a good indication of phonation type (see Fig. 6.6). Note down the duration of [oi] for each phonation type.
 - o Measure the duration for the whole diphthong [oi] by selecting the vowel
 - o You can read the duration from the panel above the selected segment

TIP To isolate [oi], you can use visual information (look for the change in the shape of the spectrogram/waveform). You can also use your ears.

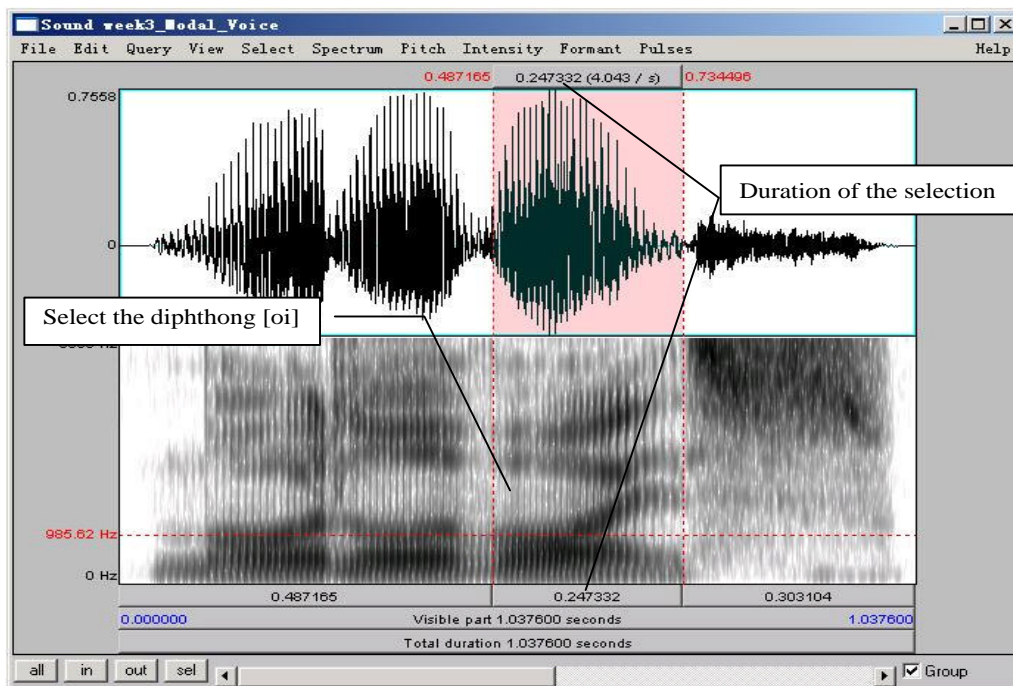


Figure 6.6 Duration measurement

G. Overall clarity of the spectrogram

10. Finally, phonation types differ in the overall clarity of the spectrogram – this has to do with the amount of noise in the signal, etc. Note down your impressions of overall clarity of the spectrogram of each phonation type.

Q1: Based on the measurements above: what is it about the articulation of these different phonation types that leads to the observed differences in your measurements? You can make any notes you'd like on the back side of the worksheet – we'll discuss this question in class.

LAB 6 – PHONATION TYPES – WORKSHEET

Table 6.1. Comparing acoustic correlates of different phonation types (enter values where measurements were taken; otherwise enter general comments)

		<i>Modal voicing</i>	<i>Creaky voicing</i>	<i>Breathy voicing</i>
1. Fundamental frequency				
Periodicity	2. jitter value			
	3. spectral noise			
Intensity	4. relative darkness on spectrogram / relative deviation on waveform			
	5. amplitude value (dB)			
Spectral tilt	6. overall slope of the spectrum			
	7. $A(H2) - A(H1)$			
8. Formant frequency (F1 value)				
9. Duration of [oi] (ms)				
10. Overall clarity of spectrogram				

LAB 6 - PHONATION TYPES

Q1: Based on the measurements above: what is it about the articulation of these different phonation types that leads to the observed differences in your measurements? You can make any notes you'd like on the back side of the worksheet – we'll discuss this question in class.

LAB 7 – SUPRASEGMENTALS

GOAL OF LAB 7

In this lab we're going to explore three different ways to use pitch (and other suprasegmental cues) within words: STRESS in Korean, PITCH-ACCENT in Japanese, and TONE in Mandarin.

RECORDING

For this lab, you will need to download the following files onto the Desktop:

<i>File name</i>	<i>Sounds included</i>
Korean_Stress.wav	(zadáli, zánzu, zá:nzu)
Japanese_PitchAccent.wav	(hási, hasí, hasi, hási o nuɾu, hasí o nuɾu, hasi o nuɾu)
Mandarin_Tone.wav	(ma55, ma35, ma214, ma51)

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
- o Download the sound files onto the desktop

SECTION I. KOREAN STRESS

The most familiar way to use pitch, at least for English speakers, is to signal what we call STRESS (c.f. *refuse* used as a noun vs. as a verb). Stressed syllables are usually signaled by some combination of raised pitch, raised amplitude, and longer duration. Like English, Korean has stress. Unlike English though, Korean also has contrastive vowel length, which leads to some interesting uses of duration – as we'll see!

- o Open **Korean_Stress.wav**, which contains the following words (´ indicates stress; periods indicate syllable boundaries):

za.dá.li	‘ladder’
zán.zu	‘landscape’
zá:n.zu	‘arithmetic’

1. Use Table 7.1 to note down the measurements of the duration, pitch, and amplitude of the relevant segments in each word.
 - o Display the pitch and amplitude contours
 - o For duration:
 - o For *zadáli*, measure the duration of each vowel.
 - o For *zánzu* and *zá:nzu*, measure the duration of the vowel and the coda consonant [n] (in ‘landscape’ and ‘arithmetic’) separately, and then measure the whole rhyme ([an] in ‘landscape’ and [a:n] in ‘arithmetic’)
 - o For pitch: measure the peak pitch in each syllable. Ignore any spikes right at the transitions between consonants and vowels.
 - o For amplitude: measure the peak amplitude in each syllable.

TIP In order to get a clear pitch contour in Praat, you may have to play with the pitch settings. (Compare Figure 7.1a with Figure 7.1b.)

LAB 7 – SUPRASEGMENTALS

- o Go to: **Pitch > Pitch settings...**
 - o Play with the Pitch range (the default pitch range is 75.0-500.0 Hz): you should be able to set the min. and max. pitches to match (approximately) the pitches in your sound file.
- This should give you a much clearer pitch contour. If even with changing the pitch range you can't get a clear contour, you can always measure the pitch off the waveform, as you did in LAB2.

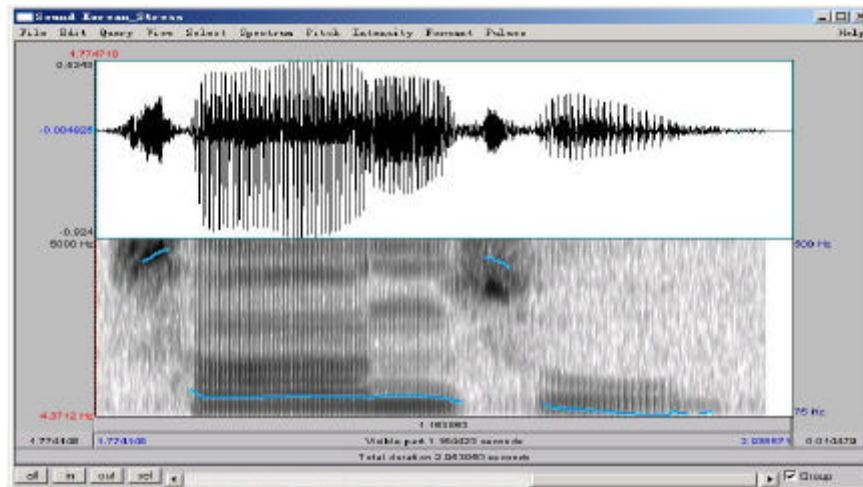


Figure 7.1a Pitch range setting in Praat: 75-500Hz

Pitch range set to 75.0-500.0 Hz: Maximum is set too high; as a result the contour is squished right at the bottom of the display and is difficult to read.

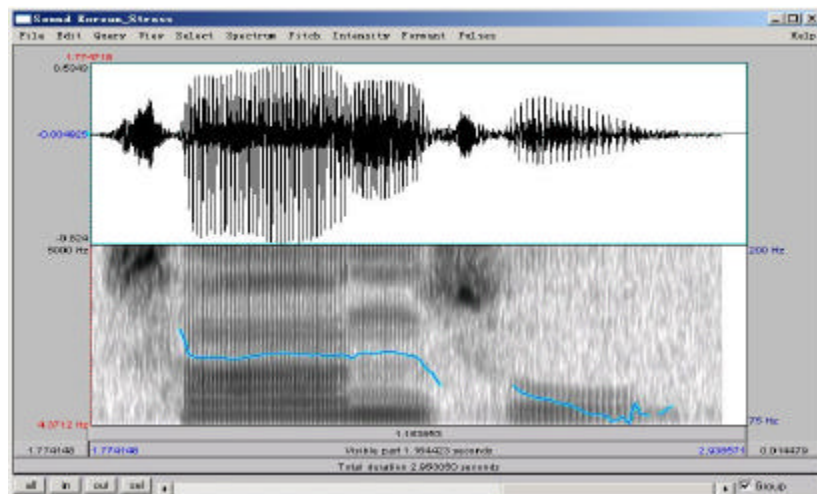


Figure 7.1b Pitch range setting in Praat: 75-200Hz

Pitch range set to 75.0-200.0 Hz: Maximum is more set more appropriately; as a result the contour is spread over the whole display and is easy to read.

- Q1: Based on your measurements of the Korean sound file, answer the following questions:
- a. Which cues (duration, pitch, amplitude) does Korean use to signal stress?
 - b. Take a look at the duration of [n] in 'landscape' vs. 'arithmetic'. Why are these two [n]s so different in duration?

SECTION II. JAPANESE PITCH-ACCENT

Pitch-accent is another way to mark prominence. Unlike stress, pitch-accent uses primarily pitch (as opposed to a combination of cues) to signal the prominent syllable. Japanese is an example of a pitch-accent language (Note: languages can have either stress or pitch-accent, but not both; they can also have neither).

- o Open the file **Japanese_PitchAccent.wav**, which contains the files below (´ indicates accent):

hási	‘chopsticks’	hási o nuɾu	‘paint a bridge’
hasí	‘bridge’	hasí o nuɾu	‘paint chopsticks’
hasi	‘end’	hasi o nuɾu	‘paint the end’

2. Use Table 7.2 to note down the pitch contours and important pitch values associated with each word/phrase (the first word is done for you as an example).
 - o For the words in isolation (first 3): measure pitch in the middle of each vowel
 - o For the words in a phrase (last 3): measure pitch in the middle of first vowel, second vowel, and a point in the following chunk of signal where the pitch has stabilized (see Fig. 7.2).

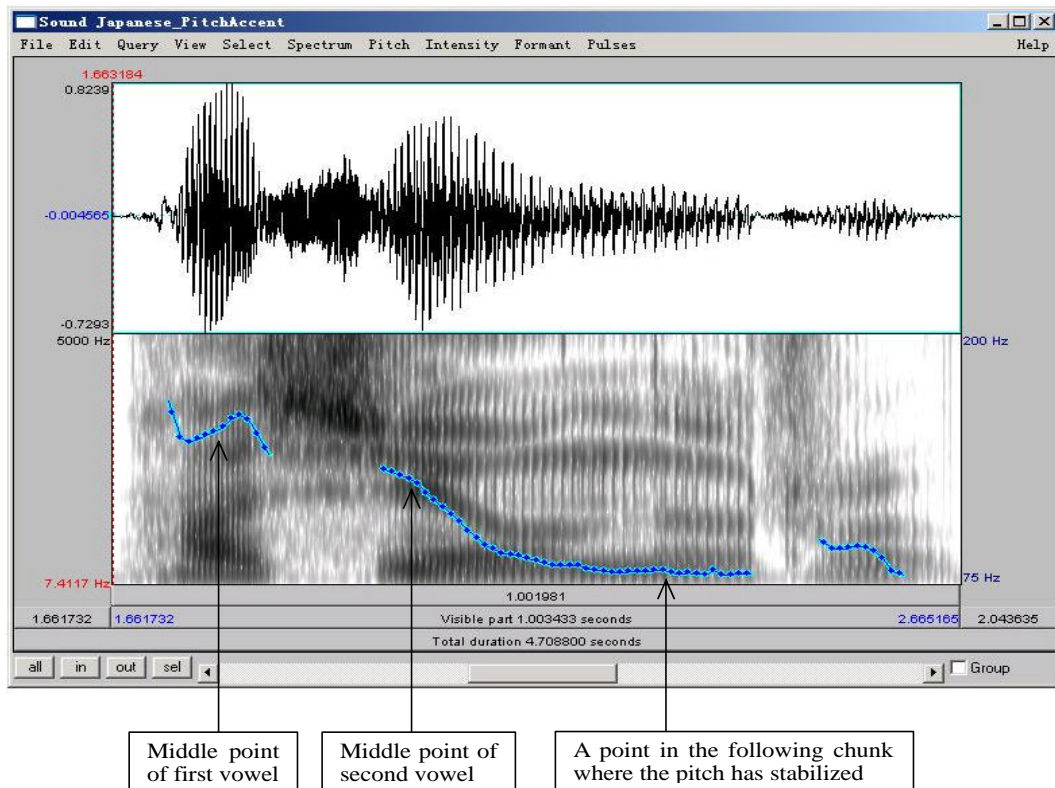


Figure 7.2 Pitch measurement in Japanese

Q2: Based on your observations, how does pitch accent work in Japanese, i.e. how does the accented syllable affect the pitch of whole the word/phrase?

SECTION III. MANDARIN TONE

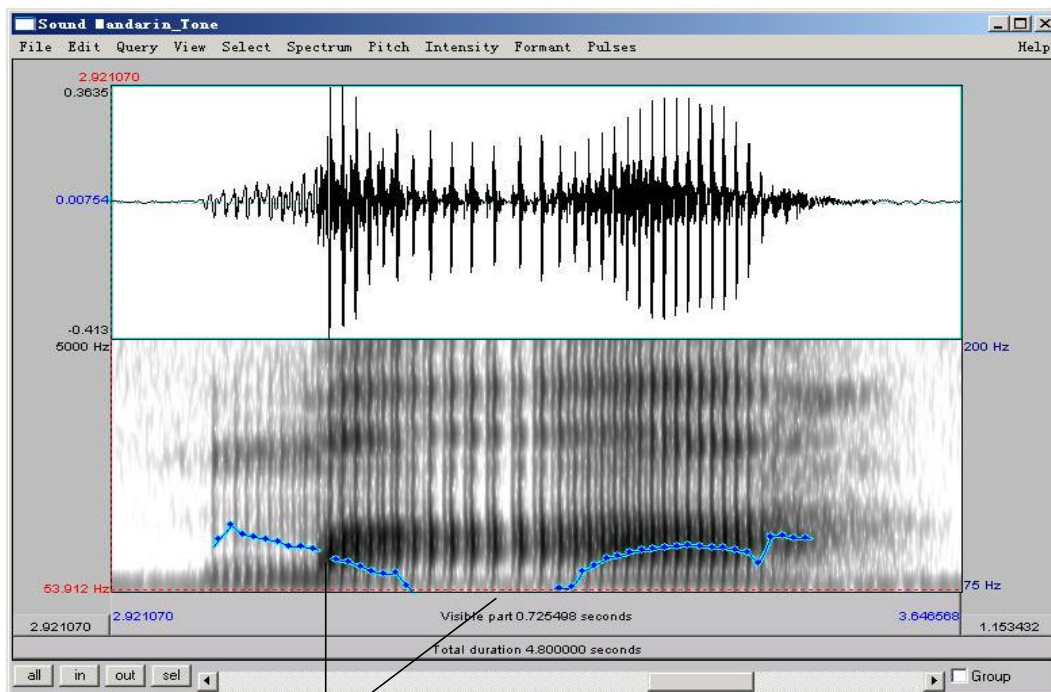
Mandarin illustrates the most complex way of using pitch. Whereas stress and pitch accent both basically involve a binary distinction in pitch (stressed vs. unstressed; accented vs. unaccented), tone involves more than a binary distinction. In the case of Mandarin, four different pitches, or TONES, are used to signal phonemic contrast.

- o Open the file **Mandarin_Tone.wav**, which contains the four words that all have [ma] as their segmental content, but that each have a different tone:

55	high level	ma55	‘mother’
35	high rising	ma35	‘hemp’
214	low falling	ma214	‘horse’
51	high falling	ma51	‘scold’

3. Use Table 3 to note down the frequencies used in each of the four tonal patterns. Measure the frequency at the start and end of the vowel, and at any turning points in the pitch contour.

TIP For the most part you can use Praat’s pitch tracking function. There are some places where the tracking function cuts out though (see Fig. 7.3). To measure in such places, use the waveform. (If you can’t remember how to do this, refer to LAB2, p.14)



Pitch tracking function cuts out here. Use the waveform to measure pitch or try lowering the min. pitch (pitch settings) to get a continuous contour.

Figure 7.3 Tone measurement in Mandarin

Q3: From what you can tell, is there a consistent frequency associated with each phonological pitch number? How is phonological tone related to phonetic pitch?

SECTION IV. TONE AND FOREIGN LANGUAGE ACQUISITION

4. Now record yourself trying to reproduce each of the Mandarin tones. Take the same measurements on your own speech as you took for the Mandarin speech, and enter the values in Table 7.4

Q4: How does your speech differ from the original Mandarin speech, in terms of:

- Overall pitch range used (absolute pitch): your minimum and maximum pitch vs. the minimum and maximum speech of the Mandarin recording.
- Relative pitch used, particularly in the contour tones: 35, 214, 51: what range of pitches do you use (min vs. max), compared to the original recording?

Q5: Do you tend to overdo (exaggerate) the tones, or underdo them?

LAB 7 – SUPRASEGMENTALS – WORKSHEET

SECTION I. KOREAN STRESS

Table 7.1 Description of stress in Korean.

	Duration (ms)			Pitch peak (Hz)			Amplitude peak (dB)		
za.dá.li	a	á	i	za	dá	li	za	dá	li
zán.zu	á n an	u		zán	zu		zán	zu	
zá:n.zu	á: n a:n	u		zá:n	zu		zá:n	zu	

Q1: Based on your measurements of Korean sound files, answer the following questions:

a: Which cues (duration, pitch, amplitude) does Korean use to signal stress?

b: Take a look at the duration of [n] in ‘landscape’ vs. ‘arithmetic’. Why are these two [n]s so different in duration?

SECTION II. JAPANESE PITCH-ACCENT

Table 7.2 Description of pitch-accent in Japanese.

	Pitch contour and key frequencies (Hz)
hási	<p>___145___</p> <p> ___85___</p> <p>[a] [i]</p>
hasí	
hasi	

Table 7.2 Description of pitch-accent in Japanese - *Continued.*

	Pitch contour and key frequencies (Hz)
hási o nuɾu	
hasí o nuɾu	
hasi o nuɾu	

Q2: Based on your observations, how does pitch accent work in Japanese, i.e. how does the accented syllable affect the pitch of whole the word/phrase?

SECTION III. MANDARIN TONE

Table 7.3 Description of the pitch contours used in Mandarin.

Word	F (start of vowel)	F (turning point)	F (end of vowel)	Stylized pitch contour (within the vowel) - draw it
ma55				
ma35				
ma214				
ma51				

Q3: From what you can tell, is there a consistent frequency associated with each phonological pitch number in Mandarin? How is phonological tone related to phonetic pitch?

Table 7.4 Description of the pitch contours used in imitating Mandarin.

Word	F (start of vowel)	F (turning point)	F (end of vowel)	Stylized pitch contour (within the vowel) - draw it
ma55				
ma35				
ma214				
ma51				

Q4: How does your speech differ from the original Mandarin speech, in terms of:

- Overall pitch range used (absolute pitch): your minimum and maximum pitch vs. the minimum and maximum speech of the Mandarin recording.
- Relative pitch used, particularly in the contour tones: 35, 214, 51: what range of pitches do you use (min vs. max), compared to the original recording?

Q5: Do you tend to overdo (exaggerate) the tones, or underdo them?

LAB 8 – DIALECTS OF ENGLISH**GOAL OF LAB 8**

Many people can recognize different dialects of English when they hear them, but why? What makes dialects of English sound so different from one another? Your goal in this lab is to try to figure out what kinds of acoustic properties distinguish between different dialects of English.

RECORDING

For this lab, you will need to download the following files onto the Desktop:

BritishRP.wav
 CanadianBC.wav
 Singapore.wav
 Tyneside.wav

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
 - o Download the sound files onto the Desktop
1. Listen carefully to each of these files on its own to get a general idea of what words / sounds /acoustic properties you want to focus on for your analysis. You will have to exam at least 4 parameters. Use Table 8.1 on the worksheet as a guide/summary for your investigation.
 - a. For each dialect, note down you impression of what makes this dialect unique: what distinguishes it from the other dialects.
 - b. Focusing on the words/sounds/acoustic properties you came up with as being unique for each dialect (see a. above), take the appropriate acoustic measurements, and compare them to similar measurements in other dialects. Note down your observations (see example tables on the worksheet).
- Q1:** What articulations are responsible for making these words/sounds/acoustic properties different from those in other dialects? Can you imitate different these words/sounds/acoustic properties based on what you know about the relationship between acoustics and articulation? If you're feeling really ambition, record your attempts and see how close you get!
- TIP**
1. To compare dialects, it's often useful to focus on specific words or phrases (e.g. 'disputing' or 'last' ; 'should be considered stronger than the other' – see example tables on the worksheet).
 2. A few examples of the segmental and suprasegmental differences that you can focus on are provided on the next page and related example tables are included in the worksheet. You are encouraged to look at other aspects that interest you.

SECTION I. SEGMENTAL DIFFERENCES

A. Consonants:

- Pronunciation of intervocalic stop consonants (see Figure 8.1 and Example Table 8.2)
- Pronunciation of coda consonants (see Table 8.3, refer to LAB5, p.42)
- Presence vs. absence of coda /r/ (refer to LAB4, p.33)
- Whether or not the stop consonants are released (aspirated) in coda position

B. Vowels:

- F1 and F2 measurements of a same vowel in different dialects (see Example Table 8.4).

C. Overall amount of glottalisation

- Remember glottalisation is usually accompanied by spreading out of the pitch pulses (see Figure 8.1 and Example Table 8.5, and refer back to LAB6, p.51)

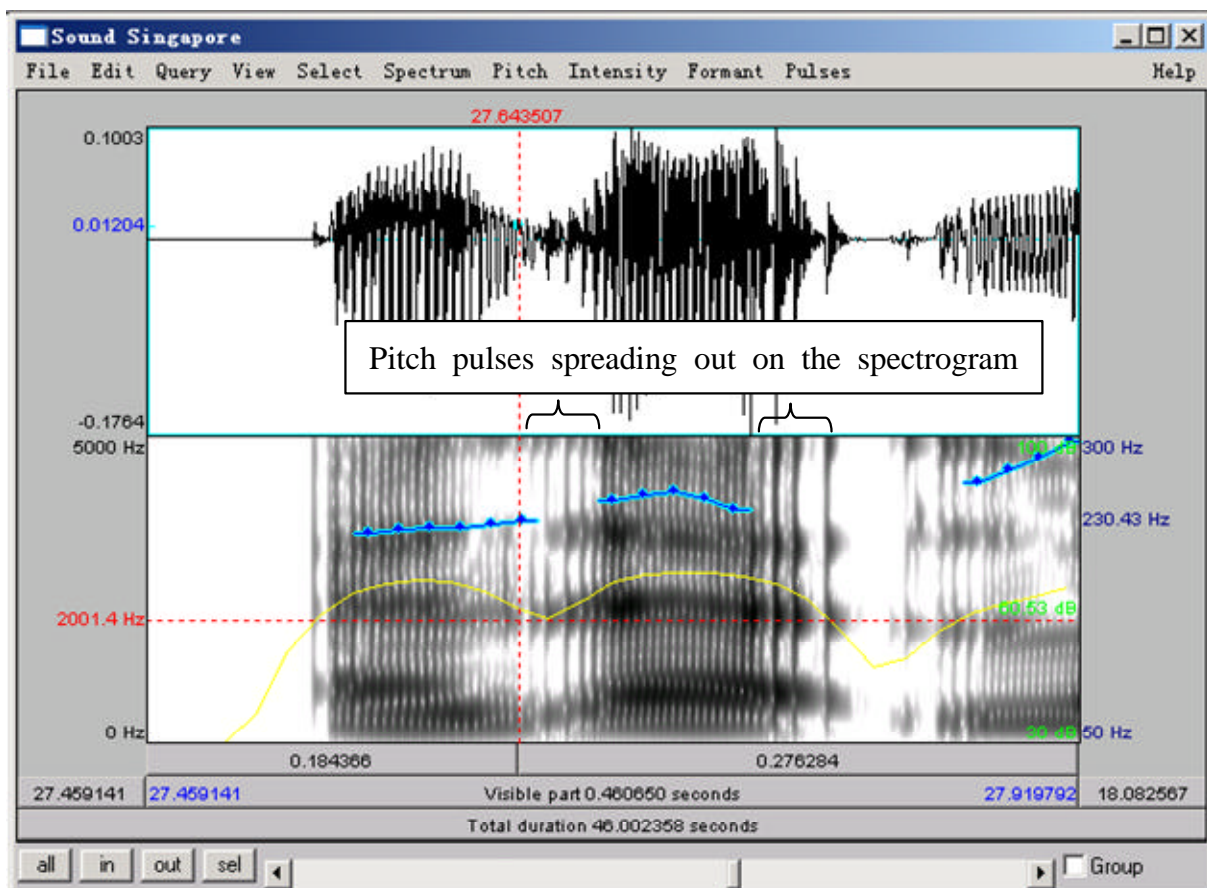


Figure 8.1 Glottalisation accompanied by spreading out of the pitch pulses

SECTION II. SUPRASEGMENTAL DIFFERENCES

A. Intonation:

- Compare general intonation contours of individual sentences: which dialect(s) have relatively flat vs. more sing-song-y contours; which words are the pitch maxima and minima aligned to? (see Example Table 8.6)

B. Rhythm

- E.g. compare Singapore English – which is supposed to be syllable-timed – to British English, by doing a quick %V calculation – as discussed in class (see Example Table 8.7):
 - o Segment a sentence of the sound file into CV sequences (see Figure 2. and refer back to LAB1 if you can't remember how to create a textgrid, p.6)
 - o Measure the duration of each vowel interval (V) in the sentence
 - o Add up the total duration of vowel intervals, and get the total sentence duration.
 - o %V = total duration of vowel intervals/sentence duration

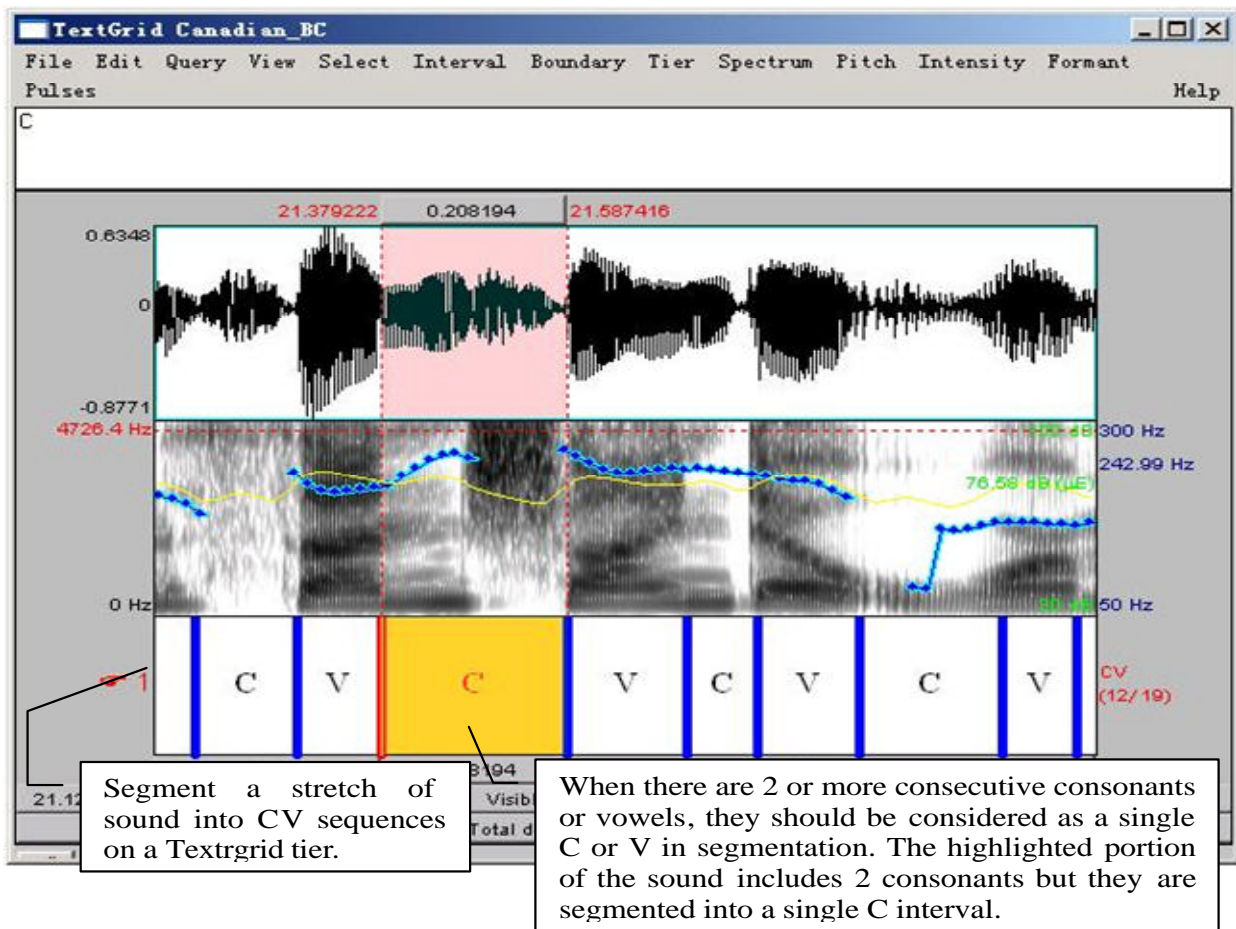


Figure 8.2 Segmenting a sound file into CV sequence

LAB 8 – DIALECTS OF ENGLISH - WORKSHEET

Table 8.1 Differences in Dialects of English

Dialects	Unique quality of the dialect	Acoustic correlate(s) of the unique quality(ies)	Q1: Articulation explanation (optional during lab time)
Canadian (BC)			
British RP			
Singapore			
Tyneside			

Q1: What articulations are responsible for making these words/sounds/acoustic properties different from those in other dialects? Can you imitate different these words/sounds/acoustic properties based on what you know about the relationship between acoustics and articulation? If you're feeling really ambition, record your attempts and see how close you get!

Example measurements

Here are some example measurements you can take in specific illustrative words. Note: you don't have to take these measurements; you may find others you think are more relevant. Use your judgment to decide what to focus on.

SECTION I. SEGMENTAL DIFFERENCES

Table 8.2. Pronunciation of /t/ in 'disputing'

	Glottalisation?	Aspiration?	IPA symbol
Canadian (BC)	no	no	ɾ
British RP			
Singapore			
Tyneside			

Table 8.3. Final nasal in 'disputing'

	F2 movement*	IPA symbol
Canadian (BC)	yes	ŋ
British RP		
Singapore		
Tyneside		

* Movement upwards = into velar pinch = velar [ŋ]

Table 8.4. Vowel quality in 'last' (you can make similar tables for other vowels)*

	F1 (Hz)	F2 (Hz)	duration (ms)	IPA symbol
British RP	769	1285	163	[ɑ]
Singapore				
Tyneside				

* Note: Canadian (BC) English is missing from this table and the next one because the relevant sentence is missing from the recording.

Table 8.5. Glottalisation of consonants in ‘and at (last)’

	Transcription of /ændætɫ/ (‘and at l...’ in ‘and at last’)
British RP	[ændət̚l] ⇨ no glottalisation
Singapore	
Tyneside	

SECTION II. SUPRASEGMENTAL DIFFERENCES

Table 8.6. Intonation pattern of ‘should be considered stronger than the other’

	Intonation pattern (qualitative observation)	Pitch range used (Hz)
Canadian BC		max: 246 (241) ‘considered’ (‘stronger’) min: 132 ‘other’ range: 114
British RP		max: min: range:
Singapore		max: min: range:
Tyneside		max: min: range:

Table 8.7. Rhythm: %V of ‘should be considered stronger than the other’

	Sum of V Duration (ms)	Total Duration (ms)	% of V
British RP			
Singapore			

LAB 9 – EXOTIC SPEECH SOUNDS

GOAL OF LAB 9

In this lab you will get a chance to take a look at some of the more ‘exotic’ speech sounds, i.e. sounds that are not found in English and that we have not yet discussed in class. Your task is to find a sound or set of sounds to explore, and provide a phonetic description of it/them. This lab work will be in preparation for the optional class presentations, and also in preparation for your last lab assignment of the term, in which you will be asked to select a set of sounds of your choice (from a language of your choice) and describe them.

RECORDING

For this lab, take a look at the following website:

<http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants/>

From this site you can click on:

- Index of languages, or
- Index of sounds

From these indices you can find lots and lots of sounds to look at.

- o Download the sounds that interest you.
 - o Right-click on the sound
 - o Save target as...

WARNING: in some cases the recording quality isn’t very good, making it difficult to analyse the sounds. Make sure you pick sounds that are clear enough (auditorily and visually) to analyze.

TIP Here are some suggestions in terms of things to look at:

- o Take a sound/set of sounds that exists in English (that you’ve worked with) and compare it to a sound/set of sounds from another language written with the same IPA symbol(s). This will give you an idea of language-specific phonetics, and the kind of variation that exists across languages, for example:
 - VOT in the stop series
 - Vowel formants
 - /l/ across languages (dark vs. light)
- o Take a sound/set of sounds that doesn’t exist in English and explore the phonetic properties:
 - Duration differences in geminates vs. singletons/long vs. short vowels
 - Acoustic properties of clicks
 - Acoustic properties of implosives
 - Acoustic properties of ejectives
 - Acoustic properties of labialized sounds

TIP Your last lab assignment involves choosing set of sounds and describing it phonetically. This is a good opportunity to start working on finding a set of sounds to work on and start doing some preliminary work towards the assignment!

LAB 9 – EXOTIC SPEECH SOUNDS

LAB 9 – EXOTIC SPEECH SOUNDS – WORKSHEET

Sound/sound set chosen:

Language and language family:

Reason for choosing this sound/sound set:

Acoustic properties:

Please create your own tables and/or diagrams below for illustrating the important acoustic properties of the sound(s) you've chosen. You can use previous worksheets as examples to figure out how to note down your measurements.

Q1. What articulations do you think are at the source of the acoustic properties you measured in this lab?

LAB 10 – SPEECH SYNTHESIS

GOAL OF LAB 10

The goal of this lab is to try your hand at some speech synthesis. The possibilities for manipulating speech are virtually unlimited. In this lab we will play with VOICING and TONE. You will also get to create your own RAP SONG!

RECORDING

For this lab, you will need to download the following files onto the Desktop:

<i>File name</i>	<i>Sounds included</i>
Lab10_pa_ba.wav	(pa, ba)
Lab10_lap_lab.wav	(lap, lab)
Lab10_T1_T4.wav	(ma in T1, ma in T4)
Lab 10_rap_example.wav	(example of synthetically created “rap”)

- o Go to <http://web.uvic.ca/ling/coursework/ling380/index.html>
- o Download the sound files onto the desktop:

SECTION I. VOICING MANIPULATION

In the first section of the lab, we will learn to change a voiceless stop [p] into a voiced one [b].

A. VOT manipulation

As we discovered in LAB5, VOT is an important acoustic cue for voicing in stops. Changing the VOT of a stop may change the identity of a stop. In this section you will manipulate the VOT of the stop in [pa] to get the stop in [ba].

1. Measure the VOT of [pa] vs. [ba] in natural speech and note down your measurements in Table 10.1 (if you can't remember how to do this, refer to LAB5, p.40).
2. Follow the instructions below to create a [pa]~[ba] continuum by gradually cutting out aspiration in [pa]. Also note down the VOT of each token along your [pa]~[ba] continuum in Table 10.1.
 - o Open sound file **LAB10_pa_ba.wav** in the Edit window.
 - o Zoom in on [pa]: leaving the burst as is, cut out the aspiration in 10-20 ms steps, until there's no more aspiration at all (Fig. 10.1):
 - o Go to Edit > Cut
 - o Each time you cut out 10-20ms of aspiration, extract the token as a new sound file:
 - o Highlight [pa]
 - o File > Extract sound selection (preserve times)
 - o In order to keep track of the tokens you are creating, rename the extracted selection:

- o In the Praat objects panel: **Rename**
- o **Sound untitled** > **Pa1** (after first cut), **Pa2** (after second cut), **P3...**
- o You'll end up with about four tokens along a [pa]~[ba] continuum.

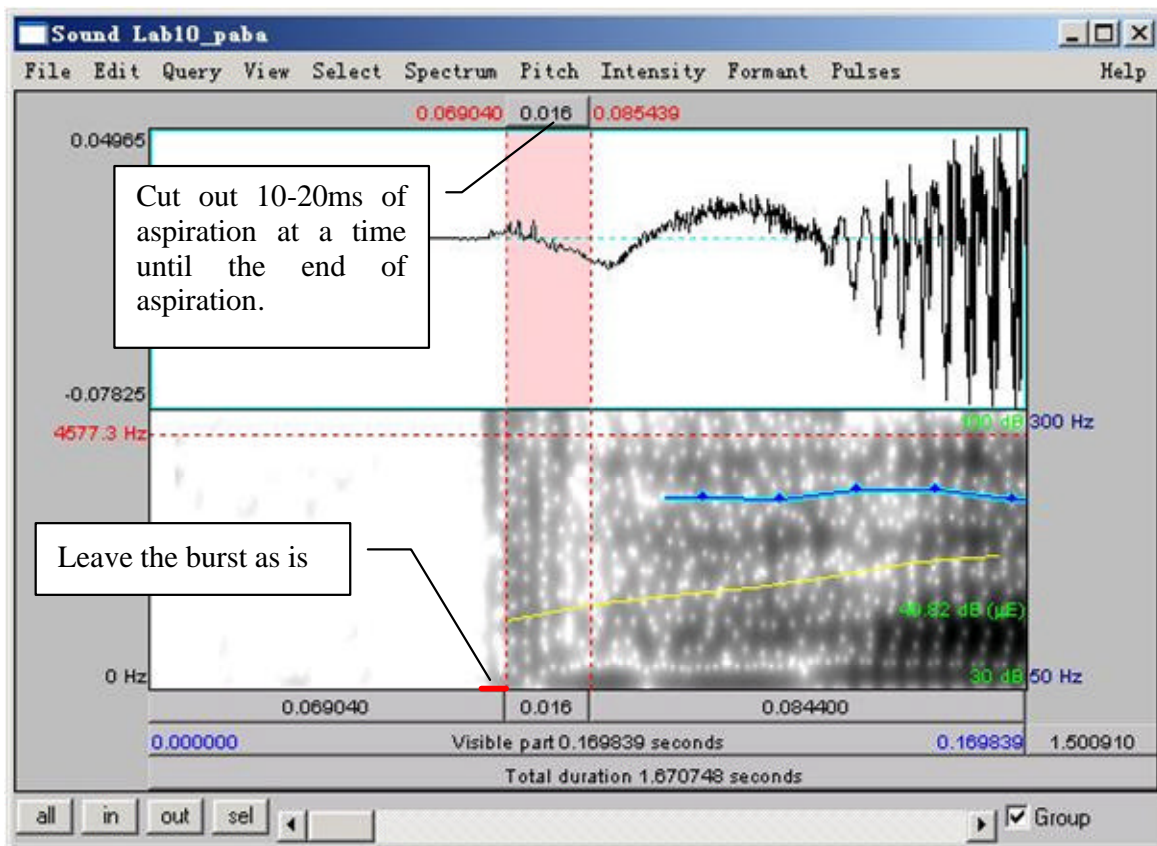


Figure 10.1 VOT manipulation

- Q1: Compare the synthesized [Pa]s⁴ you created with the natural [ba]:
- a. Which token sounds the closest to the original [ba], and how close does it sound?
 - b. What other manipulations do you think would help to make it more natural? (and how would you do these manipulations?)

B. Vowel length manipulation (optional)

Another important acoustic cue to voicing in stops in coda position is the length of the preceding vowel. In this part, you will manipulate the length of the vowel in [lap] to make [lap] sound like [lab]. This part of the lab is optional.

3. Open sound file **Lab10_laplab.wav** in the Edit window. Measure the length of the vowel in [lap] vs. [lab] in natural speech and note down your measurements in Table 10.2

⁴ “P” is used as the abstract version of [p ~b] that isn’t specified for voicing. This is common practice in phonological analysis as well.

There are two ways to manipulate vowel length: an easy/not so good way and a more difficult/better way. You can choose either way or try both.

4. Use the easy/not so good way to lengthen a vowel:
 - o In the Edit window, select a steady portion of the vowel in [lap] (20ms or so)
 - o Copy and paste it after itself as many times as is necessary to reach the duration of the [a] in the natural [lab]
 - o **Edit > Copy** selection to sound clipboard
 - o Set cursor on the endpoint of the vowel section you selected
 - o **Edit > Paste** after selection
 - o When you're done copying and pasting, extract the token as a new sound file:
 - o Highlight [lap]
 - o File > Extract sound selection (preserve times)
 - o In the Praat objects panel: **Rename**
 - o Sound untitled > **laP1**
5. Measure the duration of the new vowel duration in [laP1] and note down the values in Table 10.2.

Q2: Compare the synthesized [laP1] you created with the natural [lab].

- a. How close do they sound?
- b. What further manipulation(s) would make the synthesized and natural tokens more similar?
- c. What problems do you find with this way of manipulation?

6. Now try the more difficult/better way to lengthen a vowel:

- o Re-open sound file **LAB10_laplab.wav** (from the desktop)

TIP You have to re-open the file because the **LAB10_laplab.wav** you opened before has now been modified.

- o Create a manipulation object for the sound file:
 - o Highlight the newly opened sound file **LAB10_laplab.wav** in the Praat objects panel.
 - o Click **To manipulation...** on the right side of the objects panel (keep default settings).
 - o This will create a new object in the Praat objects list "Manipulation LAB10_laplab".
 - o In the Praat objects list, highlight "**Manipulation LAB10_laplab**" and click on **Edit** in the Praat objects panel

→ This will open an edit window with three blocks (see Fig. 10.2):

- The waveform block
- The pitch manipulation block with the pitch contour as a series of green balls
- The duration manipulation block.

Ignore the pitch manipulation block for this section of the lab and focus on the duration block.

- o To insert duration manipulation points in the duration block:
 - o Locate the vowel portion in [lap]
 - o Insert a duration point at the beginning and end of the vowel (see Fig. 10.2):
 - o Place cursor at beginning/end of the vowel
 - o Go to Dur > Add duration point at cursor
 - o Now insert two additional duration points: one immediately before the beginning of the vowel and one immediately following the vowel (during the closure duration of [p] is fine). These two points are created to ensure that the remainder of your sound file retains its original duration, which will be introduced in detail below.

→ You should now have four duration points:

- pre-vowel (immediately before the beginning of the vowel)
- vowel-initial (beginning of the vowel)
- vowel-final (end of the vowel)
- post-vowel (immediately following the vowel, i.e. following the vowel-final point)

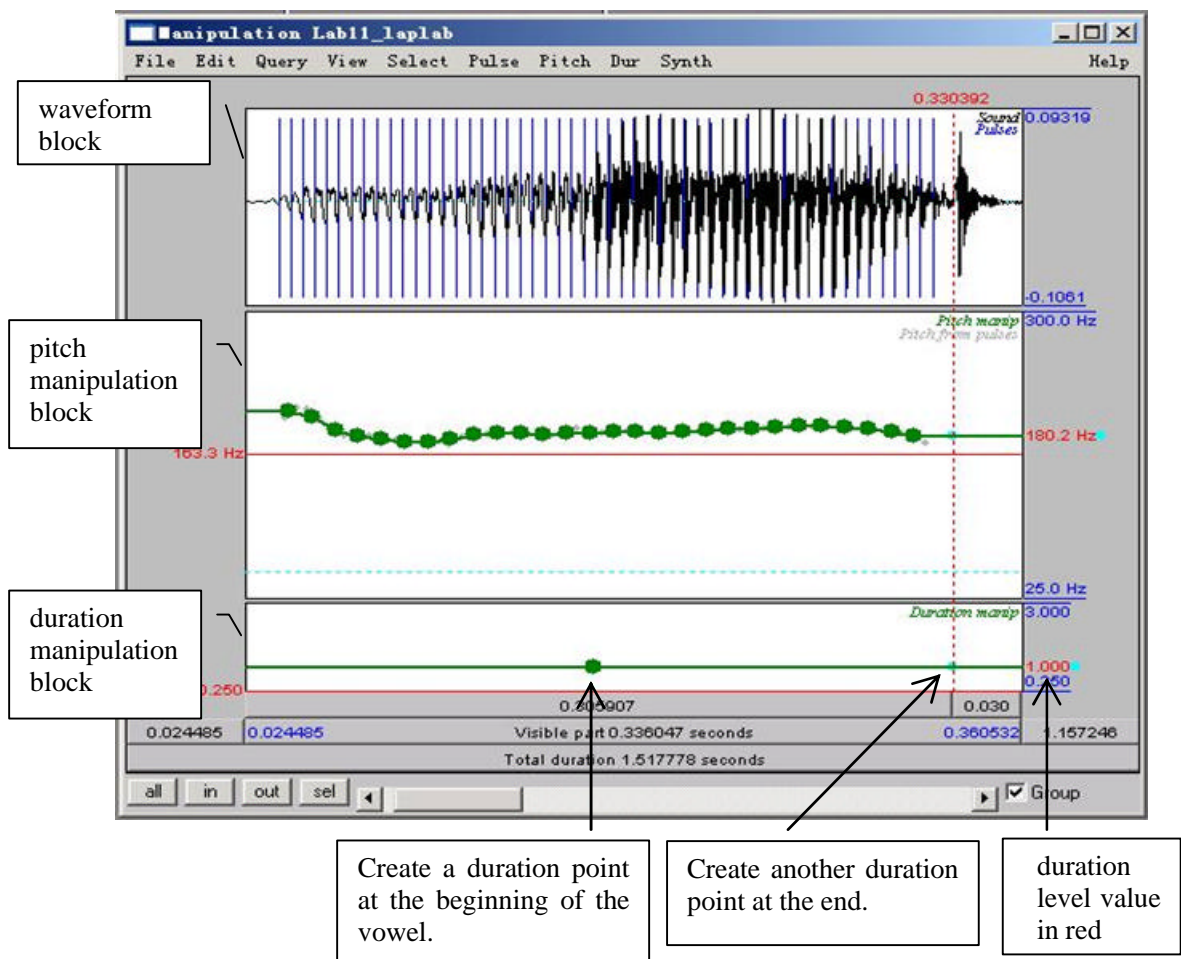


Figure 10.2 Manipulation window

Dragging the vowel-initial and vowel-final points up will increase the duration of the interval (see Fig. 10.2); dragging the points down will have the opposite effect. For example, dragging the vowel-initial and vowel-final points to a duration level of 2 will double the length of the original selection between the two points (If the vowel was 50ms, the process will change it to 100ms.) (See Fig. 10.3.)

- o To lengthen the vowel:
 - o Leave the pre-vowel and post-vowel duration points at the level of 1.000 (they should already be there by default. If they are not, drag them to the level of 1.000). You can find the duration level value in red at both ends of the red horizontal line. (See Fig. 10.1)
 - o Drag the vowel-initial and vowel-end points up as much as you feel is necessary to reach the duration of [a] in the natural [lab].
- o In the manipulation window: **File > Publish resynthesis.**

→ This will put a new sound in the Praat objects panel: SoundfromMapulationEditor

- o Select the file in the object window and **Rename: laP2**

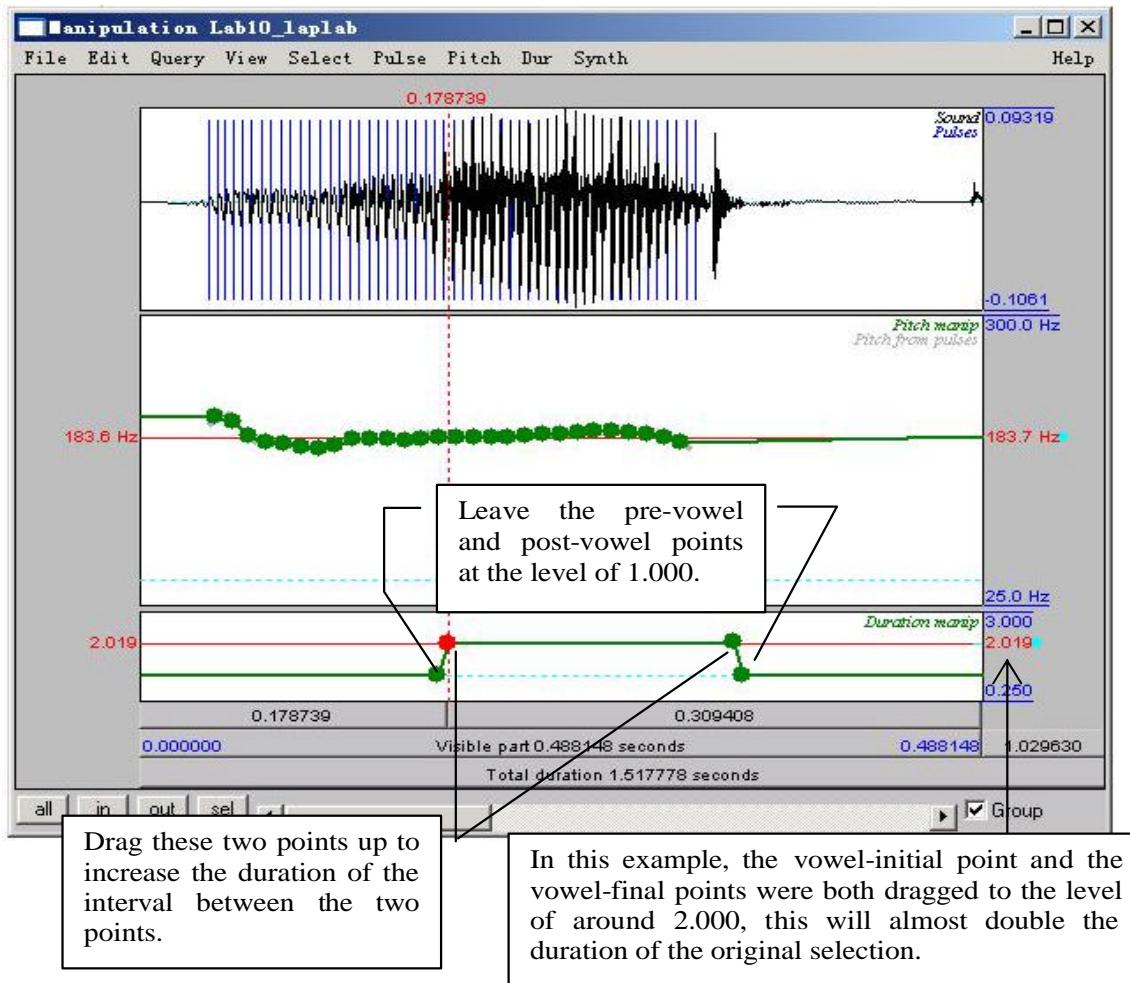


Figure 10.3 Duration Manipulation

7. Open this file in the Edit window, and measure the duration of the vowel in labP2. Note down your measurement in Table 10.2.

Q3: Compare [laP2] with [laP1] and the original [lab].

- a. Which of your synthesized tokens sounds closer to the natural [lab]?
- b. How natural are these tokens compared to the natural [lab]? Which file ([laP1] vs. [laP2]) sounds more natural?
- c. What other manipulations do you think might make it sound better?

SECTION II. TONE MANIPULATION

As we discovered in LAB8, pitch contour is used in Mandarin to signal phonemic contrast. In this component of the lab, you will transform one Mandarin tone into another one by manipulating its PITCH CONTOUR.

8. Follow the instructions below and note down the pitch and duration of the natural T1 and T4 in Table 10.3.
 - o Open the sound file **LAB10_T1T4.wav** in Praat
 - o In the Edit window, on the pitch contour, measure the frequency at the start and end of the T1 and T4 syllables. Note down your measurements in Table 10.3. If there are some places where the tracking function cuts out, use the waveform to measure and calculate the pitch (if you can't remember how to do this, refer to LAB2, p.14).
 - o Measure the duration of the natural T1 and T4, respectively and calculate the ratio between T1 and T4 (T1/T4). Note down your measurements in Table 10.3.

A. Pitch manipulation

9. Follow the instructions below to transform Tone 1 into Tone 4 by manipulating the pitch of the sound file.
 - o To create a manipulation object of the sound file:
 - o Back in the Praat objects panel, highlight LAB10_T1T4.
 - o **Click To Manipulation...** (keep default settings).
 - o This will create a new object in the Praat objects panel “Manipulation LAB10_T1T4”.
 - o Highlight this object and click on **Edit** in the Praat objects panel: this will bring up the manipulation window – the same as you saw in 6 above.
 - o
 - o This time, focus on the pitch manipulation block:
 - o Drag the pitch balls to create a new pitch contour:
 - o A series of pitch manipulation points have been generated by Praat automatically.
 - o Zoom in to T1
 - o Drag the first pitch ball of T1 up/down until its frequency is the same as the start point frequency of the natural T4 (measured in 8 above; see Table 10.3).

- o Drag the last pitch ball of T1 down until its frequency is the same as the end point frequency of natural T4 (also measured in 8 above).
 - o Drag all the balls in between until you get a contour between start and end points that is similar to the natural T4 contour.
 - o In the manipulation window: **File > Publish resynthesis**. This will put a new sound in the Praat objects panel: SoundfromMapulationEditor.
 - o Rename this: **SyntheticT4_1**
 - o Do NOT close the manipulation window at this point. We will come back to this file later.
10. Open the file SyntheticT4_1 in edit window. Measure the beginning and end-point frequencies and the duration of syntheticT4_1. Note down your measurements in Table 10.3.
- Q4. Compare SyntheticT4_1 with the natural T4.
- a. How close is it to the natural T4?
 - b. What else do you think you could do to make it sound more like T4?

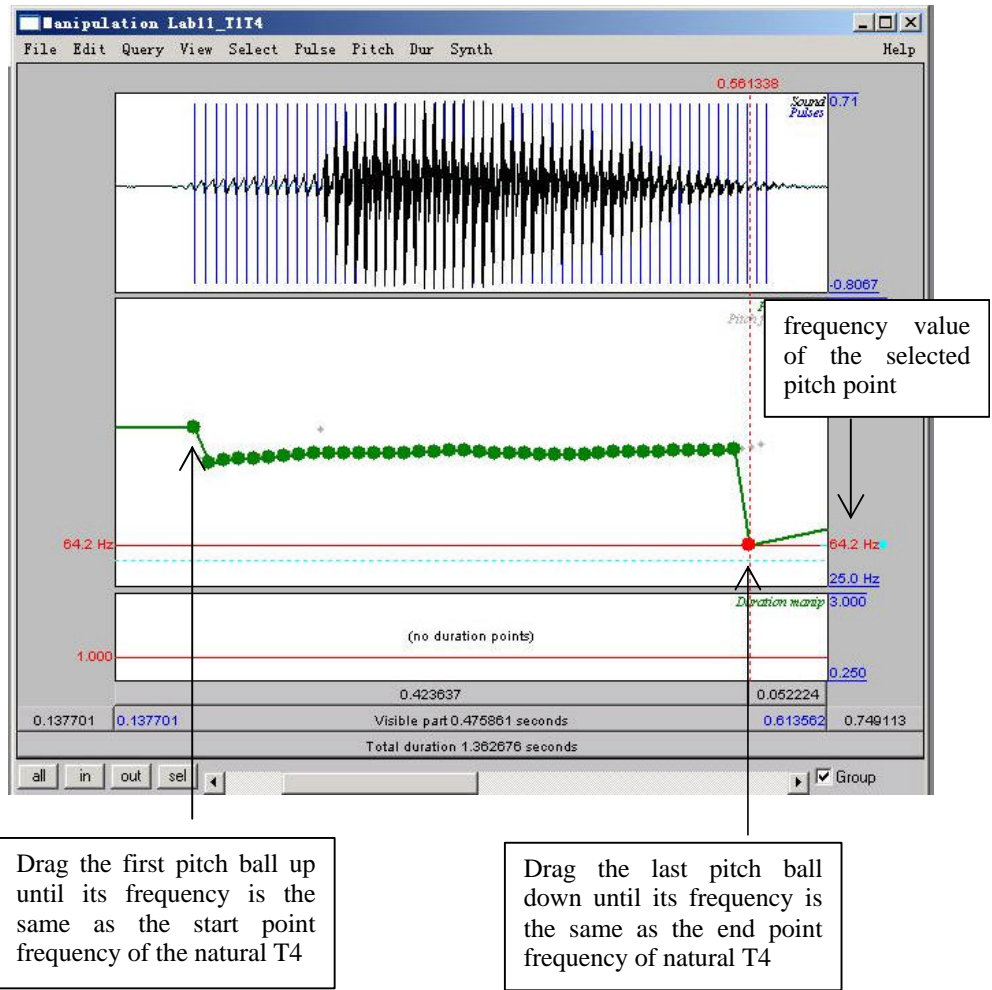


Figure 10.4 Pitch manipulation

B. Duration manipulation

11. In this section, on the basis of your pitch manipulation, you will change the duration of the original T1 to make it more similar to T4.
 - o Go back to the tone manipulation window, and identify the original T1 portion.
 - o Find the duration manipulation block (the bottom block).
 - o Insert four duration points (refer back to Section I, p.79):
 - pre-syllable (immediately before the syllable)
 - syllable-initial (at the beginning of the syllable)
 - syllable-final (at the end of the syllable)
 - post-syllable (during the pause following the syllable)⁵
 - o Manipulate the duration of T1 so that it resembles the natural T4.

TIP 1. Make sure that the pre-syllable and post-syllable duration points are set at the duration level of 1.000. They should be there by default.
2. To lengthen the duration of T1 (see above), drag the syllable-initial and syllable-final points up; to shorten it, drag the two points down.

- o Listen to the token to see if you are satisfied with the result. Change the duration if you are not.
 - o Now, to combine the result of pitch and duration manipulations, you can re-save the resynthesized file you have created.
 - o In the manipulation window: **File > Publish resynthesis**. This will put a new sound in the Praat objects panel: SoundfromMapulationEditor
 - o Rename this: **SyntheticT4_2**
12. Open **SyntheticT4_2** in the Edit window: measure the beginning and end-point frequencies and the duration of SyntheticT4_2. Note down your measurements in Table 10.3.

- Q5: Listen to SyntheticT4_1 and SyntheticT4_2 and compare them to the natural T4:
- a. Which synthesized T4 is more similar to the natural T4?
 - b. What can you conclude from the difference between the two synthesized T4s about the acoustic cues to tone in Mandarin?

SECTION III. RAP SONG

13. As an easy, fun component to this lab, you can record yourself saying a sentence and then create a rap song with it by copying and pasting bits here and there. If you do this, e-mail your resulting file to sbird@uvic.ca: we can listen to the fruits of your artistic labour in class!

⁵ See section II B (p. 4) for an explanation of this.

LAB 10 – SPEECH SYNTHESIS – WORKSHEET

SECTION I. VOICING MANIPULATION

Table 10.1. VOT manipulation

	[pa] (natural)	[Pa1]	[Pa2]	[Pa3]	([Pa4])	([Pa5])	[ba] (natural)
VOT (ms)							

Q1. Compare the synthesized [Pa]s you created with the natural [ba]:

a. Which token sounds the closest to the original [ba], and how close does it sound?

b. What other manipulations do you think will be needed to make it more natural? (and how would you do these manipulations?)

Table 10.2 Vowel length manipulation

	[lap] (natural)	[laP1]	[laP2]	[lab] (natural)
Vowel Length (ms)				

Q2: Compare the synthesized [lap1] you created with the natural [lab].

a. How close do they sound?

b. What further manipulation(s) would make the synthesized and natural tokens more similar?

c. What problems do you find with this way of manipulation?

Q3: Compare [laP1] with [laP2] and the original [lab].

- a. Which of your synthesized tokens sounds closer to the natural [lab]?

- b. How natural are these tokens compared to the natural [lab]? Which ([laP1] vs. [laP2]) sounds more natural?

- c. What other manipulations do you think might make it sound better?

SECTION II. TONE MANIPULATION

Table 10.3. Tone manipulation.

	Frequency value at the beginning point (Hz)	Frequency value at the end point (Hz)	Duration (ms)	Duration ratio = T4 / T1
T1 (natural)				
T4 (natural)				
SyntheticT4_1				
SyntheticT4_2				

Q4: Compare SyntheticT4_1 with the natural T4.

- a. How close is it to the natural T4?

- b. What else do you think you could do to make it sound more like T4? Think about what other differences there are between T1 and T4...

Q5: Listen to SyntheticT4_1 and SyntheticT4_2 and compare them to the natural T4:

- a. Which synthesized T4 is more similar to the natural T4?

- b. What can you conclude from the difference between the two synthesized T4s about the acoustic cues to tone in Mandarin?