Hoole, Akustik für Fortgeschrittene, WiSe0809

Exercise with Praat. Acoustic analysis of fricatives using spectral moment measures

Log on to the matlab account.
cd to directory akustikfort/fricatives/cip'n' (where 'n' is the number of your computer)

1. Preliminaries

Load each of the files
afa, asa, asha
ufu, usu, ushu

Use the editor to extract the fricative segment, and rename the new object in Praat's object list.
e.g afa ==> af

2. Basic script file

In the 'Praat' dropdown menu in the 'Praat objects' window choose 'New Praat script'.
Enter the following in the new window ('untitled script')

```
mysound$="as"
select Sound 'mysound$'
To Spectrum... yes
Cepstral smoothing... 500
Rename... 'mysound$'_smooth
select Spectrum 'mysound$'
cog = Get centre of gravity... 2
std = Get standard deviation... 2
kurtosis = Get kurtosis... 2
skew = Get skewness... 2
printline 'mysound$''tab$''cog''tab$''std''tab$''kurtosis''tab$''skew'
```

With 'File > Save as' save the file with a name like fricative_script_1.txt

In the script window use the 'Run' command to execute these commands. If everything has been typed correctly then in the object window you should see two new objects:
'Spectrum as' and 'Spectrum as_smooth'
Also, the Praat info window should show a line of data consisting of the name of the sound followed by 4 numeric values.

What does this script do?
Basically, it corresponds to the following interactive commands:

Select the sound 'is' then choose the command 'Spectrum > To Spectrum'.
The resulting spectrum object is then smoothed with the command 'cepstral smoothing' and renamed to distinguish it from the first spectrum.
Then the original unsmoothed spectrum is selected and a series of commands like 'Query > Get centre of gravity' is carried out.

The key feature of the script is that we use **variables**, so the whole series of commands can

be applied very quickly to further sounds, and also the results can be printed in a more convenient form.
mysound$ is a string variable (indicated by the final dollar sign) that for the initial example is given the value 'as'. Then, everywhere in the script where mysound$ appears in single quotes its current value is inserted in the corresponding command.
All the 'Get' commands return their result in a numeric variable (cog, std, etc.). Then, with the printline command we can print all the results at once in the info window. (Once again, cog etc. in single quotes means that the current value of the variable is inserted. tab$ is a predefined variable to separate each value with a tab).
This is much more convenient than the interactive 'Query > Get' procedure, since this just prints one value at a time in the info window, and always overwrites the previous value.

3. Using Praat's history mechanism

Normally, it is not necessary to write a script of this kind completely by hand.
To illustrate this, we will now figure out how to insert the overall intensity of the fricative (in dB) into our list of results

First of all, in the script window move the cursor to the bottom of the window and choose the command 'Edit > Clear history'.
Then, in the object window select 'Sound is' and then 'Query > Get intensity (dB)'
Make a note of the value that appear in the Info window.
Then, go back to the script window and choose 'Edit > Paste history'
You will now see the commands that you need to use.
Figure out how to merge them with the rest of the script so that the dB value will be printed as the first numeric value in the printline command (a total of 5 numeric values should now be displayed).
Check that the script runs correctly, and that you get the same dB value that you previously noted.
Check that the script runs correctly for other sounds.

4. Background to spectral moments

(See also the copy of the figure from Forrest et al., (1988), JASA 84)
These measures capture the shape of the spectrum using measures that are employed in statistics to characterize a probability distribution.
The **centre of gravity** corresponds to the mean of the distribution. Intuitively, it corresponds to the frequency that divides the spectrum into two halves such that the amount of energy in the top half (higher frequencies) is equal to that in the bottom half (lower frequencies).
Accordingly, **standard deviation** here captures the amount of **dispersion** of spectral energy around the mean (i.e whether the energy is concentrated mainly in a small band or spread out over a wide range of frequencies).
Skewness captures whether the distribution is tilted to the left or the right.
Kurtosis captures whether the shape deviates from that of a Gaussian distribution (basically, whether it is more peaked or more flat).
Here are the explanations from Praat Help:

"The spectral **centre of gravity** is a measure for how high the frequencies in a spectrum are on average. For a sine wave with a frequency of 377 Hz, the centre of gravity is 377 Hz. You can easily check this in Praat by creating such a sine wave (Create Sound from formula...), then converting it to a Spectrum (Sound: To Spectrum...), then querying the mean frequency. For a white noise sampled at 22050 Hz, the centre of gravity is 5512.5 Hz, i.e. one half of the Nyquist frequency.

The **standard deviation** is a measure for how much the frequencies in a spectrum can deviate from the centre of gravity. For a sine wave, the standard deviation is zero. For a white noise, the standard deviation is the Nyquist frequency divided by √12.
(Note (Phil): For the above example of white noise sampled at 22050Hz this gives 3183Hz (=11025/3.4641))

The **skewness** is a measure for how much the shape of the spectrum below the centre of gravity is different from the shape above the mean frequency. For a white noise, the skewness is zero.

The **kurtosis** is a measure for how much the shape of the spectrum around the centre of gravity is different from a Gaussian shape. For a white noise, the kurtosis is - 6/5."

5. Phonetic Analysis

5.1 Fricative place of articulation
Analyze the different places of articulation, keeping vowel context constant
i.e analyze in the order afa, asa asha, then ufu, usu ushu

When you have a complete set of analysis results in the Info window, store it to a text file named something like fricative_poa.txt

5.2 Effect of coarticulation
Analyze in the order afa, ufu, then asa, usu, then asha, ushu

When you have a complete set of analysis results in the Info window, store it to a text file named something like fricative_coarticulation.txt

When doing the coarticulation analysis try and note cases where coarticulation may make differences between place of articulation less obvious.

6. Visualizing the spectra

If desired, try and merge this step with step 5.

For each group of analyses plot the smoothed version of the spectrum in the picture window using the draw command.
e.g overlay overlay all places of articulation in /a/ context etc.
overlay /f/ in both vowel contexts etc.

Use the picture window pen command to choose a different colour for each fricative in the

plot (before starting use the pen command to set line width to 2).
Important: It will necessary to try out first what will be appropriate values for minimum power and maximum power in the draw command that can be used for ALL fricatives (and then keep these values the same every time the drawing command is used).

If at all possible, use the history mechanism to insert appropriate commands in the script.

When each picture is complete use the ‘Margins > Text top’ command to insert some text explaining what colour is used for what fricative
Save the picture as an eps file

7. Listening (mainly for fun)

Concatenate the fricative segments to a single sound, grouped first by place of articulation and then by vowel context.

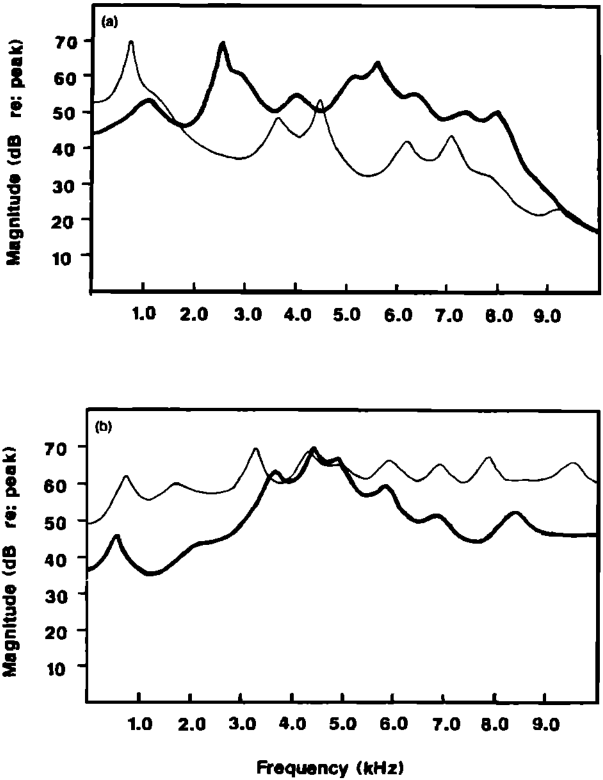

FIG. 1. (a) Two spectra that differ in mean and skewness. The thin-lined spectrum has a mean of 1.0 kHz and a positive skewness of 4.0. By contrast, the thick-lined spectrum has a mean of 4.5 kHz and a slight negative skewness of − 1.2. (b) Two spectra with similar means and skewness, but different kurtoses. The thin-lined spectrum has a kurtosis of − 0.7, which is reflective of its diffuse peaks, while the thick-lined spectrum has a kurtosis of 6.7. All spectra were LPC smoothed for easier viewing.