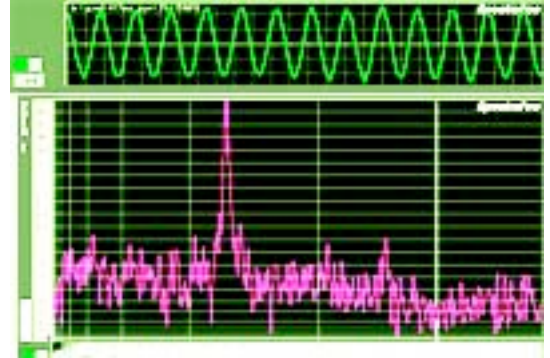


See your voice

Digital audio software

Introduction

Using free downloadable software, you can see the frequency distribution and waveforms of the human voice or music.



Materials

Macintosh:

- Download **SpectraFoo Standalone** 30-day Demo at <https://www.mhsecure.com/DemoCentral/>
- Manual is at <http://www.metric-halo.com/beta/SpectraFoo4—Manual.pdf>

Windows:

- Audacity works for Windows and Mac. It will record and import audio: Spectrafoo only shows a realtime display of incoming audio.
- The spectrograph is less sophisticated than Spectrafoo. You can see much of the same information as in Spectrafoo, but it doesn't display in real time.
- Download Audacity at <http://audacity.sourceforge.net/download/>

Other windows programs (not tested by us):

- http://www.nauta-rcs.it/SEA/seawave_index.html
- <http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=3428>
- <http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=6303>

Using Spectrafoo

- See <http://www.exo.net/~drsteph/activities.html> for screenshots.
- Click the “+” next to one of the options to open that “instrument”. Open the spectrograph.
- Change the settings by clicking the button to the right of the green power button (circle with line in it).
- Make sounds, or play some in iTunes (or similar program). The frequency (in Hertz) is displayed on the x-axis, on a log scale, and Power on the y-axis. Each doubling of frequency represents one octave.
- You can change the resolution of the screen by fractions of octaves in the settings. Notice the octaves get wider towards the higher frequencies, due to the log scale.

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<http://www.exo.net/~drsteph>

Since there are 12 notes in an octave (including sharps), then the 1/12 octave scale will show single notes.

- You can find the frequency of a spot on the graph by holding the apple key and dragging the mouse – the white line on the display will move to the point of interest. Peak frequency is read in the bottom.
- You can change the time delay in the software by increasing the number of points to 16 to 64K in the “Analyzer” menu on the top of the screen. Neat effect.
- Now, open the oscilloscope as well. The oscilloscope shows the *waveform*: amplitude on the y-axis and time on the x-axis. Thus, this shows you the number of air compressions passing a point every second – the pressure waves stretched out over time. The amplitude represents the pressure (and your ears hear pressure change).

Using Audacity

- See <http://www.exo.net/~drsteph/activities.html> for screenshots.
- Choose “File – new” and “Project – New Audio Track” to begin.
- To have some audio to play with, you may (a) click the button with the red circle to record, (b) Use the Generate menu to create a tone or a pluck, or (c) choose “Project – Import Audio” to import a .mp3 or .wav file.
- To see the waveform (as in an oscilloscope; see above), click the magnifying glass in the upper left corner, then click on your waveform repeatedly. This expands the time axis until you can see the waveform.
- To see the spectrum of the waveform (as in a spectragraph, see above), click the selection tool (looks like an “I” in the upper left hand corner), and then select a portion of your audio. Then choose “Analyze – Plot Spectrum”. In this window, you can select a greater number of data points (like 512, 1024, etc) to get better resolution. To change the range of frequencies displayed, you must go to the “Preferences” in the main menu.

1. Exploring your voice

To do and notice

- *Keeping the same pitch*, drone out the tone “aaaaaa”. While you’re doing it, hit “snap” on the left hand side. Save it as something like “A”. From the snapshot list, choose “1-ln1” next to “A” so you can see the trace of “A” on the screen.
- Now try more vowels *at the same pitch* – “eeee”, “iiii”, “ooo”. What do you see?
- Find the frequencies of the peaks. How do they relate to each other?

What’s Going On?

Our vocal tracts have a set of resonant frequencies, which you see here as spikes in frequency. When we make different vowel sounds, we are modifying the shape of our mouth and lips. Our mouth is the chamber into which the frequencies of

the vocal tract are played – changing the shape of that chamber damps out some of the resonant frequencies of the vocal tract. This makes the sound of an “e” or “o” or “u”. Thus, we hear speech in part by analyzing the amount of those frequencies in the speaker’s voice. The spikes that you see on the spectrograph when you make the “aaa” sound were probably integer multiples of the lowest frequency; ie., resonant frequencies.

In most human voice, singing, and instruments, the sound is dominated by the fundamental frequency (say, 440 Hz), and the higher harmonics give it its timbre, and are not distinguishable as separate pitches. This isn’t the case in Tuvan throat singing, in which a single harmonic resonates, gaining strength so that the sound is concentrated in that single harmonic. This is part of what gives throat singing its eerie quality.

2. Exploring musical notes

To do and notice

- You can use a pitch pipe, harmonica, or other instrument to see the notes it produces. Narrow the window (using the “Frequency Range”) so you see single notes around 440 Hz and up.
- Then widen it so you can see the harmonics of the fundamental frequency. “A” should be around 440 Hz, and its first harmonic at 880 Hz.

What’s going on?

Once again, we can see different resonant frequencies. We identify “A” as 440 Hz, but most instruments produce series of resonant frequencies, or partials, which give the sound its timbre. We *do* hear most of these resonances: the range of human hearing is about 20 – 20,000 Hz, but the ear is most sensitive from about 2000-5000 Hz.

3. Exploring the shape of music

To do and notice

- Use the pitch pipe or harmonica to play a note, like “E”, and then whistle to match that “E”. What do you see on the oscilloscope? What do you see on the spectrograph?
- You can also play music on your computer through iTunes or some other program. Be sure that the “Monitor Input” is not checked under the “Audio I/O” menu item, or you will get feedback.

What's going on?

The whistle usually looks pretty clean, like a pure sine wave. The harmonica or pitch pipe looks a bit like a standing wave with a funny shape. The pitch pipe has more *overtones* than the whistle, because the air bounces around in a complicated way inside the chamber, instead of speeding through the angled hole created by your pursed lips. Overtones are either partial or full harmonics (partial or integer multiples of the fundamental frequency). The overtones add together with the partial to produce a standing wave with a non-regular shape.

On the spectrograph, the whistled note (if your'e good) will match one of the peak frequencies of the harmonica, but you can see that there are several higher and lower harmonics in the harmonica. Try to hit these frequencies with your whistle – they're very high and very low! This wide range of harmonics is what gives harmonica a rich sound (as opposed to a flute, which sounds cleaner).

4. Escher staircase of music

To do and notice

- Play the audio files at <http://asa.aip.org/demo27.html> or http://www.exploratorium.edu/exhibits/highest_note/ . What do you hear? Are the tones ascending or descending? Find the highest note.

What's going on?

For most people, the tones appear to ascend or descend forever, although it's a continuously repeating loop. This illusion relies on our perception of pitch (ie., frequency). When a note is made of a single frequency, we can fairly accurately judge whether that note is higher or lower than the one before. Each note in this "scale" is made of a set of seven individual notes, played one octave apart. Thus, the first tone, an "A" is made of 55, 110, 220, 880, 1760, and 3520 Hertz. The middle frequency is the loudest, with the volume dropping off to either side of the middle frequency. These individual 7 frequencies change in frequency *and* volume from note to note in the series. As each individual frequency increases, its volume is changed. Volumewise, they are "sliding in" frequencies from the lower octaves, and "sliding out" frequencies from the upper octaves. Thus, our ear is fooled into thinking the tone continually increases (or decreases).

A great visualization (requires Java) is available here:

<http://www.netalive.org/tinkering/shepard-effect/>