

What does your voice look like?

Digital audio software

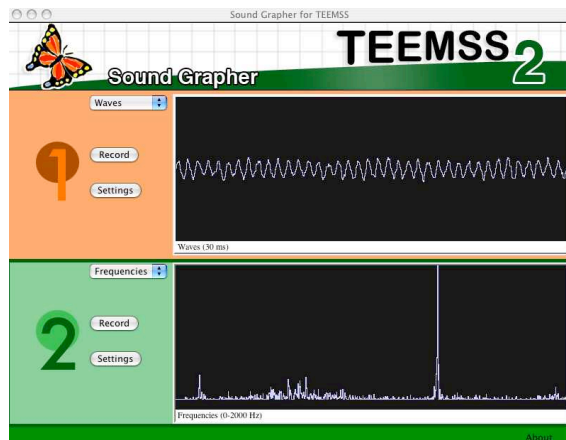
Introduction

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

Materials

TEEMSS2 (Windows or Macintosh)

- Realtime frequency and waveform analyzer
- Main drawback is that the axes are not labelled
- Download for free at <http://tinyurl.com/2qcook> and <http://tinyurl.com/2p2lwq>



Alternative programs:

See <http://www.exo.net/~drsteph/activities/sound/digitalaudio.pdf> for instructions.

Spectrafoo (Mac only)

- Real-time display of audio input from your computer microphone
- 30-day free trial at <https://www.mhsecure.com/DemoCentral/>

Audacity (Windows or Macintosh)

- Can record and import audio, but cannot give a realtime display.
- Download for free at <http://audacity.sourceforge.net/download/>

Using TEEMSS SoundGrapher

- Choose “wave” or “frequency” in the pull-down menu.
- Press “Record” to display the real-time display, and “Stop” to freeze it.
- If you want to compare two different types of sounds, “stop” the recording in panel 1, and then go “record” in panel 2.
- There is no horizontal axis, but “Settings” allows you to change the range. Ie., “30 ms” means that the axis ranges from 0 ms at the left to 30 ms at the right. You must stop recording to change the axis. For Frequencies, you can also change the number of samples (we like 8192) to make it fast and course or slow and fine.

1. Exploring musical notes

To do and notice

- You can use a pitch pipe, harmonica, or other instrument to see the notes it produces. First set the frequency range at 1000 Hz. The fundamental frequency of “A” should be around 440 Hz.
- Now widen the frequency range to 8000 Hz. What else do you see now when you play an “A”?
- Play a series of notes increasing in pitch. What do you notice about the other frequency spikes?

What’s going on?

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. As you increase the pitch, the fundamental frequency increases, and thus so do the partials, as well as the spacing between the partials!

2. Exploring the shape of music

To do and notice

- Use the “frequency” window. Use the pitch pipe or harmonica to play a note, like “C”, and press stop. Press “record” in the other window and then whistle to match that “C”. What do you see? What about in the wave window?
- What about if a singer sings a C?
- You can also play music on your computer to watch how it behaves.

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 to produce a standing wave with a non-regular shape.

In the frequency window, the whistled note (if you're 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).

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.

3. Exploring your voice

To do and notice

- Select “frequencies” and hit “record.” Say “mmmm” and hit stop. Measure the frequency.
- *Keeping the same pitch*, say “aaaaaa”.
- 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 about if a male and female make the same pitch “aaaa”? Try “freezing” one in each window to compare them.

What's Going On?

On your spectrograph, you should see evenly-spaced spikes in frequency which change amplitude as you change from eee to ooo to aaa. For a particular tone, the spikes you are seeing are the resonant frequency of your vocal chords, plus some of its overtones. The vocal *tract* (your mouth, throat, and nose) acts as a filter on the frequencies created by the vocal chords. The vocal tract is a tube closed at one end, and so it only resonates at odd-number multiples of the fundamental frequency – these allowed frequencies are called “formants”. The formants are the evenly-spaced spikes you see. When you say “mmm” you are seeing mostly the fundamental frequency of your voice at that pitch.

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 formant 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 formants are the same for men and women's voices, but the higher-pitched formants are damped out in men's voices.

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/>