Sound: Microcomputer-Based Lab

In this experiment a microphone is used to collect sound waves and a computer is used to help analyze the waves. The goal of the experiment is mainly to make observations of different kinds of sounds.

PROCEDURE

The software needed for this experiment is the “Sound” file in the Intro I folder. Double-clicking on the file should start the Logger Pro program. In Logger Pro you should see a sound versus time graph at the top of the screen and a graph of the frequency spectrum at the bottom of the screen. The frequency spectrum is known as a Fourier transform of the data – it tells you which frequencies make up the sound, and shows the dominant frequency or frequencies.

The philosophy for this experiment is a little different than the other experiments we’ve done. Basically you’re getting a chance to have some fun with sound, and you should feel free to go off on tangents at any time if there’s something you feel like investigating further. The activities given below are useful starting points but feel free to look at them only briefly if there’s something you want to explore further in more detail.

Part I – Periodic sounds

When the program starts it is set to record and display data for 0.03 seconds, at a rate of 10000 Hz, and to repeat that over and over until you turn off the data collection. These settings are excellent for investigating repeating sounds, such as those made by a tuning fork, a musical instrument playing a single note, or you whistling or singing a single note.

If you want to change the repeat time or the rate at which data is recorded, hit “Ctrl-D” to bring up the Data Collection box. Select the “Sampling” tab, and enter a new Experiment Length and/or use the slider to adjust the Sampling Speed. Don’t worry about the “Mode” or “Triggering” tabs yet – we’ll use those in Part II.

Hit the Collect button and start recording sounds – hit the “Stop” button when you want to stop recording and/or when you want to take measurements from the data. First, familiarize yourself with what you can do with the graphs.

1. Record data while you or your partner are whistling or singing a single note. What do you observe on the top graph? What do you observe on the frequency spectrum?

2. Sing or whistle a sequence of notes. As you increase or decrease the frequency what do you observe on the frequency spectrum?

3. Challenge your partner – see who can get closest to a note of a particular frequency (500 Hz, say, or whatever you choose). The frequency spectrum gives you a good idea of what the frequency is but you should stop recording and take a measurement off the top graph to accurately determine the frequency.

4. Challenge your partner – which one of you can create a musical sound of the lowest frequency? Which of you can create a musical sound of the highest frequency?

5. Challenge your partner – which one of you can create a sound that is closest to a single-frequency sound? A single-frequency sound would look like a perfect sine wave on the top graph, and give a single peak on the frequency spectrum. Which one of you can create a musical sound that is most complicated? Musical sounds that are most pleasing to the ear are generally combinations of sine waves that are integer multiples (harmonics) of a base frequency we call the fundamental. For a good musical sound the top graph should be a repeating pattern but not look like a simple sine wave, and the frequency spectrum should show peaks at regular intervals.

6. Determine the fundamental frequency of a bloogle. A bloogle is a corrugated tube which, when rotated over your head, generates sound. The frequency of the sound changes as the rotation rate changes. Measure a few of the frequencies emitted by a bloogle in the lab and, knowing that these should be multiples of a fundamental frequency, determine the fundamental frequency for the bloogle. Compare this to $f_1 = v/2L$, where L is the length of the tube, which is the predicted value of the fundamental frequency of a tube open at both ends.

7. Investigate other musical sounds, such as those from a tuning fork or a musical instrument you or someone else in the lab has brought along. What do you observe?

Part II – Single events

To investigate single events, such as a finger snap or a hand clap, it is best to adjust the Data Collection settings. Hit “Ctrl-D” to bring up the Data Collection menu. In the Mode menu select “Real Time Collect” from the pull-down menu. Hit the “Sampling” tab and enter an appropriate time (such as 0.2 seconds for a finger snap) for the Experiment Length. Hit the “Triggering” tab, put a check in the “Enable Triggering” box, and use settings of “Sound Level” is “greater than” 0.02 volts (increase the number if the triggering is too sensitive, or lower if it never triggers). Entering “100” in the Pre-Trigger data is also useful.

With triggering enabled, when you hit the [Collect] button the computer will not actually start recording data until it hears a sound loud enough to trigger it. Then it simply records sound for the time period you set for Experiment Length.

1. Pick one or more single events and investigate them. Things you might consider exploring are:

    - How repeatable is the event?

    - How does the frequency spectrum for a single event compare to that for a musical sound?

2. Investigate speech. Things you might consider exploring are:

- On the top graph, can you tell the difference between words that sound similar, like “dog” and “dot”. Try increasing the difference between the words (“dog” and “frog”, “dog” and “doom”, “dog” and “zebra”).

- Can you tell the difference between the same word spoken by different people, or twice by you in different voices? Can you see the difference between two people speaking with different accents?

Compare this to how easy it is for you, using your ear, to tell all these things apart.

3. Measure the beat frequency for two tuning forks with similar frequencies. Although this is a repeating sound it’s convenient to do the measurement in the single-event mode. An experiment length that gives you several beats is about right, and you should set both tuning forks going and be able to hear the beats (sound rising and falling over and over) before you hit the Collect button. Compare the beat frequency you measure to the expected value, which is the difference between the frequencies of the individual tuning forks (it is better to measure the individual frequencies than to take for granted that the value stamped on the tuning fork is accurate).

4. Design your own experiment. If anything in particular caught your interest you can investigate that further, or you can go on to do something new.