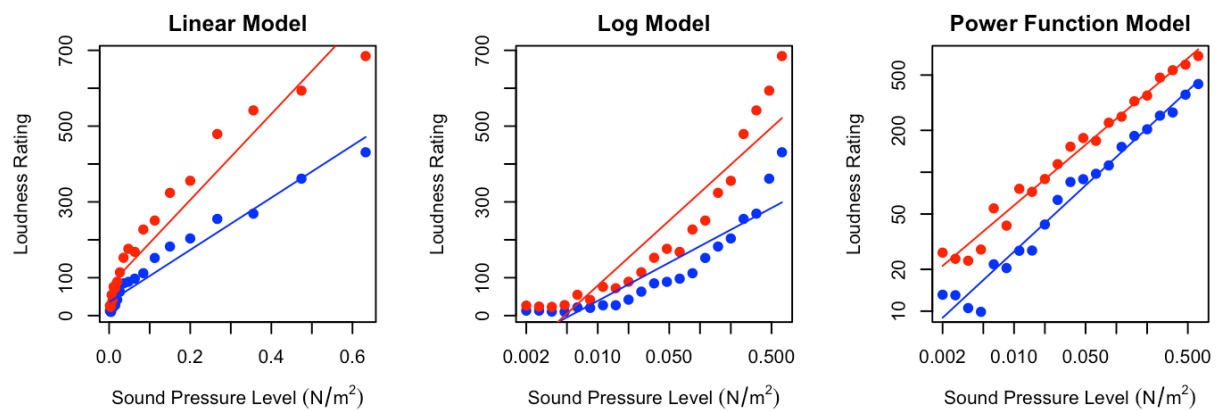


# Lab 3: Perception of Loudness

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## Overview of the Experiment

Loudness is a psychological dimension of sound experience that depends on several physical dimensions of the sound stimulus (intensity, frequency, and complexity). This laboratory exercise has two purposes:

1. To test the hypothesis that loudness of a sound is influenced by the complexity of the sound;
2. To investigate the mathematical relationship between physical intensity and the magnitude of the psychological experience using the direct magnitude estimation.

The simplest relationship between physical and psychological magnitude would be linear equation shown in Equation 1, known as the Linear Law:

$$S = b_0 + b_1 I \quad (1)$$

where  $S$  is the magnitude of psychological experience,  $I$  is the intensity of the physical stimulus,  $b_0$  is the y-intercept, and  $b_1$  is the slope of the line. If psychological magnitude is plotted on the y-axis as a function of physical intensity on the x-axis, a straight line will be found if Equation 1 correctly describes the relationship between them.

G. T. Fechner (1801–1887), concluded, however, that sensation magnitude was a function of the logarithm of the physical intensity not the intensity itself (Fechner, 1860, 1966). This logarithmic relationship is represented by Equation 2, known as Fechner's Law:

$$S = b_0 + b_1 \log(I) \quad (2)$$

If Fechner's law were a valid description of the relationship, then when psychological magnitude is plotted on the y-axis as a function of the logarithm of physical intensity on the x-axis, a straight line would be formed. S. S. Stevens (1961), after extensive experimentation, concluded that neither Equation 1 nor Equation 2 were valid. He proposed that the relationship between psychological magnitude of sensation and physical stimulus intensity is a power function, as shown in Equation 3, known as Stevens' Law:

$$S = b_0 I^{b_1} \quad (3)$$

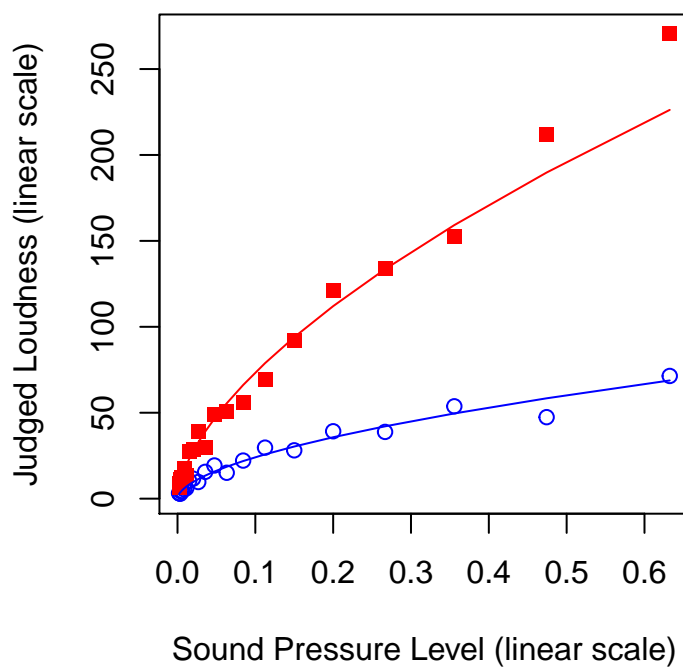
If the power function were a valid description of the relationship between psychological magnitude and physical intensity, then when the **logarithm** of the psychological magnitude is plotted on the y-axis as a function of the **logarithm** of physical intensity on the x-axis, the data would form a straight line. This property of the power function is seen by taking the logarithm of both sides of Equation 3. A simple linear equation in the form of  $y = b_0 + b_1 x$  results, as is seen in Equation 4:

$$\log(S) = \log(b_0) + b_1 \log(I) \quad (4)$$

Figure 1 illustrates the difference between Equation 3 and Equation 4. The data, when plotted on linear axes, form a curved line. When the the same data are plotted on log-log axes they form a straight line.

The results of psychological scaling experiments (Stevens, 1961, Teghtsoonian (1971), Norwich & Wong (1997)) suggest that the exponent of the power function is different for different sensory modalities. The exponent for brightness is about 0.3, for loudness about 0.6. The measured exponents for heaviness and electric current is greater than 1.0.

### Stevens' Law Predictions



### Stevens' Law Predictions

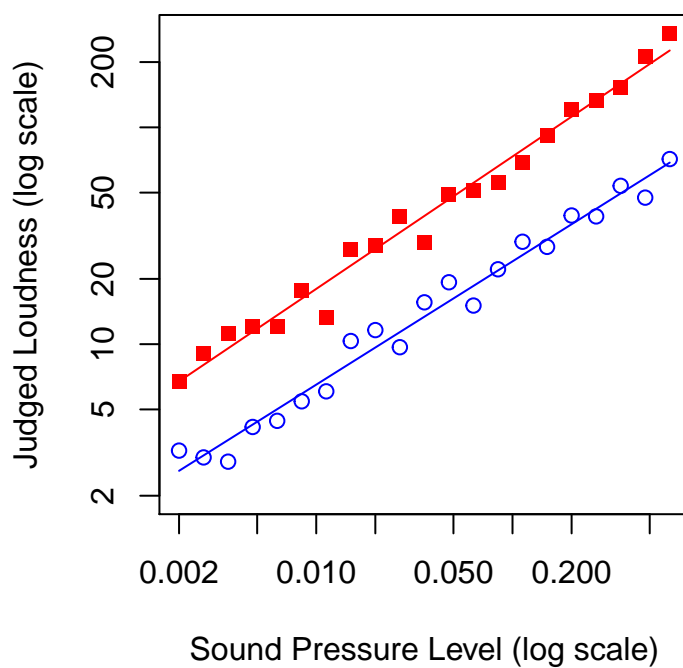


Figure 1: Loudness ratings of sine (open circles) and square wave (filled squares) sounds of equal intensity. The upper panel is plotted with linear axes; the lower with logarithmic axes.

# Loudness Scaling Experiment

In this experiment, you will make numerical estimations of the loudness magnitude of two types of tones: a 440 Hz sine wave (a simple stimulus) and a 440 Hz square wave (a complex stimulus). These tones will be presented at 21 different physical pressure intensities ranging from approximately 0.002 N/m<sup>2</sup> (40 dB) to 0.63 N/m<sup>2</sup> (90 dB). You will test your results to see if stimulus complexity affects the loudness of a tone.

As before, the experiment will be run under computer control using PsychoPy (Peirce, 2007, 2009; Peirce & MacAskill, 2018). The experiment has 2 phases: (a) a calibration phase, followed by (b) the magnitude estimation phase. During the calibration phase you will adjust the loudness on the computer so that through headphones you can just barely hear the faintest (40 dB) sound and the most intense sound (90 dB) is not dangerously loud.

## Lab Instructions

### Download *Lab 3 Tools* from the course website

1. In a web browser, navigate to the course webpage and double click on Lab 3 Tools. The folder will download to your computer;
2. The file is a zip archive and should automatically be unzipped and placed in the Downloads folder;
3. Move the Lab\_3\_Tools folder from the Downloads folder into a Lab\_3 folder (where you keep all the files for this lab) on the Desktop. Keep all your working files and folders in the Lab\_3 folder on the Desktop, that way you won't overlook a crucial file when you logout!

### Edit and Fix the Experiment

From the PsychoPy File menu, Open Lab\_3\_Tools > loudness EXPERIMENT > loudness\_experiment.psyexp with PsychoPy. To fix the experiment and make it run properly, add two components:

- a rating scale to the `trial` component
- a loop to run more than one test trial

Look at the Flow panel at the bottom of the Builder view in your PsychoPy window. The correct Flow panel, as it will appear after you fix it, is shown in the lower part of Figure 2.

The experiment has seven Routines (shown as red or green rounded boxes). Also the Flow should have 2 Loops along the way. One loop (`ptrials`) goes around the `ITI_practice` and the `Practice` routines. The other loop (`trials`) goes around the `ITI_test` and the `trial` routines. You'll note that your Flow view does not match that shown in Figure 2: The `trials` loop around `ITI_test` and `trial` is missing. The `trial` routine itself is also missing a `rating` component. Add these components.

When adding components, be certain that you have selected the correct routine to edit!!

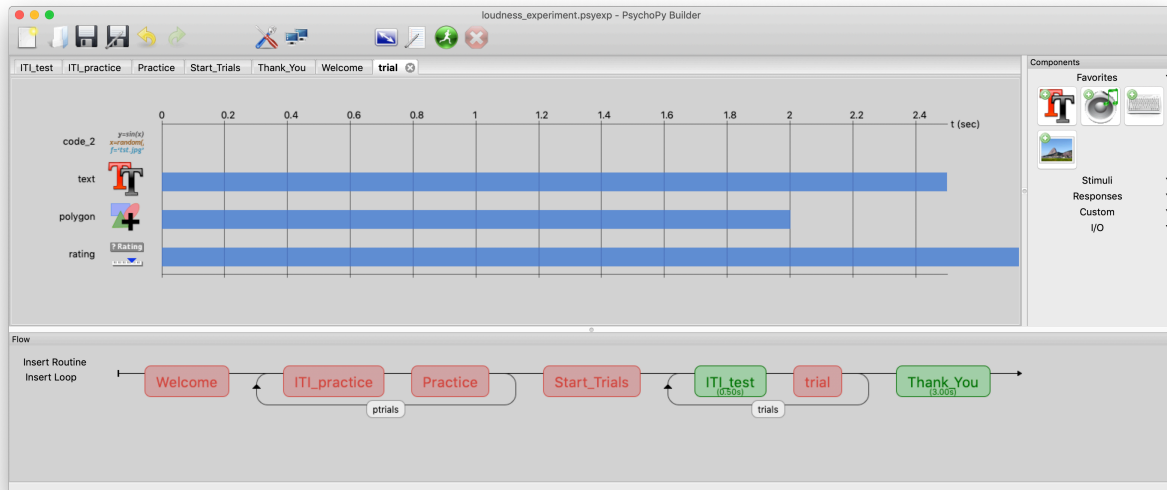


Figure 2: Flow panel for the fixed loudness experiment.psyexp PsychoPy experiment

## Fix the PsychoPy Script

### Add the rating Component to the trial Routine

- In the Builder view, select the `trials` routine.
- Add a `rating` component to the `trials` routine by clicking on the `rating` icon in the *Components* panel (right hand side) of the PsychoPy window. See Figure 3.
- Edit the settings for the new Rating component. All the correct settings are shown in Figure 4. Be absolutely certain that your rating Properties windows looks exactly the same as in Figure 4.



Figure 3: The rating component is the one with the word Rating on it under the Responses category. Click on this icon to add a rating component to a routine.

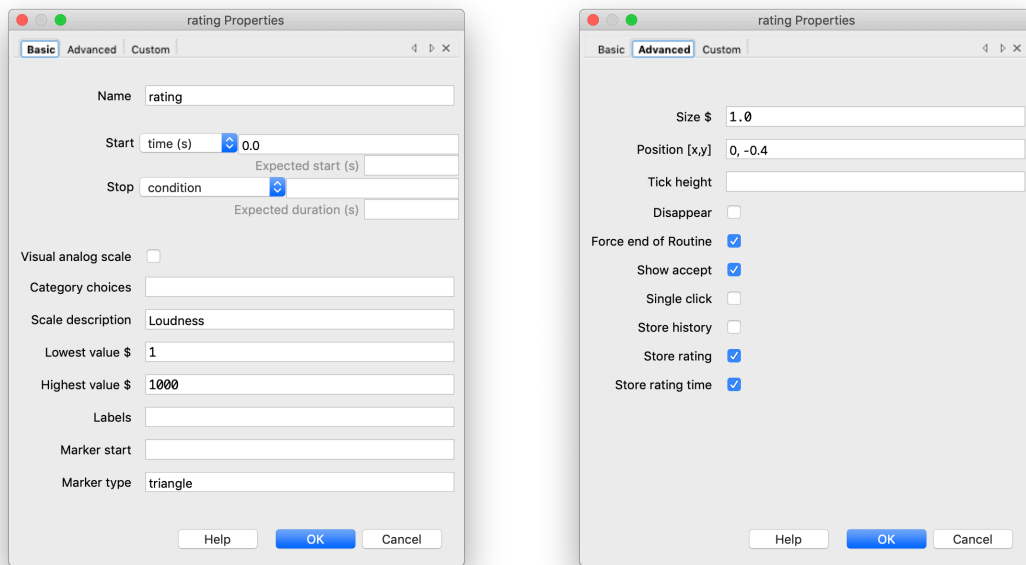


Figure 4: The basic properties (left panel) and Advanced properties (right panel) of the rating component.

## Add Loop Component Around the ITI\_test and trial Routines

- In the Flow panel, click Insert Loop (down on the left side)
- You'll see a black dot on the experiment Flow. Move the mouse so that the dot is to the left of the ITI\_trial Routine, click to set one end of the loop at that location.
- Move the mouse so that the other end of the loop (indicated by the black dot) is immediately to the right of the trial Routine (see Figure 2 for the correct placement of the trials loop).
- Loops have properties as well. The correct properties are shown in Figure 5.
- To set the condition field click on the “Browse...” button and navigate to the conditions folder and select the conditions.csv file.
- Confirm that your settings look exactly like Figure 5. **Save your changes.**

trials Properties

Name trials

loopType random

Is trials ☒

---

random seed \$

nReps \$ 2

Selected rows

Conditions conditions/condition.stimuli.csv Browse...

42 conditions, with 6 parameters  
[sound\_file, db, wave, spl, bit8, norm\_spl]

Help OK Cancel

Figure 5: The properties for trials loop.

## Run the Experiment

The experiment has two parts:

1. Loudness Calibration
2. Main Experiment Data Collection

### Loudness Calibration

- Quit PsychoPy if it is running
- Start PsychoPy and open the **loudness\_calibration.psyexp** in the **loudness CALIBRATION** folder.
- Plug your headphones into the jack on the rear of the computer
- Run the script as many times as you need to while you adjust the volume with the keyboard keys so that you can barely hear the 40 dB sounds and the 90 dB sounds are not excessively loud.
- Quit PsychoPy and don't further adjust the sound volume of your computer

### Main Experiment

- Start Psychopy again and open the **loudness\_experiment.psyexp** file in the **loudness EXPERIMENT** folder.
- Click the Run button. In the dialog box that appears (see Figure 6) you will see three items.
  - lab section: it should be L103 for Tuesday and L104 for Thursday. Edit if necessary.
  - participant: replace the **xxx** with your own initials.
  - session: Don't change it

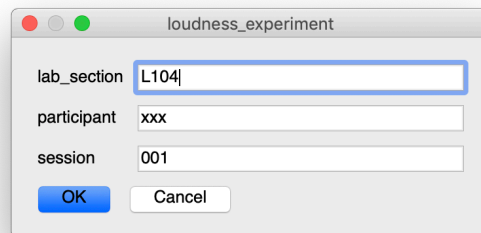


Figure 6: Experiment Dialog screen.



Click OK when you are ready to start the experiment. The experiment will take about 20 to 30 minutes.

Your data will be automatically saved in the data folder in a text file whose name starts with your initials with the date and time added to it. The file extension is csv (comma-separated values). After the experiment has finished you can double-click on the file to open it in Excel to examine it. There should be 87 rows in the csv data file. Do not modify this data file. It represents a lot of judgments and work on your part.

## Upload your CSV Data File to Canvas

If your csv data file looks complete, upload it to the Canvas Assignment dropbox *Lab 3 csv data file*. You may now quite PsychoPy.

## Individual Data Analysis

Now that you have uploaded your own csv data file to Canvas it is time to take a look at the file. Download the **Lab 3 Report Template** folder from the course website and put it into your Lab 3 folder on your desktop. This template is very similar to the one you used for Labs 0, 1, and 2. Place a copy of your csv data file (the one you uploaded to Canvas) into the Report Template my\_lab\_3.0\_additional\_files folder

The folder for the lab 3 report is an RStudio project folder. Open the folder and double click on the project file: *Lab\_3\_Report\_Folder\_2018\_Fall\_Working.Rproj*.

RStudio will launch and restore the files you were editing the last time you opened the project. Open the *my\_lab\_3.5a\_Individual\_Results\_Broken.Rmd* file. Locate the broken code chunks and fix them according to the instructions. When you finish, you should be able to knit that file into a pdf output.

## Complete Lab Report

Next week you will produce a complete lab report once we have assembled the group data from the class, as we did for Lab 0. This report will include the title page, short abstract, introduction, methods, results, discussion and reference sections that make up a standard American Psychological Association (APA) journal article. Check out the *Sample APA Manuscript (Guide)* that is posted on the course website:

[http://psych.colorado.edu/~lharvey/P4165/P4165\\_2018\\_3\\_Fall/Main\\_Page\\_2018\\_Fall\\_PSYC4165.html](http://psych.colorado.edu/~lharvey/P4165/P4165_2018_3_Fall/Main_Page_2018_Fall_PSYC4165.html)

You will use the APA journal article format for all lab reports during the semester. Next week we will provide you with the results of every person in the class and guide you through an analysis of these group data for inclusion in the final lab report.

## Checklist

- Do the properties of your `trials` loop look **exactly** like Figure 5?
- Do the properties of your `rating` component look **exactly** like Figure 4?
- The names **must** be `trials` and `rating` respectively!

## References

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