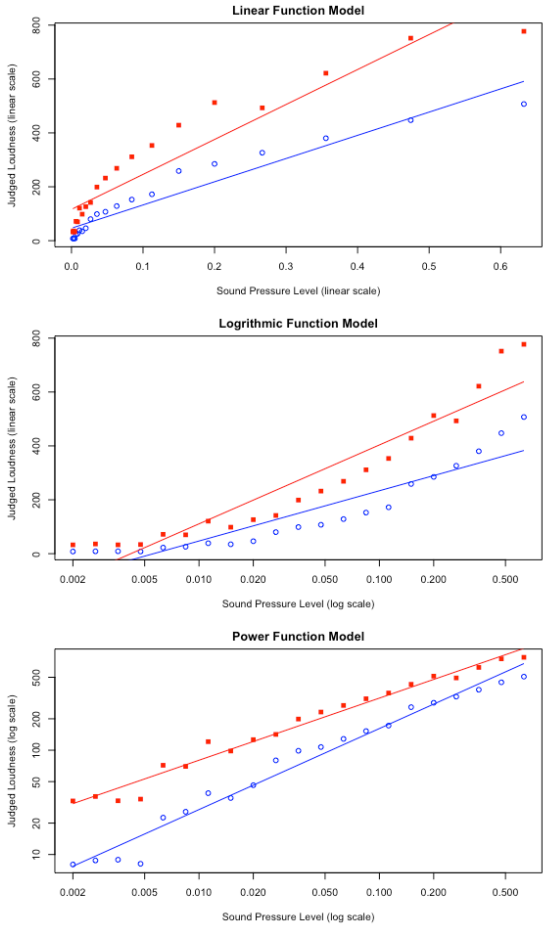
Psychology of Perception
PSYC 4165-100
Spring 2018
Laboratory 2:

Perception of Loudness



Lab Overview

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 null hypothesis that sound loudness is **not** influenced by sound complexity; 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:

$$S = b_0 + b_1 \cdot I \qquad \text{Linear Function} \qquad (1)$$

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 (Fechner, 1860, 1966):

$$S = b_0 + b_1 \cdot \log(I) \qquad \text{Fechner's Law} \qquad (2)$$

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, after extensive experimentation, concluded that neither Equation 1 nor Equation 2 were valid. He proposed that the relationship between psychological magnitude and physical intensity is a power function (Stevens, 1961):

$$S = b_0 \cdot I^{b_1} \qquad \text{Stevens' Law} \qquad (3)$$

The relationship predicted by Steven's Law is shown in the top panel of Figure 1. If the power function were a valid description of the relationship between psychological magnitude and physical intensity, 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 (shown in the bottom panel of Figure 1). This property of the power function is seen by taking the logarithm of both sides of Equation 3. A simple linear equation results:

$$\log(S) = \log(b_0) + b_1 \cdot \log(I) \qquad \text{Stevens' Law} \qquad (4)$$

Equation 4 is in the familiar linear form $y = b_0 + b_1 \cdot x$, with the slope b_1 equal to the exponent of the power law.

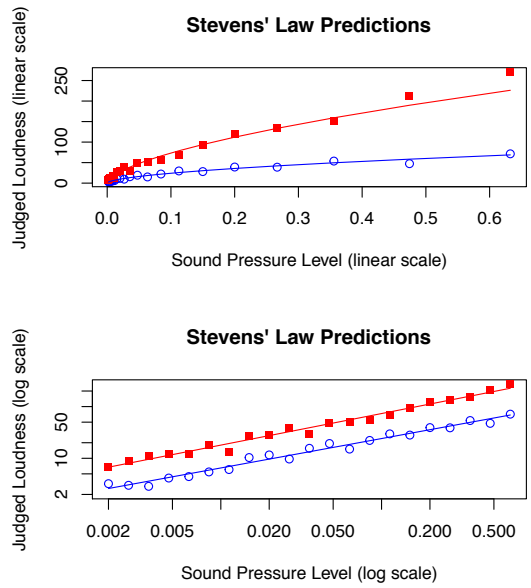


Figure 1: Loudness ratings of sine (open circles) and square wave (filled squares) sounds of equal intensity. The upper panel is ploted with linear axes; the lower with logarithmic axes.

The results of psychological scaling experiments by S. S. Stevens and others (Stevens, 1961; Teghtsoonian, 1971) 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. For heaviness and electric current the measured exponent is greater than 1.0.

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 intensities ranging from approximately 0.002 N/m^2 (40 dB) to .63 N/m^2 (90 dB). You will test the hypothesis

that stimulus complexity (a square wave is more complex than a sine wave) does not affect the loudness of a tone.

Table 1. Possible Results and their Findings for the "Complexity Effect"

Possible Result	Meaning of that Result
$F \sim 1.0$	Waveform complexity has no effect on perceived loudness.
$F >> 1.0$	Simple waveforms are perceived as louder than complex waveforms.
$F >> 1.0$	Complex waveforms are perceived as louder than simple waveforms.

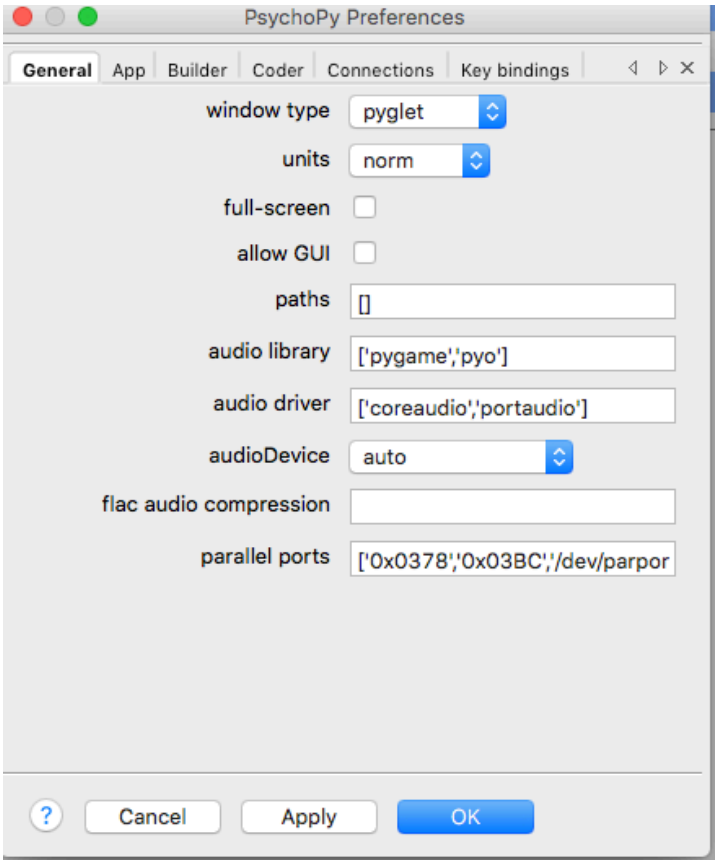
By the end of this lab you should be able to:

- **Measure the relationship between physical stimulus intensity and sensation magnitude using direct magnitude estimation.**
- **Carry out appropriate statistical tests of hypotheses**

LAB INSTRUCTIONS

PsychoPy Preferences

Open PsychoPy and check the Preferences: click on the  PsychoPy toolbar. Make sure that the order of the audio library looks like this ['pygame','pyo'], not the other way around. Edit it if necessary to look like the screen shot below:



Sound Check

1.	**You will need headphones for this lab. You can use your own headphones, or borrow a pair of the official PSYC 4165 headphones.** 1. Plug in your headphones to the back of the computer.
2.	**Download "Lab 2 Tools" from the course website:** 1. In a web browser, navigate to the course website and download *Lab_2_Tools*. Move *Lab_2_Tools* folder from the Downloads folder, to the Desktop PROTIP**: Keep all your working files in the Lab_2_Tools folder** on the Desktop, that way you won't overlook a crucial file when you logout!

3.	**Start PsychoPy 2 application, and Open the loudness calibration script:** 1. From the File menu, Open (⌘O) *Lab_2_Tools > loudness CALIBRATION > loudness_calibration.psyexp* 2. Run the script (⌘R). 3. Follow the onscreen instructions, also shown below: *1. Verify your headphones are plugged into the computer.* *2. Using the keyboard volume controls, turn the volume down to a low to mid-level of volume.* *3. Once you start the calibration, you will hear four tones (2 sine and 2 square) at two levels (40 and 90 dB).* *4. Your task is to use the keyboard volume controls to increase the volume until you can "just notice" the 40 dB tones, but that the 90 db tones are loud but NOT painful.* *5. Repeat as necessary.*
4.	**Once you have calibrated the volume, do not adjust the volume for the duration of the lab.**

Fix PsychoPy 'loudness_experiment.psyexp' script

5.	**Open the loudness experiment script** 1. From the File menu, Open (⌘O) *Lab_2_Tools > loudness EXPERIMENT > loudness_experiment.psyexp*

This is a relatively simple experiment script. You already have experience adding components in PsychoPy, so today's experiment will be a piece of cake! You will be adding components and loops to each Routine in the experiment. The Flow of this experiment is shown in Figure 2.

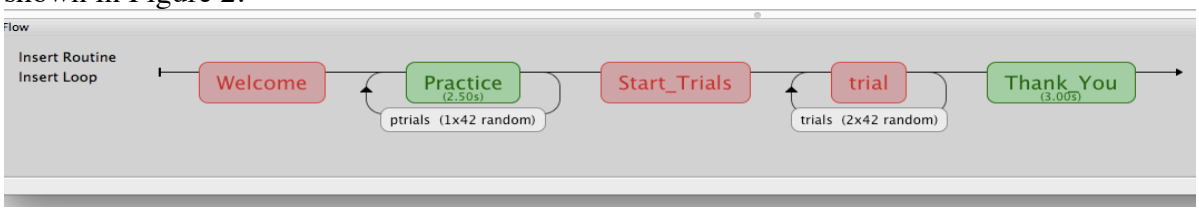
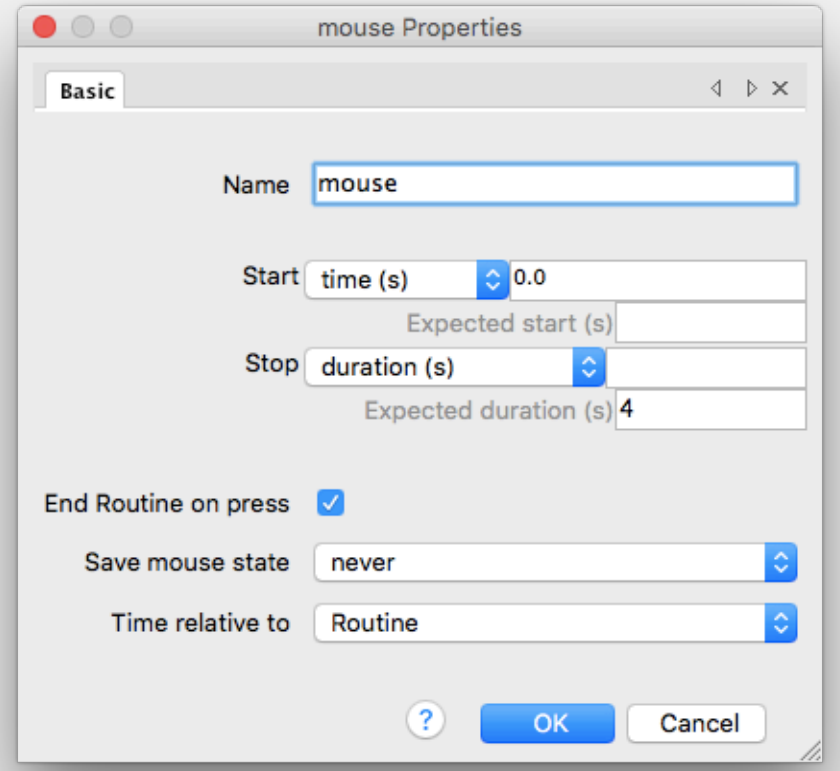
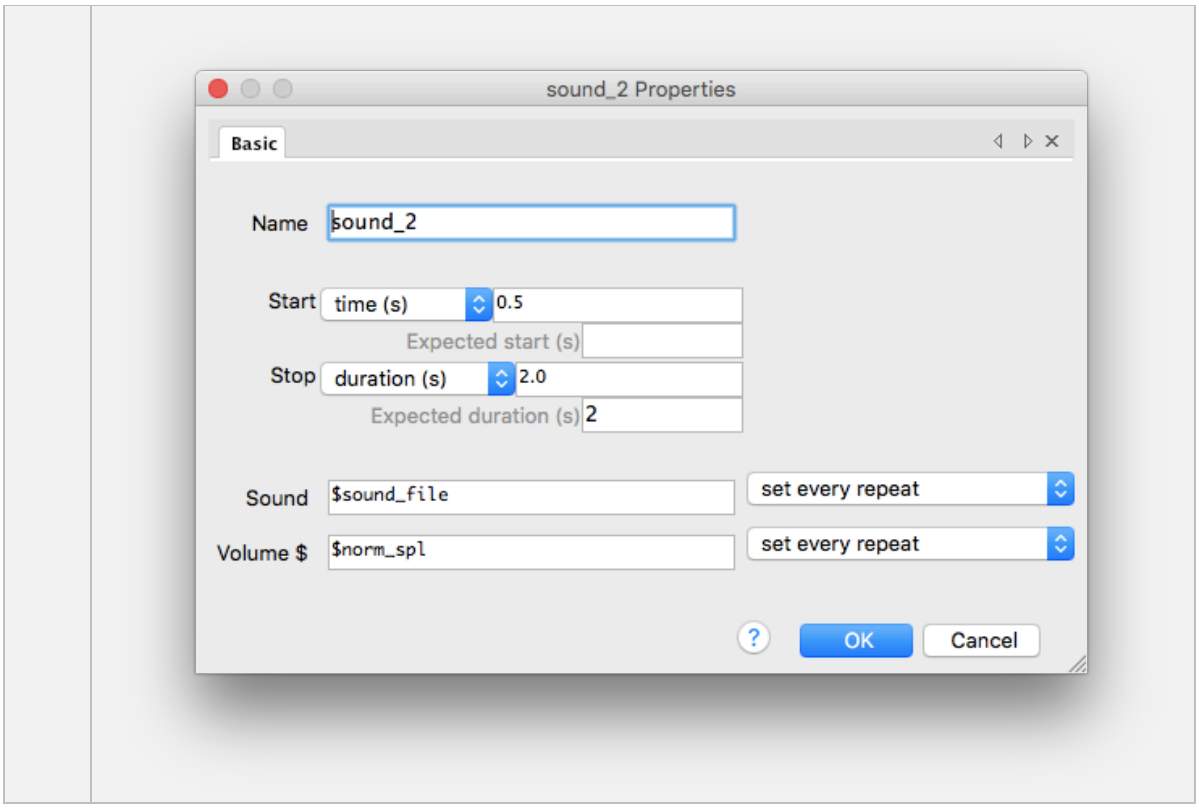


Figure 2: Flow panel for the "fixed" loudness_experiment.psyexp Psychopy script.

6.	**Select the *Welcome* routine in the Flow panel (bottom)**
7.	**Add a mouse component to the *Welcome* routine. The properties are shown below:**

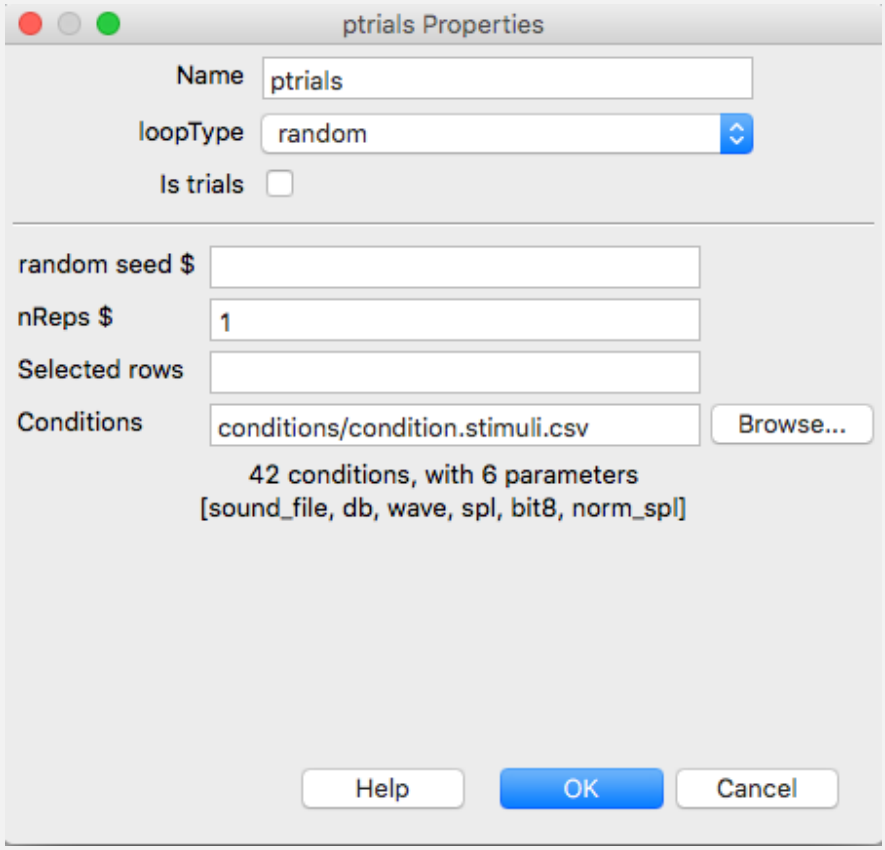


8. **Add a sound component to the *Practice* routine.**


sound_2 Properties
Basic
Name
sound_2
Start
time (s)
0.5
Expected start (s)
Stop
duration (s)
2.0
Expected duration (s)
2
Sound
$sound_file
set every repeat
Volume $
$norm_spl
set every repeat
?
OK
Cancel

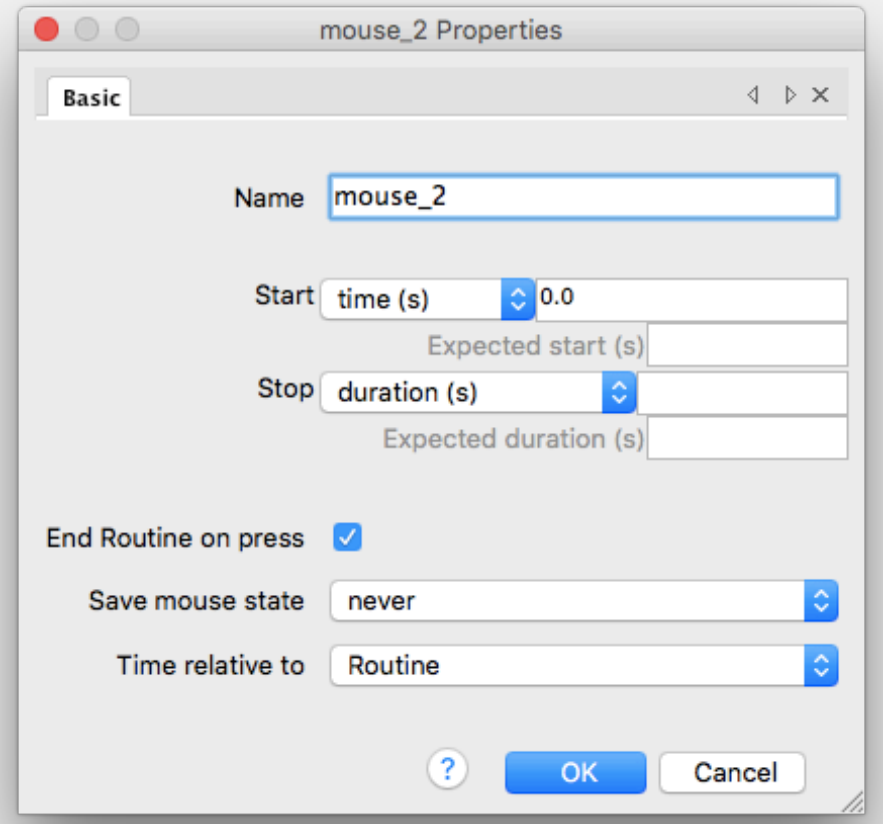
9. **Add a Loop around the *Practice* routine (see** Figure 2 **above for help positioning this loop).**

1. Click "Insert Loop" in the Flow panel
2. In the Flow panel, move the mouse left and right to position the black dots to position the ends of the loop. (you did this last week)



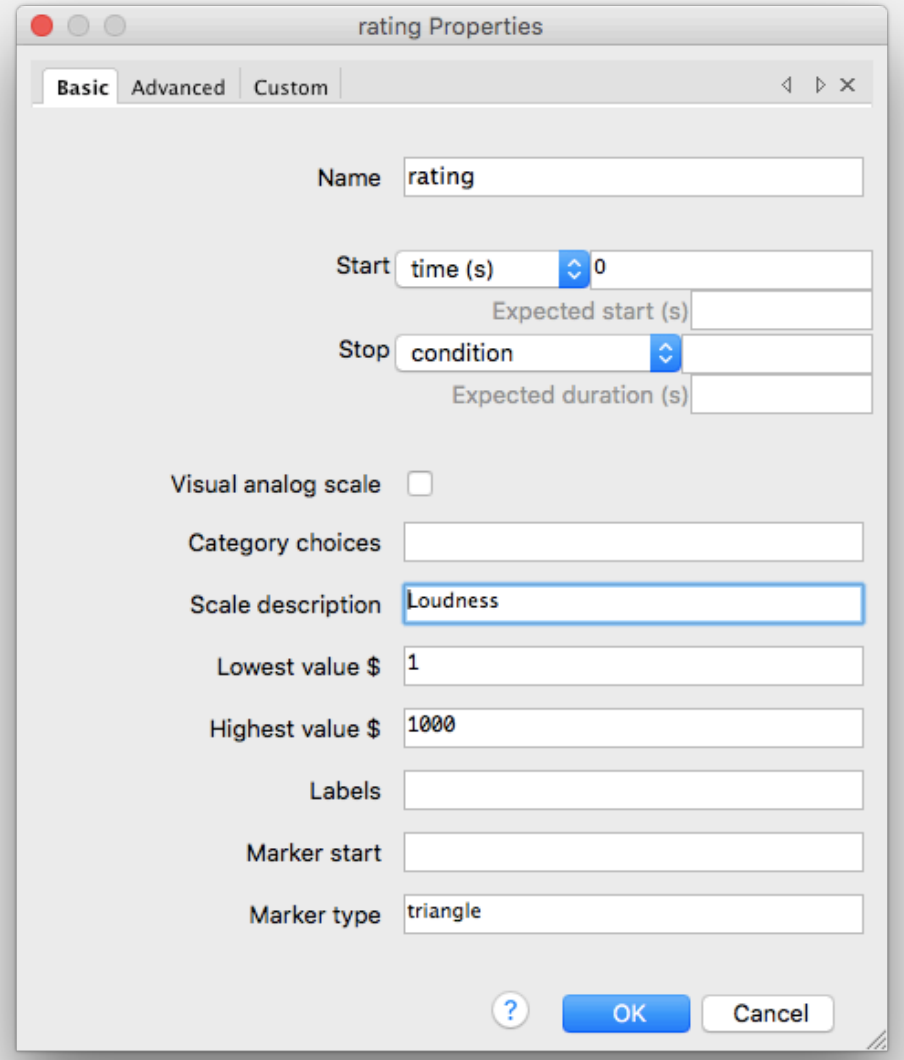
3. Use the "Browse…" button to select the conditions file (*Lab 2 Tools > loudness experiment > conditions > condition.stimuli.csv*)

10. **Add a mouse component to the *Start_Trials* routine.**

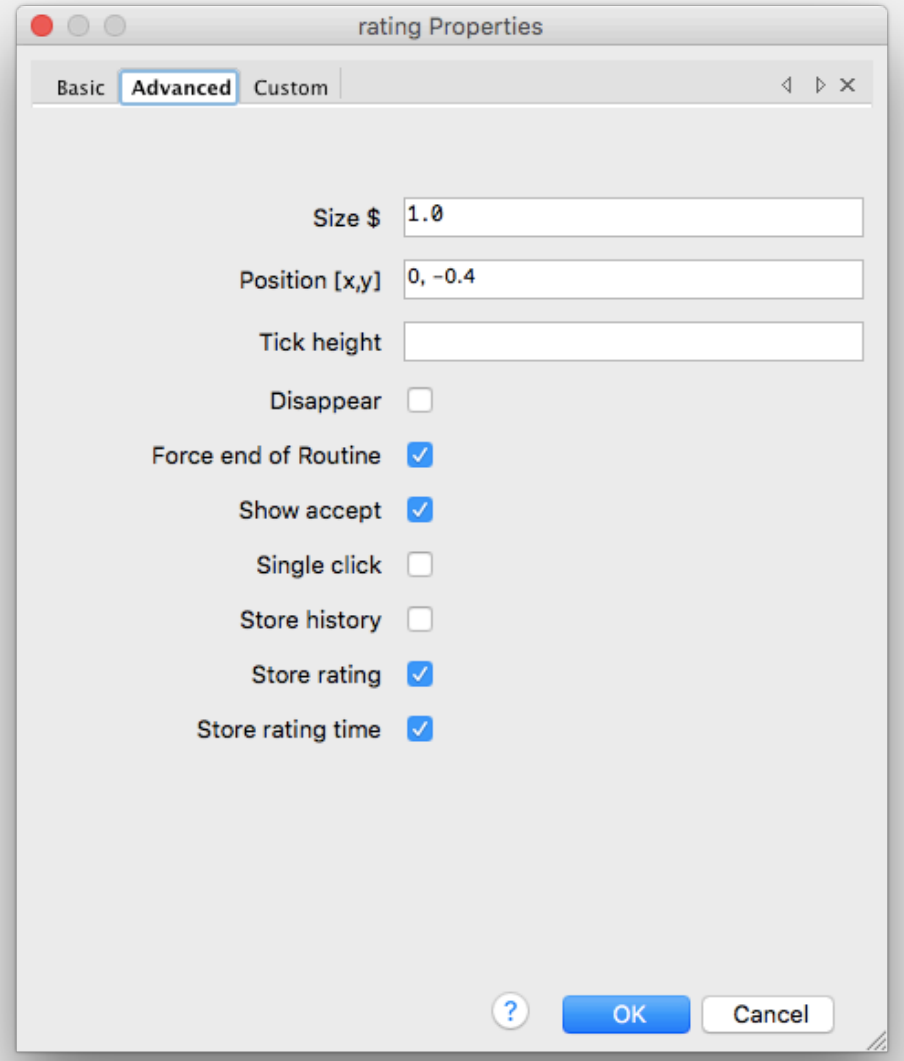


11. **Add a rating component to the *trial* routine.**

Settings for Basic Tab:



Settings for Advanced Tab (rating component):



12. **Test the script to ensure that it works properly.**

1. If the script crashes, the error message usually gives you a clue as to where/when the problem occurred. Double check your settings!
2. Remember to include "$" in the appropriate settings.
3. Make sure the names of your objects match EXACTLY, these are *case-sensitive!*

13.	**Run a few trials to test whether the experiment is saving your data properly.** 1. Respond to the perceived loudness by using the mouse to click on the rating scale, then click the button below the rating scale (the one with the number) to confirm your response. 2. After a few responses, press the Escape key to end the experiment 3. Verify your latest CSV file properly recorded your responses (*Lab 2 Tools > loudness experiment > data*) 4. The values of your rating responses should be numerical values in the "rating.response" column. PROTIP: Once you get the experiment script in working order, you might find it helpful to delete all the excess files in the "data" folder before taking the experiment for real.

Collect Data

The 21 intensities of the 440 Hz sine wave tone and the 21 intensities of the square wave tone will be presented twice in a random sequence. After each presentation of a tone, use the rating scale assign a number which best represents its subjective loudness to you. There is no right or wrong answer. Pay attention to your "loudness experience" and assign whatever number seems appropriate to represent the magnitude of your experience. If one sound seems twice as loud as a previous sound, then the number should be twice as big. Do not use zero unless you had no sensation on a trial (not very likely if you followed the calibration instructions!). All 42 stimuli will be presented in each block of 42 trials. Remember, your task is **not** to guess which stimulus was given, but is to pay attention to your experienced loudness and assign a number to represent it.

14.	**Once you have completed the experiment, verify that your data file is complete** 1. Open the most recent CSV file (use the timestamp in the filename) 2. The CSV file should have 87 total rows: a. 1 header row b. 2 blank rows from the mouse clicks that advanced the experiment c. 84 trials (2 x 42 stimulus conditions)
15.	**Once verified, upload your CSV to Canvas (Lab 2 Dropbox). Everyone's data will be the basis for the group data analysis next week!**

Individual Data Analysis

After the experiment is finished, download the folder

Lab_2_Report_Folder_2018_Spring Broken

from the course web site. Copy your PsychoPy csv data file into the my_lab_2.0_additional_files folder inside the Report folder. It will be needed there when you analyze your data using the *my_lab_2.5_Individual_Results broken.Rmd* file. Fix the 2.5 Rmd file so that your individual data analysis is successful. Read the comments and text in this file and strive to understand what each step does.

You must save your report folder on Google Drive or on your own flash drive or in some manner to preserve all your hard work. All files on the lab computer will be forever lost when you log off, unless you save them somewhere.

References

Fechner, G. T. (1860). *Elemente der Psychophysik*. Leipzig, Germany: Breitkopf and Härtel.

Fechner, G. T. (1966). *Elements of Psychophysics* (H. E. Adler, Trans. Vol. 1). New York: Holt, Rinehart and Winston.

Stevens, S. S. (1961). To Honor Fechner and Repeal His Law. *Science, 133*(3446), 80-86. doi: 10.1126/science.133.3446.80

Teghtsoonian, R. (1971). On the exponents in Stevens' Law and the constant in Ekman's Law. *Psychological Review, 78*(1), 71–80.