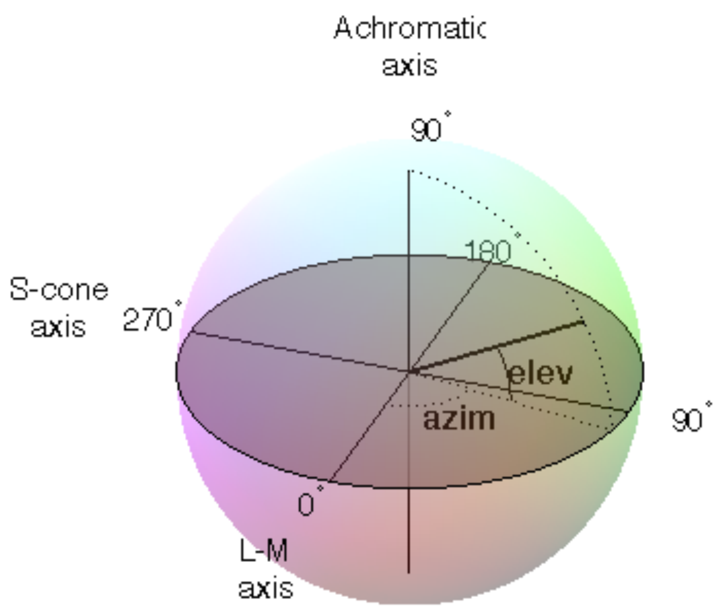
Psychology of Perception

Psychology 4165, Fall 2015

Laboratory 1a: Equiluminance Motion Detection



Derrington-Krauskopf-Lennie (DKL) Color Space

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Lab Overview

Color is a psychological experience created by three perceptual mechanisms: red-green and yellow-blue chromatic opponent processes, and the luminance process. Our ability to detect motion and see fine spatial detail comes largely from the information in the luminance channel (Ramachandran & Gregory, 1978). So if we create red targets against a green background (for example) our ability to process fine detail and motion is determined by the luminance contrast, not the color contrast, between target and background. Furthermore, if we make the two colors equal in luminance (so-called equiluminant or isoluminant stimuli), our ability to detect motion and fine detail should be hindered.

In this lab you will measure your ability to detect motion in a field of random dots that are biased to move slightly to the left or two the right. These random dot kinematograms (RDK) are widely used in perceptual research (Cavanagh, Boeglin, & Favreau, 1985; Scase, Braddick, & Raymond, 1996) and are easy to generate in PsychoPy. Download the Lab1a_Tools folder from the course web page: http://psych.colorado.edu/~lharvey/P4165/P4165_2015_3_Fall/Main%20Page%202015_Fall%20PSYC4165.html

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

- **Add components to a experiment in PsychoPy & adjust settings for those components.**
- **Query the contents in data frames, including single columns of data**
- **Perform basic computations on arrays of data (e.g.. use the `mean()` command)**
- **Describe the meaning of data at every stage in the analysis.**

Instructions

Procedure: There are two steps for measuring your motion thresholds for equiluminant and non-equiluminant stimuli:

Step 1: Measure the luminance values of red and green that will make them equal. You will use the PsychoPy program **heterochromatic_flicker.psyexp** found in the Lab_1 Tools in the heterochromatic flicker exp folder to make these measurements.

Step 2: Run the **motion_coherence.psyexp** script and make judgments about whether you perceive motion to the left ('left' key) or to the right ('right' key). On each trial of the experiment you will see a square field of random dots presented for four seconds. Some of the dots are moving in random directions. A percentage of the dots, however, are all moving in the same direction: either to the left or to the right. The proportion of dots moving coherently in on direction is called the coherence. This proportion is varied from trial to trial. The values of coherence and the direction of the motion are determined by the Excel conditions file named conditions_coherence.xlsx. Press the "left" or "right" key to indicate which direction you think the coherent dots were drifting.

There are two blocks of trials. Their order is randomly chosen. In one block, the red dots seen against the green background have a high luminance contrast. It is labeled 30 degrees of elevation in the Derrington-Krauskopf-Lennie (DKL) color space (Derrington, Krauskopf, & Lennie, 1984; MacLeod & Boynton, 1979). This color space is (like other color spaces) three-dimensional and uses spherical coordinates. One dimension is called elevation and it is an angle tilt above the isoluminant plane in the sphere. The second dimension is azimuth, which corresponds to hue in a color circle. The third dimension is contrast, which corresponds to height above and below the center of the sphere at a right angle to the isoluminant plane along the achromatic axis. The DKL system is built into PsychoPy, along with RGB and HSV color spaces. The other block of trials is labeled 0 elevation above the isoluminant plane and therefore gives a red and green that are isoluminant, based on the setting you entered.

After you finish the experiment, upload your trial-by-trial data file (it is found in the data folder as a csv file.) from the experiment to D2L: Upload your csv data file to the dropbox folder for *Lab 3 csv data* in Desire2Learn. Go to D2L; click and hold the Assessments tab and select the Dropbox option; Now click on *Lab 3 csv data* folder; follow the instructions for uploading your csv data file. We will use these files next week.

LAB INSTRUCTIONS

2.1	**Download "Lab 1a Tools" from the course website:** 1. In a web browser, navigate to the course webpage (or click the link below): http://psych.colorado.edu/~lharvey/P4165/P4165_2015_3_Fall/Main Page 2015_Fall PSYC4165.html 2. Move *Lab_1a_Tools.zip* from the Downloads folder, to the Desktop 3. Unzip the *Lab_1a_Tools.zip* by double-clicking the file. PROTIP: Keep all your working files in the Lab_1_Tools folder on the Desktop, that way you won't overlook a crucial file when you logout!
2.2	**Start PsychoPy 2 application, and Open the monitor calibration script:** 1. From the File menu, Open (⌘O) *Lab_1a_Tools > heterochromatic flicker exp > heterochromatic_flicker.psyexp* 2. Follow the onscreen instructions. 3. Move the mouse back and forth so that the flicker in the pattern is minimized. Play around with the settings until you are satisfied. Then click the mouse to record the value and run another trial. After 10 trials, the mean of your ten values will be displayed.
2.3	**Write the value of your mean equiluminance point:**
2.4	**Close the *heterochromatic_flicker.psyexp* (don't save), and Open the experiment script:** 1. From the File menu, Open (⌘O) *Lab_1a_Tools > motion_coherence exp > 1A_motion_coherence.psyexp*
2.5	**Run the script (⌘R).**

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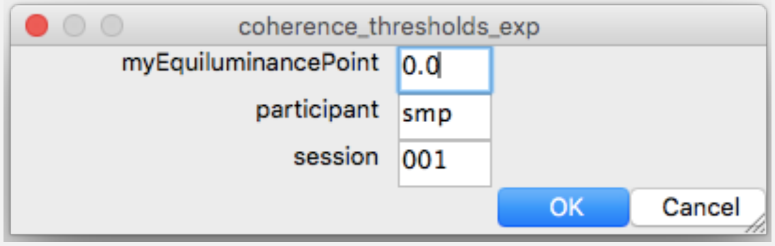


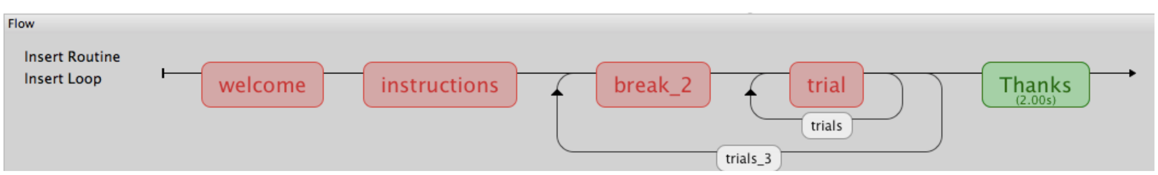
1. Enter the value of your equiluminance point in the top field.
2. Enter your initials.

Ooops! The script crashed. Don't worry, this was on purpose so that by fixing the crash, you can learn a little about how to use PsychoPy. The error you'll get when the program crashes is informative. Take a close look at the bottom lines:

```
        File "/Users/stevenparker/Dropbox/for Steve Parker/Lab_1a_Tools/Lab 1A/Lab_1A_Tools/motion_coherence exp/1A_motion_coherence_lastrun.py", line 277, in <module>
        dots.setColor(myColor1, colorSpace = 'dkl')
NameError: name 'dots' is not defined
```

PsychoPy has a very detailed error logging system to make debugging easier for non-programmers (e.g., us). In this case, PsychoPy is receiving a command on line 277 to define the way colors are displayed for the object "dots." There is no object "dots." We're going to add it to the script, and a keyboard object so you can respond. The error is in the trial routine, shown in Figure 1.

Figure 1. Flow view of motion_coherence_exp.psyexp.



2.6	**In the Builder view, click the trial routine.**
2.7	**In the "Components" panel (right-hand side), click stimuli, and click the icon shown in Figure 2 to add a Random Dot Kinetogram (RDK):** **Figure 2. Add RDK**

2.8 **There are several settings you'll need to change for the experiment to work properly. The correct settings are shown in Figure 3 and Figure 4.**

Figure 3. dots Properties > Basic tab

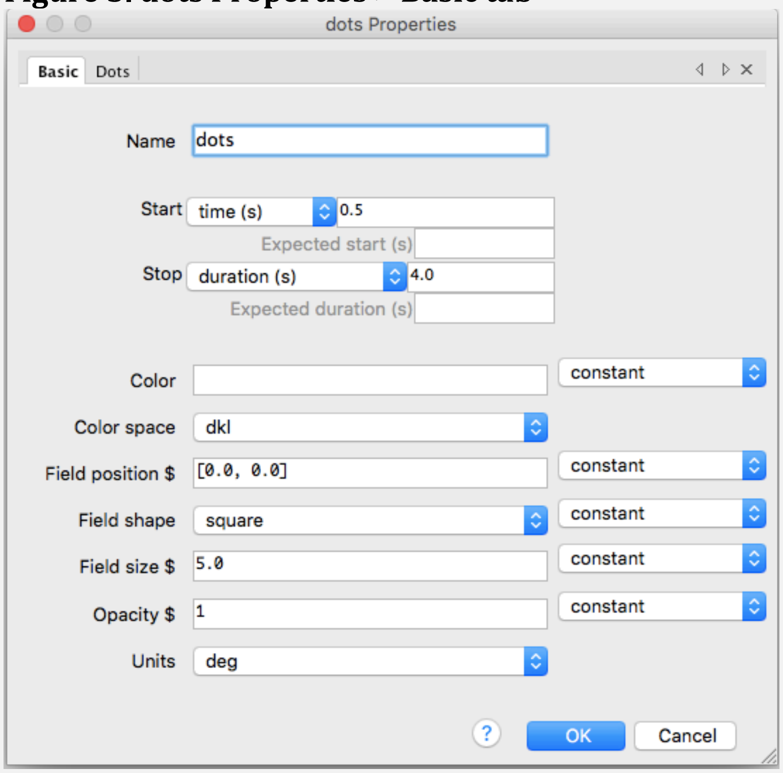
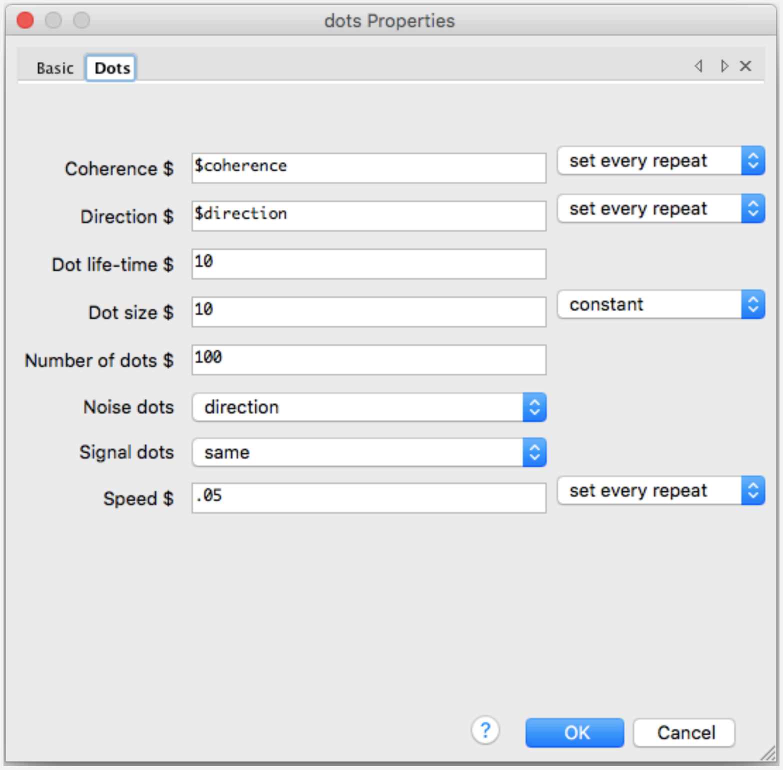
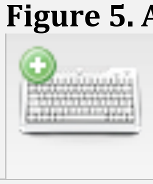


Figure 4. dots Properties > Dots tab



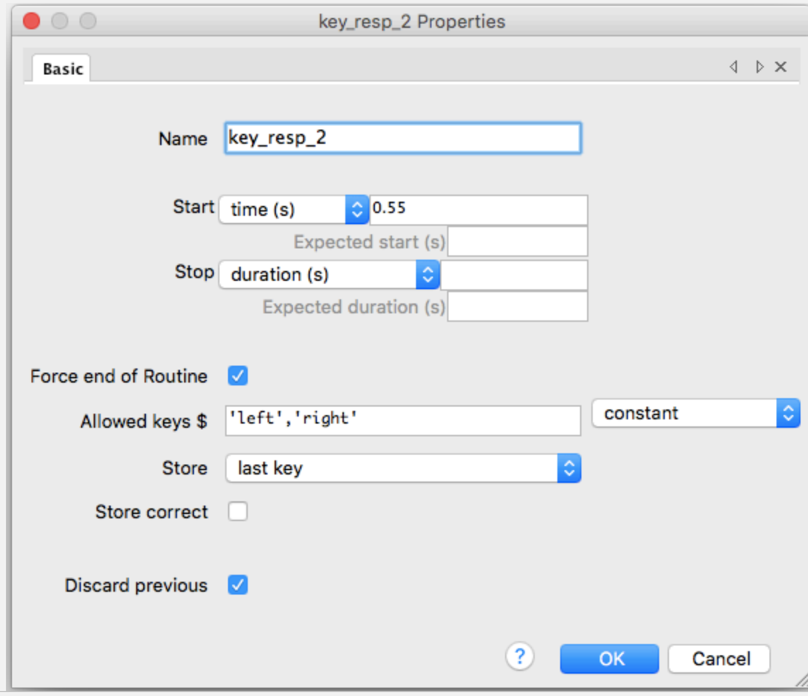
2.9 **Add a keyboard object to record responses. In the Components panel, Click the icon shown in Figure 5 to add a Keyboard object:**

Figure 5. Add Keyboard object

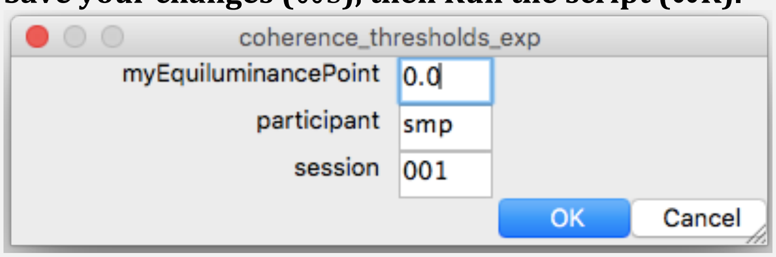


2.10 **Change the settings in the keyboard object so they match those shown in Figure 6. (pay special attention to the Name of the keyboard object!)**

Figure 6. key_resp_2 Properties



2.11 **Save your changes (⌘S), then Run the script (⌘R).**



1. Enter the value of your equiluminance point in the top field.
2. Enter your initials.
3. Follow on-screen instructions.

Data Analysis

Individual Data Analysis: Your data are found in the csv file: the one you just uploaded to D2L. You will use R to compute the number of ‘right’ responses to the different motion speeds set in the conditions_coherence.xlsx file. The R-script for transforming the raw data into response frequencies and into response probabilities, for fitting an s-shaped psychometric function to the data, and for plotting your results, is in the file lab1a_glm.R found in the Data Analysis folder. The analysis of these data is very similar to the one you made on the orientation discrimination data in Lab 0. The coherence needed to discriminate left from right is the coherence needed to achieve 16% and 84% "right" response performance levels. The script reports these values in jnd.00 and jnd.30 for the two luminance conditions, 0 deg elevation (isoluminance) and 30 deg elevation tilt above the isoluminance plane. We expect that jnd.30 will be smaller than jnd.00 if the equiluminance stimuli are not processed by the motion perception channels in the visual system.

The R script, *lab1a_glm.R*, contains 11 code snippets to help you carry out the analysis of your individual data. Execute them in order and explore what each snippet does.

Code Snippet 1 imports the .csv file that you choose (it normally would be your own data file), then extracts only those columns that are needed in order to make the data frame simpler to look at.

2.12	**Open the R script** *Lab_1a_Tools > R scripts > lab1a_glm.R* 1. Organize your windows so you can see both the script window, and the console window
2.13	**Run Code Snippet 1** 1. In the script window, highlight lines 22-34, then execute just those lines by pressing ⌘Return
2.14	**In the console, type `ls()` to list all the objects created so far.** 1. Code Snippet 1 created 4 objects. What are their names? What lines in the script created those objects?

Object name	Line number

2.15 **Call up the object `df.raw`**

1. In the console, type the name of the object you want to view. In this case: `df.raw`
2. How many rows are in `df.raw`?
3. How many columns are in `df.raw`?

2.16 **Call up the object `df`**

1. How many rows are in `df`?
2. How many columns are in `df`?
3. Which line in the script cropped the number of columns from `df.raw` to `df`?
4. Which line in the script cropped the number of rows from `df.raw` to `df`?
5. Which row in `df.raw` was cropped?

2.17 **In the dataframe df, there are 3 independent variable columns that describe what the viewing and stimuli conditions were for each trial. What are the names of the columns? What do the values mean?**

Column name	What was varied?

Code Snippet 2 does some additional house keeping on the data frame, changes the key press name to "response", and computes a new column which combines direction of movement with the coherence variable to create a coherence variable that is negative for leftward movement and positive for rightward movement.

2.18 **Run Code Snippet 2**

1. lines 44-54

2.19	**Call up the values in the column `coherence` from the data frame `df`.** 1. In the console, type `df$coherence`, then press Return. Note the "`$`" between the name of the data frame, and the name of the column in that data frame.
2.20	**Call up the values in the column `direction_coherence` from the data frame `df`.** 1. What is the difference between the values in `df$coherence` and `df$direction_coherence`? 2. What do the negative values in the `df$direction_coherence` column mean?
2.21	**Code Snippet 2 also created a new column in the data frame `df`: `df$response`.** 1. Skim the values in `df$direction_coherence` comparing them to the values in `df$response`. 2. Do you see a general relationship between stimuli and response? 3. If so, what relationship do you see?

Code Snippet 3 computes the frequencies of left and right judgments need later for the `glm()` analysis.

2.22	**Run Code Snippet 3** 1. lines 61-63
2.23	**Call up the object `df.freq`.** 1. What does the new column `df.freq$Freq` tell us? 2. What does the 1st row mean (ELI5; Explain Like I'm 5): 3. Take a look at the first 4 rows of `df.freq`. What might you conclude from these 4 rows?

Code Snippet 4 computes the probabilities of each response for plotting.

2.24	**Run Code Snippet 4** 1. lines 71-94
2.25	**Call up the object `df.freq.wide`** 1. What do the values in the column `total` tell you? 2. How were these values computed? (HINT: line 84) 3. Similarly, how were the values in `prob.left` and `prob.right` computed? Which lines in the script are these values computed?
2.26	**On lines 93 and 94, this R script makes use of the `subset()` command. What are these two lines doing? Specifically, how? (ELI5)**

Code Snippet 5 fits separate generalized linear functions to the 0 deg elevation and the 30 deg elevation data. It also fits a sequence of increasingly complex glm models to the complete data set to set an idea of whether or not there is a difference between the two luminance contrast conditions.

2.24	**Run Code Snippet 5** 1. lines 105-119 2. Code Snippet 5 fits 6 different models to these data, and store the results in the objects `glm.00, glm.20, glm.m0, glm.m1, glm.m2, glm.m3.` 3. These models aren't used to estimate an effect in the population, but are instead used to calculate the Just Noticeable Difference (JND). 4. Once we plot graphs of these models, we'll discuss them in detail. For now, call each of the models, and paste the outputs below. 5. The reported results of these models are in standard deviation units (which correspond to probabilities in a normal distribution!)
2.25	**Call up the object `glm.00`, copy-paste the output here:**

2.26	`glm.30`
2.27	`glm.m0`
2.28	`glm.m1`
2.29	`glm.m2`
2.30	`glm.m3`
2.31	**Rerun line 119 and copy-paste the output here:**

Code Snippet 6 extracts the glm coefficients and computes the mean and standard deviation of the underlying Gaussian representation of the two luminance conditions. It also computes the motion detection JNDs based on plus and minus one standard deviation of these representations.

2.32	**Run Code Snippet 6** 1. lines 125-168 2. Code Snippet 6 uses the fitted glm.00 and glm.30 models to compute the means (`mu`), standard deviations (`sd`), and just noticeable differences (`jnd`) for both elevation levels (`00, 30`). 3. The extracted coefficients are in standard deviation units! 4. Call up the following objects, and copy-paste the values below:
2.33	`mu.00`

2.34	`mu.30`
2.35	`sd.00`
2.36	`sd.30`
2.37	`jnd.00`
2.38	`jnd.30`

Code Snippet 7 defines `plot1()` function that creates a separate plot for each of the luminance conditions in one window.

2.39	**Run Code Snippet 7** 1. lines 192-281
2.40	**Call up `plot1()`** 1. In the console, type `plot1()` 2. Save the graph as plot1.pdf 3. Insert plot1.pdf here:
2.41	**Graphs like these are used to display a relationship between the abscissa (x-axis) and the ordinate (y-axis). What are the abscissa(s) representing?**
2.42	**What are the Ordinates showing?**

2.43	**In general, what relationship do both of these graphs show?**

Code Snippet 8 defines `plot1a()` which plots the two conditions in one plot so that they can be easily compared with each other.

2.44	**Run Code Snippet 8** 1. lines 289-371 **2. In the console, type plot1()**
2.45	**Call up** `plot1a()` 1. In the console, type `plot1a()` 2. Save the graph as plot1a.pdf 3. Insert plot1a.pdf here:
2.46	**Does displaying results in this fashion (superimposed) add anything to your understanding of your performance? If so, what?**

Code Snippet 9 defines `plot2()` with draws the two Gaussian distributions, one for each luminance contrast condition.

2.47	**Run Code Snippet 9** 1. lines 379-464
2.48	**Call up** `plot2()` 1. In the console, type `plot2()` 2. Save the graph as plot2.pdf 3. Insert plot2.pdf here:

Code Snippet 10 defines a series of `plot3()`s that plot increasingly complex generalized linear models. `Plot3a()` plots the simplest model that uses the mean frequency of left and right to predict the data as represented by the R formula:

```
cbind(freq.right, freq.left) ~ 1.
```

`Plot3b` adds the variable direction_coherence to the formula. `Plot3c` adds the variable of luminance elevation to the formula. `Plot3d` adds the interaction of coherence and elevation to the formula. The aic of each model is printed on the corresponding graph so you can see which model fits the data the best. The snippet also creates the `plot3.aic` function that plots the aic for each of the models we have fit to the data. Finally the snippet defines `plot3()` which creates a window with all four plots in it.

2.49	**Run Code Snippet 10** 1. lines 472-699
2.50	**Call up** `plot3()` 1. In the console, type `plot3()` 2. Save the graph as plot3.pdf 3. Insert plot3.pdf here:
2.51	**Call up** `plot3.aic()` 1. In the console, type `plot3.aic()` 2. Save the graph as plot3_aic.pdf 3. Insert plot3_aic.pdf here:
2.52	**Based on the AIC values, which of these four models is a better fit?**

Plot3 is has 4 panels that each display a different model: glm.m0 (top left; Box 2.27), glm.m1 (top right; Box 2.28), glm.m2 (bottom left; Box 2.29), and glm.m3 (bottom right; Box 2.30). Plot3 is generated to show how each model fits the data, and is a great example of multivariate regression.

Group Data Analysis

CODE SNIPPET 12 - set options and read in the group data

2.53	**Open the R script** *Lab_1a_Tools > Lab_1a_Group_Data > lab1a_group_analysis.R* 1. Clear the workspace by running line 6
2.54	**Run Code Snippet 12** 1. lines 11-28 2. You may need to download and install an analysis package.
2.55	**Call up `df.wide`** 1. How many subjects are included in this analysis? (N=?) 2. Assuming an "ideal observer" would have a `mu.00` value of 0.00 for the equiluminant condition: which subject had the least amount of response bias? The most bias? 3. For s35, jnd.00=0.079 and jnd.30=0.139. What can we conclude about subject s35's performance on this task? 4. What about s33?
2.56	**Compute some summary statistics from `df.wide`** 1. Some very useful R commands[1]: `mean(), median(), sd(), var()` 2. For example, in the console, type `mean([name of data frame]$[name of column])`

CODE SNIPPET 13 - compute the isoluminance effect size

2.56	**Run Code Snippet 13** 1. line 36 2. What does this new value represent?

[1] Here's a Table of Useful R Commands a maths professor at Calvin College compiled https://www.calvin.edu/~scofield/courses/m143/materials/RcmdsFromClass.pdf

CODE SNIPPET 14 - reshape data frame from wide to long format

2.57	**Run Code Snippet 14** 1. lines 48-63 2. What are the key differences between a wide-format data frame, and a long format data frame?

CODE SNIPPET 15 - table of means

2.58	**Run Code Snippet 15** 1. lines 73-74 2. Copy-paste the output of Code Snippet 15 here:
2.59	**These two tables show the mean JNDs for the isoluminant and luminance contrast conditions, for each lab section (L101=Tues and L102=Thurs), and the order of presentation.** 1. Which subset and under what condition had the "BEST" performance? **2.** The "WORST" performance?

CODE SNIPPET 16 - mixed effects linear model

2.60	**Run Code Snippet 16** 1. lines 83-89 2. Copy-paste the output of Code Snippet 16 here (if you need, you can rerun line 88 and line 89):
2.61	**Take a close look at the `elevation` line from `print(mod)`** 1. What is the beta coefficient for the `elevation` effect? 2. What does this beta coefficient value mean? (ELI5)

	3. Was the effect of luminance on motion detection *statistically significant*? 4. How else can you interpret the p-value for the `elevation` effect? 5. How might you report this result in prose? (HINT: state the result in prose, then report the numbers).

CODE SNIPPET 17 - Bootstrap effect size

2.62	**Run Code Snippet 17** 1. lines 94-117
2.63	**Call up the object `bs.jnd`** 1. Copy-paste the output below:
2.64	**Inspect the output of bs.jnd** 1. Compute the mean of `df.long$con.30vs00` and compare that value to the Stat value from `bs.jnd`. Are they similar? 2. Does the value 0 fall within the range of the 95% confidence interval? What does that mean? 3. How might you report this result in prose?
2.65	**The bootES package has a built in plotting function. Call up the object `plot(bs.jnd)`.** 1. Save this plot as plot_bs_jnd.pdf. 2. Insert plot_bs_jnd.pdf here:

2.66	`bs.jnd.d` 1. Copy-paste the output below:
2.67	**Inspect the output of bs.jnd.d** 1. This estimates the standardized effect size as Cohen's d 2. According to Cohen (1977)[2], is the estimated effect of luminance contrast (as measured by Cohen's d) a small, medium, or large effect? 3. How might you report this result in prose?
2.68	`bs.jnd.section` 1. Copy-paste the output below:
2.69	**What does the output of `bs.jnd.section` tell you? (HINT: look at the confidence interval)**

CODE SNIPPET 18 - plot1(): Effect of equiluminance on AIC

2.70	**Run Code Snippet 18** 1. lines 132-200 2. Save the plot, insert here:
2.71	**What can you conclude from `plot1`?**

CODE SNIPPET 19 - plot2(): Effect of equiluminance on motion

2.72	**Run Code Snippet 19** 1. lines 206-276 2. Save the plot, insert here:

[2] Here's a neat website that summarizes how to interpret Cohen's d: [http://rpsychologist.com/d3/cohend/

2.73	**What can you conclude from `plot2`?**

CODE SNIPPET 20 - plo3(): Effect Size of equiluminance on motion detection

2.74	**Run Code Snippet 20** 1. lines 282-366 2. Save the plot, insert here:
2.75	**What can you conclude from `plot3`? (HINT: The red line is 0, the gray lines are the upper and lower bounds of the 95% confidence interval).**

CODE SNIPPET 21 - plo4(): Effect Size of equiluminance on motion detection

2.76	**Run Code Snippet 21** 1. lines 372-456 2. Save the plot, insert here:
2.77	**What can you conclude from `plot4`? (HINT: The red line is 0, the gray lines are the upper and lower bounds of the 95% confidence interval).**

With these results, you can use the Lab1a_Report_2015_Fall_P4165.docx to assemble these results into a lab report!

References

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