Psychology of Perception Psychology
4165, Fall 2015

Laboratory 0

Introduction to Experimental Methods in Perception Research: The Oblique Effect
Lab Overview

Classical methods of psychophysics involve the measurement of two types of sensory thresholds: the absolute threshold, RL (*Reiz Limen*), the weakest stimulus that is *just* detectable, and the difference threshold, DL (*Differenz Limen*), the smallest stimulus increment away from a standard stimulus that is *just* detectable (also called the Just-Noticeable Difference, the JND). Gustav Theodor Fechner (1801–1887), in *Elemente der Psychophysik* (Fechner, 1860) introduced three psychophysical methods for measuring absolute and difference (JND) thresholds: the method of adjustment; the method of limits; the method of constant stimuli. In the method of constant stimuli, a standard stimulus is compared a number of times with test stimuli of slightly different orientation. When the difference between the standard and the comparison stimulus is large, the subject nearly always can correctly judge the difference between the test stimulus relative to the standard. When the difference is small, however, errors are often made. The difference threshold is the transition point between differences large enough to be easily detected and those too small to be detected.

The purpose of this laboratory to provide participants (you) with an introductory experience to the method of constant stimuli, and also to introduce you to the software tools that we’ll be using throughout the semester (PsychoPy and R). We will use these software tools to observe the “Oblique Effect,” a well-known and reliable phenomenon in visual perception. Today’s lab activities are organized “holistically” to present the entire lifecycle of a perception experiment in a single lab session, beginning with reading a classic review paper on the Oblique Effect, using PsychoPy to perform an experiment designed to observe the Oblique Effect, and finally tabulating and analyzing data in “R.” Throughout this lab you will find sample text provided as a model of each of the lab competencies.

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

- Download “Lab Tools” folders from the class website and run scripts in PsychoPy and R.
- Generate and save data and data visualizations (graphs) in R.
1. Introduction Section

Describe a perceptual phenomenon using prior research literature.

Before any experimentation, researchers must begin by ensuring that they clearly understand the phenomenon of interest by reading prior relevant literature on the topic. Review articles are especially useful in this regard in assembling relevant literature and critiquing the current scientific understanding, state of the art, of a particular topic or phenomenon. For today’s experiment we will use a classic review article, Appelle (1972) to begin our understanding of the Oblique Effect phenomenon.

1.1 Open the Appelle (1972).pdf.


1.2 In prose, how does Appelle (1972) describe the oblique effect? (Hint: it’s on page 266)

Identify a “Gap”; formulate a problem statement.

Following the literature review, a quality research article will clearly provide a compelling motivation for the current study in the form of a problem statement. For example:

1.3 “Throughout the literature, the oblique effect has been described as a near universal characteristic of animal visual systems; however, I have not yet observed the oblique effect myself under controlled conditions.”

Formulate a purpose statement to address the problem statement.

The purpose explicitly tells the reader that (a) the purpose of the current project is to solve the stated problem, and (b) how. For example:

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1 Our problems are pedagogical rather than theoretical.
Formulate a clear, testable/falsifiable hypothesis.

Crucial to any scientific endeavor is clearly determining and stating the hypothesis to be tested. Here is an example:

1.4 “The purpose of this experiment was to demonstrate the presence of the oblique effect in human visual perception. To do so we used the method of constant stimuli to compare orientation discrimination under two different visual orientation conditions.”

1.5 “We tested the hypothesis that visual orientation discrimination for vertically oriented stimuli (0.0 deg) would be superior to discrimination for obliquely oriented stimuli (45 deg).”

The logical “If, Then” statement is a particularly useful way to explicitly state how we’ll determine if hypothesis is true in terms of subject performance. For example:

1.6 “If the Just Noticeable Difference (JND) for the vertical condition (0.0 deg) was less than the JND for the oblique condition (45.0 deg) then we could conclude that the oblique effect was present.”

But what does it look like when we assemble all these elements together? Below, the text from 1.3, 1.4, 1.5, and 1.6 are concatenated into a complete paragraph as might be seen in an APA-formatted publication:

1.7 “Throughout the literature, the oblique effect has been described as a near universal characteristic of animal visual systems; however, I have not yet observed the oblique effect myself under controlled conditions. The purpose of this experiment was to demonstrate the presence of the oblique effect in human visual perception. To do so we used the method of constant stimuli to compare orientation discrimination under two different visual orientation conditions. We tested the hypothesis that visual orientation discrimination for vertically oriented stimuli (0.0 deg) would be superior to discrimination for obliquely oriented stimuli (45 deg). If the Just Noticeable Difference (JND) for the vertical condition (0.0 deg) was less than the JND for the oblique condition (45.0 deg) then we could conclude that the oblique effect was present.”
2. Method Section

LAB INSTRUCTIONS
The experiment will be run under computer control using PsychoPy, a popular program written in Python by Jonathan Peirce, at the University of Nottingham, England (Peirce, 2007, 2009). PsychoPy allows you to run experiments with carefully controlled visual and auditory stimuli and to collect response data and reaction times. You’ll need to download, then run the experiment file.

<table>
<thead>
<tr>
<th>2.1 Download “Lab 0 Tools” from the course website:</th>
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<tbody>
<tr>
<td>1. In a web browser, navigate to the course webpage (or click the link below):</td>
</tr>
<tr>
<td><a href="http://psych.colorado.edu/~lharvey/P4165/P4165_2015_3_Fall/Main">http://psych.colorado.edu/~lharvey/P4165/P4165_2015_3_Fall/Main</a> Page 2015_Fall_PSYC4165.html</td>
</tr>
<tr>
<td>2. Move Lab 0 Tools.zip from the Downloads folder, to the Desktop</td>
</tr>
<tr>
<td>3. Unzip the Lab 0 Tools.zip by double-clicking the file.</td>
</tr>
<tr>
<td>PROTIP: Keep all your working files in the Lab 0 Tools folder on the Desktop, that way you won’t overlook a crucial file when you logout!</td>
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<tr>
<th>2.2 Start PsychoPy 2 application</th>
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<tbody>
<tr>
<td>1. In the applications folder, select the PsychoPy 2 icon (shown in Figure 1)</td>
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</table>

**Figure 1. PsychoPy 2 icon**

<table>
<thead>
<tr>
<th>2.3 Execute the Orientation JND Exp.py script:</th>
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<tbody>
<tr>
<td>1. From the File menu, Open (⌘O) Lab0_Tools &gt; Orientation JND Exp &gt; Orientation JND Exp.py</td>
</tr>
<tr>
<td>2. Execute the experiment script by clicking the Run button in the toolbar (it’s green with a silhouette of a running person; see Figure 2). Alternately, you can use the keyboard shortcut ⌘R.</td>
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</tbody>
</table>

**Figure 2. PsychoPy Coder View**
2.4 Enter your information in the info dialog.
1. You will be shown the “info dialog,” as shown in Figure 3.
2. Enter your own initials in the observer field
3. Verify that the value 10 is in the repeats field. This tells the PsychoPy how many blocks of trials to run.
4. Click OK to begin the experiment.

Figure 3. info dialog

Follow on screen instructions to take the experiment.

The computer will randomly decide which of the two orientations to test first: 0 or 45 deg. On each trial you will first be presented with the standard stimulus (either 0 or 45 deg, depending on the condition) followed by a test stimulus. The test will be rotated slightly counterclockwise or clockwise relative to the standard. You must judge which by pressing the left arrow key (if you think the second stimulus is counterclockwise) or the right arrow key (if you think it was clockwise). The computer will record your responses on each trial. Some of the judgments will be easy and some will be difficult. The whole experiment should not take more than 30 minutes. On the cover of this lab are two examples of Gabor patches: one is oriented at
0.0 degrees (vertical) and the other is tilted clockwise by 2.0 degrees. Can you see the difference?

Your experimental data will be saved in a text file in the data folder whose name is your initials with the date and time added to it. The file extension is .csv, for comma separated values. If you double click on the file name, it will open in Excel. Do not modify this data file. It represents a lot of judgments and work on your part.

**Design & describe an experiment to investigate behaviors (human judgments) under contrasting perceptual conditions.**

The Method section describes the actions you took to test the hypothesis at a level of detail necessary to the reader to understand the logical connection between those actions and your theoretical question, and if needed, replicate the experiment. All experiments involve the manipulation of one or more independent variables to observe the effect on some outcome (dependent variable). There are many ways to design experiments in experimental psychology, but one of the things that makes perception experimentation different than other domains of psychological research, is the heavy reliance on *within-subjects designs*, rather than *between-subjects designs*: Experiments are often designed so that subjects perform the same judgment task under 2 or more conditions. Here is a sample description of our experimental design:

2.5 “To demonstrate the presence of the oblique effect, we used the method of constant stimuli (Fechner, 1860) to compare the ability of participants to detect small orientation differences from vertical (0.0 deg) and oblique (45.0 deg) standard stimuli. Each participant was tested in both vertical and oblique standard orientation conditions, with the order of tasks randomly counterbalanced across participants. Both conditions involved judging the direction test stimuli were rotated relative to standard stimuli (clockwise, counterclockwise). Linear mixed-effects regression was used to analyze responses. Factors were ‘orientation’ (vertical, oblique), ‘testing order’ (00-45, 45-00), and ‘subject’ as a random effect. The dependent variable was the Just Noticeable Difference (JND), equal to 1 standard deviation of the Gaussian distribution underlying the psychometric function.”

**Describe participants to a level of detail appropriate to the experiment.**

Descriptions of participants help the reader understand to whom any findings may be generalized. For example:
2.6  “Participants were students enrolled in an undergraduate Psychology of Perception course (N=35), and were 18–26 years of age (M 21.2). All participants had normal or corrected to normal vision.”

Design & describe Materials and Apparatus used to measure a behavior.
Careful descriptions of stimuli and apparatus should allow another interested researcher to replicate your experiment. Here is an example:

2.7  “Viewing distance was not fixed, but was the typical distance when viewing a desktop computer. The stimuli were Gabor patches: Sinusoidal gratings with a Gaussian envelope. The Gabor patches had a spatial frequency of 0.8 cycles per degree (cpd), with and were sized to be approximately 16 deg in diameter from the typical viewing distance of a desktop computer. Stimuli were presented on a 27 in. RGB Apple monitor, in the center of the screen on a grey background (RGB (128, 128, 128)). For both standard orientation conditions, 19 test stimuli were prepared that were rotated to vary from the standard orientations in increments of 0.5 deg. The computer program PsychoPy 1.81.03 (Peirce, 2007) used present stimuli and record participant responses.”

Design & describe a task procedure to measure a behavior.
The procedure should be limited to describing the events between the beginning of the experiment (Clicking “Run” in PsychoPy), and when the participant is “Thanked” at the end. Here is an example:

2.8  “Participants were tested individually during class. To start, participants were shown brief task instructions. The time course for each trial consisted of a standard stimulus briefly displayed for 0.5 seconds, a blank grey field for 1.5 seconds, followed by a test stimulus also displayed for 0.5 seconds. Subjects responded with the left arrow key (←) if they judged the test stimuli was rotated counter-clockwise relative to the standard, and the right arrow key (→) if they judged the test stimuli was rotated clockwise. The 19 test stimuli were presented in a different random order in each of 10 blocks of trials, for a total of 380 trials (190 trials x 2 standard orientation conditions). Subjects could take a brief break between standard orientation conditions. After completing the experiment, participants were thanked. The entire experimental procedure took approximately 30 minutes.”
3. Results Section

Individual Data Analysis

You have been provided with an R script to analyze your individual data: `lab0_glm.R`. For this lab, it contains all the commands needed to completely analyze your individual data. Later in the semester you will be writing more and more R commands on your own. There are four basic steps to any data analysis, and the `lab0_glm.R` script performs all of these steps for you.

1. IMPORT data into R (e.g., lines 17-20).
2. RE-ORGANIZE imported data for analysis (e.g., lines 25-34).
3. ANALYZE data by fitting a mathematical/statistical model to your data (e.g., lines 43-146).
4. PLOT graphs of your results (e.g., lines 164-700).

The goal of this individual data analysis phase is to figure out how well an individual (in this case, you) performed on the orientation discrimination task. We do this by regressing response probabilities (dependent or measurement variable) onto the various orientation offsets (the independent or predictor variable). The section below deals entirely with interpreting the analysis.

Compute dependent/measurement variables (JND).

3.1 Execute the `lab0_glm.R` script:
1. Open the R application from the Application menu.
2. From the File menu, Open (⌘O) the file `lab0_glm.R` in the Lab0_Tools folder.
3. Execute the entire script by selecting all of the text in the `lab0_glm.R` script window (Ctrl-A), then pressing ⌘Enter. Alternately, you can select the script window, then press ⌘E.
4. A “Choose File” dialog box will appear. Select your data file: `Lab0_Tools > Orientation JND Exp > data > [initials] [timestamp].csv`, and click “Open.”

R PROTIP: Organize your windows so that you can see both the script window, and the console window. Alternately, you can use RStudio, an application that has a much more organized interface.
In general, the best thing to start with is to visualize your results in a graph. This script prepares two graphs that illustrate your results. In the R-script `lab0_glm.R`, the two graphs are encapsulated in functions, `plot1()` and `plot2()` so you can redraw them any time by giving either command.

### 3.2 In the R console, call up the function `plot1()`
1. In the R Console, scroll to the bottom of the screen.
2. At the prompt (>), type the name of the function: `plot1()`
3. Press enter.

### 3.3 Save the graphic as `plot1.pdf`
1. Select the Quartz 2 [*] window
2. From the File menu, select Save As… (⇧⌘S)
3. In the Save Quartz to PDF File dialog box, change the filename from Rplot.pdf to “plot1.pdf”

**PROTIP:** I strongly recommend saving all lab files to a folder labeled “Lab 0” on the Desktop. That way, when you logout you won’t overlook any files you’ve worked so hard on!

### 3.4 Insert `plot1.pdf` into this table
1. Drag the file `plot1.pdf` from the Finder onto this document window
2. The cursor shows where the file will appear when you release the mouse button.

`plot2()` shows the same response probabilities as `plot1()`, but as normally distributed probability density functions. Representing our data in this way will be more important to use later in the semester. For now, save `plot2()` using the same steps you used for `plot1()`.

### 3.5
1. **In the R console, call up the object `plot2()` and insert plot2.pdf here:**

Visualizations are great and all, but we need to compare precise numeric results to make any solid conclusions. The results of the analysis which are stored in objects `glm.00` and `glm.45`, and the R objects `mu.00`, `sd.00`, `mu.45`, and `sd.45` respectively.
Compute, interpret, & report summary statistics (graph, prose).

| 3.6  | In the R console, call up the object glm.00:  
|      | 1. In the R Console, scroll to the bottom of the screen.  
|      | 2. At the prompt (>), type the name of the object: glm.00  
|      | 3. Press enter.  
| 3.7  | Copy/paste the output of glm.00 here:  
| 3.8  | Copy/paste the output of glm.45 here:  
| 3.9  | What was the value for object mu.00?  
| 3.10 | Object mu.45?  
| 3.11 | Object jnd.00?  
| 3.12 | Object jnd.45?  
| 3.13 | Compare the JNDs for both conditions. Under which orientation condition were you more sensitive to small differences in orientation?  

With these JND values, you can conclude under which viewing condition you were most sensitive to differences in orientation. But are these results typical?

**Group Data Analysis**

The goal of the sample, or group, data analysis phase is to figure out how well all of the observed subjects performed on the orientation discrimination task. Under typical lab conditions, you would upload your data file to D2L so that we can perform a proper group data analysis using all students currently enrolled in the lab. But cleaning and compiling all the data files takes a while, so in the interest of time, you have been provided with actual experimental data from a prior semesters lab section. Use the R commands listed in the file lab0_lme.R in the Lab0_Group_Data folder to carry out the next phase in the data analysis. Just like the individual data analysis, there are four basic steps:

1. IMPORT data into R (e.g., lines 10-15).
2. RE-ORGANIZE imported data for analysis (e.g., lines 27-42).
3. ANALYZE data by fitting a mathematical/statistical model to your data (e.g., lines 195-225).
4. PLOT graphs of your results (e.g., lines 59-193).

### 3.14 Executing the lab0_lme.R Script:
1. Open the R application from the Application menu.
2. From the File menu, Open (⌘O) the file lab0_lme.R in the Lab0_Tools folder.
3. Execute the entire script by selecting all of the text in the lab0_lme.R script window (Ctrl-A), then pressing ⌘E. Alternatively, you can select the script window, then press ⌘E. A “Choose File” dialog box will appear. Select your data file: Lab0_Tools > Orientation JND Exp > data > lab_1_group_data_wide_Spring_2015.csv, and click “Open.”

### Compute, Interpret, & Report Summary Statistics (Graph, Prose)

#### 3.15 In the R console, call up the function plot4() & plot5(). Save the plots as PDF files.

#### 3.16 Insert plot4.pdf here:

#### 3.17 Insert plot5.pdf here:

#### 3.18 Which of these plots (plot4 or plot5) is more relevant to report?

From these data, we can calculate statistics that summarize this dataset (means, standard deviations), so called summary statistics. The lab0_lme.R script did not store these values separately, so you’ll need to provide the code to calculate them. We’ll use the mean() function to compute the means of columns in the df.wide data frame.

#### 3.19 Compute the mean JND values for for both the vertical and oblique conditions.
1. In the console, type mean(df.wide$sd00)

---

2 Sometimes you’ll see these statistics called descriptive statistics. I detest this term because ALL STATISTICS are descriptive!
2. Copy/paste the result in Table 3.23.
3. In the console, type `mean(df.wide$sd45)`
4. Copy/paste the result in Table 3.24.

3.20 Use the `mean()` function repeat to calculate the means for the columns `mu00`, `mu45`, `aic00`, and `aic45`.

3.21 What was the mean value for `mu00`?

3.22 Column `mu45`?

3.23 Column `sd00`?

3.24 Column `sd45`?

3.25 Column `aic00`?

3.26 Column `aic45`?

3.27 Compare the means of `sd00` and `sd45`. Under which orientation condition were subjects in our sample more sensitive to small differences in orientation?

Here’s an example of how to report relevant summary statistics:

3.28 “The average JND values for both the vertical (M=1.73 deg) and oblique standard orientations (M=9.03 deg) show that as a group, subjects appeared to be far more sensitive to deviations from the vertical standard.”

**Inferential Statistical Tests**

So far, we have observed and analyzed the pattern of an individual’s responses, and the responses made by a sample of college students (N=35) to find that subjects tend to be much more sensitive to deviations from vertical standard orientations than oblique: in other words, the oblique effect is clearly present in our sample. Further statistical analysis is only necessary if we
were interested in estimating how likely the observed effect is also present in the [unobserved] general population. Said another way: If all we cared about was how well our observed sample of 35 subjects performed on this task, then we would halt our analysis right here!!!

**Select, perform, and report appropriate statistical contrasts to test hypothesis (graph, prose).**

The `lab0_lme.R` script uses Linear Mixed-Effects model (hence, lme) to test the hypothesis that the oblique effect is present in the general population of persons with normal vision. Mixed-effects refers to the fact that the statistical model contains both *fixed* and *random effects*. More likely than not, all of the statistical tests you studied in your statistics classes were *fixed effects* statistical tests (t-tests, F-test, ANOVA, etc.). The statistical model that tests our hypothesis can be found in `lab0_lme.R` on line 216, shown below.

```
lme.jnd <- lme(sd ~ standard * order, data = df, random = ~ 1 | subject)
```

There is a lot to unpack at this level of analysis, but for now let’s just focus on the analysis germane to our hypothesis.

| 3.29 | **Call up the object `lme.jnd`**  
1. In the console, type `summary(lme.jnd)`  
2. Copy/paste the output into Table 3.30. |
| 3.30 | **Copy/paste the output of `summary(lme.jnd)` here:** |
| 3.31 | **Examine the line `standard45`. Was our observed effect statistically significant?** |

Here is an example of how to report the results of this statistical test:

```
“On average, the Just Noticeable Difference for the oblique condition (M=7.71 deg) was significantly greater than the vertical condition (M = 1.09 deg) [t(1, 31)=4.59, p=.0001], showing that humans possess a clear advantage when detecting small changes in vertical orientation.”
```
To this point, we’ve generated results from our data at 3 levels: individual data analysis, group data analysis, and inferential statistics. The following discussion section is where we tie it all together and report our findings.
4. Discussion Section

The goal of a discussion section is to summarize your experiment and explain to the reader what your results mean. Very often readers are overwhelmed with information by the time they get to the discussion section, and have more than likely forgotten the important contextual information from the introduction. Well-written discussion sections:

- Restate the purpose of the experiment.
- Restate the hypothesis/expected results.
- Explicitly state your findings in prose.
- Explicitly compare/contrast your findings to the prior literature (discussed in your literature review).
- Discuss any unexpected results.
- Discuss methodological limitations in the present study.
- Discuss practical implications of your findings.

Restate the purpose of the experiment.

This reminds the reader what the whole experimental endeavor was about. Here is the purpose statement from above:

4.1 “The purpose of this experiment was to demonstrate the presence of the oblique effect in human visual perception.”

Restate the hypothesis/expected results.

Restating the hypothesis/expected results serves a similar function to the reader. Here is our hypothesis combined with part of the purpose statement:

4.2 “To do so we used the method of constant stimuli to test the hypothesis that visual orientation discrimination for vertically oriented stimuli (0.0 deg) would be superior to discrimination for obliquely oriented stimuli (45 deg).”

Explicitly state your findings in prose.

Remember: Findings are what the researcher concludes after a logical examination of the results. Do not report any new results (numbers), just explain what the numbers mean.
4.3 “Our results supported our hypothesis; subjects were far more responsive to small deviations from vertical orientations than differences from oblique orientations.”

**Explicitly compare/contrast your findings to the prior literature (discussed in your literature review).**

Did you observe a similar effect as reported in a prior study? This is where you point out similarities and differences to the experiments you cited in the introduction section.

4.4 “Our findings are in line with numerous prior investigations into the oblique effect in humans (as reviewed in Appelle, 1972).”

**Discuss any unexpected results.**

If warranted, this section is very helpful to the reader, especially when proposing followup experiments. But, keep in mind that the “unexpected results” should probably be connected with your original hypothesis somehow.

4.5 “Although the presence of the oblique effect was expected, what was not expected was its magnitude: On average, subjects required an orientation difference seven times larger when detecting differences from the oblique standard than for the vertical standard.”

**Discuss methodological limitations in the present study**

This should be an honest critique of the methods used, but don’t go crazy here. Remember the old adage, “It’s easy to criticize.” Every experiment has limitations, but smart researchers limit their criticisms to aspects of the study that might have changed the finding of the study.

**Discuss practical implications of your findings**

Finish with what your finding means in the real world It’s helpful to think of this as making recommendations for some kind of real-world task or problem. These sections are patently speculative, so authors are often afforded a wide latitude in this regard.

4.6 “The robust presence of the oblique effect implies that the confidence that structural engineers develop from detecting misalignment of vertical supports should not be generalized to detecting similar faults in diagonal bracing. Non-vertical structural elements should always be inspected using well-calibrated..."
measurement instruments, such as protractors, trammels, or rafter squares.”
References


