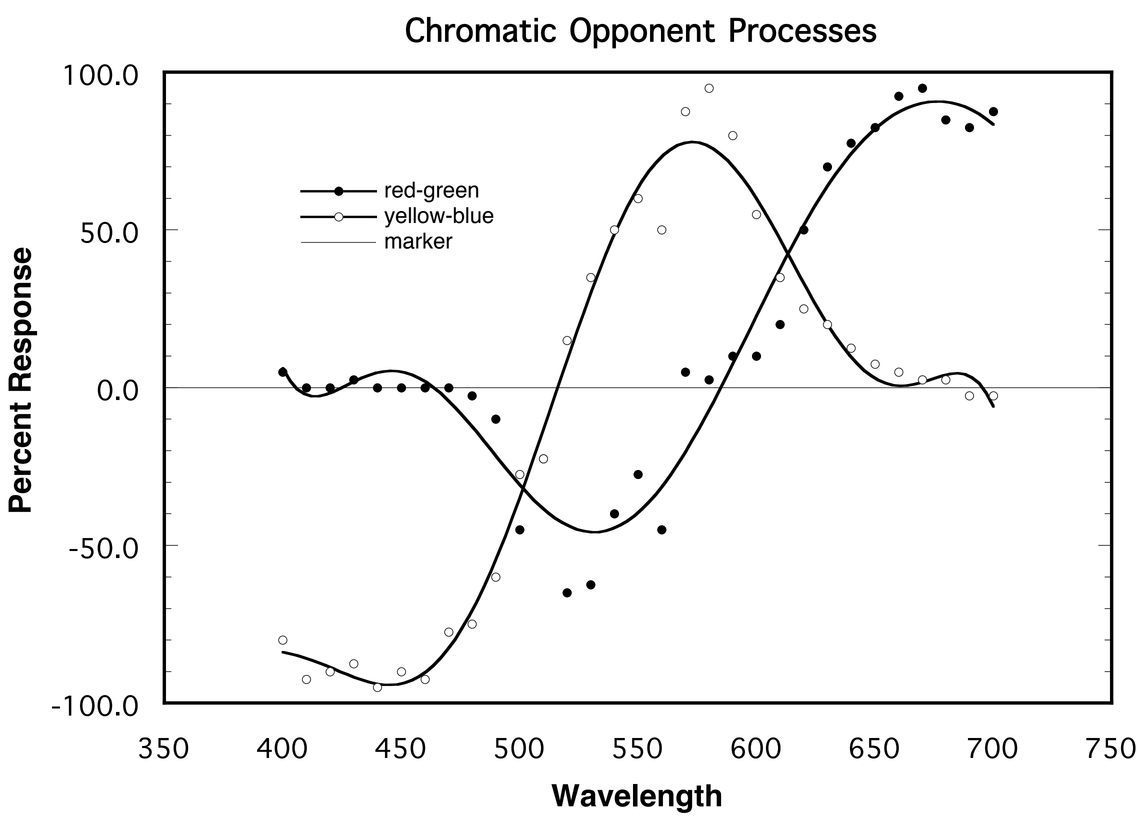
Psychology of Perception

Psychology 4165, Fall 2005

Laboratory 3

Hue-Naming Functions



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Lab 3: Hue Naming

Introduction

Color is a psychological experience composed of at least three psychological dimensions: **hue**, **saturation**, and **brightness**. Hue is the experience that we describe with color name labels such as red or blue. Saturation describes the intensity of the hue experience, ranging from hueless to deeply saturated. Pink, for example, is a desaturated red. Brightness is the dimension of experience that permits us to order colors from dark to light. Yellow usually appears brighter than navy blue. In this experiment you will explore the color dimension of hue and gain some insight into the perceptual mechanisms that create it.

Physical light is composed of discrete packets of energy called quanta. A quantum of light has only a single physical property that can be described in one of three ways: By the energy in the quantum; by the frequency of the quantum; or by the wavelength of the quantum. Quanta having wavelengths in the range of approximately 400 to 700 nm (1 nanometer = 10^{-9} meter) are called photons because, under the right circumstances, they can lead to visual experiences. Light has no color; color is an experience created by the visual system in response to stimulation by light.

There are hundreds of different color names in English and most languages. In spite of the plethora of color words, people with normal color vision can describe almost all colors as being composed of various percentages of red, yellow, green, and blue. For example, one might describe orange as being 60% red and 40% yellow or lime as 70% green and 30% yellow and so on. In this experiment you are going to view monochromatic lights (light composed of a single wavelength) and estimate the percentage of red, yellow, green, and blue making up the color experience you have of each light.

Methods

Procedure: Form groups of 2 or 3. Each will view monochromatic light projected on a white screen by a Bausch and Lomb monochrometer. Thirty-one separate wavelengths ranging from 400 nm to 700 nm in 10 nm steps will be viewed. These wavelengths should be presented in a random order. Record the size of the colored spot and your viewing distance from it. Viewing distance should remain constant throughout the experiment.

Present each of the 31 wavelengths one at a time. On each trial, write down on your data sheet (see Appendix I) what percentage of the color experience evoked by the wavelength is red. Write down 0 percent if there is no red in your experience.. This task may seem very strange at first. You might want to practice a bit before you start in earnest. After all 31 wavelengths have been judged for their redness, repeat the process for yellow, then for green and finally for blue. Be sure to judge all 31 wavelengths for a given color before moving on to the next color. Use a different random order of the wavelengths for each color judgment.

After you have collected the color naming data above, use the method of adjustment to determine the wavelength that gives you the psychological pure colors of blue, green, and yellow. If you have a dichromatic color deficiency, find the wavelength that appears hueless or neutral white or gray. Record these wavelengths on your data sheet. Make at least 10 trials per color (i.e., blue, green, and yellow). Compute the mean wavelength for each color and enter them on the group data sheet.

Individual Data Analyses: For each wavelength, add up the percentages of red, yellow, green, and blue. Transfer your data from the table in Appendix 1 to the Hue_Naming_Template in KaleidaGraph. Make a graph presenting your data on linear coordinates: Wavelength should be plotted on the abscissa and percent on the ordinate. Plot four separate curves on the graph: one for red, one for yellow, one for green, and one for blue, as is shown in Figure 1 below. Create two new data columns from your data: red minus green and yellow minus blue. Use the Formula window to compute these values. Plot a second graph of your red-green data and your yellow-blue data, like Figure 2. Do these new curves resemble opponent-processes? Fit a 9th order polynomial to the data using the Polynomial item under the Curve Fit menu of KaleidaGraph.

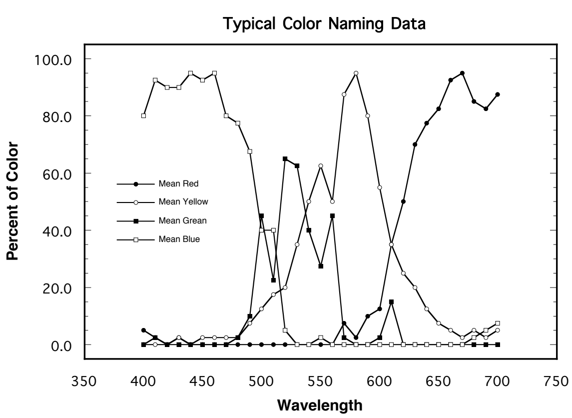

Figure 1

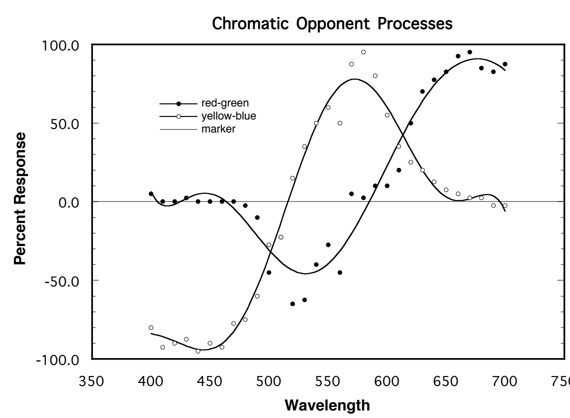

Figure 2

From your color curves in Figure 2, determine the wavelengths giving psychologically pure blue (where red and green are zero), green (where blue and yellow are zero), and yellow (where red and green are zero). How do these wavelengths compare with those measured directly? In your discussion relate your findings to the opponent-process theory of color vision.

Compare your data (graph) with those of your group members. How are they alike and how do they differ? If you have someone in your group who has a color deficiency examine his (most likely it would be a male) data carefully and compare them with the members of your group who have normal trichromatic color vision.

Group Data Analysis: The data file lab3.txt contains the mean wavelengths corresponding to psychologically pure blue, pure green, and pure yellow for each observer in the class. Examine the data to see if there is much consensus among observers. You could plot the wavelengths for the three colors on a strip chart or make a box and whiskers plot to look at the spread of your data. You could also look at the means and standard deviations for each color. Finally, test the hypothesis that the wavelengths giving pure blue, pure green and pure yellow are the same (the null hypothesis). The series of commands in R that create these graphs and compute the statistics are given at the end of this handout.

Laboratory Report

Your lab report should contain five parts**:** ***Cover Sheet, Introduction, Methods, Results,*** and ***Discussion***. In the ***Introduction*** explain why you did the experiment. In the ***Methods*** section describe what you did. In the ***Results*** section present your findings, including graphs of your data. In the ***Discussion*** of your results, here are some important questions to answer. Is there a systematic relationship between wavelength of light and the percentages of red, yellow, green, and blue experience evoked by it? Are there any points in the wavelength spectrum that give rise to a unique hue? A unique hue would occur at a wavelength that gave 100% of one color name and 0% of the other three. Look at the relationship among the four curves. Do pairs of curves seem to have a special relationship with one another? Relate your findings to the trichromatic theory of color vision proposed by Helmholtz and to the opponent-process theory proposed by Hering. Examine the spread of the unique hue wavelength across the students in the class. Is there good agreement or not?

Your lab report should be brief and contain six sections: cover page, introduction, methods, results, discussion, and references. These sections should conform to the American Psychological Association (APA) style as described in Chapter 13 of the Martin book. The results section should contain the graphs plotting your data and the opponent-process transformation. The report is due at lab meeting (**8 or 10 November 2005**). Late labs will receive a grade of zero. All lab reports must be prepared with a word processor. It is worth 50 points.

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Appendix I: Data Tabulation

	Wavelength	Red	Yellow	Green	Blue	Total
1	400 nm					
2	410 nm					
3	420 nm					
4	430 nm					
5	440 nm					
6	450 nm					
7	460 nm					
8	470 nm					
9	480 nm					
10	490 nm					
11	500 nm					
12	510 nm					
13	520 nm					
14	530 nm					
15	540 nm					
16	550 nm					
17	560 nm					
18	570 nm					
19	580 nm					
20	590 nm					
21	600 nm					
22	610 nm					
23	620 nm					
24	630 nm					
25	640 nm					
26	650 nm					
27	660 nm					
28	670 nm					
29	680 nm					
30	690 nm					
31	700 nm					

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Appendix II: Psychologically Pure Colors

	Wavelength for psychologically pure color		
Trial	Blue	Green	Yellow
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Mean			

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Using R for Lab 3 Analysis

The general strategy with any data analysis is to first examine the data graphically and then do a formal statistical test of hypotheses. The commands below are the minimum required to compute a repeated-measures design with one within factor (eyes). You might have to download the data file (lab3.txt) from the course website (ask us for help if the file is not in the lab folder):

http://psych.colorado.edu/~lharvey

\# Step 1: Set the working directory to the folder where data file "lab3.txt" is located.
Choose **Change Working Directory** under the **Misc** menu.

\# Step 2: Read data into R and store it in a data frame (here called df):
df <- read.delim("lab3.txt")

\# Step 3: Make the variables available outside the data frame
attach(df)

\# Step 4: Write out a summary of the variables in the data frame:
summary(df)

\# Step 5: Make a strip chart of the data
**stripchart(wavelength ~ color, method = "jitter", jitter = 0.03,
ylab = "Wavelength (nm)",
xlab = "Color", ylim = c(400, 650), vertical = TRUE)**

\# Step 6: Make a box plot of the data:
**boxplot(wavelength ~ color, ylim = c(400, 650), data = df,
ylab = "Wavelength (nm)",
xlab = "Color", ylim = c(400, 650))**

\# **Testing the hypothesis that color is independent of wavelength**
\# Step 7: Compute the repeated measures ANOVA and store the results in object a:
a <- aov(wavelength ~ color + Error(subj/(color)), data = df)

\# Step 8: print a summary of the analysis of variance
summary(a)

\# Step 9: Print a table of means:
print(model.tables(a,"means"))