Psychology of Perception

Psychology 4165, Fall 2006

Laboratory 2

Face Recognition: Are Eyes Important?

Intentionally Blank

Introduction

Recognition of human faces is a remarkably good skill. Even after 50 years have passed, people are able to choose which of two photographs is a high school classmate with an accuracy of almost 90 percent correct (Bahrick, Bahrick, & Wittlinger, 1975). The eyes and surrounding areas of the face are thought to be very important for face recognition (Bruce, 1988). In this lab you test the hypothesis that obscuring the eyes makes it more difficult to later recognize a face.

There are two principle theories that describe how observers detect weak stimuli: The High Threshold Model (HTM) and Signal Detection Theory (SDT). In this lab you will test the predictions of these two models for face recognition. First you will be shown a series of photographs of faces to remember. Some will have their eyes covered and some will not. Then you will be tested with another series of faces, half of which you have seen before and half of which are new. Your task is to decide on each trial whether or not the face had been previously seen. You will use a six-point confidence rating scale. A six-point rating scale corresponds to having five different decision criteria. From your data you will calculate five hit rate false alarm rate (HR-FAR) pairs (one pair for each of these response criteria) for the two types of faces. The two detection models will be compared to see how well each model can predict the observed data.

The objectives of this laboratory exercise are:

1. To test which model, the High Threshold Model or the Signal Detection Theory Model, better predicts your observed data in the face recognition experiment;

2. To test whether or not seeing the eyes enhance your ability to later recognize faces.

Experimental Procedure

You will first be shown a series of 64 target faces. Thirty-two of the faces have the eyes covered over and the other 32 are normal faces with the eyes visible. Study each face carefully during the 2 sec exposure time. Then in the test phase of the experiment, you will be shown a series of 128 test faces. Half of them will be target faces and half of them will be new faces that you have not previously seen. Using the six-point rating scale below rate each face on your confidence that it is a new face or a target face:

> 1 = certain the face was not seen before
> 2 = perhaps the face was not seen before
> 3 = guessing that the face was not seen before
> 4 = guessing that the face was seen before
> 5 = perhaps the face was seen before
> 6 = certain the face was seen before

Record your responses in the "Ratings" column of the data sheet given in Appendix I. Don't worry about the difficulty of the task. Making these decisions sometimes is frustrating.

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Just relax and after each trial, respond with a number from 1 to 6. Be sure, though, to use all of the response categories.

Data Analysis

1. Data Tabulation And Transformation

Your data analysis begins with a series of transformations of the raw data through the following sequence:

1. response scale frequencies;
2. response scale probabilities;
3. cumulative probabilities (hit rates and false alarm rates);
4. z-score transformation of the cumulative probabilities.

First: Count up the number of times you used each of the rating categories for the new face trials, for the old faces no-eyes trials, and for the old faces with eyes trials. These are the response scale frequencies. Record them in the column labeled "Rating Frequency" in Appendix II. We will give you a decoding key after the experiment is over so that you know what kind of trial each of 128 test trials was.

Second: Use the computer program *RscorePlus* to compute the remaining data transformations. First double click on the data template file (rscoreDataTemplate.txt) so that you can edit it in Microsoft Word. Enter the frequency of each confidence rating for the three types of stimulus trials: new faces, old faces that were previously seen without eyes, old faces that were previously seen with eyes. Insert your name in the title line. Make sure that you save this file as text only. Quit Word. Now double click on *RscorePlus*, and type in your input file name at the prompt. You should analyze your data twice: once for the Gaussian signal detection model and once for the high threshold model. For each analysis, the program will produce three output files having the same name as your input file, but with different extensions:

1. myfile_gauss.doc   a Word file with the printed output of each analysis
2. myfile_gauss.grf   a text file to be imported into KaleidaGraph for making graphs
3. myfile_gauss.alt   a results file for statistical analysis (you will not use this file)

Print the *_gauss.doc and the *_htm.doc files by double clicking on each file to open it in Microsoft Word. Before printing, you should select all the text and set the font size to 8 and the font type to Courier to make the printed results easier to read. Print each file.

2. ROC Analysis

The high threshold model of detection predicts that the ROC will be a straight line when plotted in probability coordinates. The signal detection theory model predicts that the ROC will be a straight line when plotted in z-score coordinates. The first step, therefore, is to plot your HR FAR pairs on two types of graphs: one with linear probability coordinates and one with z-score coordinates.

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Double click on the KaleidaGraph icon in the Dock to start it up. Next, import the *_htm.grf and the *_gauss.grf files into KaleidaGraph using the **Import->Text** menu command. You will now have two data windows open: one containing the results of the Gaussian signal detection model analysis and the other containing the high threshold detection model results. Next you should create three graphs from these data windows. The two probability ROC graphs should be square, with horizontal (p_{FAR}) and vertical axes (p_{HR}) ranging from -0.02 to 1.02. The z-score graph also should be square, with horizontal (z_{FAR}) and vertical (z_{HR}) axes ranging from -3.0 to +3.0 (see Appendix III for examples).

1. Graph 1: **Linear probability ROC for the high threshold model**:
   Click on the *_htm.grf window to bring it forward. Choose **Gallery->Linear->Line**. In the dialog box that appears select the following variables for the graph:

   a. X-axis = "Obs P(Y|s)0" (the false alarm rate for new faces).
      Y-axis = "Obs P(Y|s)1 " (the hit rate for old faces without eyes)
      Y-axis = "Obs P(Y|s)2" (the hit rate for the old faces with eyes).

      These choices will plot your observed data. To plot the ROC predicted by the best-fitting high threshold model also, select X2 by clicking and holding on the X at the top of the window. Now select the following variables for the graph:

   b. X2-axis = "Pred P(Y|s)0" (the false alarm rate predicted by the model)
      Y2-axis = "Pred P(Y|s)1" (the hit rate predicted by the model)
      Y2-axis = "Pred P(Y|s)2" (the hit rate predicted by the model)
      for the Y-axis. Tidy up the probability graph to make it square, with horizontal (FAR) and vertical (HR) axes ranging from –0.02 to 1.02.

2. Graph 2: **Linear probability ROC for the Gaussian signal detection model**:
   Click on the *_gauss.grf data window to bring it forward. Now follow exactly the same procedure as in Graph 1.

3. Graph 3: **Z-score probability ROC for the Gaussian signal detection model**:
   Make sure that the *_gauss.grf data window is selected. Follow the procedure as in Graph 2 but chose these variables for plotting:

   a. X-axis = "Obs z(Y|s)0"
      Y-axis = "Obs z Y|s)1"
      Y-axis = "Obs z(Y|s)2"

   b. X2-axis = "Pred z(Y|s)0"
      Y2-axis = "Pred z(Y|s)1"
      Y2-axis = "Pred z(Y|s)2"

RscorePlus computes the parameters of the best-fitting detection model using a maximum-likelihood technique. The goodness-of-fit of the model is computed using the chi-square statistic, χ^2. These results are given in your printed output. Judging from the chi-square and from visual inspection of your graphs, which model, the high-threshold or the signal detection, gives a better description of your data? If you can reject one of the models, then you should not use the sensitivity and response bias measures from that model.

4. Goodness of Fit

The ultimate test of each model is by how well it predicts the observed data. Since the parameters of each model were computed using a maximum-likelihood regression, the appropriate test is to calculate how well each model predicts the six response frequencies under the three stimulus conditions. The goodness of fit of these predictions can be formally computed using the chi square (χ^2) test. The value of χ^2 for each model is given on your printed output pages. Note that the degrees of freedom for the High Threshold Model are different than for the Signal Detection Model because the High Threshold Model has fewer free parameters to be computed from the data. To compare the fit of models having different numbers of free parameters we use a modified version of χ^2 that "corrects" penalizes models with more free parameters. This modified χ^2 is called the Akaike Information Criterion (AIC) after the scientist who developed it (Akaike, 1974). Which model fits your observed data better (has the lower AIC)? Can you reject the hypothesis that each model is a good predictor of the data?

5. Recommended further reading

There is a large literature on signal detection theory. Although no additional reading is needed for this assignment, here are some references that you might wish to read if you want to enhance your understanding in this area. There are several books that are worthwhile (Egan, 1975; Green & Swets, 1966/1974; Macmillan & Creelman, 2005; McNicol, 1972; Swets & Pickett, 1982; Wickens, 2002). Here are some journal articles that will introduce you to the research literature (Harvey, 1992; Krantz, 1969; Simpson & Fitter, 1973; Swets, 1961, 1986a, 1986b; Swets, Tanner, & Birdsall, 1961).

6. Group Data

When you have finished your *RscorePlus* analysis, enter the appropriate results from the printed output on the summary sheet in Appendix IV. Transfer these results to the group sheet that we will have for you so that we can prepare a group data for further analysis. You will test two null hypotheses:

1. H0: The signal detection model is just as good as the high threshold model;

2. H0: that seeing the eyes does not improve face recognition.

For the first hypothesis, compute a repeated measures analysis of variance on AIC, the modified *chi-square*, the badness-of-fit measure we are using (the higher the AIC, the worse the fit). For the second hypotheses, compute a repeated measures analysis of variance on d_a, the index of sensitivity in the signal detection model.

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Lab Report

Your lab report should contain five parts: Cover Page, 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. Your conclusions should be based on your statistical analyses, not your unsupported speculation. In the discussion you can let your creativity run wild. Give the reader your interpretation of the results. Discuss any implications and leads for further research. Laboratory reports must be typed, double-spaced on 8.5 x 11 paper with at least 1 inch margins. Conciseness and clarity are extremely important characteristics of good scientific writing. Strive for them. Worth 40 points. **Due in lab on 3 and 5 October 2006**.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, AC-19*(6), 716–723.

Bahrick, H. P., Bahrick, P. O., & Wittlinger, R. P. (1975). Fifty years of memory for names and faces: A cross-sectional approach. *Journal of Experimental Psychology: General, 104*(1), 54–75.

Bruce, V. (1988). *Recognising faces*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Egan, J. P. (1975). *Signal Detection Theory and ROC Analysis*. New York: Academic Press.

Green, D. M., & Swets, J. A. (1966/1974). *Signal detection theory and psychophysics* (A reprint, with corrections of the original 1966 ed.). Huntington, NY: Robert E. Krieger Publishing Co.

Harvey, L. O., Jr. (1992). The critical operating characteristic and the evaluation of expert judgment. *Organizational Behavior & Human Decision Processes, 53*(2), 229–251.

Krantz, D. H. (1969). Threshold theories of signal detection. *Psychological Review, 76*(3), 308–324.

Macmillan, N. A., & Creelman, C. D. (2005). *Detection theory: A user's guide* (2nd ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates.

McNicol, D. (1972). *A primer of signal detection theory*. London: George Allen & Unwin.

Simpson, A. J., & Fitter, M. J. (1973). What is the best index of detectability? *Psychological Bulletin, 80*(6), 481–488.

Swets, J. A. (1961). Is there a sensory threshold? *Science, 134*, 168–177.

Swets, J. A. (1986a). Form of empirical ROCs in discrimination and diagnostic tasks: Implications for theory and measurement of performance. *Psychological Bulletin, 99*(2), 181–198.

Swets, J. A. (1986b). Indices of discrimination or diagnostic accuracy: Their ROCs and implied models. *Psychological Bulletin, 99*(1), 100–117.

Swets, J. A., & Pickett, R. M. (1982). *Evaluation of diagnostic systems: methods from signal detection theory*. New York: Academic Press.

Swets, J. A., Tanner, W. P., Jr., & Birdsall, T. G. (1961). Decision processes in perception. *Psychological Review, 68*(5), 301–340.

Wickens, T. D. (2002). *Elementary signal detection theory*. New York: Oxford University Press.

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Appendix I: Data Sheet

Trial	Rating	Target
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Appendix II: Summary of Raw Data from Appendix I

Rating Frequencies for RscorePlus input file

	R_1	R_2	R_3	R_4	R_5	R_6	Total
New Faces							64
Old Faces no eyes							32
Old Faces with eyes							32

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Appendix III: Recommended format for the ROC graphs

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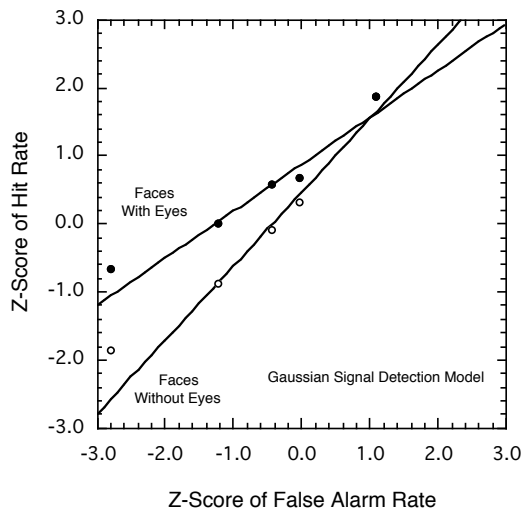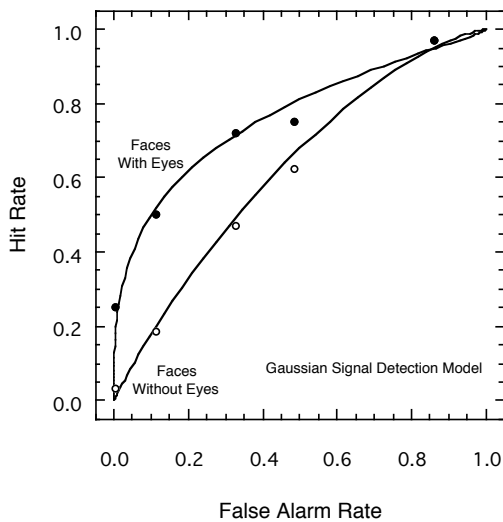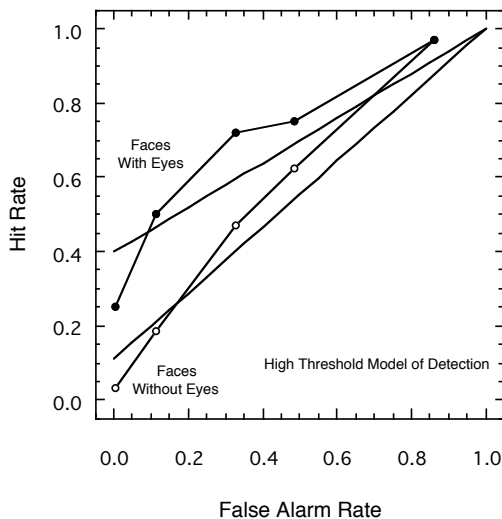
Appendix IV: Summary of Results

Signal Detection Theory Results

Sensory Process Sensitivity (d_a)		Goodness-of-Fit Measures		
Without eyes	With eyes	Chi-Square	Probability	AIC

High Threshold Model Results

Sensory Process Sensitivity (p)		Goodness-of-Fit Measures		
Without eyes	With eyes	Chi-Square	Probability	AIC

Using R for Lab 2 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 (lab2_data.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 "lab2.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("lab2.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)

Testing the First Hypothesis (that SDT and HTM are equally good in describing data)

Step 5: Make a strip chart of the data
        **stripchart(AIC ~ mod, method = "jitter", jitter = 0.03, xlab = "Badness-of-Fit (AIC)",
        ylab = "Eyes (Yes or No)")**

Step 6: Make a box plot of the data:
        boxplot(AIC ~ mod, data = df, xlab = "Eyes (Yes or No)"), ylab = "Badness-of-Fit (AIC)"

Step 7: Compute a repeated measures ANOVA and store the results in object b:
        a <- aov(AIC ~ mod + Error(subj/mod), data = df)

Step 8: Write out a summary of the results:
        summary(a)

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

 # Testing the Second Hypothesis (that seeing eyes has no influence on face recognition).

Step 10: Make a strip chart of the data
    **stripchart(da ~ eyes, method = "jitter", jitter = 0.03, xlab = "Sensitivity (Da)",
ylab = "Eyes (Yes or No)")**

Step 11: Make a box plot of the data:
    boxplot(da ~ eyes, data = df, xlab = "Eyes (Yes or No)"), ylab = "Sensitivity (Da)")

Step 12: Compute the repeated measures ANOVA and store the results in object a:
    b <- aov(da ~ eyes + Error(subj/eyes), data = df)

Step 13: print a summary of the analysis of variance
    summary(b)

Step 14: Print a table of means:
    print(model.tables(b, "means"))