Psychology of Perception

Psychology 4165, Spring 2002

Laboratory 2

Face Recognition: Are Eyes Important?

Lab 2: Signal Detection Theory and Face Recognition

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 whether or not seeing the eyes enhance your ability to later recognize faces;
2. To test which model, the High Threshold Model or the Signal Detection Theory Model, better predicts your observed data in the face recognition experiment.

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

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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. 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 *Rscore* 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 had no eyes, old faces 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 *Rscore*, 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. You can select all the text and set the font size to 10 and the font type to Courier to make the formatting of the results easier to read. Print each one.

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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.

Double click on KaleidaGraph 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.

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 for the X-axis “Obs P(Y|s)1” (the false alarm rate for new faces). For the Y-axis select “Obs P(Y|s)2 ” (the hit rate for old faces without eyes) and “Obs P(Y|s)3” (the hit rate for the old faces with eyes). This selection 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 “Pred P(Y|s)1” (the false alarm rate predicted by the high threshold model) for the X2-axis and select “Pred P(Y|s)2” and “Pred P(Y|s)3” 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 except choose “Obs z(Y|s)1”, “Obs z Y|s)2”, “Obs z(Y|s)3”, “Pred z(Y|s)1”, “Pred z(Y|s)2”, and “Pred z(Y|s)3” in place of the probability variables used above. 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).

Rscore 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?

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3. Sensory Process Sensitivity Analysis

Both models have a sensory process and a decision process. The sensory process is supposed to operate independently from the decision process (it is supposed to be unaffected by different decision criteria). You can test this claim of independence by calculating the value of the sensitivity index for each of the HR, FAR pairs in your data. These are the cumulative probabilities on the computer printout of your results.

$$p = \frac{HR - FAR}{1 - FAR} \qquad \text{(High Threshold Model)}$$

$$d_a = \left(\sqrt{\frac{\sigma_n^2 + \sigma_s^2}{2}}\right)\left(z_{HR} - \frac{\sigma_n}{\sigma_s} \cdot z_{FAR}\right) \qquad \text{(Gaussian Signal Detection Model)}$$

For each face type, calculate five values of p for the five observed HR, FAR pairs and plot these on a graph. The graph should have FAR on the horizontal axis and p plotted on the vertical axis. Also calculate five values of d_a for each of the observed z(HR), z(FAR) pairs and plot these on a second graph. This graph should have FAR on the horizontal axis and d_a plotted on the vertical axis. Each graph will have two curves: one for faces without eyes and one for faces with eyes. Which set of sensitivity indices is independent of decision criterion: those from the high threshold model or those from signal detection theory?

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 is different than for the Signal Detection Model. Which model fits the observed data better (has the lower χ^2 and the higher probability)? 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 classic books that are worthwhile (Egan, 1975; Green & Swets, 1966/1974; Macmillan & Creelman, 1991; McNicol, 1972; Swets & Picket, 1982). 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 Rescore 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 use the statistical analysis program, StatView, to test two hypotheses:

1. Seeing the eyes improves face recognition;

2. The signal detection model is better than the high threshold model

The easiest way to test the first hypotheses is to compute a repeated measures analysis of variance on d_a, the index of sensitivity in signal detection theory. For the second hypothesis, compute a repeated measures analysis of variance on *p*, the goodness-of-fit measure associated with chi-square.

Lab Report

Your lab report should contain four parts: 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 26 and 28 of February 2002**.

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References

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

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Lewis O. Harvey, Jr. – Instructor
Paula M. Beall – Assistant
Room MUEN D-156, 11:00–13:50 T & Th

Appendix I: Data Sheet

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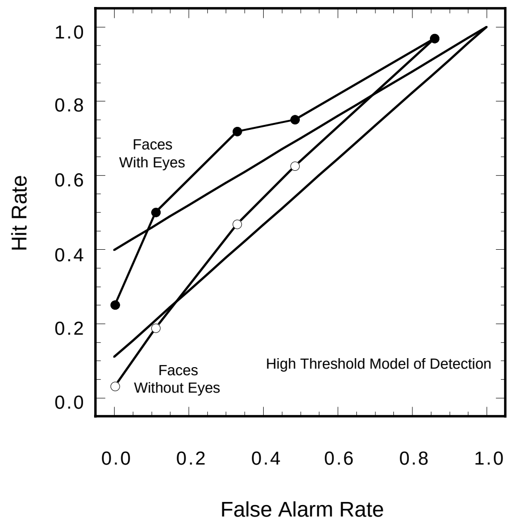
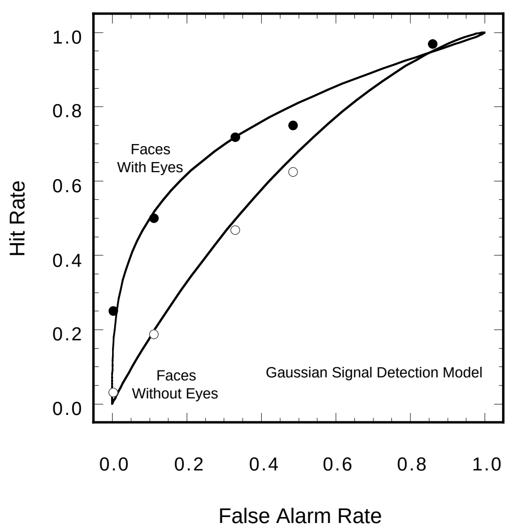
Appendix II: Summary of Raw Data from Appendix I

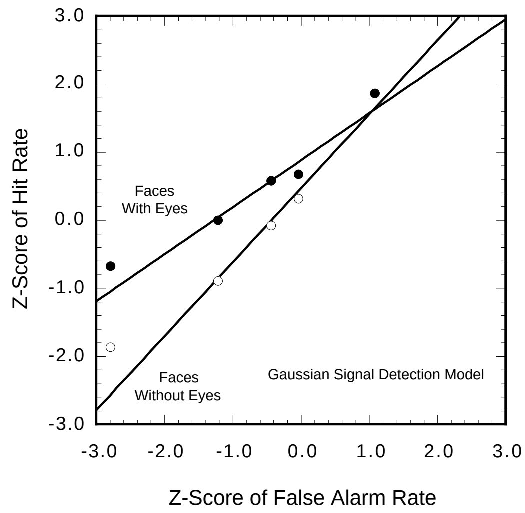
Rating Frequencies for Rscore input file

	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**

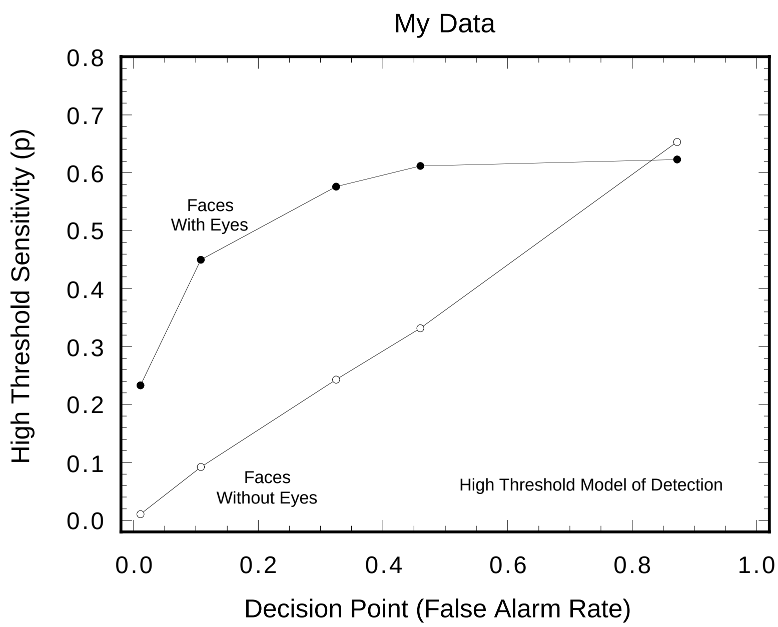
Appendix IIIa: Recommended format for the ROC graphs

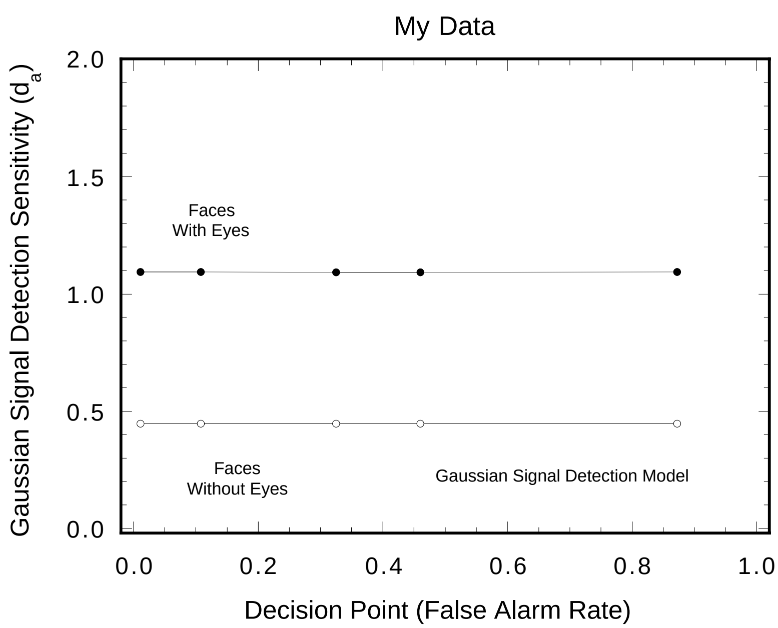






Appendix IIIb: Recommended format for the sensitivity graphs





Appendix IV: Summary of Results

Signal Detection Theory Results

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

High Threshold Model Results

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