An Experiment in Graphical Perception

ACTIVITY 3

Graphical perception is "the visual decoding of information encoded on graphs." As you read in Keen Chapter 1, Cleveland and McGill were leaders in the exploration of graphical perceptions. This activity replicates, to some degree, to one of the original Cleveland and McGill experiments about graphical perception from 1986[1]. A set of basic graphical methods were identified for the perceptual experiment. Presentation of elements such as position scale, direction, area and angle were tested on how accurately quantitative information could be extracted. In this activity, you will be asked to extract quantitative information from graphs and test results will be analyzed in a group setting. In addition to gaining an appreciation for the ability of making graphical judgments, you will be asked to critique the quality of the graphs analyzing the data. Finally, you will see an example of how R can be used to analyze and produce graphs quickly and with surprising depth.

Purpose

The purpose of this activity is to:

- Give you the opportunity to make actual judgments on various graphical elements in a controlled experiment and analyze the results.
- Expose you to the ease with which data can be explored graphically and in depth with R scripts.

Learning Objective

- Add to your conceptual knowledge about graphical perception by making connections between the activity, lecture, and reading.
- Increase your awareness of how your selection of the types of graphs may improve or reduce an audience's ability to make accurate judgments.

Required Resources

- Pencil or pen
- Answer sheet (provided)
- Log sheets (provided)
- Experimental instrument (provided)

Time Allocated

50 minutes in-class

Tasks

A. Introduction

This activity gives you the opportunity to conduct a series of predesigned graphical perception tests and report the statistical analyses of the test results. Each student will answer four sets of graphical perception tests with six plot methods in each set, or 24 plots in total. The six plots are designed to allow you to assess how easy it is to make quantitative judgments about the information presented in graphs. You will be asked to judge graphs that show the following:

- Dot position along a common scale
- Dot position along identical non-aligned scales
- Vertical length
- Horizontal length

[1] Cleveland, William S., and Robert McGill. 1986. "An Experiment in Graphical Perception." *International Journal of Man-Machine Studies* 25 (5) (November): 491–500. doi:10.1016/S0020-7373(86)80019-0.

- Area
- Angle

The original Cleveland and McGill experiment stimuli are shown below:

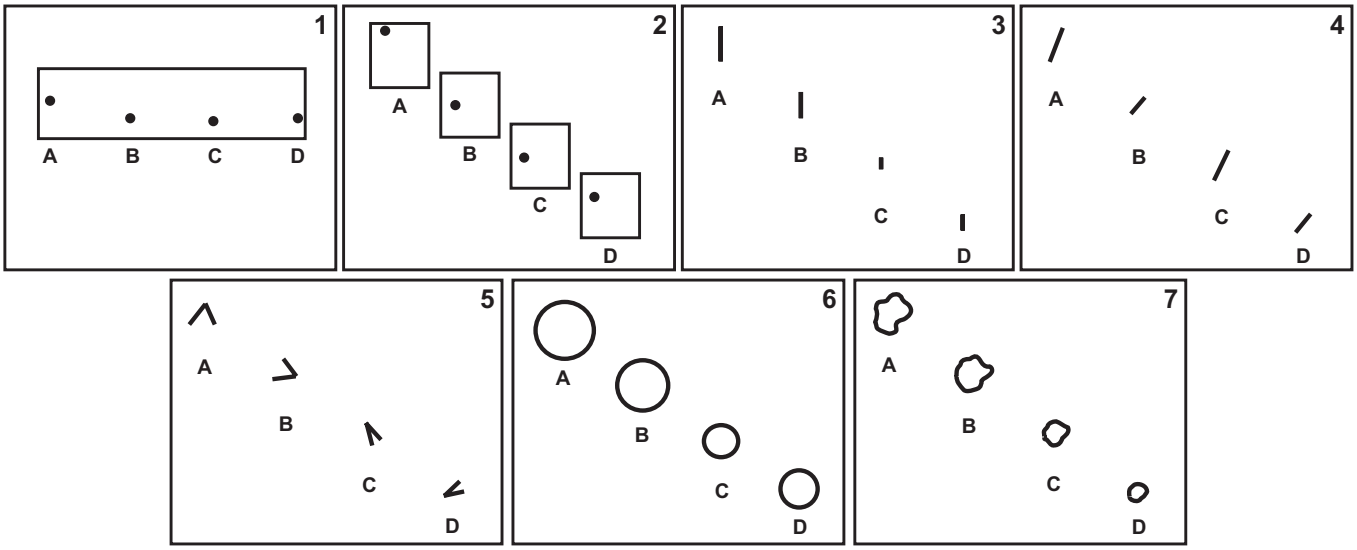

Fig. 2. Stimuli from experiment. An experiment was run to investigate the relative accuracy of basic graphical judgments. The seven types of displays in this figure were judged by subjects. The displays required the following judgments (proceeding from left to right and top to bottom). (1) position along a common scale; (2) postition along identical, non-aligned scales; (3) length, (4) slope; (5) angle; (6) area; (7) area.

Figure 1 Original Cleveland and McGill experiment stimuli (Cleveland and McGill, 1986)

We have created similar instruments and log sheets where you will record your observations. Unlike the original experiment we did not include type 7 for area. The types of plots and the judgments have been randomly generated.

B. Instructions

1. The instructor will assign you a student number. Record this in at the top of the answer sheet for each of the four color-coded logs.

2. The code on the Student Answer Log sheet (11-16, 21-26, 31-36, 41-46) corresponds to the code on the Experiment Instrument, in the lower right-hand corner.

3. For each plot you will make 3 judgments about the relative size of elements B, C, D using A as the benchmark. The scale is not provided to you but the value of A is always 1.0. For each plot code, enter your observations in the column for B, C, and D. So if B is half (½) the size of A in your judgment, you should record "0.5". Alternatively, if B is twice the size of A, you should record "2.0". You can make any marks on the experiment instrument you want but there is no need to spend much time on each set, as the objective is to show how *easily* you can extract quantitative judgments quickly. Enter your answers as shown in Figure 2. Answers for instrument 12 will go in the next column. Answers precise to one decimal place are sufficient.

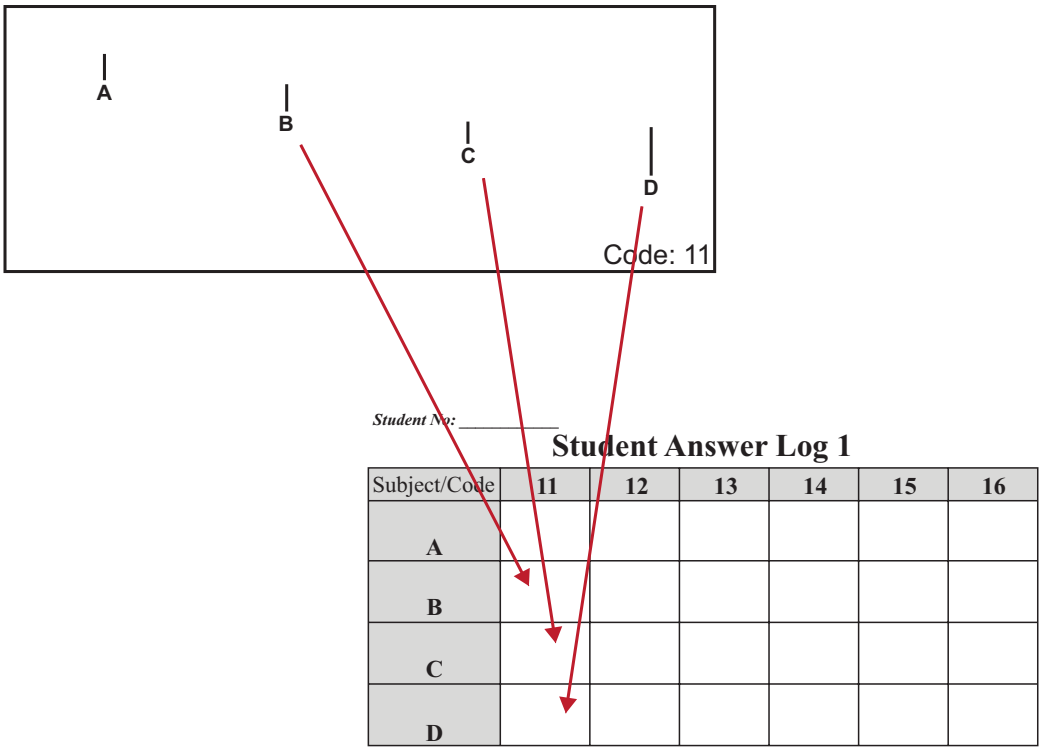

Figure 2 Placement of observation values on the Answer Log

4. This assessment is not concerned with correct answers. Please make reasonably quick judgments. You should be able to complete all four sets of test within 15 minutes in class based on previous experience.
5. Please wait to start until everyone is ready and the instructor announces "start". Enter your answers in each COLUMN for each numbered experimental instrument. When you are finished with the first answer log, place it at the upper right corner of your desk for your instructor to collect. He or she will begin entering these data in the overall class spreadsheet while you continue working.
6. When you are finished and while your instructor is compiling the results, write down a short sentence or two reflecting on the activity on the Activity Worksheet responding to the following questions:
    - Which of the graph types did you find the easiest to make the relative judgments about?
    - On which of the graph types did you think you were most accurate at judging the differences?
7. When you have finished responding to the questions in 6, please read section C below while your instructor is recording all student responses.
8. Please remain quiet until all answer logs are completed at which time you may discuss the activity with fellow students.

C. Data Presentation and Analysis

The observed data will be processed by a previously written R script. The initial exploration of the experimental data will then be displayed to the class. You will be able to see responses by student number but the focus will be on presenting data from the entire class.

In groups of two, you will discuss the plot results and the information that can be gleaned from it.

For each plot, write down your answers to the following questions on the activity sheet (both students should make their own notes of the joint discussion):

1. For which graphical presentation does it appear that most people were able to make the "best" extraction of quantitative information from? The "worst"?
2. Describe how you made this judgment from the plot.
3. Make one additional observation about the data shown in the plot.
4. What information is missing or hard to make inferences about that would be useful to know in making your judgment about the "best" and "worst"?
5. What was/were the good graphical features about the plot(s)?
6. What suggestions could you make regarding improvement of the plot(s)?

Your group will be asked to share your answers with the class. A description of the three data analysis plots are:

- ***Plot 1:*** A set of six plots for each of the graphical judgments. The scatterplots show the observed observation on the y-axis and the true value on the x-axis. An equal line is plotted in dashed dark grey. If all observations are accurate, they will be clustered around this line. Points below the equal line show observations where students overestimated the difference. Two additional pieces of information are annotated on the plots: 1) a least-squares linear regression line and 2) tabulation of the root mean square error (RMSE).
- ***Plot 2:*** A horizontal boxplot of the deviance by each of the graphical judgment types. Boxplots are a plot that you may not have seen yet. In short, the plot is information dense. It shows five descriptive statistics: smallest observation by the left edge of the fence, lower quartile (25^{th} percentile) by the left edge of the box, median (50^{th} percentile) represented by the solid dark black line, upper quartile (75^{th} percentile) the right most edge of the box, and largest observation by the right end of the fence. The width of the box (the spacing between Q1 and Q3) represents dispersion.
- ***Plot 3:*** A set of six plots for each of the graphical judgments that shows boxplots of the deviance values for each student OR a plot of the deviance by true value for each graphical judgment.

Deliverable

Turn in your activity worksheet.

Assessment

This is a participation activity. Your attendance and active participation in the discussion are required to earn all 10 points available for this activity.