Line Length Discrimination

Cognition Lab – Rutgers University

Learning goals

- Learn some of the basic methods that are used to measure how we perceive or represent objects. *These methods are relevant to the study of perception and cognition.*
- Learn about Weber's Law and its significance
- Learn about the Mueller-Lyer illusion

Overview of the Line Length task I

We'll be doing a simple exercise that measures your perceptual ability to compare the length of two lines. It uses a well-known psychophysical method, the Method of Adjustment.

Why would we do such a simple task in our class?

As you'll find out, your ability to match the length of two lines – under the conditions we're using – is not perfect! In fact, no one is able to perfectly match the two lines repeatedly.

And this gets at why we do the task. Matching the length of two lines is a simple way of characterizing how the visual system stores & uses actual spatial size: how the system codes spatial extent. By measuring the extent and nature of the imperfections in the matching, it is possible to find out a lot about how perception works.

RUTGERS

Overview of the Line Length task II

After all, the ability to perceive the spatial extent of a line (and the ability to perceive distances) accurately and precisely is an important component to the perception of form, depth, or motion. Without the ability to perceive line lengths and distances accurately and precisely, everything from our ability to recognize letters of the alphabet (and thus to read) to our ability to steer our cars without collision would be affected.

But we aren't perfect at it. So somehow, our brain is compensating for it.

First, let's take a step back and look at some basics about the method we'll be using

Psychophysics

- **"**The science of defining quantitative relationships between physical and psychological events" (Wolfe et al., 2015, Sensation and Perception, p 6).

- The term "psychophysics" is used because we are measuring the psychological response to a physical stimulus.

There are 3 methods: the Method of Adjustment, Method of Limits and Method of Constant Stimuli.

All psychophysical methods present a *standard* stimulus, and a *comparison* stimulus. Participants are asked to respond to the comparison stimulus somehow with respect to the standard stimulus

Today's exercise uses the simplest of the three methods, the **Method of Adjustment**

RUTGERS

Method of Adjustment

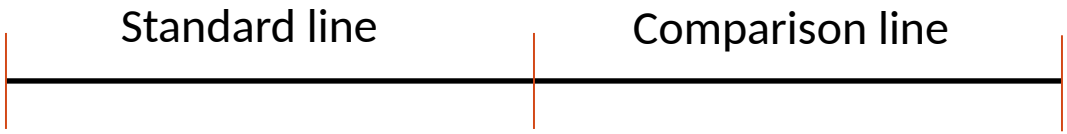
In the Method of Adjustment, the *standard* and *comparison* are presented at the same time, and the participant is asked to adjust the comparison until it matches the standard.

As said on the second slide, our ability to match two stimuli is not perfect. In fact, we rarely can match two stimuli perfectly! But it is our errors are quite informative about perception and cognition.

As a task, the Method of Adjustment "is much like day to day activities, such as adjusting the volume of a speaker or the dimmer switch for a light" (Wolfe et al., 2015, p 9), except in everyday life we usually make the adjustment only once.

In the laboratory we make the measurements many times – comparing to the same standard over and over

Method of Adjustment used for the perception of Line Length

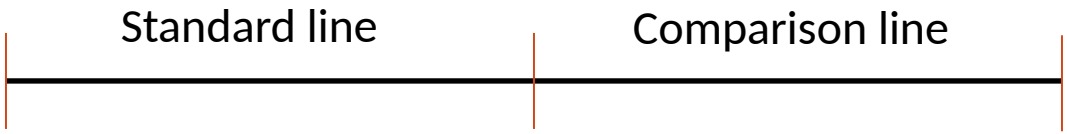


The detailed information about how to run the lab exercise are presented in the instructional videos. For now, we just need an overview to get the basic idea of the Method of Adjustment.

The length of the standard line is fixed. On each trial, the observer (you) adjusts the length of the comparison line by using the keyboard until the two lines appear to have the same length. The length you eventually decided to settle on is stored in a data file.

Remember from the power point “Scientific Methods”, the exercise will have an independent variable (IV) and a dependent variable (DV). Which is which here?

Method of Adjustment used for the perception of Line Length



The detailed information about how to run the lab exercise are presented in the instructional videos. For now, we just need an overview to get the basic idea of the Method of Adjustment.

The length of the standard line is fixed. On each trial, the observer (you) adjusts the length of the comparison line by using the keyboard until the two lines appear to have the same length. The length you eventually decided to settle on is stored in a data file.

Remember from the power point “Scientific Methods”, the exercise will have an independent variable (IV) and a dependent variable (DV). Which is which here?

Right! The standard is the IV, and the comparison is the DV

RUTGERS

Here's a realistic example of some settings you might get for a set of 10 trials and a standard line equal to 200 mm. Each setting in the table below is the value the observer decided was equal to the standard on each of the 10 trials.

Trial	Setting
	1201 mm
	2205 mm
	3195 mm
	4185 mm
	5205 mm
	6213 mm
	7187 mm

Here's a realistic example of some settings you might get for a set of 10 trials and a standard line equal to 200 mm. Each setting in the table below is the value the observer decided was equal to the standard on each of the 10 trials.

Remember, the observer isn't using numbers – she's judging how the lines look

Trial	Setting
1	1201 mm
2	2205 mm
3	3195 mm
4	4185 mm
5	5205 mm
6	6213 mm
7	7187 mm

Here's a realistic example of some settings you might get for a set of 10 trials and a standard line equal to 200 mm. Each setting in the table below is the value the observer decided was equal to the standard on each of the 10 trials.

Trial	Setting
1	1201 mm
2	2205 mm
3	3195 mm
4	4185 mm
5	5205 mm
6	6213 mm
7	7187 mm

Remember, the observer isn't using numbers – she's judging how the lines look

So: what are we going to do with these numbers???

1 - Point of Subjective Equality: the Mean (Average)

- In the Method of Adjustment we take the mean (average) of all the adjustments. The mean is known as the *Point of Subjective Equality*, or **PSE.**

- In the line length exercise, the PSE represents the value of the Comparison line that appears to you to be the same length as the Standard Line.

- What is the mean of the adjustments made in the 10 trials in the sample data set in the previous slide?

2 - Constant Error: PSE – Value of the Standard

- It is likely that the PSE will not equal the value of the standard.
- The difference between the PSE and the Standard is known as the Constant Error, or CE.
- What is the value of the CE for the sample data presented earlier? (It's probably not zero!)
- When you do the "Mueller-Lyer" version of the Line Length exercise, it is likely that the CE will be very different from zero. The non-zero value is an indication of a perceptual illusion known as the Mueller-Lyer illusion.

2 - Constant Error: PSE – Value of the Standard

- We will be discussing later how to interpret the CE. We will ask: Is the CE large enough to be important? How can we make this determination?
- More relevant for now, why are CE's rarely equal to zero?
- A related question: In the sample data set, why are the judgments on each trial different from the value of the standard? Let's tackle this question next.

3 - Standard deviation: a measure of the precision of judgments

RUTGERS

- As noted in the previous slide, judgments on each trial when using the Method of Adjustment are typically not going to be identical to each other.
- We can say that the judgments are **variable**, or, **noisy,** or **imprecise.** We can never get rid of all the variability. We can't be perfect.
- There are three main sources of variability in perceptual judgments:

- Physical (variability in the equipment)
- Neural (variability of the firing patterns in different regions of the brain)
- Psychological (variability due to attention; memory; decision criteria)

- Realistically, some variability due to all 3 sources is unavoidable.

3 - Standard deviation: a measure of the precision of judgments

RUTGERS

- It's often hard to know how much variability is due to each of these 3 sources, or to pinpoint the exact source of variability within each source (and trying to do so is an interesting line of research).
- But cheer up: Even if we can't know the exact sources of the variability, we can certainly measure it.
- In the Method of Adjustment, the variability of judgments is summarized by the **Standard Deviation (SD)**. As you'll see it will be easy to compute the SD using a spreadsheet program.
- The smaller the standard deviation, the more **precise** your judgments are.

Standard Deviation example

- Here's an example of variability when applied to test scores. The standard deviation reflects to what degree measurements vary from one another.

Barbie's exam scores	Ken's exam scores
80	89
90	90
100	91

- Both Barbie and Ken have mean scores of 90, but look how Barbie's scores are spread out more than Ken's. Barbie is more variable. Her scores have a higher standard deviation. There is a way to compute the standard deviation and we'll tell you about that later.

Why are perceptual and cognitive scientists interested in the precision of judgments?...

During the semester you'll see many different answers to this question. The precision of judgments turns out to be very informative about how our perceptual or cognitive systems work. (Remember that we measure precision by computing the Standard Deviation of the judgments.)

What can we say about precision in terms of the **Line Length exercise?**

The next few slides will address this question.

…To learn about how our perceptual system represents the properties of objects.

Ernst Weber, in 1834, discovered that the longer two lines were, the harder it became to distinguish their lengths.

In other words, the longer the lines, the more they had to differ from each other in order to tell them apart.

…To learn about how our perceptual system represents the properties of objects.

Weber was surprised and could not come up with an explanation.

He had assumed that it should be the *absolute* difference in line lengths that would be important. For example, two lines could be distinguished if they differed by a fixed amount, say, 1 millimeter.

This was not the outcome he obtained.

Noise

Weber and others (notably, Gustav Fechner, who invented the Method of Adjustment and other psychophysical methods) realized that the explanation for Weber's result stemmed from the following:

Our perceptual system cannot "represent" the length of lines with perfect precision. There is always some variability or "noise" (see prior slides).

In other words, a line may be 3 centimeters long on the computer screen, but as far as our perceptual system is concerned, we're a bit fuzzy: maybe it's 2.8, or 2.9 or 3.1 cm.

Variability increases with the magnitude of the stimulus

Weber and Fechner both realized that to explain Weber's results, we have to assume that the amount of this "fuzziness" (or, more technically, the amount of variability) in our perceptual representations increases with the magnitude of the stimulus.

If the variability in representing the length of the line increases with line length, then we would expect Weber's result, namely: the longer the lines, the more they will have to differ from one another in order for someone to be able to confidently tell them apart.

And, it's not just the length of lines. **The variability of all sorts of representations increases with their magnitude.** This has come to be known as **Weber's Law**, because he was the first to notice it.

Variability increases with the magnitude of the stimulus

The variability of representations even not strictly in the perceptual domain increases with their magnitude.

Money is a good example that you're already familiar with.

If you don't have much money, you might be careful about estimating your savings to the last penny. But if you're a billionaire, a few cents (or dollars) more or less won't make much difference. Our internal estimate or our memory for how much money we have is "fuzzier" (more variable) the more money we have.

Can you think of other examples?

The Difference Threshold

The variability of judgments is so important that Fechner coined the term **Difference Threshold** to represent the variability of the judgments.

Technically, the **Difference Threshold is the minimum amount by which two objects must differ in order for an observer to tell the objects apart.**

Variability and the Difference Threshold go hand in hand: The more variable (fuzzy) our judgments of line length are, the more the lines will need to differ from one another in order to tell them apart.

Variability and Significance

All this discussion of variability and difference thresholds might also remind you of a topic you learned about in quantitative methods.

How much do two values need to differ from either other in order for us to say that the difference is “significant”?

Variability and Significance

To consider this issue in terms of our Line Length exercise, let's return to the Constant Error described earlier.

Remember that the CE is the difference between the PSE and the Standard stimulus.

Variability and Significance

If our judgments are very variable (large value of the Standard Deviation) then the CE would have to be pretty large for us to take the CE seriously.

If our judgments are not too variable (small SD) then even small CE's are meaningful.

So, what's important isn't the value of the CE by itself, but the value of the CE relative to the variability of our judgments.