Memorization

Many times during the semester, you may feel like your brain just cannot hold all of the information you are learning in classes. Are there ways to improve our memories so that we can comprehend even more information? Research in cognitive psychology has suggested that the answer to that question is a resounding "yes". This literature has suggested several strategies to improve memory, enhance recall and increase retention of information.

One of the strategies identified by cognitive psychologists is that of chunking. Chunking refers to the process of taking individual units of information and grouping them into larger units (chunks). One common example of chunking occurs when we write and recall phone numbers. For example, a sequence of digits in a phone number, say 8-6-7-5-3-0-9, would be chunked into 867-5309.

In this activity, you will be exploring the following research question:

Does chunking improve memory?

To examine this research question, you will use the data collected from the memory experiment your class just partook in.

Examining the Observed Data

The first part of any analysis is to examine the observed data. These are the *data that are actually observed* in the research study. In this study we have data on two attributes for each participant in the study.

- The first attribute we have information about is the participant's score (i.e., the number of letters recalled) from the memory experiment. This is called the **response variable** since it contains data on the subjects' responses to the experiment.
- The second attribute we have information about indicate the treatment condition that the subject was assigned to. This is called a **treatment variable**. In this research study the two *levels of the treatment variable* (the two conditions) are the **experimental condition** (chunking) and the **control condition** (no chunking).

1. Based on the scores, does it seem like there is an effect of chunking? In other words, does it seem like the scores are higher for the chunking group than for the non-chunking group? Explain.

Summarizing the Difference Between the Two Conditions

In order to answer the research question, you need to summarize the difference between the treatment and control conditions into a single number.

When the response variable is quantitative, it is conventional to do this by finding the mean value of the response variable for each condition, and then *compute the difference between the two means*. The difference in means satisfies the need for a single number statistic. It also has another very nice quality, and that is the difference in means is interpretable. The difference in means indicates *how much better* the typical subject in the experimental condition does than a typical subject in the control condition.

2. Compute and record the mean score for each of the two conditions.

3. Compute the difference in means by subtracting the mean score for the non-chunking condition from the mean score for the chunking condition.

Note that this difference is the difference in means for the observed data because we used the observed data (the data from our study) to compute it.

4. Interpret this difference using the context of the memory study.

5. Does the difference you found in the observed data *suggest there is an effect* of chunking on memory or not? Explain.

Considering Experimental Variation as an Explanation for the Difference in Means

Before you conclude that chunking has an effect on memory, consider another alternative: *the difference in means you saw in the observed data is solely attributable to experimental (chance) variation*. Under this model, the difference in means is not because chunking works, but rather because **the random assignment to conditions/groups introduces variation into the results**.

6. If there is *not* an effect of chunking on memory, what would you expect the difference in means to be? Explain.

The No-Effect Model

To examine whether a result obtained in the observed data is solely due to chance (i.e., all the variation is due to the random assignment), one approach is to imagine the *scenario under which the chunking had no effect,* whatsoever. Under this assumption or scenario, evidence would be collected to determine if the difference in means that was observed in the data is too large to probabilistically believe that there is no effect of chunking. This statement or assumption of no effect of chunking is called the **null hypothesis** and is written as,

> H_0: There is no difference in the mean number of letters recalled between the control and experimental conditions.

If chunking is truly ineffective, then each subject's score on the memory test is only a function of that person and not a function of anything systematic, such as the chunking. The implication of this is that, had a subject been assigned to the other condition (through a different random assignment), her score on the memory test would have been identical since, in a sense, both conditions are doing nothing in terms of affecting the memory test scores.

Re-randomization: Inspecting Other Possible Random Assignments of the Subjects

A researcher can take advantage of the idea that each subject's score on the memory test would be identical whether she was assigned to treatment or control and examine other possible random assignments of the subjects to conditions that could have occurred. To do this, you will carry out a physical simulation (not using TinkerPlots™).

Physical Simulation of the Re-Randomization

To aid you in creating these “new” random assignments of conditions, fill in the following:

> In the original experiment, ______ subjects were randomly assigned to the experimental (chunking) condition and ______ subjects were assigned to the control (no chunking) condition.

- You will be given several index cards. Each index card represents a single subject. On each card you will write an *E* (for experimental) or a *C* (for control). When you are done, you should have the same number of *E* cards as subjects originally assigned to the experimental condition and the same number of *C* cards as subjects originally assigned to the control condition. Set the *E* and *C* cards to the side.
- Now, record the first subject’s name and score (number of letters correct) on new card. Continue with the other subjects’ names and scores, recording each subject on a different card. At this point you should have n subject cards (with names and scores), and n condition cards (with an *E* or a *C*), where n is the total number of subjects in the combined control and experimental groups.
- Shuffle the *E* and *C* index cards together several times.
- Shuffle the index cards with the scores several times.
- Deal the shuffled *E* and *C* index cards out one at a time. Now deal the score cards out one at a time, placing each score card you deal on one of the *E* or *C* index cards.

This represents one possible randomization of subjects to either the experimental or control conditions. It is another possible way the subjects could have been assigned to conditions. This random assignment likely has different subjects in the control and experimental conditions than the observed data. Because of this, the mean memory score for the two conditions will also likely differ from the observed data. This, in turn, implies that the difference in means will also be different.

7. Record the subjects' scores based on this possible randomization below. Record subjects assigned to the *E* condition under *Experimental* heading, and those assigned to the *C* condition under the *Control* heading.

Experimental	**Control**

8. Compute the means for the data from this random assignment for each condition and record them below.

9. Compute and record the **difference in means** for this random assignment of the data. Be sure that the order you use when subtracting is consistent with the order you subtracted to obtain the original observed result. (Note: You may obtain a negative number here.)

- Repeat the random assignment process four more times (five total). Each time, record the data, compute and record the mean score for each condition, and compute and record the difference between the means of the two groups. (Remember to subtract in the same order each time.)
- Record each of the five differences you obtained on the board.

Examining the Distribution of the Difference in Means

10. Enter all the groups' mean differences into TinkerPlots™. Create a plot of the difference in means. Sketch the plot of the difference in means below.

11. Does it look like it centers around zero? Explain why the distribution should be centered at zero. (Hint: Think back to what the null hypothesis was.)

12. Use TinkerPlots™ to compute the standard deviation of the differences in means. Record that value below.

13. Use the mean and standard deviation to provide a range of likely results.

14. Now include a vertical line at the difference in means for the original (observed) data. How compatible is the observed difference in means with the results produced by the model specified in the null hypothesis?

15. Based on your response to the previous question, is the “no effect” model supported by the observed data or not? What does this suggest about the answer the research question? Explain.

Overview of the Inferential Process for Comparing the Two Conditions in the Memorization Experiment

If there really were no effect of the grouping of letters, is it possible that random chance alone could have resulted in such an extreme observed difference between the two conditions? Once again, the answer is yes, this is indeed possible. Also once again, the key question is *how likely would it be for random chance alone to produce experimental data that favor the chunking condition by at least as much as the observational data do*. You will aim to answer that question using the following simulation analysis strategy:

- **Model:** Assume that there is no effect of the grouping of letters on the scores (the "no effect" model).

- **Simulate:** Replicate the random assignment of these subjects and their memory scores between the two conditions. You will repeat this random assignment a large number of times. Each time you will calculate a measure of how different the conditions are, in order to get a sense for what is expected and what is surprising.

- **Evaluate:** Using the observed result, evaluate how compatible the observed result is with the simulated results produced by the model specified in the null hypothesis.