Memorization Using TinkerPlots™

In this activity, you will learn how to use TinkerPlots™ to carry out the randomization test.

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.

- Enter the data collected in the study into a TinkerPlots™ case table.

Setting up the Case Table for the Randomization Test

- Drag a Table from the object toolbar into your document.
- Create a new attribute called *Score* in the first column of the case table.
- Create another new attribute called *Condition* in the second column of the case table.

Each row in the table will comprise a subject in the research study. Each column will comprise an attribute of the subject. For our purposes, you will need to enter data for two attributes. The first attribute will indicate the subject'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 will indicate the treatment condition that the subject was assigned to. This is called a **treatment variable**. In this research study the two treatment conditions are the **experimental condition** (chunking) and the **control condition** (no chunking).

- Enter the observed data from your class experiment into a TinkerPlots™ case table.
- Plot the observed data (see instructions on next page).

Plotting Data to Compare Groups

- Drag a Plot from the object toolbar into your document.
- Drag the response variable from the case table to the x-axis of the plot.
- Drag a case icon to the right until the cases in the plot are fully separated (e.g., no vertical bin lines). You can also double-click on one of the endpoints and change Bin width = 0.
- Drag the treatment variable from the case table to the y-axis of the plot.
- Click the Vertical Stack button in the upper plot toolbar to organize the icons.

1. Sketch the plot below that you just created in TinkerPlots™.

Model the Experimental Variation Due to RaNdom Assignment

In order to carry out a randomization test using TinkerPlots™, you need to include multiple sampling devices in the sampler. The first sampling device will include the observed response data for all of the subjects. The second device will contain the experimental conditions.

Modeling a Set of Fixed Responses Under the "No Effect" Model

Under the null hypothesis of no difference between the two experimental conditions, the response values for the subjects are **fixed**—they will always be the same for the subjects, regardless of which experimental condition the subject is assigned. To produce simulated data that are fixed, you can use a Mixer, but the values need to be *selected without replacement*.

- Set up a Mixer that will produce the fixed responses for the subjects under the "no effect" model (see instructions below).
- Run the model a couple times.

Setting Up the Model: Fixed Responses

- Drag a new Sampler from the object toolbar into your blank document.
- The default device in the sampler is a Mixer with three elements. Add elements to the mixer until you have the same number of elements as there are responses. (Each element represents a participant in the experiment.)
- Change the values of the elements so that they represent the response values (i.e., the number of correctly memorized letters).
- Change the mixer to sample values without replacement. Do this by clicking on the Device Options button for the stacks device (upside-down triangle) and selecting Replacement.
- Change the name of the device from *Attr1* to *Responses*.
- Change the Draw value to *1*. Change the Repeat value to reflect the total number of participants in the experiment.

2. Do you get different response values in the outcomes when you run the model? Use your answer to explain why we refer to these as **fixed** outcomes.

Modeling the Random Assignment of the Treatment Condition Labels by Linking Multiple Devices

3. Write a detailed explanation describing the process you used to physically re-randomized the notecards in the previous activity. Be specific enough in this description that another student could replicate what you did.

To model the random assignment of the treatment condition labels that might have occurred, you need to produce simulated data from another model that generates labels of *JFK* and *JFKC*. To do this you will use the Stacks sampling device. We also need to include this sampling device in the same Sampler as the outcomes. To do this, you *link* multiple sampling devices in the same sampler the same way you did in the *Cat Factory* course activity.

You need to replicate the original experiment and have the same number of *JFK* labels and *JFKC* labels as were in the original experiment.

- Link another sampling device that includes the **fixed group/condition labels** to the sampling device containing the outcomes. (See instructions on next page.)
- Run the model.

Linking a Sampling Device to Model the Random Assignment of Conditions

- Drag a Stacks sampling device from the device menu to the right-hand side of the existing *Responses* device. The sampler should now contain two devices linked by a grey line.
- Change the device name from *Attr2* to *Conditions*.
- Click the Add Element button (+) twice to add two elements to the stacks. These elements will indicate the condition/group labels.
- Change the label of the first bar from *a* to *JFK*. Change the label of the second bar from *b* to *JFKC*.
- Click on the Device Options button for the stacks device (upside-down triangle) and select Show Count.
- Change the count value for the *JFK* label to reflect the number of participants originally assigned to the *JFK* condition. Change the count value for the *JFKC* label to reflect the number of participants originally assigned to the *JFKC* condition.
- Change the device to sample values without replacement.

When you add linked devices, remember that the value for Draw changes automatically to the number of devices included in the sampler. A TinkerPlots™ sampler showing two linked devices modeling the random assignment of responses to conditions is shown below.

The outcomes from both linked devices are recorded in the case table, each in their own attribute. In addition, an attribute called Join is also created that includes the outcomes of both linked devices separated by a comma.

Each trial represents w*hat might have occurred* under another random assignment of subjects to conditions *if there was no difference between the conditions*.

- Plot the trial data to obtain the difference in means. (Remember the response attribute from the trial's case table is dragged to the x-axis of the plot and the condition is dragged to the y-axis of the plot.)

4. Sketch the plot below.

Simulate: Collect Results from Many Trials

As you have done in previous simulations, you will numerically summarize the trial results. We summarized the observed data by computing,

$$\bar{X}_{\text{JFK}} - \bar{X}_{\text{JFKC}}$$

5. Compute the value (by hand) for this difference. Be sure you are subtracting the *JFKC* mean from the *JFK* mean.

To use TinkerPlots™ to collect the difference in means, we need to collect both the *JFK* and the *JFKC* means. Fortunately, we can collect multiple summaries in TinkerPlots™.

- Use TinkerPlots™ to collect the mean score for the *JFK* condition.
- Similarly, collect the mean score for the *JFKC* condition.

Now you should have a case table of results that includes the *JFK* and the *JFKC* mean in the same row (but in different columns).

Computing the Difference in Means

To compute the difference in means we will use the Formula Editor. The Formula Editor allows us to compute new measures from existing information in a case table.

- Use the Formula Editor to compute the difference in the trial's means (see instructions below).
- Check that the difference in means is the same as the difference you computed in the previous question. (If the difference calculated by TinkerPlots™ is correct, but has a reversed sign, you need to re-open the Formula Editor and re-compute the mean difference.)

Computing the Difference in Means

- Create a third attribute (column) in the case table by clicking the column name, <new>. Rename this attribute *Difference*
- Select the *Difference* attribute to highlight it and then right-click the attribute and select Edit Formula.
- Select the *Attribute* triangle to display the names of the case table's attributes in the Formula Editor.
- Double-click the attribute for the *JFK* mean value. Then click the subtraction key (–) in the Formula Editor calculator. Finally, double-click the attribute for the *JFKC* mean value.
- Click the Apply button and then click OK.

Collect Many Results

- In the *History of Results* table, collect an additional 499 measures. (See instructions below for speeding up the simulation.)
- Plot the differences in means from the 500 simulated trials.

Speeding Up the Simulation

- Minimize all of the objects (sampler, results table, plot of the results) except for the collection window.
- Select the collection window and from the Objects menu select Inspect Collection.
- Uncheck the Animation On option.
- Close the inspector window.
- In the History of Results table, change the number of samples to collect to 499.
- Click the Collect button.

6. Sketch the plot of the results (i.e., mean differences) from the 500 simulated trials below.

7. What are the cases in the plot? (Hint: Ask yourself what each individual dot represents.)

8. Where is the plot of the results centered (at which value)? Explain why this makes sense. (Hint: Think about what the hypothesis for the "no effect" model is.)

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

10. Using the mean and standard deviation, provide a range of likely values under the model that assumes the difference in means is due completely to random chance.

11. 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?

12. 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.