# Chunk It!

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## Student Handout

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PART 1: Analyzing our Class Data

So, how good is your memory? Some students memorized more letters than others. Are they better at memorizing or is something else going on?

1. Compare the letters you were asked to memorize with those of others in class. What is different about the sequence of letters?

2. Which group would you expect to memorize more letters? Explain your answer.

3. Count the number of letters you correctly recalled. Starting on the left, count the letters that are exactly the same as the given sequence. As soon as a letter is incorrect, stop counting. For example, if you had the grouping CATF-BIU-SAN-FLLO … and you wrote down CATF-BUI-SAN-… , you would record a count of 5. Letters must be in order!

   Record your count in the class data sheet. When all students have entered their data, copy it to the table below.

| # Letters Correctly Recalled | CAT or CATF Group | # Letters Correctly Recalled | CAT or CATF Group | # Letters Correctly Recalled | CAT or CATF Group | # Letters Correctly Recalled | CAT or CATF Group |
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4. For each group (CAT or CATF) of data, create a dotplot. Your plots should be well-labeled, have the same scale, and be such that one is stacked above the other for easy comparison.

5. Describe the shape, center ($\bar{x}_{CAT}$ or $\bar{x}_{CATF}$) and variability of each dotplot.

6. We can also compare the two centers by computing the observed difference in the means:

$$\bar{x}_{CAT} - \bar{x}_{CATF} =$$

7. Consider your answers from the previous two questions. Does the data *suggest* that one grouping of letters is easier to memorize than the other? Explain your answer.

PART 2: Could this Have Happened by Chance?

**Does chunking (grouping letters to form recognizable chunks of letters) impact the number of letters people can correctly recall, or did we just get lucky with our sample?**

To answer this question, we will perform a *two-sample randomization test*. The purpose of this test is to determine whether the results that we obtained in #3 and #6 are really due to chunking or if they could have happened just by chance. If there really were no difference between groups, then we would expect the counts for the two groups to be the same and the mean difference to be 0. So, we start with this assumption. We will investigate the following question: Could the results we obtained have occurred just by chance?

To see whether the number of letters memorized was due to chance, we are going to randomly assign the number of letters memorized to either the CAT or CATF group. To do this, we mix up all the counts of letters memorized and randomly deal each to either the group CAT or CATF. Then we are going calculate a new mean difference. We will repeat this process many times, and then see how often this randomization produces a mean difference at least as extreme (farther from zero) as the one we observed in #6.

If we obtain many results as extreme (farther from zero) as we did in #6, then we will know that we could have obtained results like we did just by randomization alone, and chunking doesn't really aid memorization. That is, the results that we saw in #6 could have occurred just by chance alone. If we do not obtain many results as extreme (farther from zero) as we did in #6, then we know that it wasn't just by the random process alone that we were able to obtain a mean difference like we did; that is chunking really aids memorization.

To understand the process of randomization, each pair of students is going to perform three simulations by hand. Then we are going to pool our results and see how often we obtain results like we did in #6.

Before carrying out the simulation, read all directions!

To keep track of which group our data belonged to originally, we are going to use colored paper. All the data from the CAT grouping should be written on red slips of paper. All the data from the CATF grouping should be written on blue paper.

Simulation:

a. On the correct color (red or blue) of slip of paper, write the number of letters you memorized.
b. Repeat this process for every data point collected by the class (see #3).
c. Next, put all the slips of paper into a brown bag and shake it up.
d. Without looking, draw a slip of paper and assign it to pile A.
e. Draw a second slip and assign it to pile B.
f. Continue to alternate which pile receives a slip of paper until pile A has the same number of data points that our CAT group did. That is, Pile A is our random

assignment of people to the CAT chunking group (A = re-randomized CAT) and Pile B is our new CATF (B = re-randomized CATF).

g. Calculate the following statistics:

$\bar{x}_A = \bar{x}_{\text{re-randomized } CAT} =$ $\bar{x}_B = \bar{x}_{\text{re-randomized } CATF} =$

$\bar{x}_{\text{re-randomized } CAT} - \bar{x}_{\text{re-randomized } CATF} =$

8. Is this difference from your first randomization more extreme (farther from zero) than the observed mean difference given by the data (#6)?

9. Complete the randomization two more times and record your mean differences in the table below.

| | **Trial 1** | **Trial 2** | **Trial 3** |
|---|---|---|---|
| **Mean difference:** $\bar{x}_{\text{re-randomized } CAT} - \bar{x}_{\text{re-randomized } CATF}$ | | | |

You have just completed three simulations. If we repeated this simulation many times, how often would we obtain values as extreme (farther from zero) as that in #6?

Instead of each group doing more simulations, we are going to pool everyone's data. On each of the three sticky notes you have, write one mean difference from the table above.

Add your sticky notes to the class dotplot on the board.

**CHECKPOINT**

10. How many sample mean difference fall above our observed mean difference?

11. What proportion of the randomized mean differences fall above our observed mean difference from #6?

12. What conclusion would you draw from this simulation analysis regarding the question of whether there is sufficient evidence that chunking aids memorization?

Our class results are actually a small subset of all the possible randomizations. To really investigate whether chunking aids memorization, we should perform 1000 trials and record the mean difference for each trial. Thankfully, we can use technology to quickly perform 1000 trials.

As you use technology to simulate the randomization, **carefully read instructions** -- they are going to instruct you how to use the applet as well as explain what is happening at each step.

Open the Randomization Test applet at
http://www.rossmanchance.com/applets/randomization20/Randomization.html.
Open the **Stacked Format** region of the applet. Note the order in which data is entered: the numeric value (number of letters memorized) is listed first followed by the grouping (CAT or CATF). Also, note that all members of group 1 (CAT) are listed first.

We need to enter the data collected in #3; list all CAT counts and labels first! Doing so will ensure that the CAT data is denoted by a red dot on the dotplot and the CATF data is denoted by a blue dot. Note that this is the same order that you used in the tactile simulation with red and blue slips of paper and a paper bag.

Once you are finished, press "OK".

Note: If you ever want to return to the original data just click on the **Split** or **Stacked Format** buttons and then press OK.

13. Our next step is to mix up all the data and randomly reassign it to the CAT or CATF group. Check **Animate**, and press the **Re-Randomize** button. Notice that the applet combines all the counts of letters memorized into one pile, mixes them up, and then redistributes them, at random, to the two groups. The applet also computes the mean of each group as well as the mean difference for you.

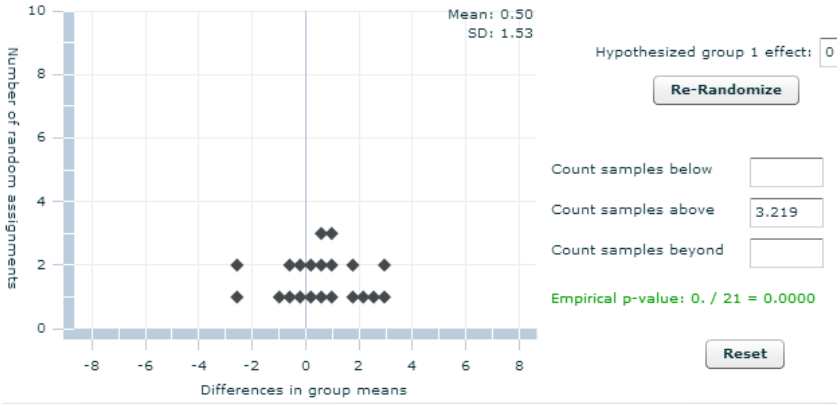
    What did you find for the difference in mean letters counted?

    $$\bar{x}_{\text{re-randomized } CAT} - \bar{x}_{\text{re-randomized } CATF} = \_\_\_\_\_$$

    Is this difference more extreme (farther from zero) than the observed mean difference in the data (from question #3)?

Now, we are going to quickly perform 20 trials. Change the **Number of repetitions** from 1 to 20. Select **Re-Randomize** again and observe how the dotplots of "could have been" data change. With each new "could have been" distribution (each new random assignment of counts to either

CAT or CATF), the applet calculates the difference in group means and adds a dot to the dotplot at the bottom of the screen. You should see something like the display below.




Next, we are going to quickly perform 1000 trials. Press the **Reset** button in the bottom right corner of the applet. Change the **Number of repetitions** from 1 to 1000. Uncheck the **Animate** box. Select **Re-Randomize** and wait a few seconds.

Just as we did in our tactile simulation, the computer can count the number of mean differences that are at least as extreme as our observed difference (from #6).

14. Now enter the observed difference in means (question 6) into the **Count samples above** box and select the **Count** button.
    a. How many sample means fall above our observed mean difference?

    b. What proportion of the observations fall above our observed mean?

15. Interpret your value of $p$ in terms of obtaining differences in the number of letters memorized as extreme as the data provide for each group.

16. What conclusion would you draw from this simulation analysis regarding the question of whether the number of letters memorized due to chunking is significantly less than that due to not chunking?