Changing Gears: Using Activities to Link Study Design, Data Analysis, and Inference

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Activity #1   Hiring discrimination: It just won't fly!
(from *The Practice of Statistics,* fifth edition, by Starnes, Tabor, Yates, and Moore)

An airline has just finished training 25 junior pilots—15 male and 10 female—to become captains. Unfortunately, only eight captain positions are available right now. Airline managers announce that they will use a lottery process to determine which pilots will fill the available positions. The names of all 25 pilots will be written on identical slips of paper, placed in a hat, mixed thoroughly, and drawn out one at a time until all eight captains have been identified.

A day later, managers announce the results of the lottery. Of the 8 captains chosen, 5 are female and only 3 are male. Some of the male pilots who were not selected suspect that the lottery was not carried out fairly. One of the pilots knows that you are taking a statistics class, and comes to you for advice. You offer to consult with your classmates and get back to him.

The key question in this possible discrimination case seems to be: **is it plausible (believable) that these results happened just by chance**? To find out, you and your classmates will simulate the lottery process that airline managers said they used.

1. Without looking, remove 8 beads/slips from the bag. Count the number of female pilots selected. Then return them to beads/slips to the bag.

2. Your teacher will draw and label axes for a class dotplot. Plot the number of females you obtained in Step 1 on the graph.

3. Repeat Steps 1 and 2 if needed to get a total of at least 40 simulated lottery results for your class.

4. Discuss the results with your classmates. Does it seem believable that airline managers carried out a fair lottery? What advice would you give the male pilot who contacted you?

5. Would your advice change if the lottery had chosen 6 female (and 2 male) pilots? Explain.

Activity #2   Distracted Driving
(from The Practice of Statistics, fourth edition, by Starnes, Yates, and Moore)

Is talking on a cell phone while driving more distracting than talking to a passenger? David Strayer and his colleagues at the University of Utah designed an experiment to help answer this question. They used 48 undergraduate students as subjects. The researchers randomly assigned half of the subjects to drive in a simulator while talking on a cell phone, and the other half to drive in the simulator while talking to a passenger. One response variable was whether the driver stopped at a rest area that was specified by researchers before the simulation started. The table below shows the results:

		Distraction	
		Cell phone	Passenger
Stopped at rest area?	Yes	12	21
	No	12	3

Are these results statistically significant? To find out, let's see what would happen just by chance if we randomly reassign the 48 people in this experiment to the two groups many times, *assuming the treatment received doesn't affect whether a driver missed the exit*.

1. We need 48 cards from the deck to represent the drivers in this study. In the original experiment, 33 drivers stopped at the rest area and 15 didn't. Since we're assuming that the treatment received won't change whether each driver misses the exit, we need 33 cards to represent drivers who stop at the rest area and 15 cards to represent those who don't. Remove the ace of spades and any three of the 2's from the deck.
   - Stop: All cards with denominations 2 through 10 (36 – 3 missing 2's = 33)
   - Don't stop: All jacks, queens, kings, and aces (16 – 1 missing ace = 15)

2. "Shuffle up and deal" two piles of 24 cards—the first pile represents the cell phone group and the second pile represents the passenger group. The shuffling follows our assumption that the outcome for each subject is not affected by the treatment. Record the number of drivers who failed to stop at the rest area in each group.

3. Repeat this process 4 more times so that you have a total of 5 trials. Record your results in a table like the one shown.

Trial	Number who didn't stop in cell phone group	Number who didn't stop in passenger group
1		
2		
3		
4		
5		

In how many of your 5 trials did 12 or more drivers in the cell phone group fail to stop?

4. Make a class dotplot of the number of drivers in the cell phone group who failed to stop at the rest area in each trial. In what percent of the class's simulation trials did 12 or more people in the cell phone group fail to stop at the rest area?

5. In the original experiment, 12 of the 24 drivers using cell phones didn't stop at the rest area. Based on the class's simulation results, how surprising would it be to get a result this large or larger simply due to the chance involved in the random assignment? Is the result statistically significant?

6. What conclusion would you draw about whether talking on a cell phone is more distracting than talking to a passenger?

This lesson is based upon data collected by researchers at the University of Utah (Strayer and Johnston, 2001). The researchers asked student volunteers (subjects) to use a machine that simulated driving situations. At irregular intervals, a target would flash red or green. Participants were instructed to press a "brake" button as soon as possible when they detected a red light. The machine would calculate the mean reaction time to the red flashing targets for each subject in milliseconds.

The subjects were given a warm-up period to familiarize themselves with the driving simulator. Then the researchers had each subject use the driving simulation machine while talking on a Cell Phone about politics to someone in another room and then again with music or a book-on-tape playing in the background (Control). The subjects were randomly assigned as to whether they used the Cell Phone or the Control setting for the first trial.

The following data are for 16 subjects from the experiment. Calculate the change in the reaction time for each subject (defined as Cell Phone reaction time minus Control reaction time):

Subject	Cell Phone Reaction Time	Control Reaction Time	Difference (Cell Phone – Control)
A	636	604	
B	623	556	
C	615	540	
D	672	522	
E	601	459	
F	600	544	
G	542	513	
H	554	470	
I	543	556	
J	520	531	
K	609	599	
L	559	537	
M	595	619	
N	565	536	
O	573	554	
P	554	467	

A boxplot that displays the change in reaction time (defined as the Cell Phone time minus the Control time) is displayed in the Figure below.

Difference in Reaction Time (Cell Phone minus Control)

Milliseconds
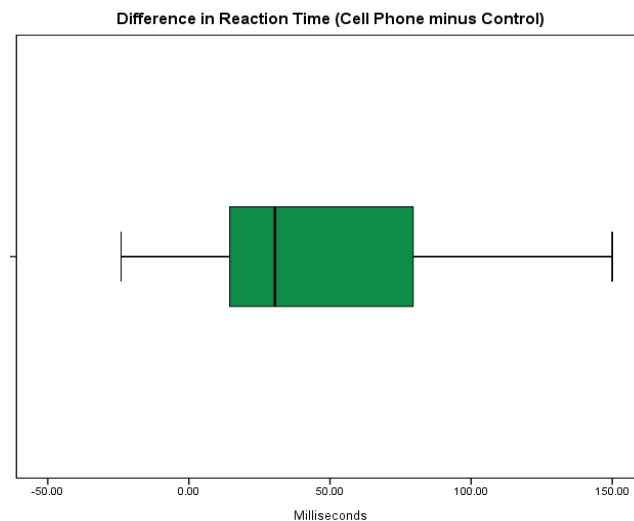
Simulation approach

From these data, it is possible to test the hypothesis that Cell Phone use does not increase reaction time, on the average. If the null model is true (and the reaction time is the same for the Cell Phone group and the Control group), then it really should not matter if a subject is talking on the Cell Phone or not in regards to reaction time. This can be investigated by using a *randomization test*. **Under the null model, the strategy is to assume that the subject would have obtained the same two reaction times, but the two times were just as likely to be (Cell Phone, Control) or (Control, Cell Phone).** This can be simulated in the classroom by tossing a coin for each subject, with Heads, for example, meaning that the reaction times remain as they really were; and Tails indicating that the reaction times should be swapped. In the matched pairs design, the randomization occurs within each pair – either using the Cell Phone or Control. To assess whether the observed difference in reaction time could be due to chance alone and not due to treatment difference, re-randomization must occur within the pairs. This implies that re-randomization is merely a matter of randomly assigning a plus or minus sign to the numerical values of the observed differences.

In order to perform a simulation:

1. Use the original difference data to calculate the mean difference in reaction time (Cell Phone minus Control).
2. Flip a coin. If the coin lands "Heads" then the reaction times are to stay exactly as they were originally. If the coin lands "Tails" then the original reaction times should be swapped within the pair. For example, for subject A, if the coin lands "Heads," then the Cell Phone reaction time remains 636 milliseconds and the Control reaction time remains 604 milliseconds. If the coin lands "Tails," then the Cell Phone reaction time becomes 604 and the Control reaction time becomes 636. Repeat for each subject. Then calculate the difference for each subject (once again taking the Cell Phone time minus the Control Time). Calculate the new mean of the differences and write your result onto the board.

Subject	Cell Phone Reaction Time	Control Reaction Time	Re-Randomized Cell Phone Reaction Time	Re-Randomized Control Reaction Time	Re-Randomized Difference (Cell Phone – Control)
A	636	604			
B	623	556			
C	615	540			
D	672	522			
E	601	459			
F	600	544			
G	542	513			
H	554	470			
I	543	556			
J	520	531			
K	609	599			
L	559	537			
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3. Construct a dot plot of the re-randomized results from the class. How many times was the simulated value of the difference larger than the actual experimental result of 47.1 milliseconds?

4. Use the Matched Pairs applet at www.rossmanchance.com to perform a simulation. What conclusion do you draw?