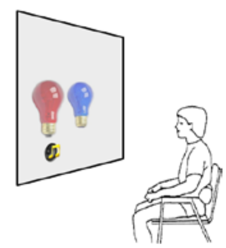
STAT 110
Fall 2017

Activity: Evaluating a Claim of Hearing Loss

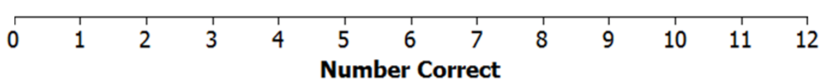
Consider the case study presented in an article by Pankratz, Fausti, and Peed titled "A Forced-Choice Technique to Evaluate Deafness in the Hysterical or Malingering Patient." *Source: Journal of Consulting and Clinical Psychology, 1975, Vol. 43, pg. 421-422.* The following is an excerpt from the article:

> *The patient was a 27-year-old male with a history of multiple hospitalizations for idiopathic convulsive disorder, functional disabilities, accidents, and personality problems. His hospital records indicated that he was manipulative, exaggerated his symptoms to his advantage, and that he was a generally disruptive patient. He made repeated attempts to obtain compensation for his disabilities. During his present hospitalization he complained of bilateral hearing loss, left-sided weakness, left-sided numbness, intermittent speech difficulty, and memory deficit. There were few consistent or objective findings for these complaints. All of his symptoms disappeared quickly with the exception of the alleged hearing loss.*

To assess his alleged hearing loss, testing was conducted through earphones with the subject seated in a sound-treated audiologic testing chamber. Visual stimuli utilized during the investigation were produced by a red and a blue light bulb, which were mounted behind a one-way mirror so that the subject could see the bulbs only when they were illuminated by the examiner. The subject was presented several trials on each of which the red and then the blue light were turned on consecutively for 2 seconds each. On each trial, a 1,000-Hz tone was randomly paired with the illumination of either the blue or red light bulb, and the subject was instructed to indicate with which light bulb the tone was paired.



Suppose that the subject was asked to do this a total of 12 times. The possible outcomes for the number of correct answers the subject gives overall will range from 0 to 12.



Questions:

1. What is the expected number of correct answers if the subject actually suffers from hearing loss and is therefore guessing on each trial?

2. Are there other values for the number of correct answers you would anticipate possibly observing if the subject is guessing on each trial? What are these values?

3. What values would you anticipate observing if the subject were intentionally giving the wrong answer to make it look as though he couldn't hear?

Statistics can be used to determine whether or not there is evidence a subject is intentionally giving the wrong answers. To investigate this situation, we can *simulate* the possible outcomes that a hearing impaired person would give for 12 trials of this experiment. For each replication of this experiment, we will keep track of how many times the subject was **correct**. Once we've repeated this process several times, we'll have a pretty good sense for what outcomes would be very surprising, or somewhat surprising, or not so surprising if the subject is truly hearing impaired.

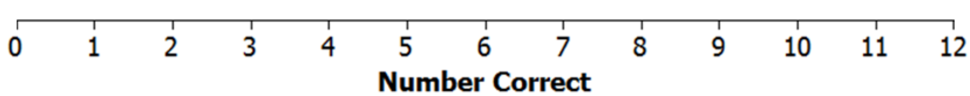
Questions:

4. Carry out 12 trials that simulate the responses of a hearing impaired individual and record your results below.

Trial	Choice		Correct?	
1	Red	Blue	Yes	No
2	Red	Blue	Yes	No
3	Red	Blue	Yes	No
4	Red	Blue	Yes	No
5	Red	Blue	Yes	No
6	Red	Blue	Yes	No
7	Red	Blue	Yes	No
8	Red	Blue	Yes	No
9	Red	Blue	Yes	No
10	Red	Blue	Yes	No
11	Red	Blue	Yes	No
12	Red	Blue	Yes	No

How many correct answers did you have? ________________

Collect the simulation results from everybody in the class. Make a dot for your outcome and that of all others in your class on the following number line.



Questions:

5. Given the simulation results on the above dotplot, what would you think about the subject's claim that he suffered hearing loss if he answered ...

   a. 5 correctly?

   b. 0 or 1 correctly?

   c. 2 or 3 correctly?

6. In your opinion, on how many of the 12 trials would a suspect have to answer correctly in order for you to believe they were intentionally giving the wrong answers?

7. Ask some of your neighbors at what point they would believe the suspect was intentionally giving the wrong answers.

Neighbor 1: ___________ Neighbor 2: _____________

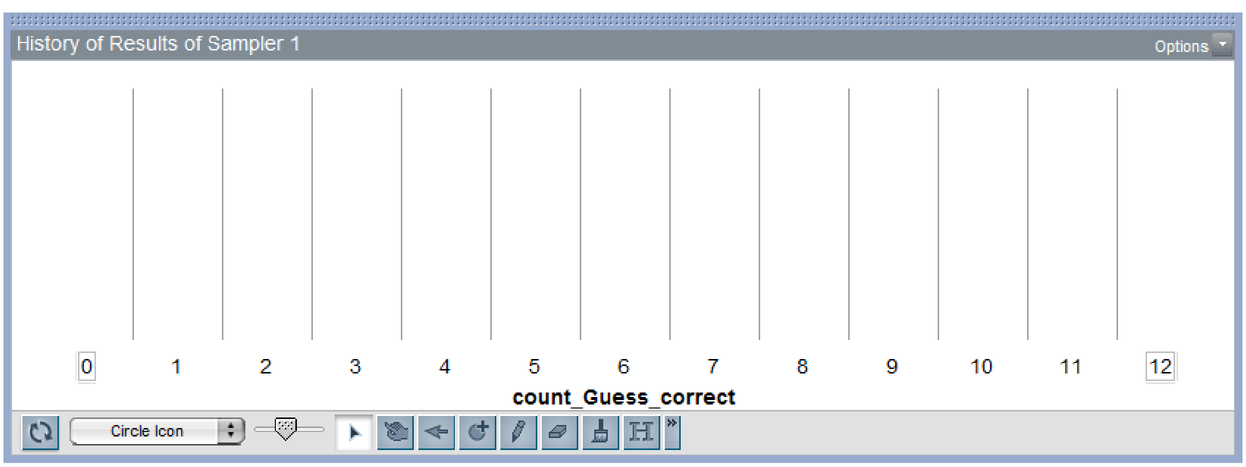
Neighbor 3: ___________ Neighbor 4: _____________

8. What potential issues arise when different people use different values for the point at which they start to believe the suspect is intentionally giving the wrong answers?

<u>Obtaining More Simulated Results</u>

Because guessing on each trial is a random process, we know that we won't observe the same number of correct answers with every simulation of 12 trials of this experiment. However, the *distribution* of the number of correct answers obtained in 12 trials does follow a predictable pattern. This pattern started to emerge in the above dotplot of the class's results; however, to get a more accurate sense of this pattern we should simulate the process of guessing on 12 trials over and over again, say 1,000 times. To do this efficiently, we will use a software package called Tinkerplots 2 ®.

Roughly sketch the final plot obtained below (include the counts for each outcome):



Questions:

9. What does each dot on the above plot represent?

10. Suppose the subject answered 4 out of 12 trials correctly. Would you think they were probably just guessing, even though they had fewer than the expected number of correct answers? Why or why not?

11. Suppose a subject answered only 1 out of 12 trials correctly. Would you think they were just guessing, or would you think they were answering incorrectly on purpose? Explain your reasoning.

12. What about 2, 3, or 4 correct answers, etc.? At what point would you start to think they were intentionally giving the wrong answers? You should be using the simulation results obtained from Tinkerplots to help you answer this question.

13. You gave your personal opinion of this cutoff point earlier in question 7. This was based on only a few simulated results. Has your cutoff changed now that you have seen the result of 1,000 simulations of guessing on 12 trials?

14. Ask some of your neighbors at what point they would now start to believe the suspect was intentionally giving the wrong answers.

    Neighbor 1: ___________ Neighbor 2: _____________

    Neighbor 3: ___________ Neighbor 4: _____________

    Keep in mind that potential issues arise when different people use different values for the point at which they start to believe the suspect is intentionally giving the wrong answers! So, in the next week or so, we will discuss the decision rule commonly used by statisticians.

Using Tinkerplots to Conduct a Simulation Study

Consider the previous example investigating the claim of a hearing loss. Note that in the actual study, the subject was presented with 100 trials (not 12).

Questions:

1. If he truly has suffered hearing loss, he is essentially guessing on each trial. If this is the case, in how many trials would you expect the suspect to correctly identify with which stimulus the tone was paired?

2. Suppose the subject correctly identifies with which stimulus the tone was paired in only 45 out of 100 trials. A researcher argues that since this was less than the expected number of correct matches, the subject must be intentionally answering incorrectly in order to convince them he can't hear. What is wrong with their reasoning?

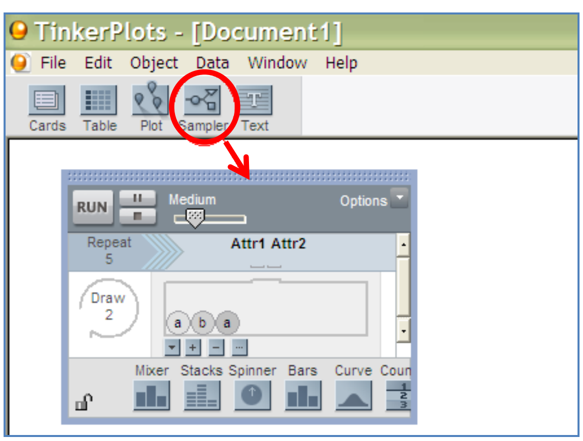
3. Suppose the subject correctly identifies with which stimulus the tone was paired in none of 100 trials. A researcher believes this result provides evidence that the subject is intentionally answering incorrectly in order to convince them he can't hear. Do you agree?

Once again, the key question is how to determine whether the subject's result on the 100 trials is surprising under the assumption that he truly has hearing loss and is simply guessing on each trial. To answer this, we will *simulate* the process of guessing on 100 trials of this experiment, over and over again. Each time we simulate the process, we'll keep track of how many times the subject was **correct** (note that you could also keep track of the number of times he was incorrect). Once we've repeated this process a large number of times, we'll have a pretty good sense for what outcomes would be very surprising, or somewhat surprising, or not so surprising if the subject is really guessing.

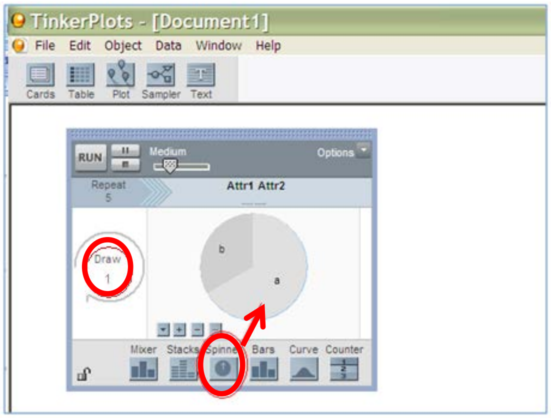
We will use Tinkerplots to help us carry out the simulation study:

Setting up the Simulation

- Open Tinkerkplots 2® on your computer. Drag a new **Sampler** from the tool shelf into your blank document, as shown below.

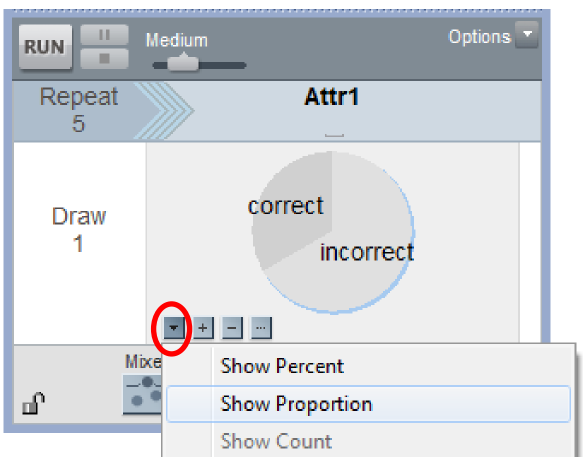


- Click on the **Spinner** icon below the Mixer and drag it over the Mixer. To consider answering for only one trial at a time, change **Draw** to 1.



- Now, there should be two outcomes on your spinner, *a* and *b*. Highlight these and change their names to *Correct* and *Incorrect*.

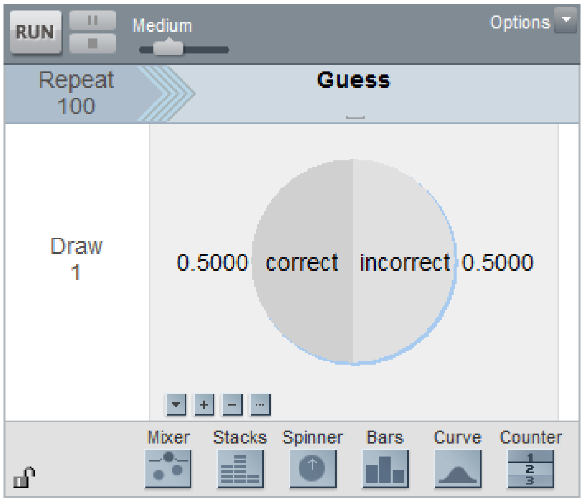
- Click on the drop-down arrow below the Mixer and select either **Show Percent** or **Show Proportion**.



- Because we are assuming the subject is guessing and has a 50% chance of guessing correctly, we need to change the proportions so that each is 0.50 (or chance the percentage to 50). This can be done by either dragging the dividing line in the **Spinner**, or by highlighting the proportions (i.e., percentages) shown on the spinner and changing them to the desired value. *Note: you may have to resize the window containing the mixer so that is larger in order to view the proportions.*

- In the upper left-hand corner, change the **Repeat** value to 100 to simulate guessing on 100 trials of the red/blue light bulb experiment.

- Finally change the Spinner label from *Attr1* to *Guess*. We're ready to run the simulation! Your window should look like this:

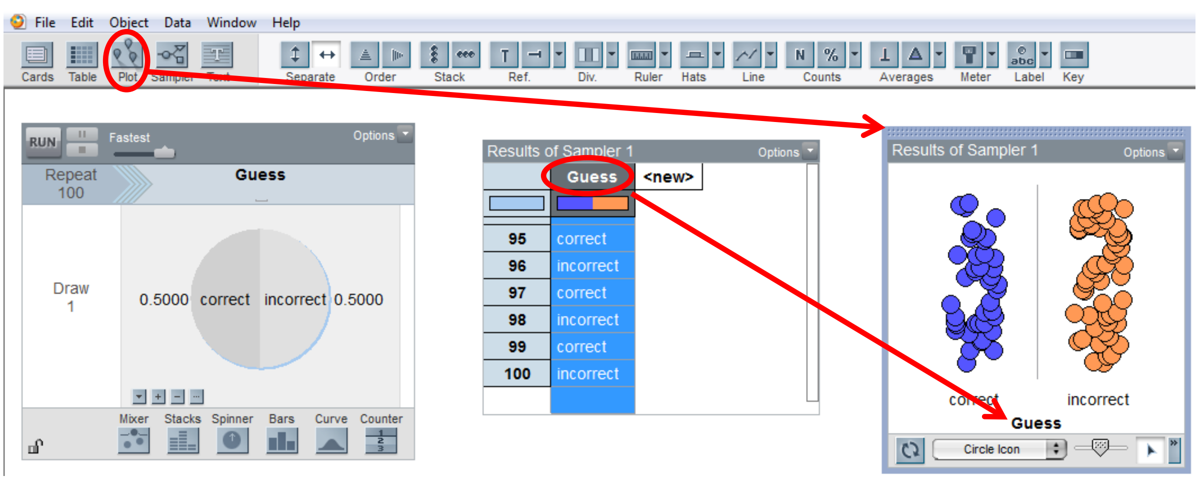


Running the Simulation

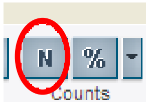
- Click the **Run** button in the upper-left corner. A *case table* of the outcomes for 100 trials should have been produced.

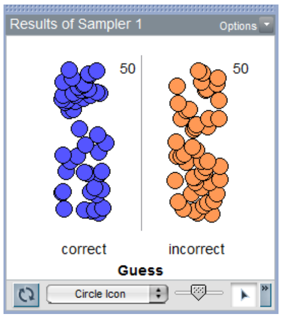
- Next, let's use Tinkerplots 2® to plot the 100 outcomes from your first run of the simulation. By plotting the results, we can more easily count the number of *Correct* answers in each run. Note that the attribute called *Guess* in the case table has the 100 outcomes from your first run.

- Drag a new **Plot** from the tool shelf into your blank document. Then, click on the column header *Guess* in the case table and drag it to the x-axis of your plot. You should now have a plot with the 100 outcomes obtained in the first run of the simulation color coded by whether each was *Correct* or *Incorrect*, as shown below.



Click on the **Case Count** tool in the tool shelf (**N**) to count the number of *Correct* and *Incorrect* in your plot of the outcomes. How many correct answers did you get in the first run of the simulation?

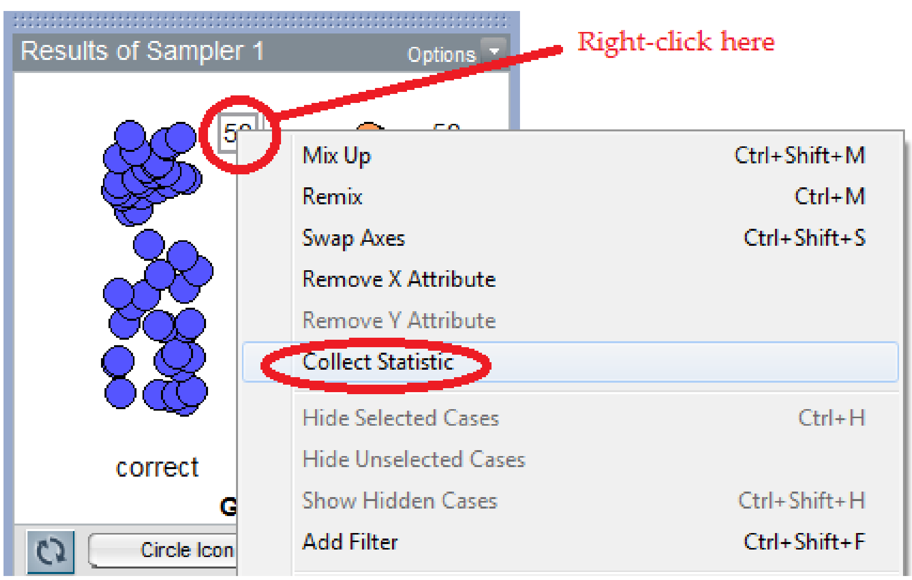




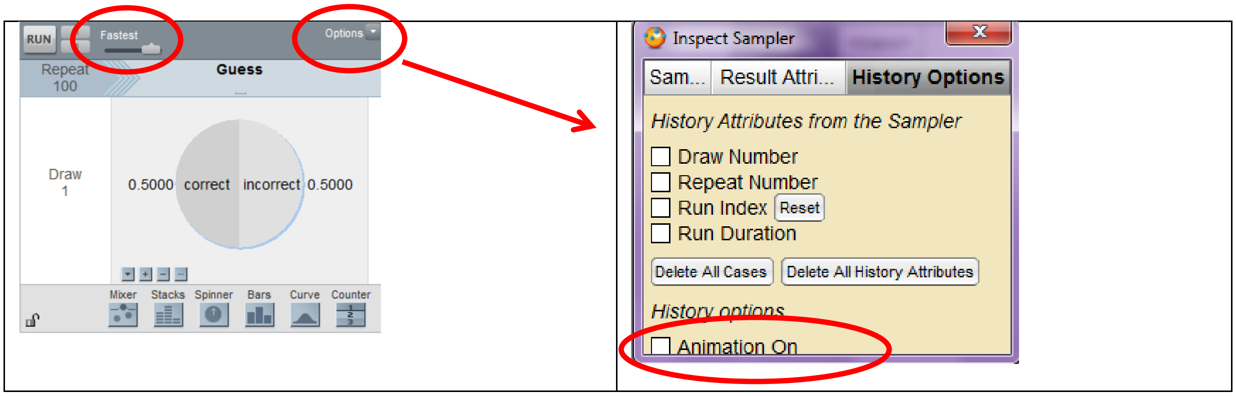
Collecting the Results from Many Runs of the Simulation

Next, we will carry out the simulated experiment many more times and use Tinkerplots 2® to collect the number of *Correct* answers obtained each time.

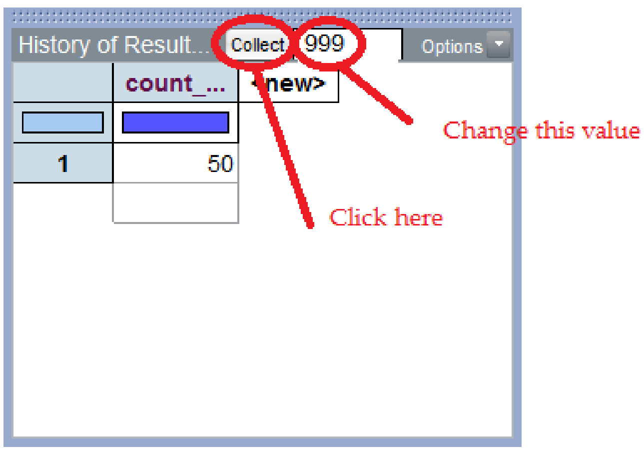
- Place your cursor over the number of *Correct* answers in your plot of the outcomes from the first run, right-click, and select **Collect Statistic**.



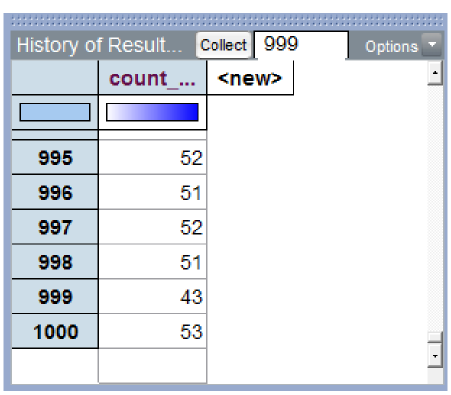
- Next, we will run the simulation 999 more times and collect the number of *Correct* answers each time. ***Before doing this, you will want to use the slider bar above the spinner to change the speed from Medium to <u>Fastest</u>!*** Also, click on the *Options* menu in the upper right-hand corner. Choose **History Options** and turn off the animation by un-checking the box next to the "Animation On."



Then, change the value in the collection window from 1 to 999 and click on the **Collect** button. This will add 999 more simulated results to the result that you initially stored in your collection, so that you will have the results of 1,000 simulated experiments.



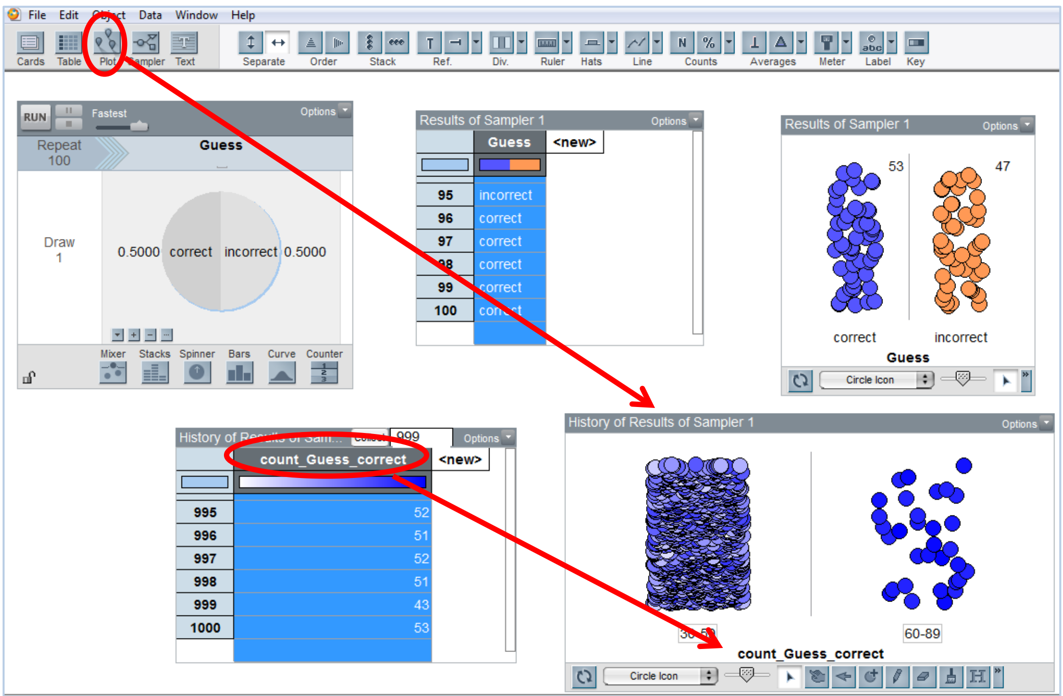
- Each of the 1,000 results is stored on a card in the collection. You can examine the result from any individual run by scrolling up or down in the window shown below. For example, in <u>your</u> 1,000th simulated experiment, how many of the 100 guesses were *Correct*?



Plotting the Results from Many Runs

Although we can see the individual results in the table shown above, this is not a good way to organize or use the results. A better way to organize these results is to plot them. Plot the results from your 1,000 runs of the simulation as shown below.

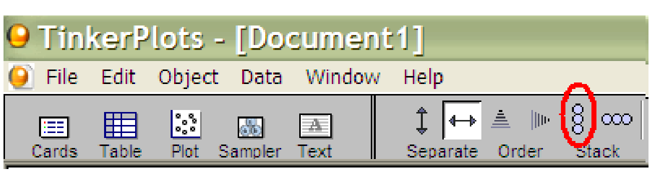
- Drag another new plot from the tool shelf to the workspace. Then, click on the attribute from your collection in which the trial results are stored (**count_Guess_correct**) and drag it to the x-axis of the plot.



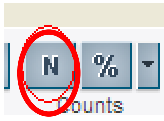
- All 1,000 results are now displayed in your plot, but in an unorganized manner. Grab one of the circle icons towards the left side of the plot and drag it all the way to the right. This will help organize the counts. You may want to resize the window so it is larger.

- Double-click on either one of the endpoints on the axis labels (they are outlined with a box) and change the value for **Bin Width** to **1** and click **OK**.

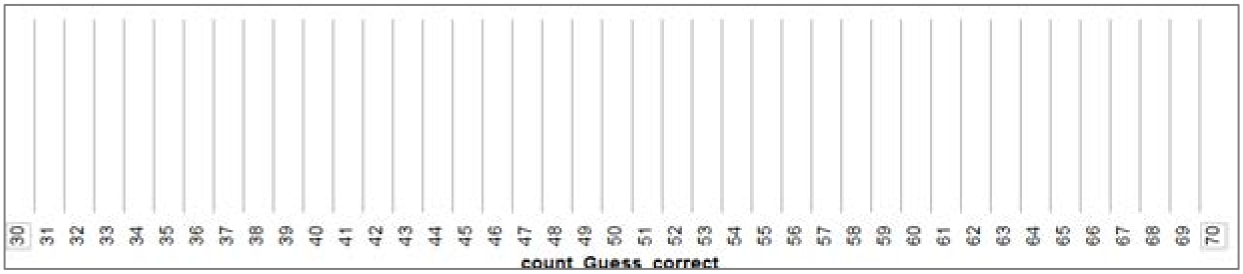
- Although the data are now more organized along the horizontal axis, the heights of the data points are still arbitrary. You can change this by clicking the vertical **Stack** tool in the tool shelf.



- Click on the **Case Count** tool in the toolshelf (**N**) to count how often each of the possible outcomes for number of tails occurred.



Roughly sketch the final plot you obtain below (include the counts for each outcome):



<u>Questions</u>:

4. What does each dot on this plot represent?

5. Suppose a subject was correct on 43 out of 100 trials. Would you believe they were probably just guessing, even though they had fewer than the expected number of correct answers? Why or why not?

6. The actual subject was correct on 36 out of 100 trials. Based on this statistical investigation, do you believe he was just guessing, or do these results indicate that he may have been answering incorrectly on purpose in order to mislead the researchers into thinking he was deaf? Explain your reasoning, and use the dotplot of the simulation results to defend your answer.

A Forensic Investigation

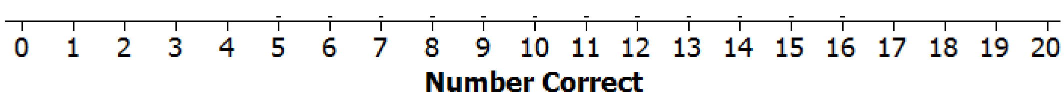
A suspected serial-rape murderer, an ex-con with a history of sex crimes, was interrogated by police after he was overheard bragging to others that he raped, killed, and buried a young woman victim in an isolated valley outside of the city in which he resided. He told police that he had never met the victim and that he had never been to the valley. A series of binary (yes/no) questions embedded within the interrogation was designed to test his knowledge of victim characteristics that only the perpetrator would know.

Source: Harold V. Hall and Jane Thompson. "Explicit Alternative Testing: Applications of the Binominal Probability Distribution to Clinical-Forensic Evaluations." The Forensic Examiner, Spring 2007.

Questions:

1. Suppose the suspect had no knowledge of the victim and thus was merely guessing the answers to the 20 questions. How many questions would you expect the suspect to answer correctly?

2. At what point would you start to believe the suspect was intentionally giving incorrect answers in order to make the investigators believe they had no knowledge of the crime?

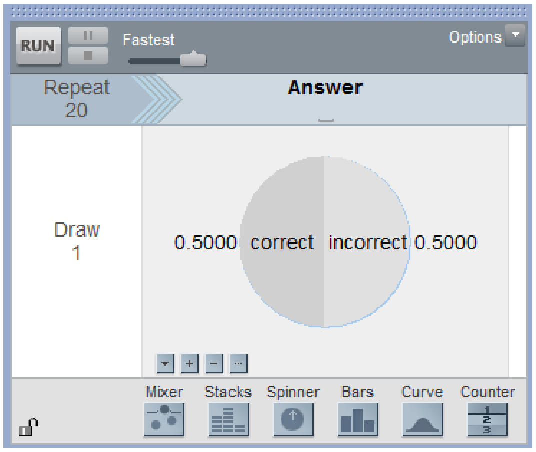


Note that even if the observed number of correct answers is less than would be expected, this is not necessarily enough statistical evidence to support the suspect's guilt.

A key question is how to determine whether the suspect's result is surprising under the assumption that he was merely guessing the answers to 20 questions asked about the victim.

To answer this, we will use Tinkerplots 2® to *simulate* the process of answering 20 questions by merely guessing with 50% chance of answering correctly, over and over again. Each time we simulate the process, we'll keep track of how many questions a suspect who was simply guessing got right. Once we've repeated this process a large number of times, we'll have a pretty good sense for what outcomes would be very surprising, or somewhat surprising, or not so surprising if the suspect was simply guessing answers to the questions about the victim.

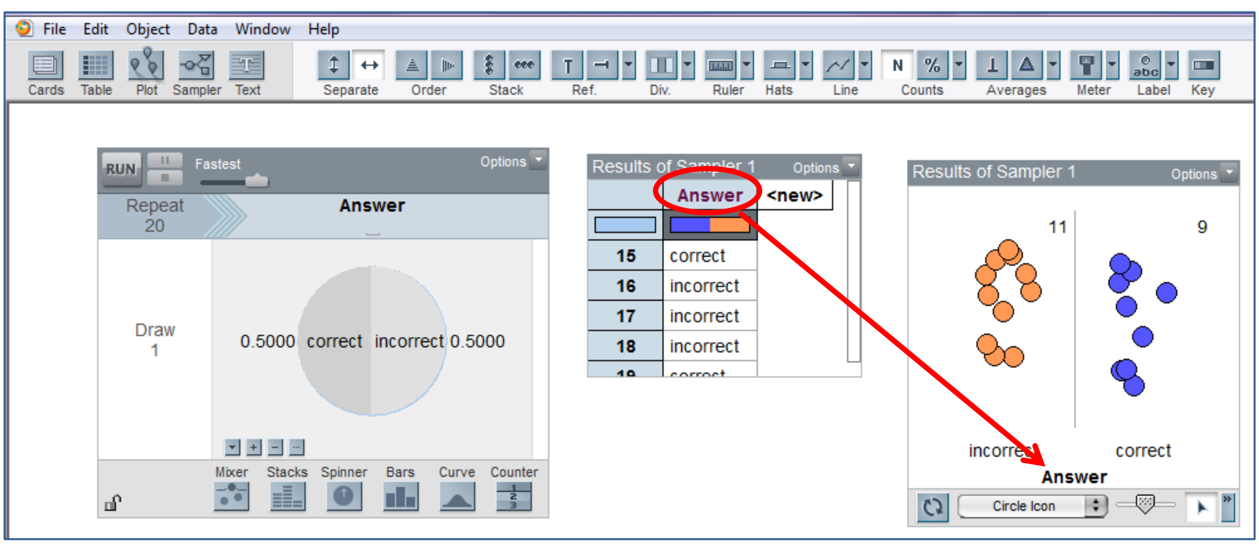
Setting up the simulation:



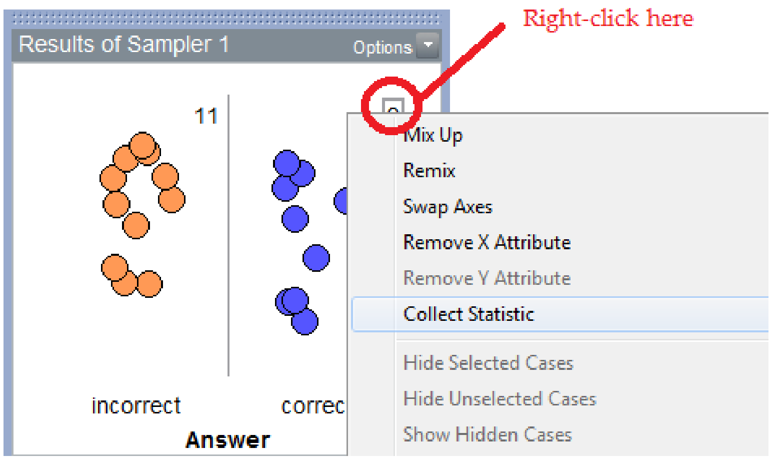
- Why do we set the probability of being correct to .5?

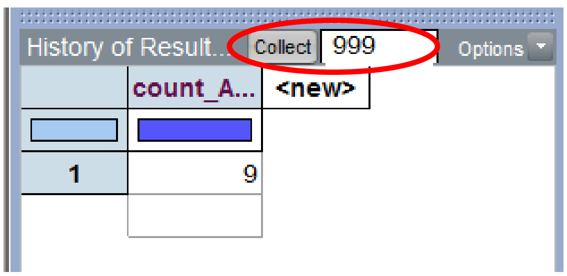
- Why is the repeat value set to 20?

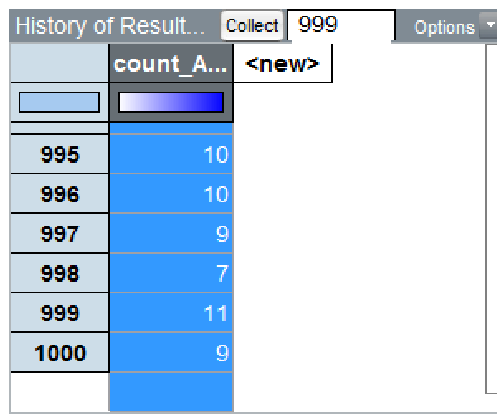
Carrying out the first run of the simulation:



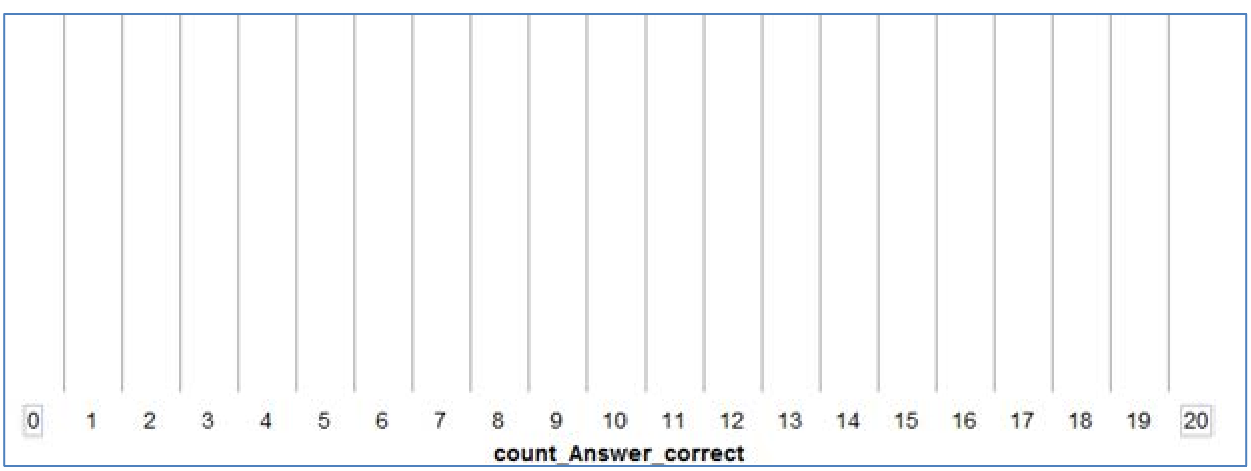
Collecting the results from many runs of the simulation:







Plotting the results from the 1,000 runs:



Questions:

3. Of the 20 questions regarding victim characteristics, clothing, and information obtained from family and friends who last saw her, the actual suspect answered 3 questions correctly. Do you think this result provides statistical evidence that the suspect was guilty of the crime? Why or why not?

Another Criminal Investigation

During the early portion of the Iraq War, a lieutenant was suspected of reading and then stealing war plans with which he was entrusted to transport between headquarters. The division's lead intelligence officer who had read these plans helped devise 20 true-false questions that only someone who had read the plans would be able to answer with confidence.

Questions:

1. Explain why the same plot of the simulation results used in the previous example is useful for helping us decide whether we have evidence this suspect is answering the questions incorrectly on purpose.

2. Suppose that the suspect answered 8 out of 20 questions correctly. Would you believe he had knowledge of the war plans and was trying to hide it? Use the above plot of the simulation results to defend your answer.