# Stimulating Simulations (Throughout AP Statistics)

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Simulation 1 – Smelling Parkinson's Disease (Test for a Count/Proportion)

Simulation 2 – Show Me The Money (Random Sampling)

Copies of this or handout can be found at MrTysonStats.com or tinyurl.com/TysonAPAC2019

# SMELLING PARKINSON'S DISEASE

## INTRODUCTION

As reported by the Washington Post (http://tinyurl.com/SmellPark), Joy Milne of Perth, UK, smelled a "subtle musky odor" on her husband Les that she had never smelled before. At first, Joy thought maybe it was just from the sweat after long hours of work. But when Les was diagnosed with Parkinson's 6 years later, Joy suspected the odor might be a result of the disease.

Scientists were intrigued by Joy's claim and designed an experiment to test her ability to "smell Parkinson's." Joy was presented with 12 different shirts, each worn by a different person, some of whom had Parkinson's and some of whom did not. The shirts were given to Joy in a random order and she had to decide whether each shirt was worn by a Parkinson's patient or not.

1. Why would it be important to know that someone can smell Parkinson's disease?

2. How many correct decisions (out of 12) would you expect Joy make if she couldn't really smell Parkinson's and was just guessing?

3. How many correct decisions (out of 12) would it take to *convince* you that Joy really could smell Parkinson's?

## SIMULATING THE EXPERIMENT

Although the researchers wanted to believe Joy, there was a chance that she may not really be able to tell Parkinson's by smell. It's logical to be skeptical of claims that are very different than our experiences. If Joy couldn't really distinguish Parkinson's by smell, then she would just have been guessing which shirt was which. The researchers were not willing to commit time and resources to a larger investigation unless they could be convinced to that Joy's wasn't just guessing. When researchers have a claim that they suspect (or hope) to find evidence against, it's called the **null hypothesis**.

4. What claim were the researchers hoping to find evidence *against*? That is, what was their prior belief (**null hypothesis**) about the ability to smell Parkinson's?

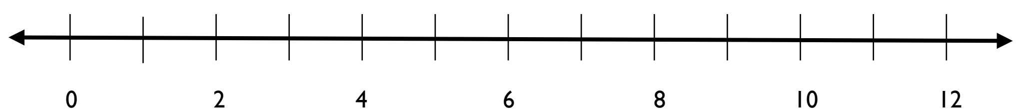
5. What claim were the researchers hoping to find evidence *for*? This is called the **alternative hypothesis** or the **research hypothesis**.

To investigate the idea that Joy was just guessing which shirt was worn by which type of person, we will assume that the null hypothesis is true.

6. Your instructor will hand you 12 cards (shirts) that have been shuffled into a random order. Don't turn them over yet! On the back of some of them is "Parkinson's" and on the back of others is "No Parkinson's." For each card, guess Parkinson's or No Parkinson's. Once you have made your guess, turn the card over and see if you were correct. Repeat this for each card and record the number of correct identifications (out of 12) below.

| Tally of correct identifications | Number of correct identifications | Proportion of correct identifications |
|---|---|---|
| | | |

7. Create a dotplot of the number of correct identifications with the rest of the class. Record the results below.




8. In the actual experiment, Joy identified 11 of the 12 shirts correctly. Based on the very small-scale simulation by you and your classmates, what proportion of the simulations resulted in 11 or more shirts correctly identified, assuming that the person was guessing?

9. The proportion you just calculated is a crude estimate of a true probability called a ***P*-value**. How might we improve our estimate of the true probability?

## STATISTICAL INFERENCE FROM THE SIMULATION

10. Use the SPA Applet for One Categorical Variable at stapplet.com/SPA to run this simulation 10000 times. Then use that simulation to get a (likely) better estimate of the $p$-value for 11 or more shirts correctly identified, assuming that this person was just guessing. Is it *possible* that Joy correctly identified 11 shirts just by random chance (guessing)? Is it *likely*?

11. An interesting side note is that Joy's one "mistake" really wasn't a mistake. The shirt was worn by a person who supposedly didn't have Parkinson's even though Joy claimed that she could smell the telltale smell on that shirt. That person called the experimenters a little while after the experiment and reported that he had just been diagnosed with Parkinson's disease. That meant that Joy correctly identified 12 out of 12 shirts. What is the approximate $P$-value for 12 shirts correctly identified, assuming that this person was just guessing?

*Note:* A small $P$-value is considered strong evidence against the null hypothesis and in favor of the alternative hypothesis. But how small is small? As a rule of thumb, statisticians generally agree that $P$-values below 0.05 provide pretty strong evidence against the null hypothesis. Observed results with small $P$-values are said to be **statistically significant**.

## DEEPER MATHEMATICAL CONNECTIONS

12. The true theoretical probability to get $k$ successes in $n$ trials when there is a true probability $p$ of a success on each trial is given by the **binomial probability formula**: $\binom{n}{k} p^k (1-p)^{n-k}$. Compute the exact theoretical probability to get 11 or more successes in 12 trials when the true probability of success is 0.5. (*Hint*: calculate the probability for 11 successes and then do another calculation for 12 successes and then add these probabilities together.)

# SHOW ME THE MONEY

## INTRODUCTION

1. Name your favorite movie of all time.

2. Guess the average box office gross income in theaters for movies in 2018 (US theaters only).

3. Guess the title of the top-grossing movie of 2018.

4. Guess the maximum gross income (US box office sales) by a movie in 2018.

## CHOOSE YOUR SAMPLE

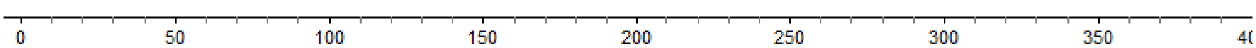
5. Look at the list of the 200 top-grossing movies of 2018 and select a **sample** of 10 that you saw (or wanted to see) in theaters. For purposes of this activity, we will consider these 200 movies as a small **population**. Record the gross box office gross income for each movie.

6. Compute and record the **sample mean** box office gross income, $\bar{x}$.

   $\bar{x} =$

7. Is your sample mean the same as the other sample means of the other students in your class?

8. The fact that different samples yield different statistics (in this case different sample means) is called **sampling variability**. As a class, create a dotplot of sample means on the board. Record this dotplot on the number line below, carefully labeling the axis.




9. Based on the previous dotplot, without any calculations, what do you suppose the **population mean** box office gross income, μ?

   μ =

The method you used to choose a sample from the population is based on your experience and interest in movies. Instead of using human experience, judgment, or interest to choose a sample, statisticians use chance to select a sample from a large population. A sample selected by a chance process is called a **random sample**.

## Random Sampling

10. Your instructor will give you instructions on how to use random chance to select 10 movies from the population of 200 movies. You will draw chips from a container, use a table of random digits, or use technology to generate 10 random numbers from 1-200. Find the corresponding ID numbers in the table and record the gross box office for each of these movies.

11. Compute and record the **sample mean** box office gross income, $\bar{x}$.

    $\bar{x} =$

12. As a class, create a dotplot of sample means on the board. Record this dotplot on the number line below, carefully labeling the axis.


13. Based on the previous dotplot, without any calculations, what do you suppose the **population mean** box office gross income, $\mu$?

    $\mu =$

14. Is your guess for the mean gross income from a random sample noticeably different from or about the same as your guess when you chose your own sample? If so, why do you think they are different? If not, why do you think they are about the same?

## Big Ideas

15. The population mean gross income for all 200 movies is $\mu$ = $57.13 million. Go back to your dotplots and draw a vertical line at 57.13. Did the sample means ($\bar{x}$) do a good job of estimating the population mean for both types of sampling? What have you learned about the use of random sampling?