

BE THE BABE WITH THE POWER\*

**\*Not the power of Voodoo**

# EVERYTHING YOU LOOK AT IS A MODEL

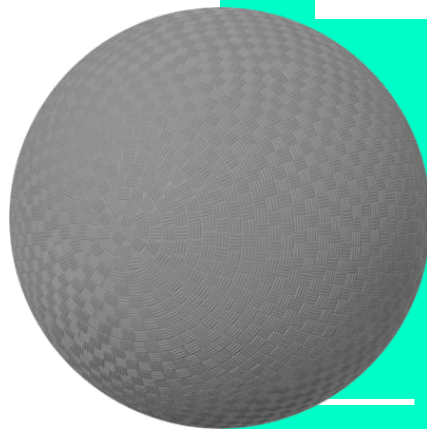


HYPOTHESIS TESTING

(WHAT ARE YOU MODELING?)

THE BALL IS RED

THE BALL IS NOT RED



# SOMETIMES, YOU NEED TO TEST MANY HYPOTHESES

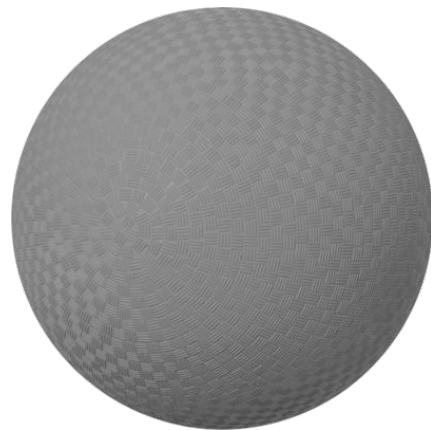
The ball is red

The ball is blue

The ball is green

The ball is purple

The ball is yellow



PICKING A TESTING

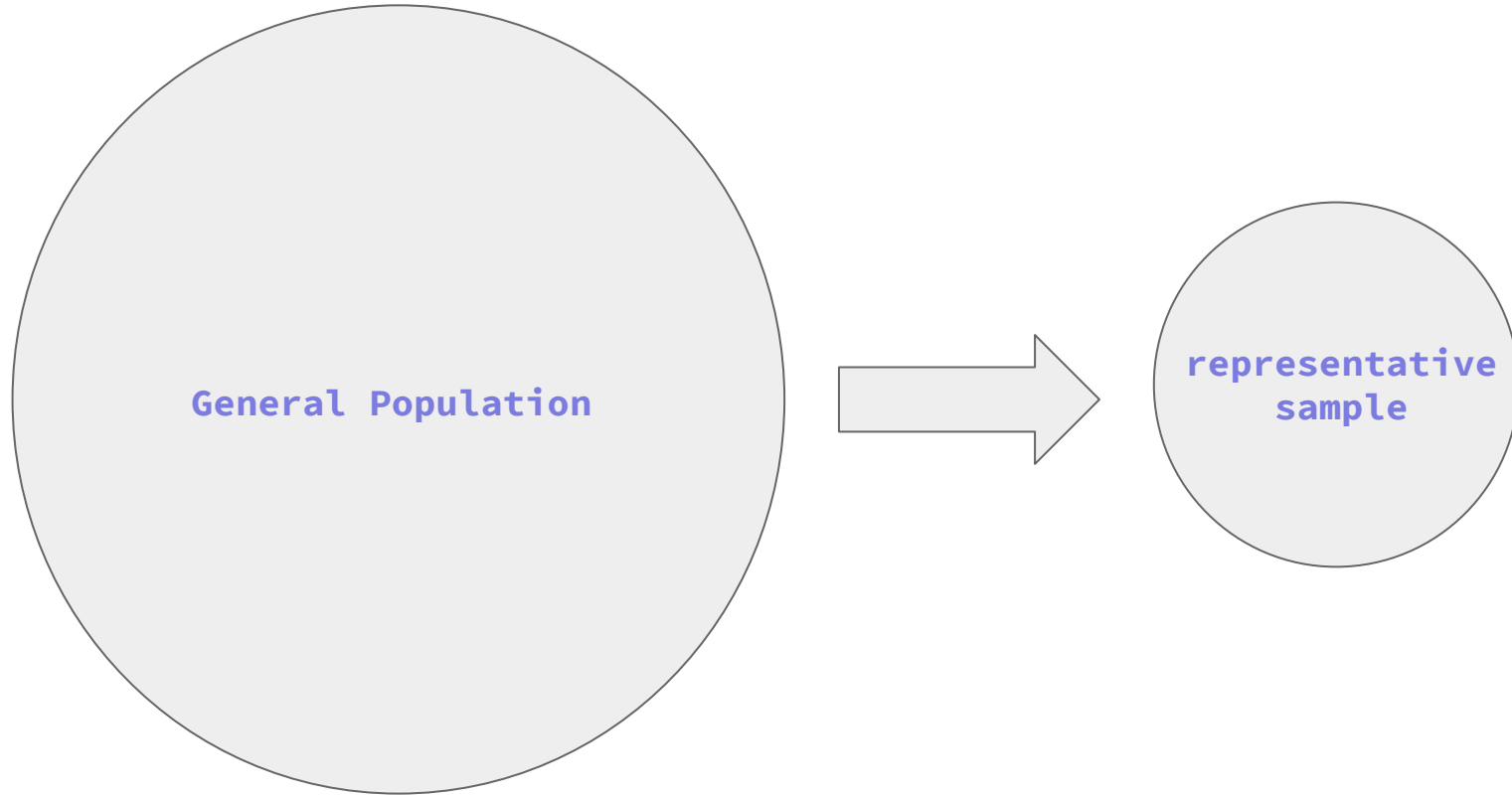
FRAMEWORK

(FILL IN THE BUBBLES WITH A #2 PENCIL)

# WHAT STUDY DESIGN DO YOU NEED TO TEST THAT HYPOTHESIS?

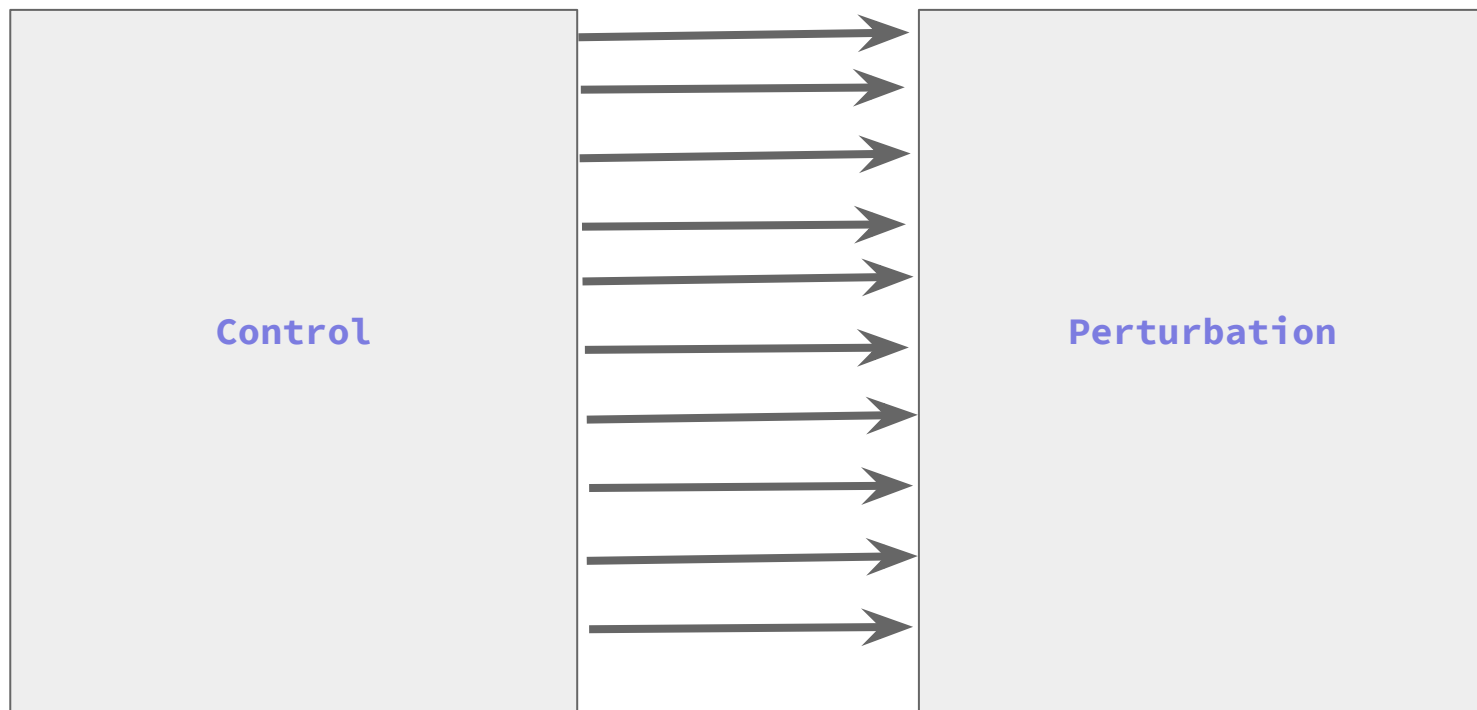
- **Cross-sectional**  
(Look at the population as a whole to find about about features)
- **Case-control**  
(Enrich for a specific group and matched individuals)
- **Intervention**  
(Change what one group is doing, and leave the other alone)
- **Cross-over design**  
(Use people as their own controls)
- **Survival**  
(What predicts some end point)

# CROSS SECTIONAL

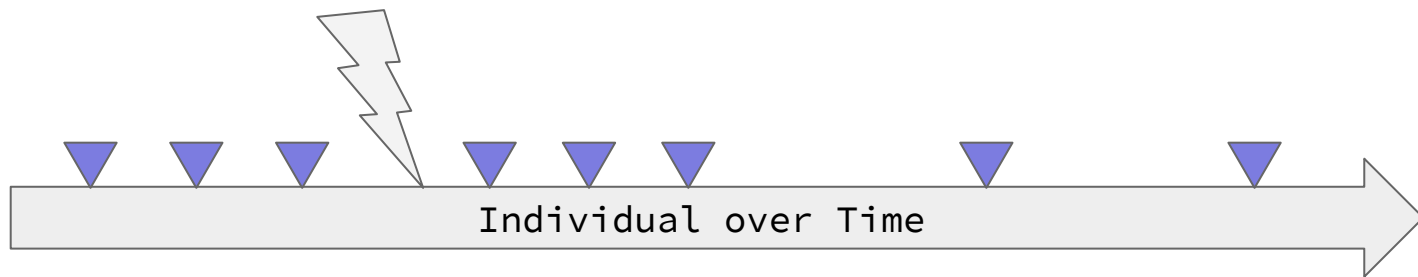
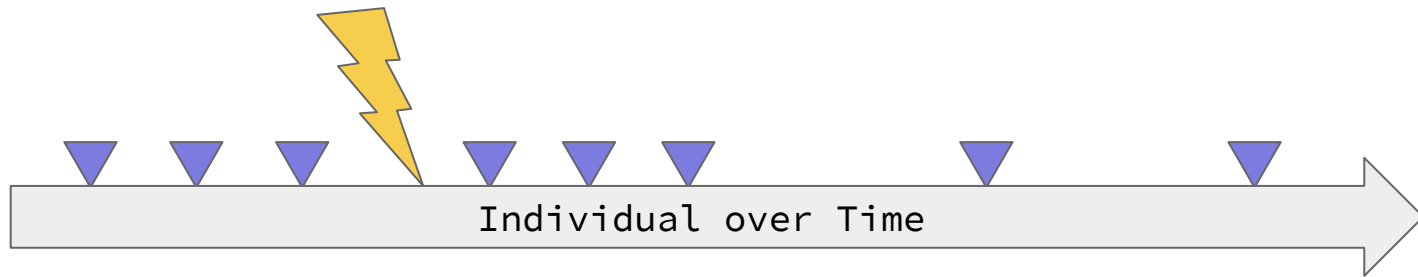




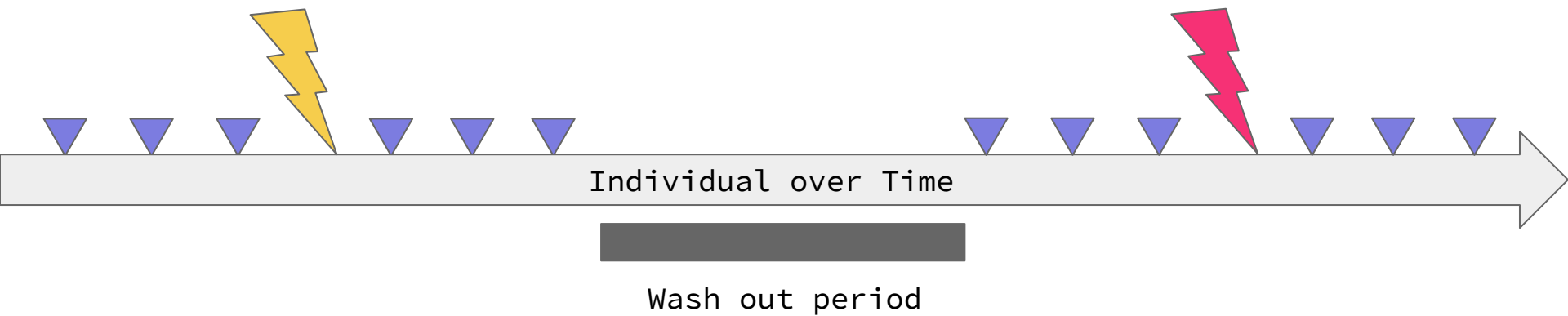
# CASE-CONTROL



# INTERVENTION STUDY



# CROSS-OVER



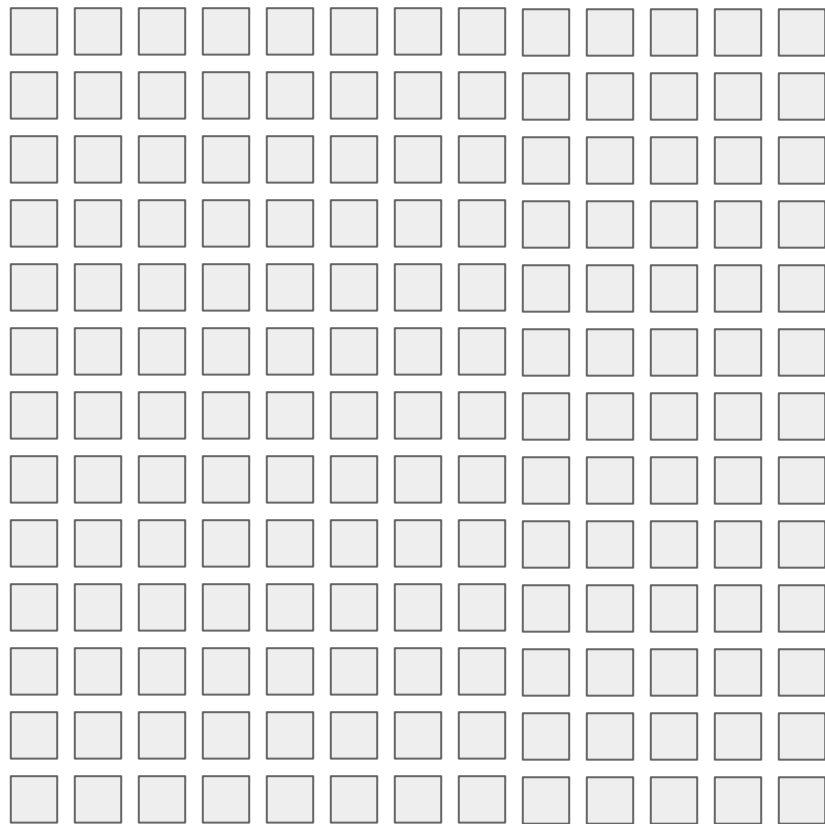
# SURVIVAL

Individual over Time



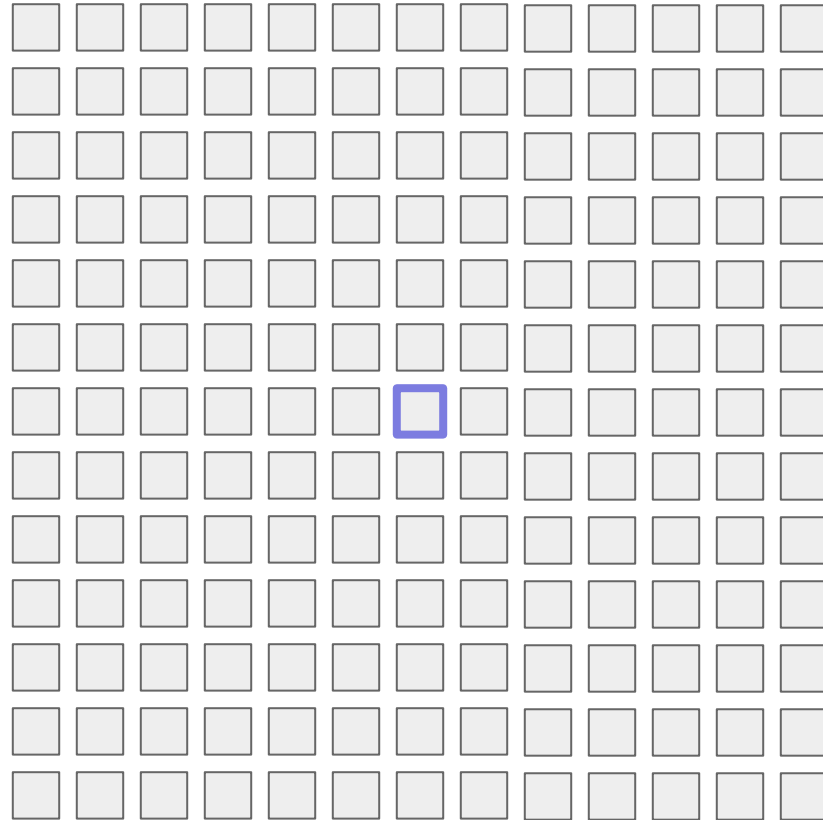
RANDOM AND  
REPRESENTATIVE


# POPULATION: ALL THE MEMBERS OF A GROUP



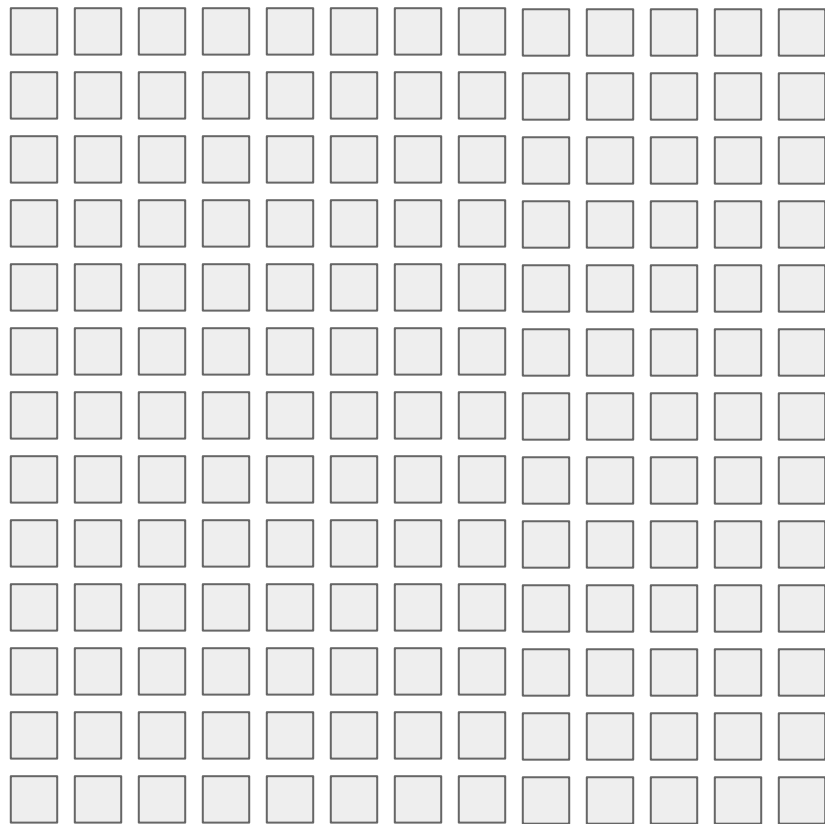
# OBSERVATION: SINGLE MEMBER OF THE GROUP

Population



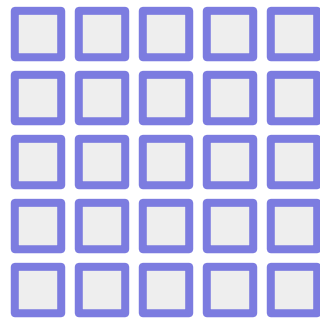
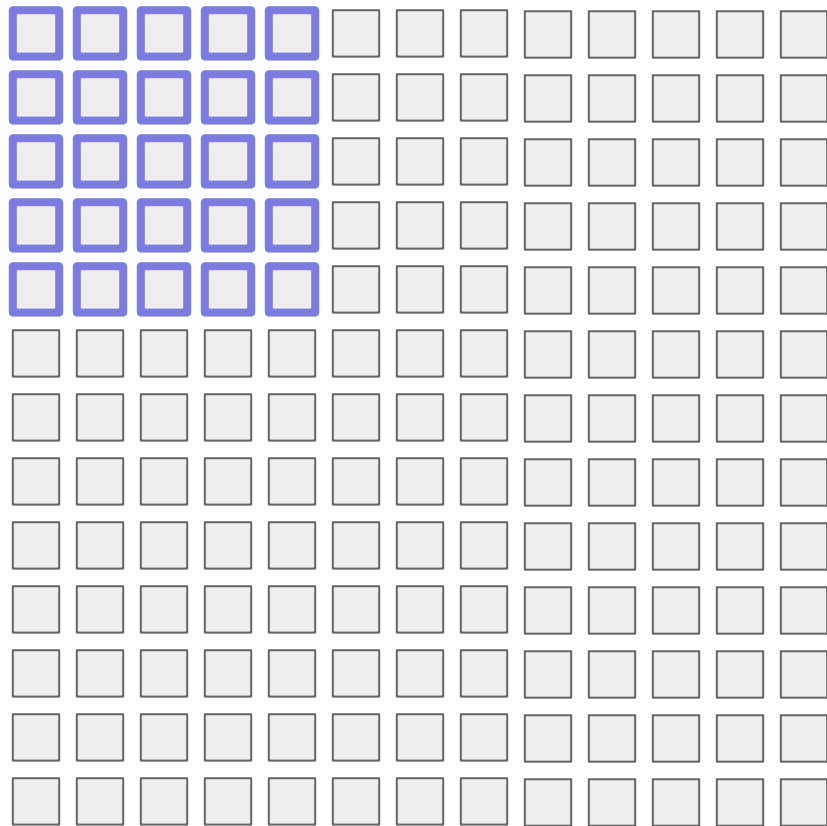
 Observation

# POPULATION: ALL THE MEMBERS OF A GROUP

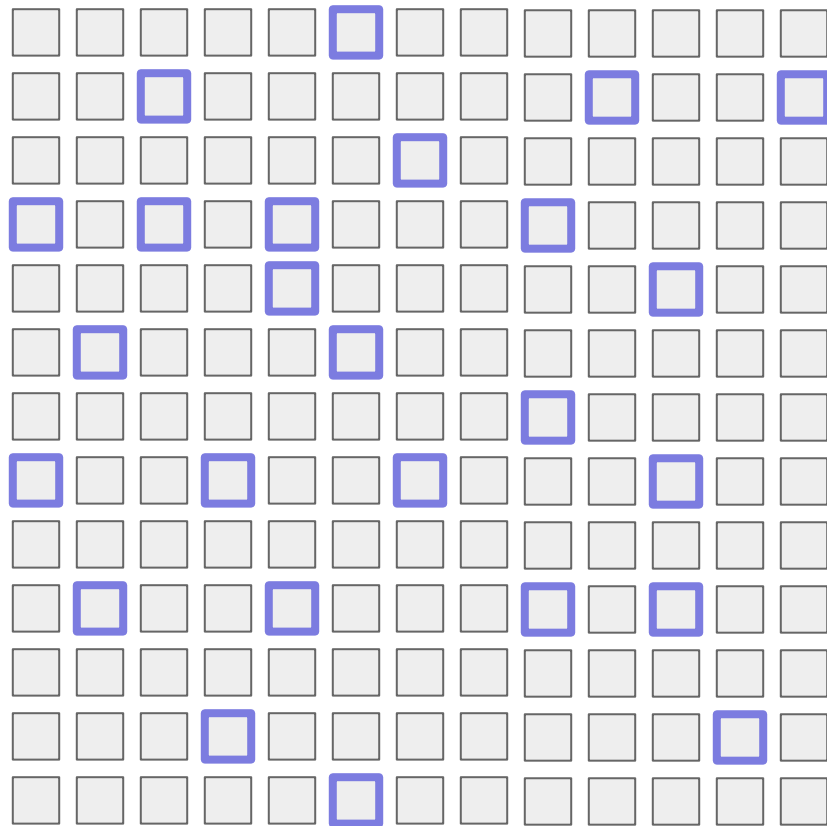




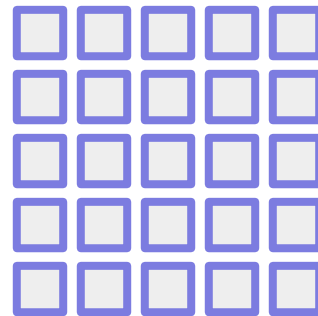
# SAMPLE: A SUBSET OF THE MEMBERS OF A GROUP



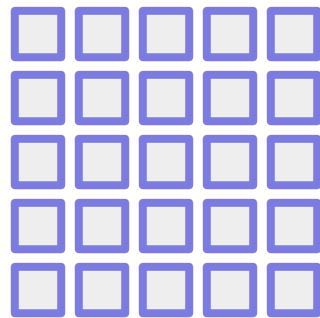
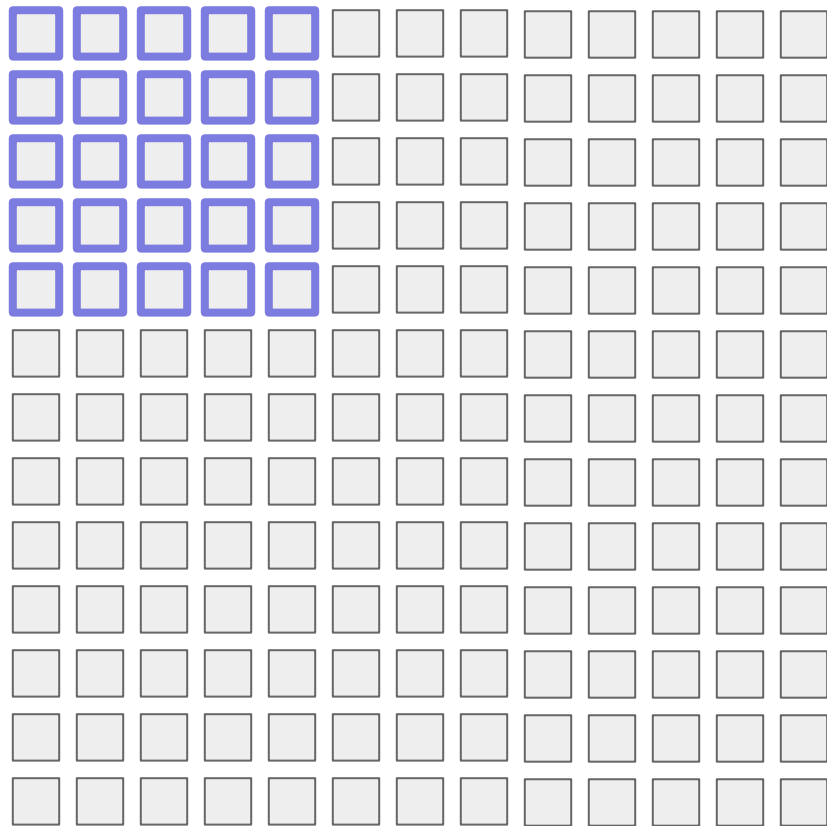
# RANDOM SAMPLING



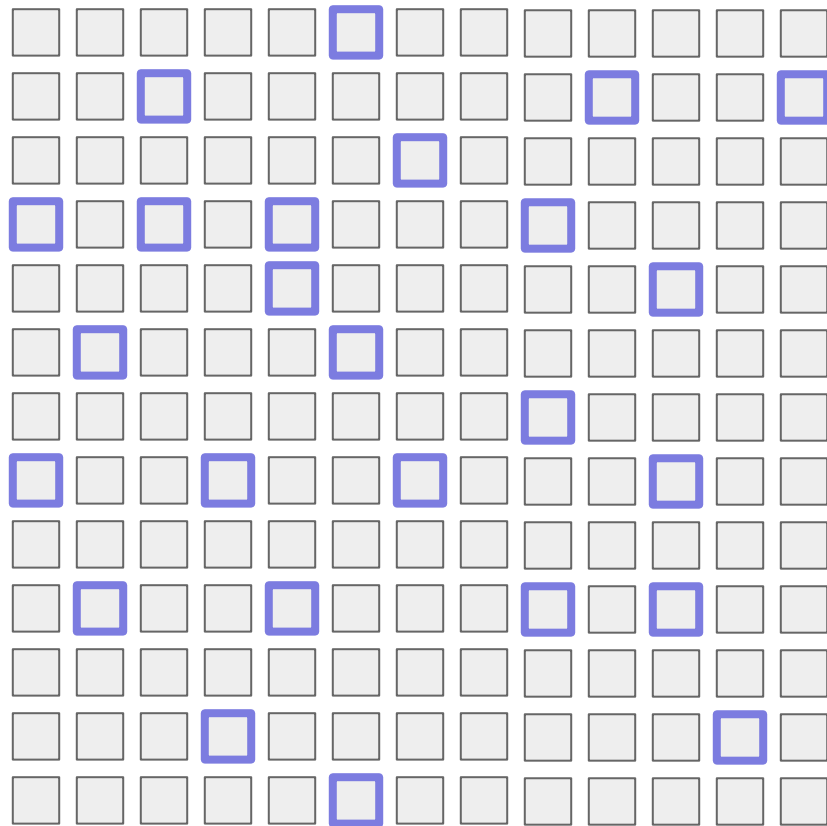
Random Sample



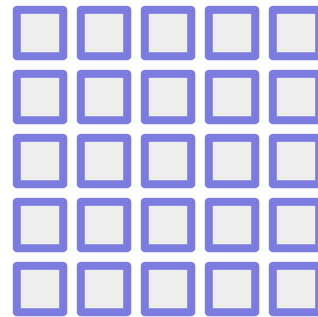
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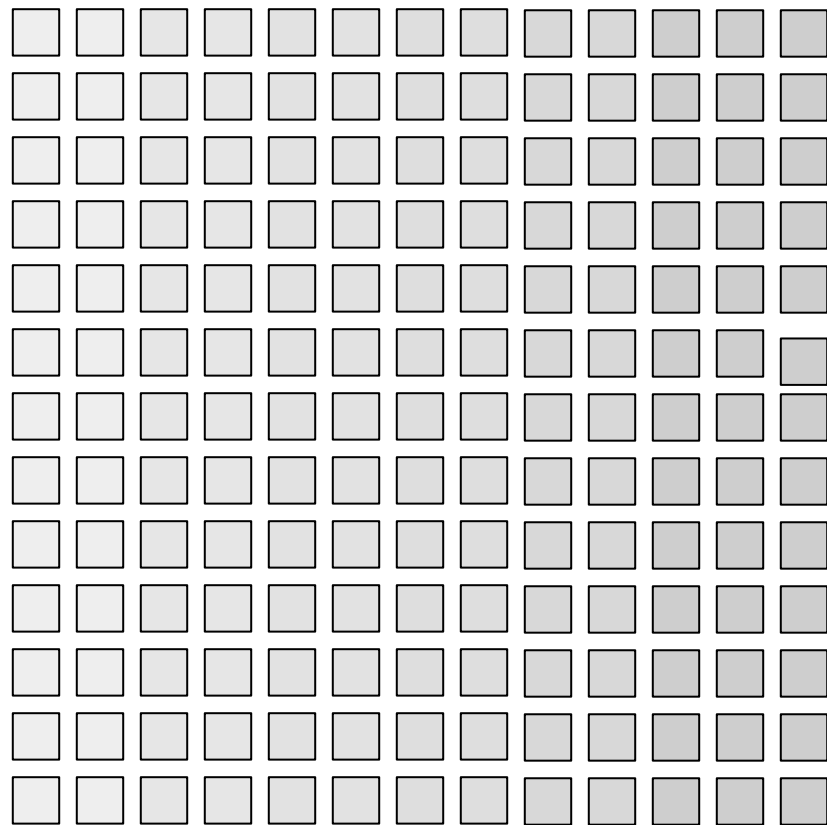
# RANDOM SAMPLING



Random Sample

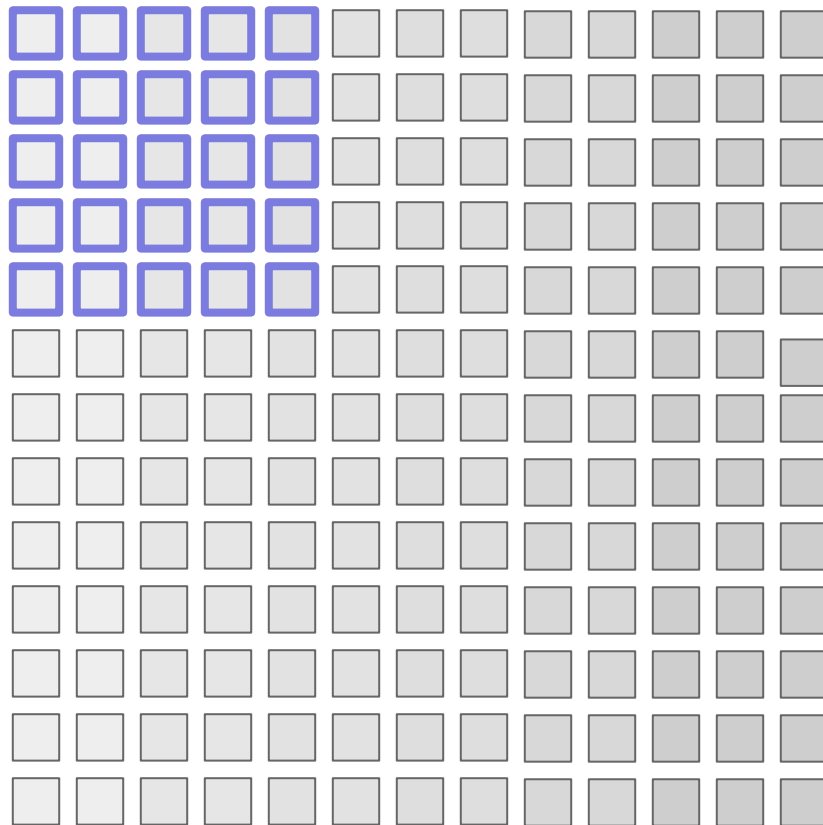
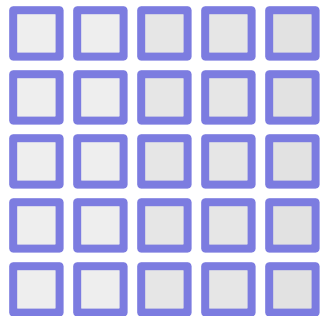


# WHY DO YOU NEED A RANDOM SAMPLE?

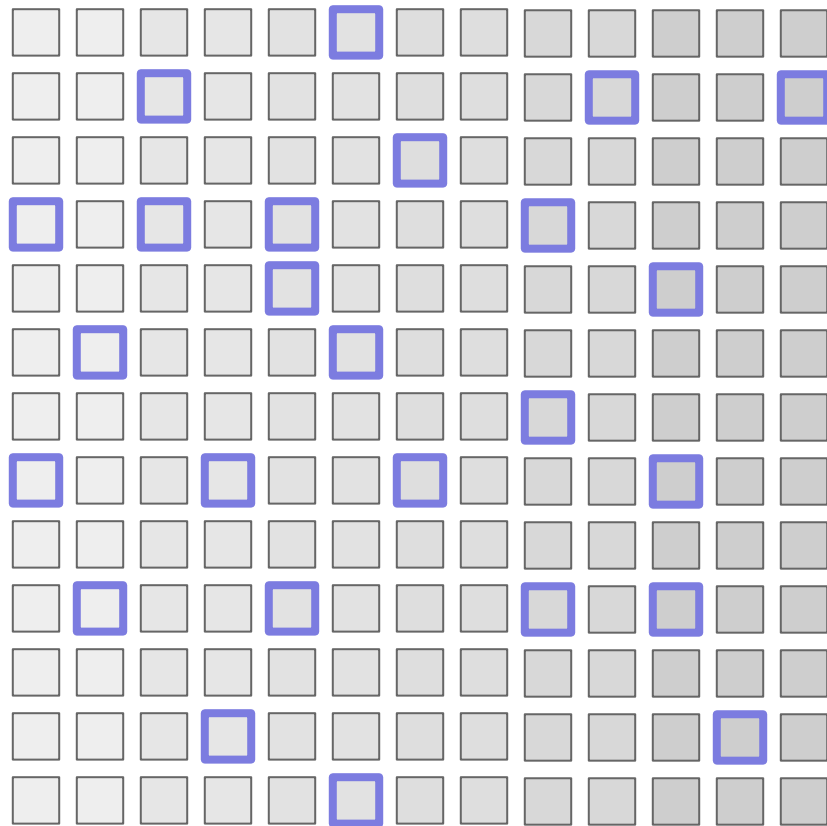


# WHY DO YOU NEED A RANDOM SAMPLE?

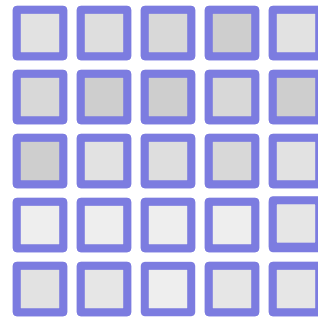
Biased Sample



# RANDOM SAMPLE



Random Sample





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THE 2016 RACE

# How One 19-Year-Old Illinois Man Is Distorting National Polling Averages



Nate Cohn @Nate\_Cohn OCT. 12, 2016



505

There is a 19-year-old black man in Illinois who has no idea of the role he is playing in this election.

He is sure he is going to vote for [Donald J. Trump](#).

And he has been held up as proof by conservatives — including outlets like Breitbart News and The New York Post — that Mr. Trump is excelling among black voters. He has even played a modest role in shifting entire polling aggregates, like the Real Clear Politics average, toward Mr. Trump.

How? He's a panelist on the U.S.C. Dornsife/Los Angeles Times Daybreak poll, which has emerged as the biggest polling outlier of the presidential campaign. Despite falling behind by double digits in some national surveys, Mr. Trump has generally led in the U.S.C./LAT poll. He held the lead for a full month, until Wednesday, when Hillary Clinton took a narrow lead.

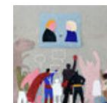
## RELATED COVERAGE



THE 2016 RACE  
**America's New Reporters of the Vote, and How Pennsylvania Explains G.O.P.'s Problems** OCT. 13, 2016



**2016 Senate Election Forecast** AUG. 24, 2016



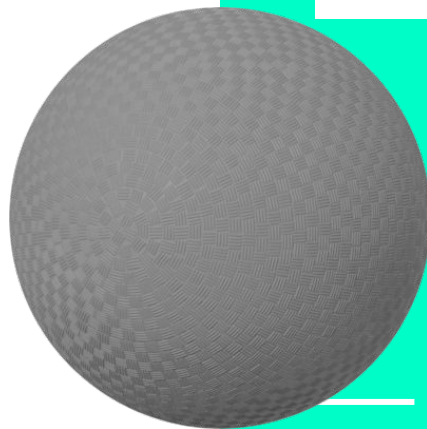
PULSE OF THE PEOPLE?  
**The Savvy Person's Guide to Reading the Latest Polls** OCT. 12, 2016



# HYPOTHESIS TESTING (AND NOW FOR SOME MATH)

THE BALL IS RED

THE BALL IS NOT RED

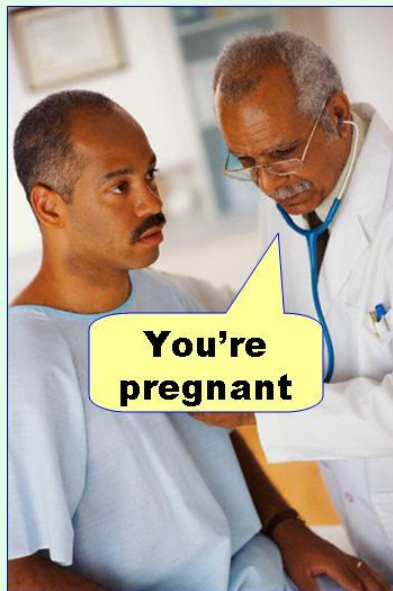


# HYPOTHESIS TEST OUTCOMES

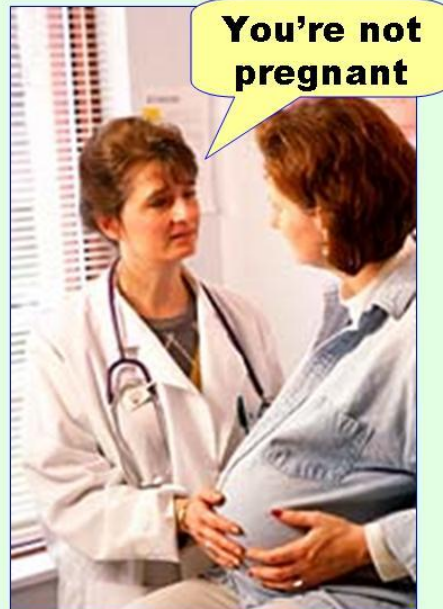
	WE SAY "THE BALL IS RED"	WE SAY "THE BALL IS NOT RED"
THE BALL IS REALLY RED	True	False Negative
THE BALL IS NOT RED	False Positive	True

# WHY SHOULD YOU CARE ABOUT ERRORS?

**Type I error**  
(false positive)



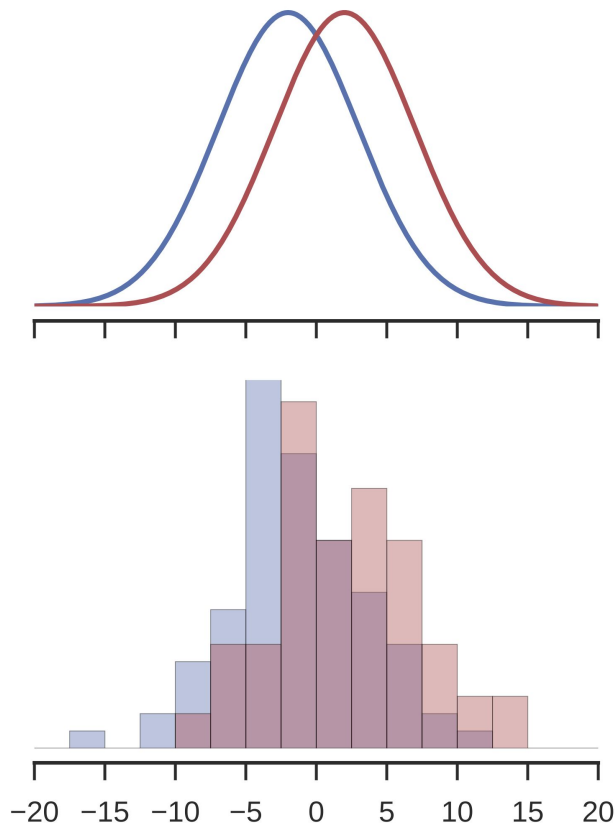
**Type II error**  
(false negative)



## A MORE THEORETICAL EXAMPLE

$H_0$ : Red mean = Blue mean

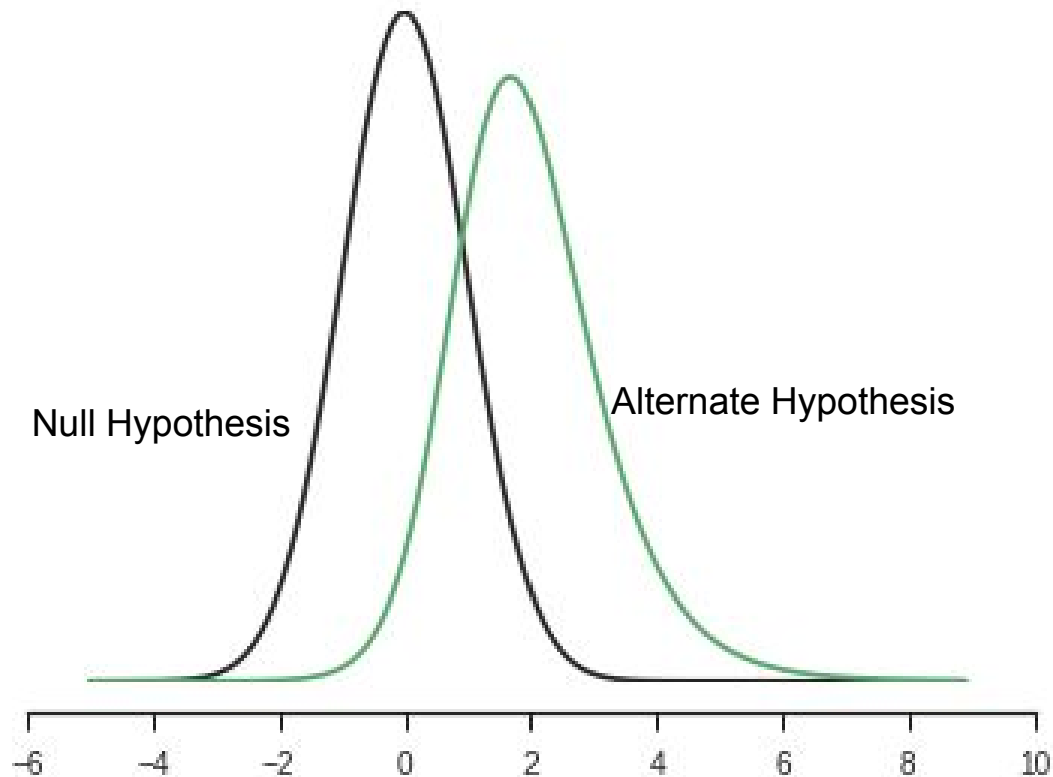
$H_1$ : Red mean  $\neq$  blue mean



# HYPOTHESIS ABSTRACTION

$H_0$ : Red mean = Blue mean

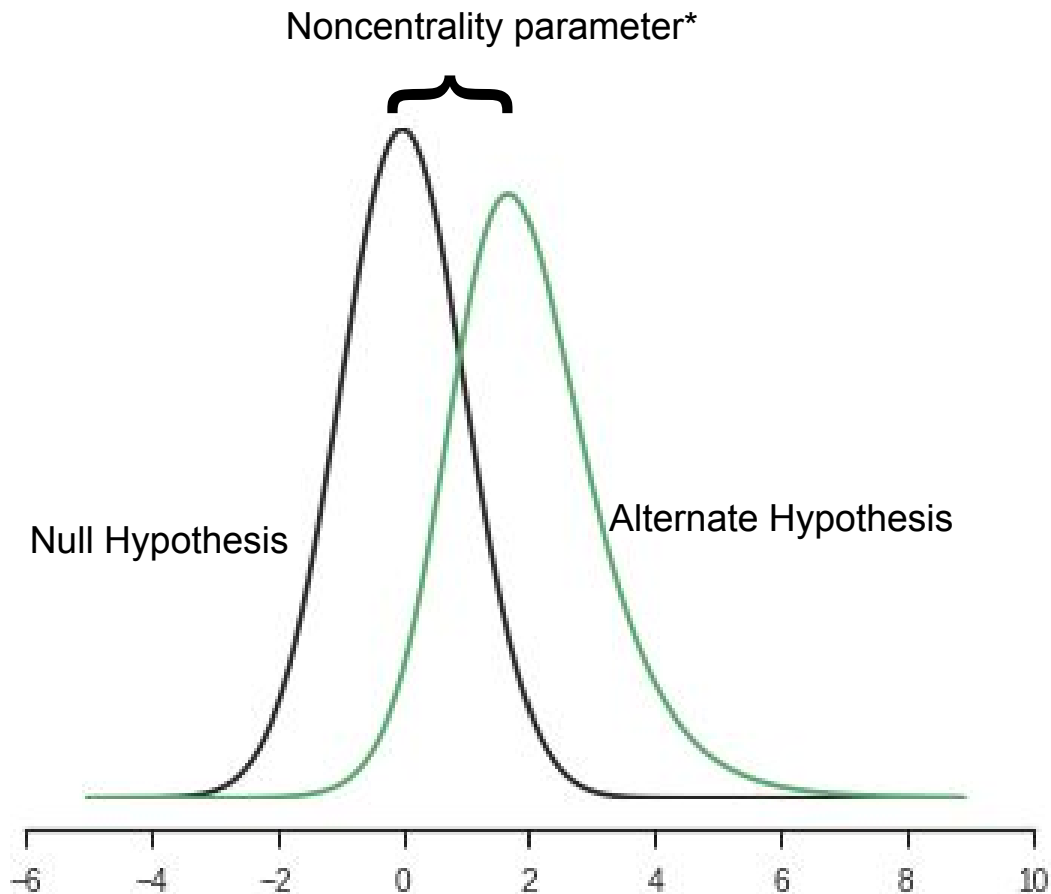
$H_1$ : Red mean  $\neq$  blue mean



# HYPOTHESIS ABSTRACTION

$H_0$ : Red mean = Blue mean

$H_1$ : Red mean  $\neq$  blue mean



\*This is a function of the sample size

# NONCENTRALITY VS EFFECT SIZE

Noncentrality parameter is a function of sample size and the data

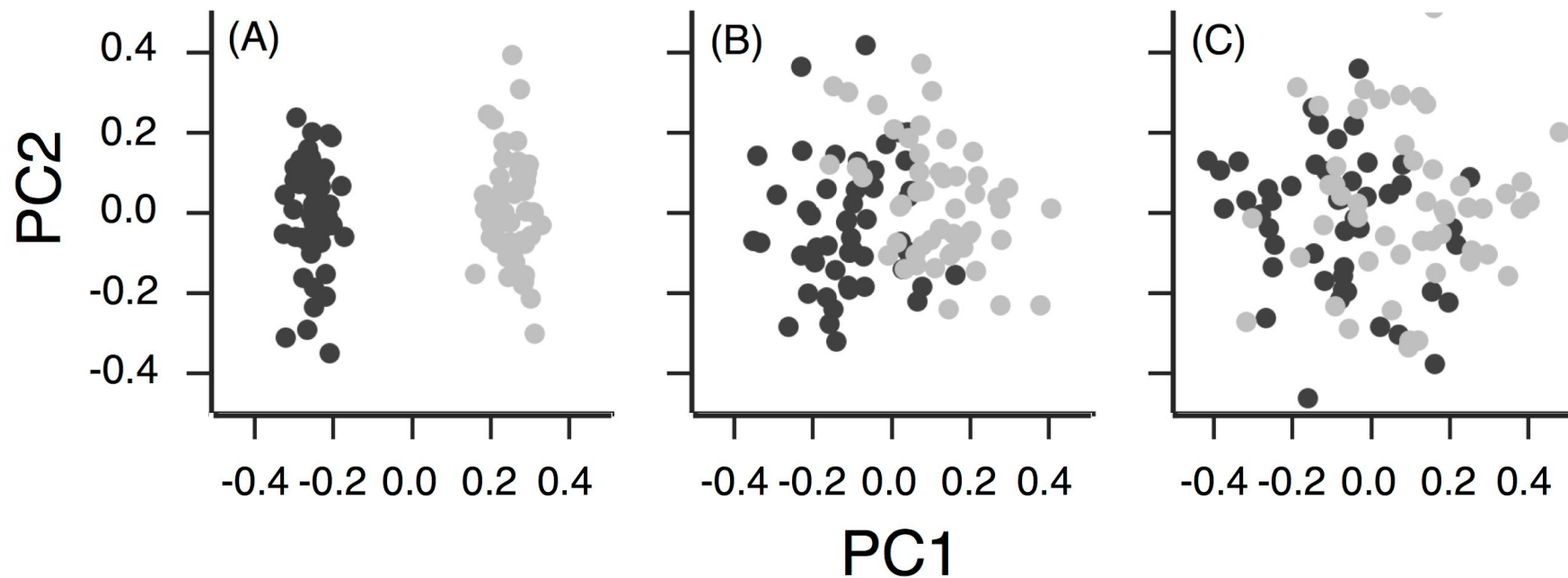
Effect size a property of the data



# EFFECT SIZES

- Measure difference in your data
- Useful for comparison **independent of sample size**
- Excellent for meta analysis
- Associated with your test

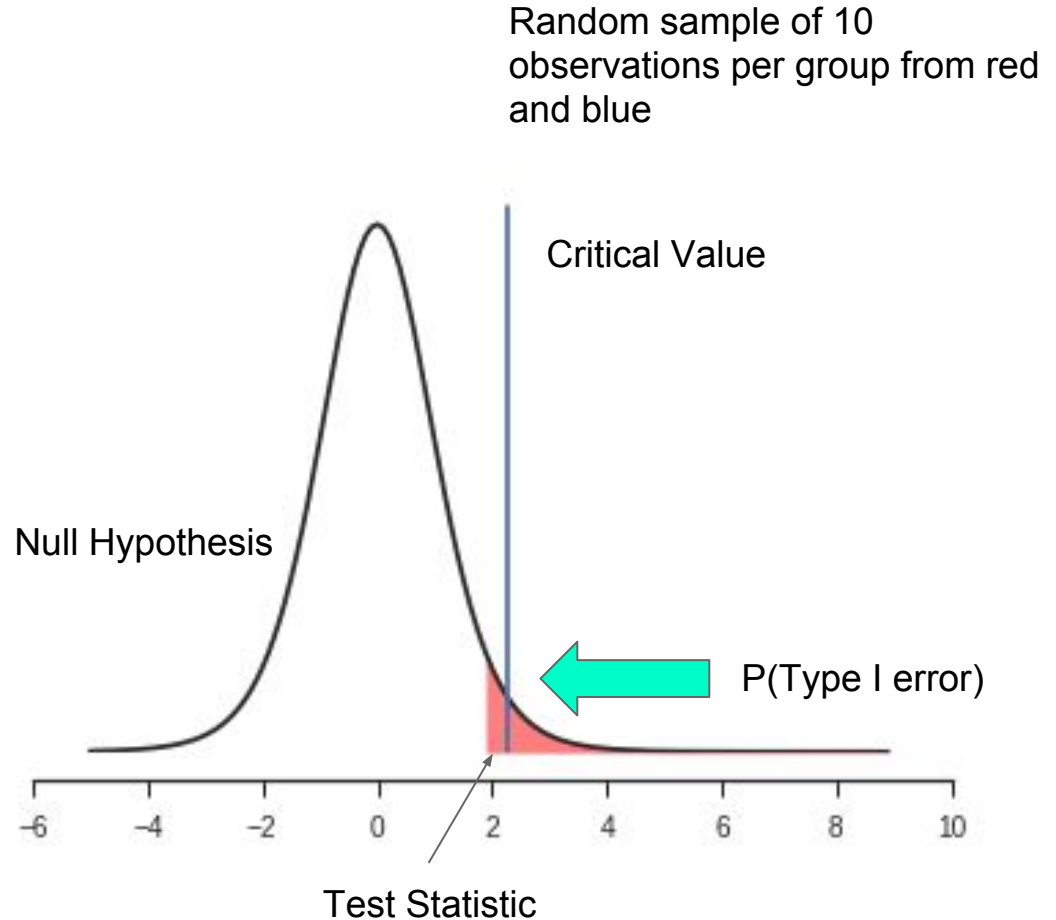
# SEEING EFFECT SIZES IN PCOA SPACE



# THE STATISTICAL TEST

1. Calculate test statistic
2. Compare to distribution
3. Get probability
4. Publish\*

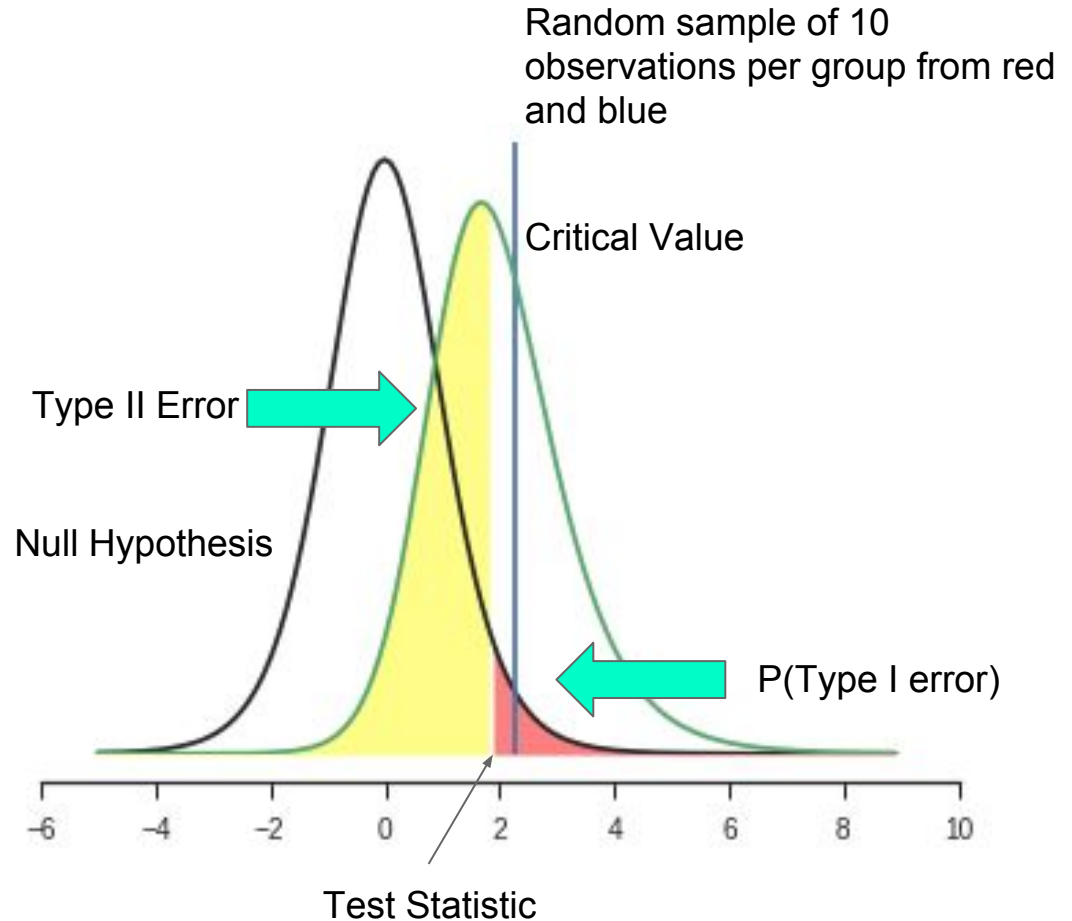
\*If  $p < 0.05$



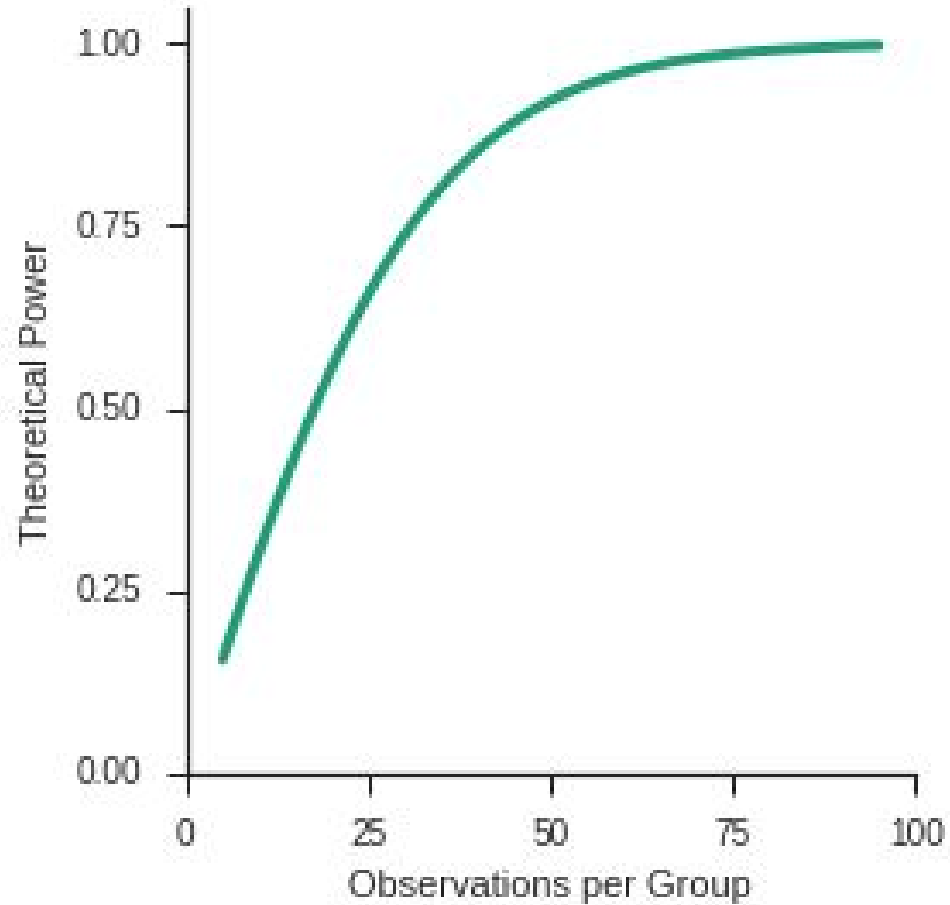
# THE STATISTICAL TEST

1. Calculate test statistic
2. Compare to distribution
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4. Publish\*

\*If  $p < 0.05$



$$\text{POWER} = 1 - (\text{TYPE II ERROR})$$



# WHAT DOES POWER TELL YOU?

Power = Probability of finding a difference between your two groups as a function of sample size

--> The relative scale of different effects

--> How many samples per group you need to be sure of your results

# WHAT DOES POWER TELL YOU?

Power = Probability of finding a difference between your two groups as a function of sample size

--> The relative scale of different effects

**--> How many samples per group you need to be sure of your results**

# \*CAVEATS

Some people use power to justify *why* they didn't see the difference they expected.

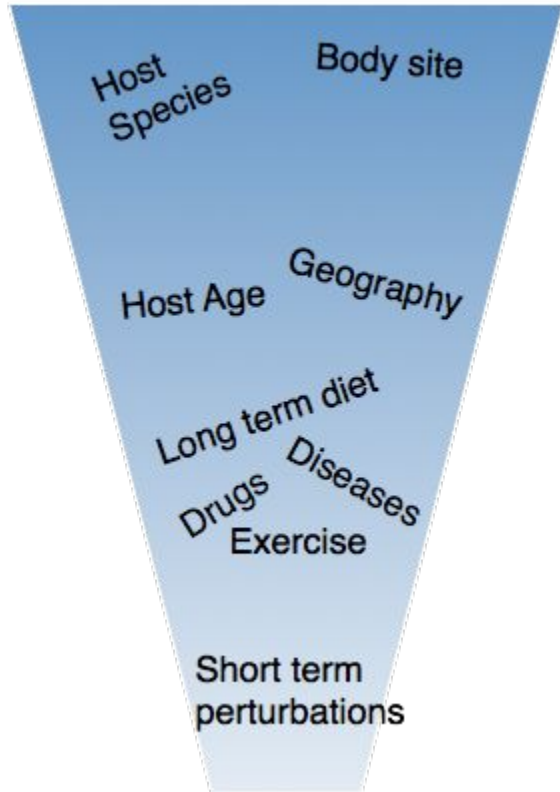
It's worth being wary.

High power doesn't necessarily mean biological significance

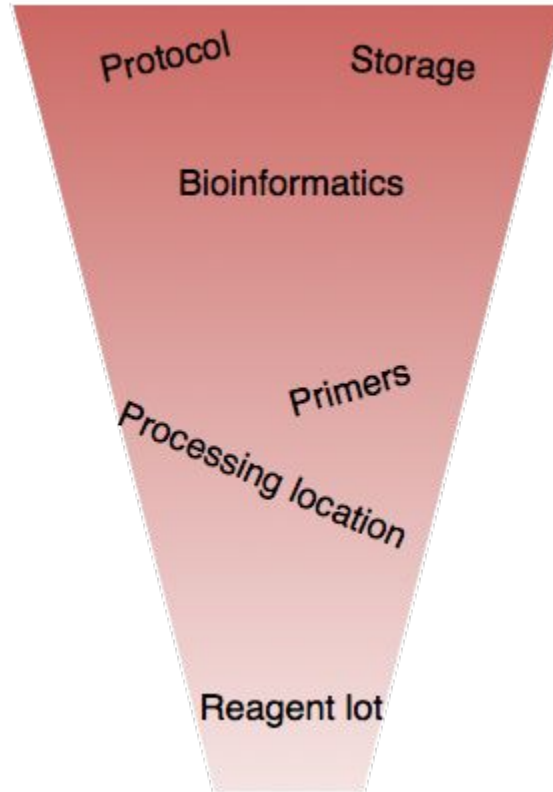


# SOURCES OF VARIATION

## Biological effect size



## Technical Considerations



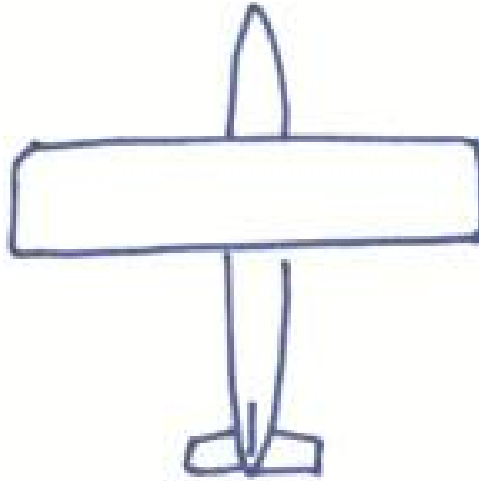
## WATCH FOR LITERATURE BIAS

Studies that find a difference get published

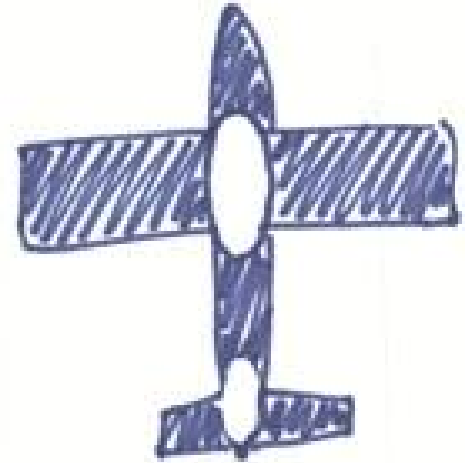
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Studies with negative results don't.

Studies don't get repeated



bullet-free  
airplane



● = bullet hole  
locations on returning  
airplanes

# POWER FOR MICROBIOME DATA

- Two published methods directly address power:
  - La Rosa 2011 (Power for dirlicl multinomial test)
  - Kelly 2015 (Power for permanova)
- Flemish Gut includes effect size discussion based on variance

# WHERE TO GO?

**Read this review:**

<https://www.ncbi.nlm.nih.gov/pubmed/17944619>

**In Python:**

```
statsmodels.stats.power
```

**Online:**

<https://www.stat.ubc.ca/~rollin/stats/ssize/>

<http://www.sample-size.net/>