SWE3053
Human Computer Interaction

Lecture 20

Data Analysis

Assignment #8 – Coming up with a Research Question

Submit on iCampus before **(Monday) May 9 <u>23:59 pm</u>**.

Objective: In this assignment, you will come up with a research idea in Human Computer Interaction, and then narrow it down into a specific research question with testable hypothesis.

1. Pick an area in HCI that you are interested. Briefly describe the area you picked.
2. Based on the area you pick, formalize a specific research question in Human Computer Interaction.
3. Further narrow down your research hypothesis, and try to narrow it down to some independent variable(s).
4. Specify your research question into a testable hypothesis, with measurable dependent variable(s).
5. Design your experiment based on within or between subject design.
6. Try to perform an initial literature search on academic database such as PyscInfo and ScienceDirect.
7. Based on your literature search, is your research question being explored previously by other scientists?

Your submitted answer must address all of the above 7 issues.

Sensory Substitution

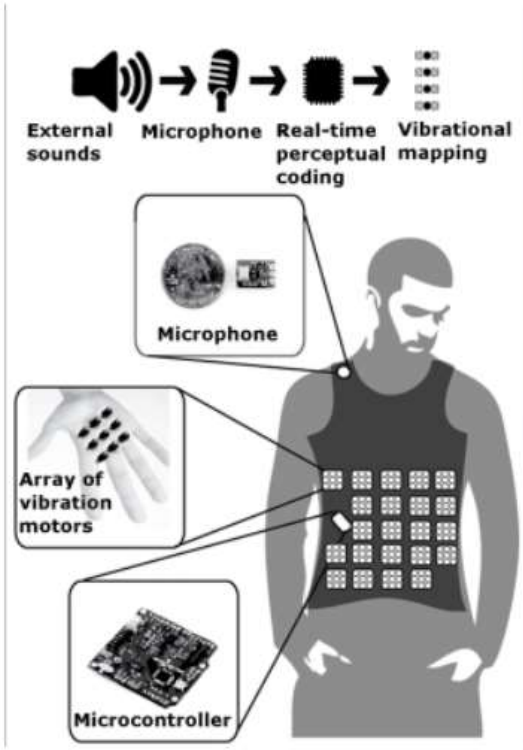
DAVID EAGLEMAN

HOME Sweet Home | WRITING By David Eagleman | RESEARCH David's Neuroscience | BLOG Latest Ideas | SCHEDULE Where To Catch David | CONTACT Reach Us

SENSORY SUBSTITUTION

Can sensory data be fed through unusual sensory channels? And can the brain learn to extract the meaning of such information streams?

Yes and yes. *Sensory substitution* is a non-invasive technique for circumventing the loss of one sense by feeding its information through another channel. We are leveraging this technique to develop a non-invasive, low-cost vibratory vest to allow those with deafness or severe hearing impairments to perceive auditory information through small vibrations on their torso.



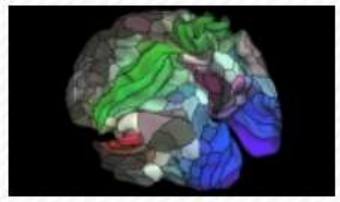
(Figure from Scott Novich and David Eagleman)

FROM THE BLOG

HAD A GREAT TIME AT THE NYT SUMMIT WITH FRIEND AND FELLOW AUTHOR CHARLES DUHIGG.

Really good companies are the ones that are constantly reinventing themselves. I spoke with Charles Duhigg about habit, unconscious processing and the workspace at the 2016 New Work Summit. Watch the full interview: http://trib.al/1nwghb1

A NEW MAP OF THE HUMAN BRAIN



New paper in Nature describes the most highly detailed map of the human cortex so far.

https://www.eagleman.com/research/sensory-substitution

Agenda

- Inferential Statistic
  - T-test

Review

- Descriptive Statistic
  - Central Tendency
    - Mean
    - Mode
    - Median
  - Variability
    - Range
    - Variance

Inferential Statistics

How to reach scientific conclusions based on data

*that **caused** by everything else*

What are the sources of variability?

"Error" Variance

- differences in driving ability
- differences in alertness
- differences in concentration
- differences in mood
- chance factors

Systematic Variability

-  versus 

*variability **caused** by manipulating the IV (i.e., difference between the means)*

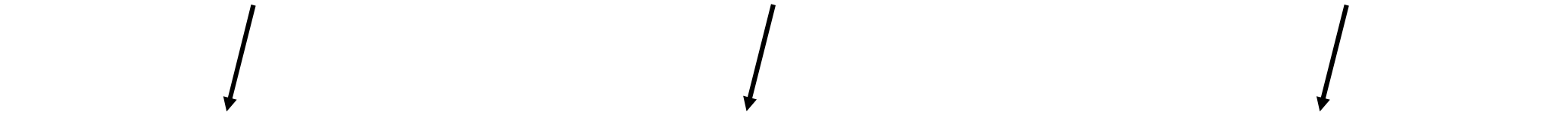
Some Typical Sources of “Error” Variance

- Individual differences
- Random factors
- Misunderstood instructions
- Unexpected events
- Experimenter errors
- Equipment errors
- Errors in data collection
-

Only some are true errors

• Inferential Statistics

Total Variance = Systematic Variance + Error Variance



`total variability from all factors`

`variability due to manipulating IV`

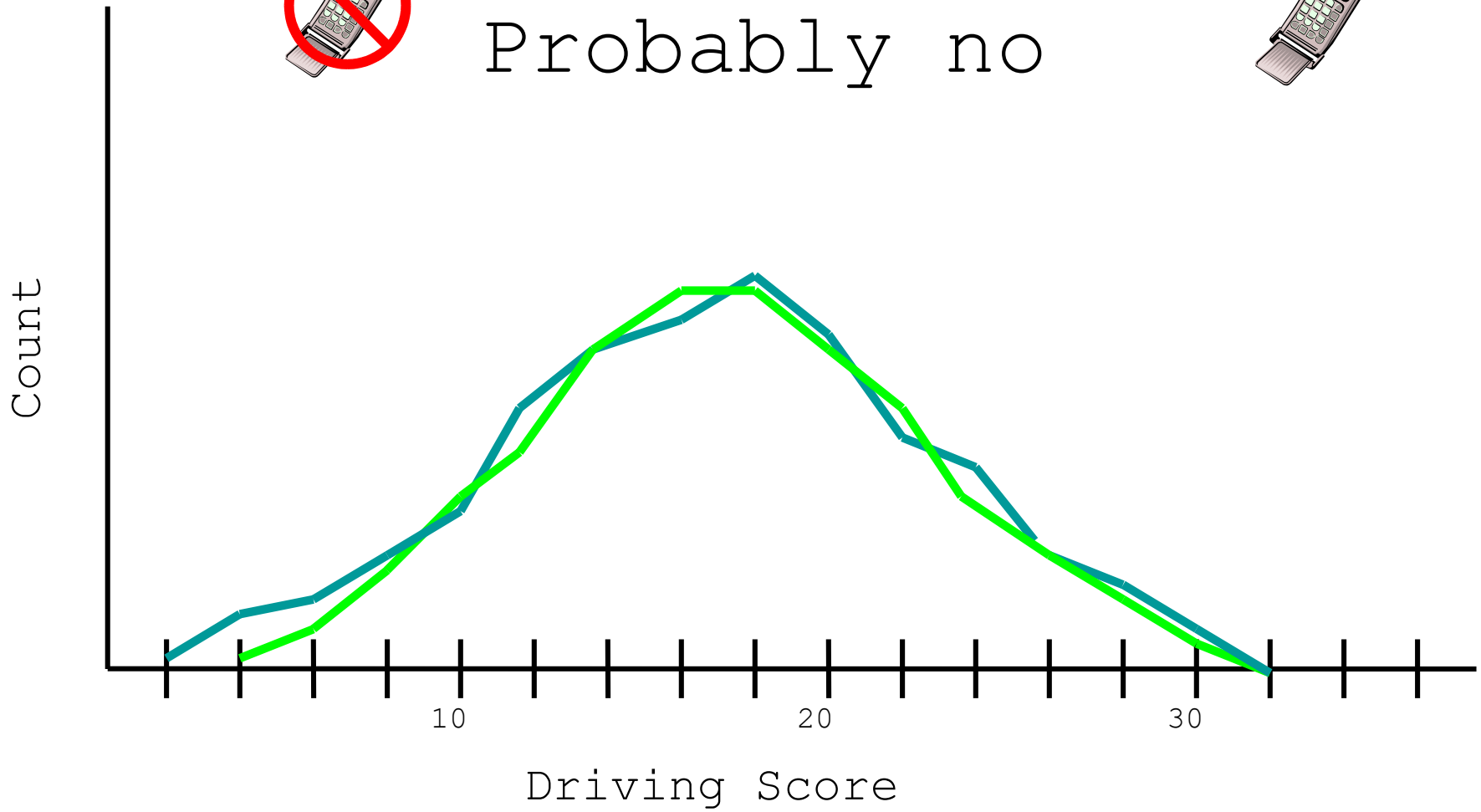
`variability due to everything else`

Is this "big enough"?

relative to this

Is significant variability introduced by the independent variable?

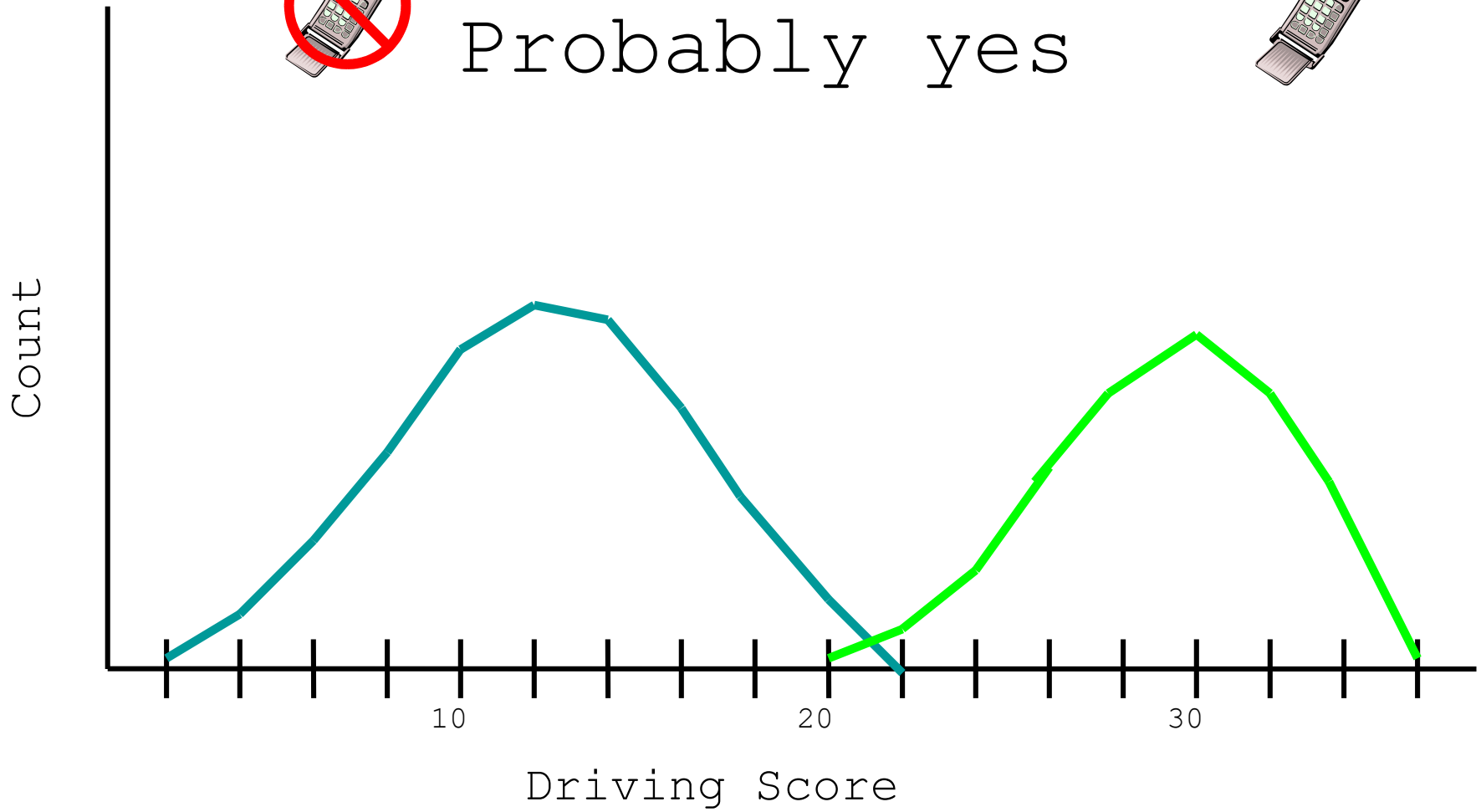
Probably no



Total Variance = Systematic Variance + Error Variance

Is significant variability introduced by the independent variable?

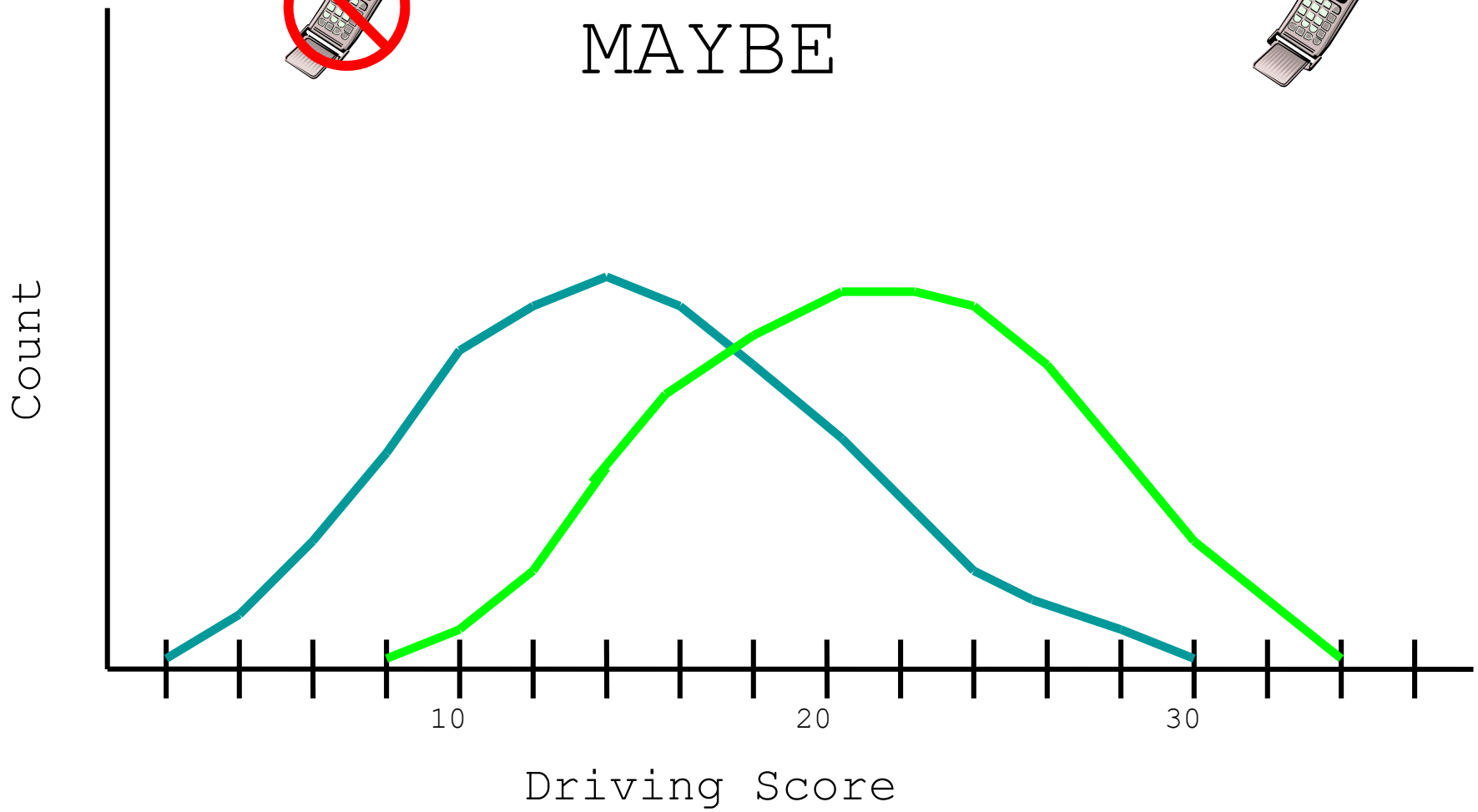
Probably yes



Total Variance = Systematic Variance + Error Variance

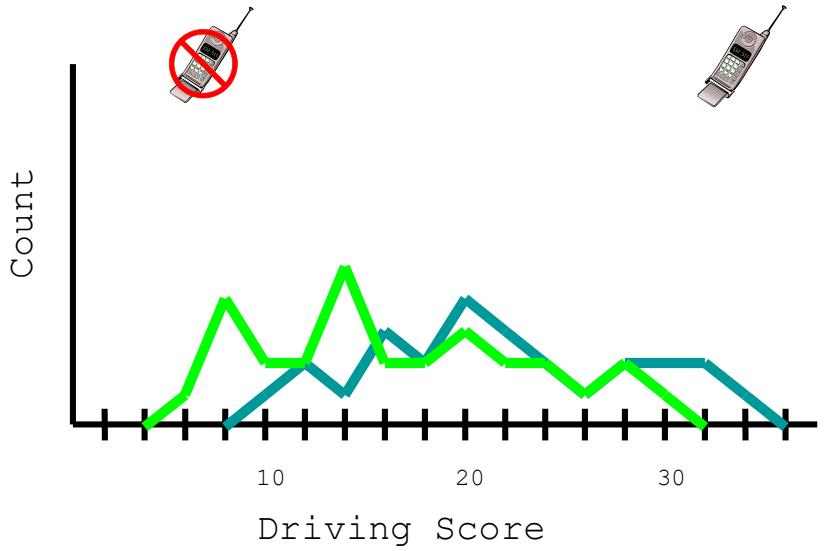
Is significant variability introduced by the independent variable?

MAYBE



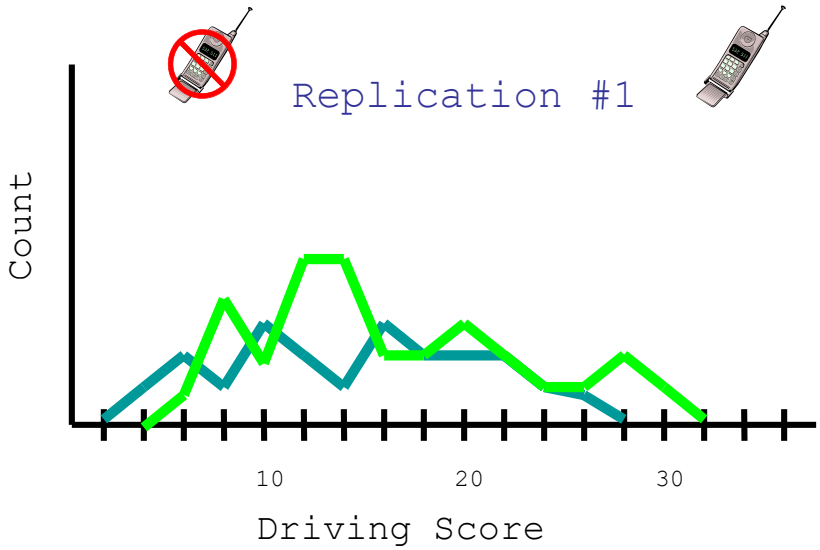
Total Variance = Systematic Variance + Error Variance

Experiment

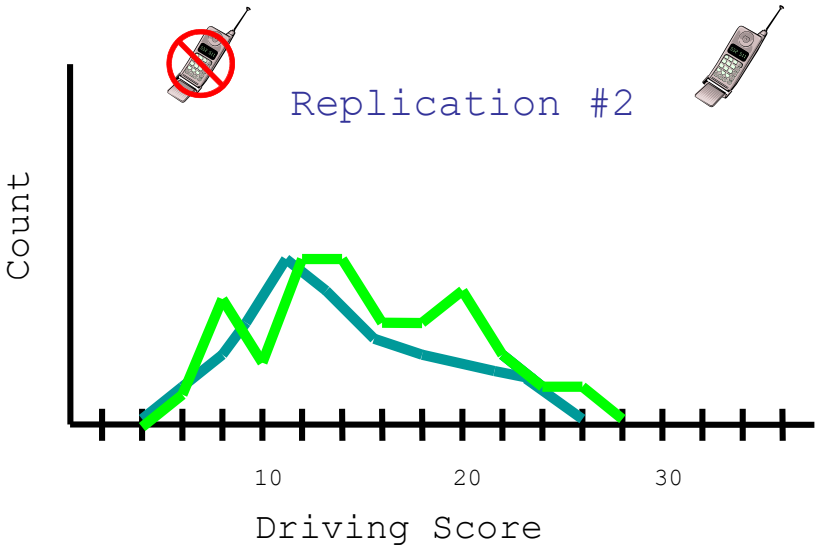


Imagine we say "Yes, cell phones are bad"

Replication #1



Replication #2



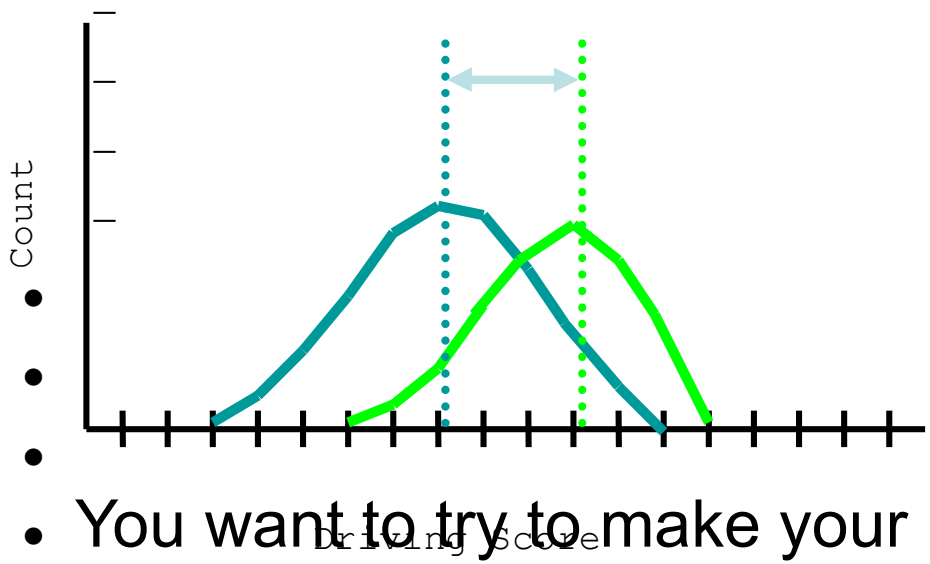
Inferential Statistics

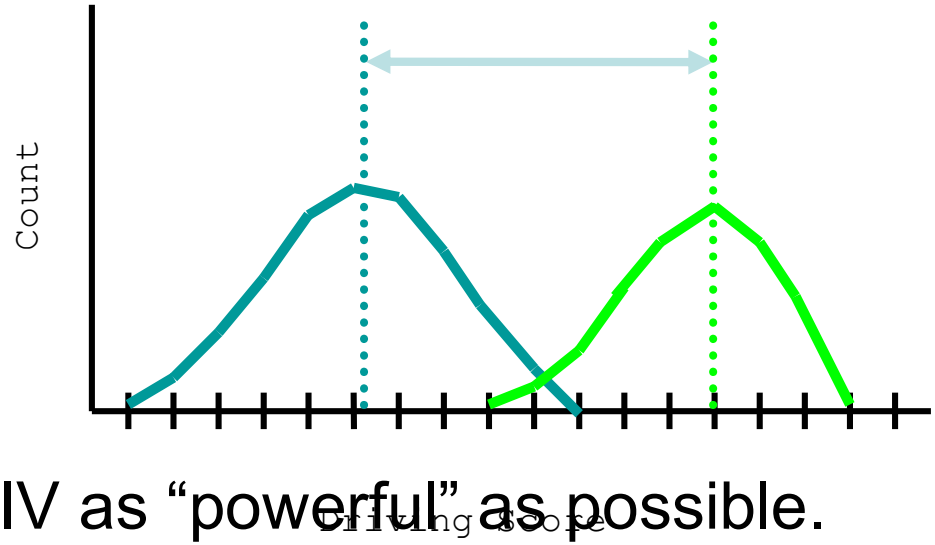
- Inferential statistics helps let us minimize the chance of an “Oops!”
-
- In a sense, inferential statistics allows you to say “yes” or “no” without having to run a replication.
-
- Used to determine if difference found is unlikely to have occurred by chance alone.
-
- In other words, are differences “statistically significant”?
  - “Significance” does not mean importance.

What determines statistical significance?

(1) Magnitude of difference between the means

- Due to systematic variance

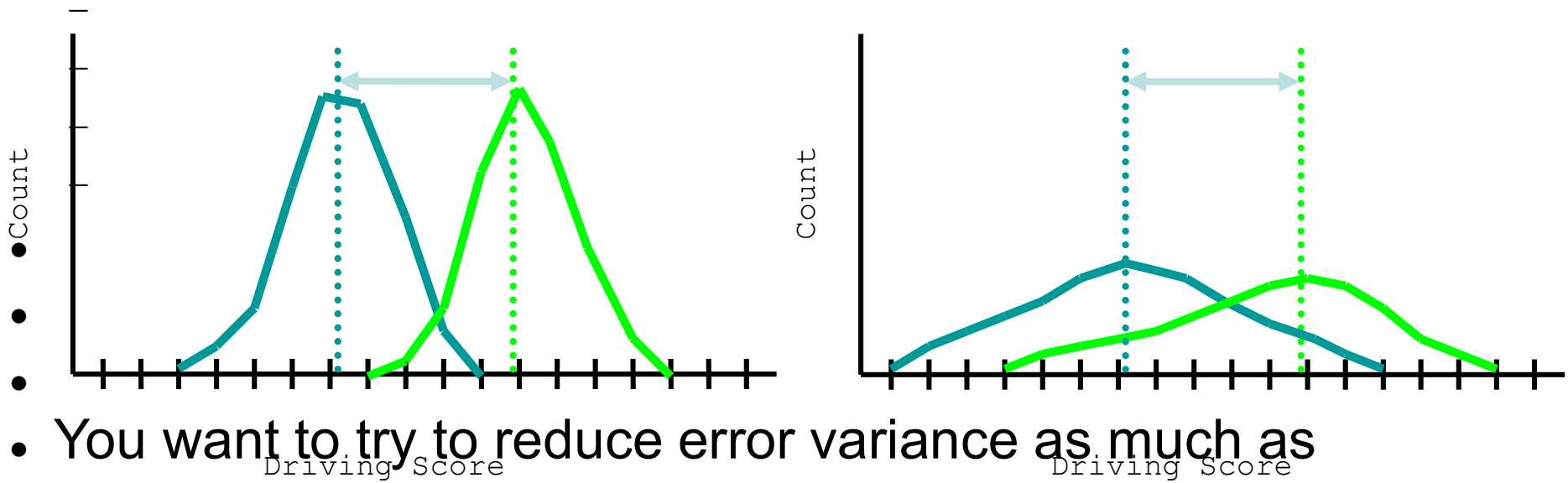




- You want to try to make your IV as "powerful" as possible.
  - Instead of a subtle manipulation

- What determines statistical significance?

(2) Variability within groups
  - Due to error variance

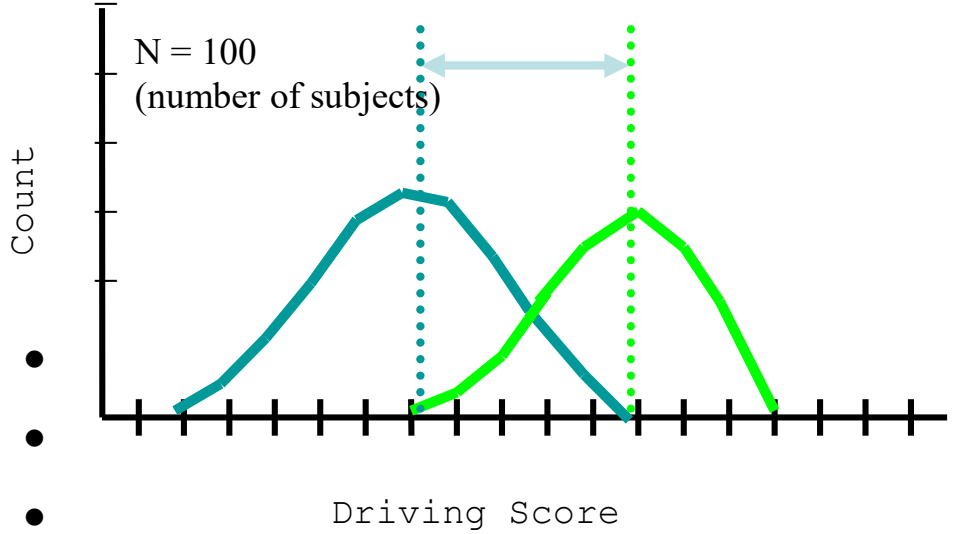


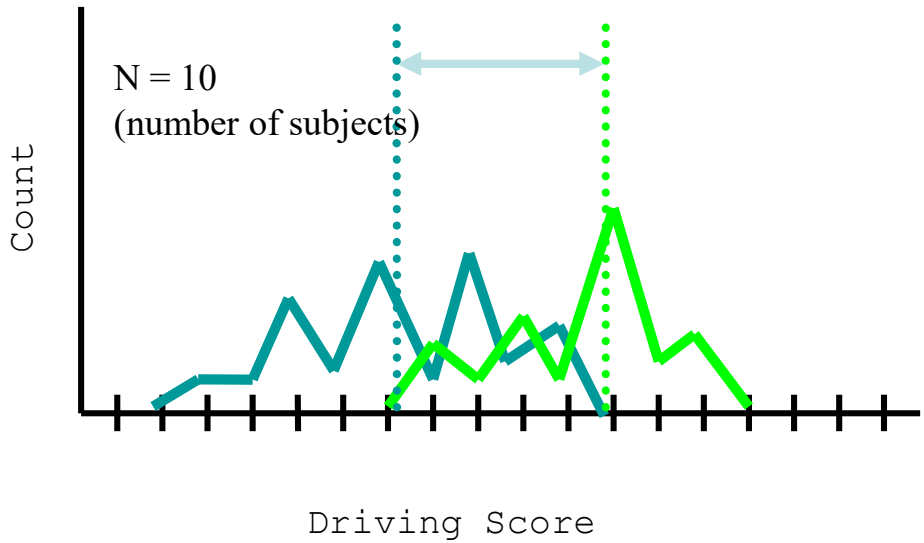
- You want to try to reduce error variance as much as possible.
  - Through careful experimental control.

What determines statistical significance?

(3) Number of subjects / number of observations per subject

- Influences the confidence in your measures of means and variances
-
-





- More subjects is better…
- More data per subject is better…

- E.g., t-test

difference between means
(SYSTEMATIC)

if "large enough" (e.g., |t|>1.96) then you say difference is statistically significant

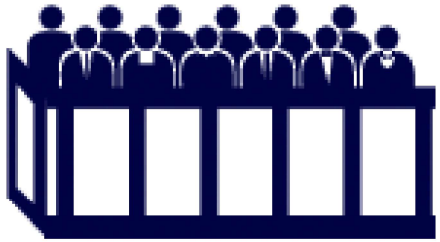
$$t = \frac{\bar{x} - \bar{y}}{s_{x\&y}}$$

large values indicate statistical significance

variability of both distributions
(ERROR)

Statistical significance

- Determining statistical significance is a probabilistic judgment …
-
- Science is conservative.
-
- Don’t claim effects of an IV that are due to chance.



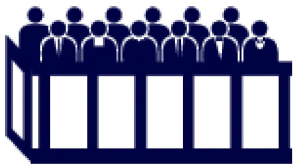
Jury Decision

True State		Guilty	Not Guilty
	Guilty	Hit	Type II Error
	Innocent	Type I Error	Correct Rejection

sending innocent to jail …

letting guilty go free …

- Errors are minimized by better police work, better legal representation, better judges…
  - But let's assume those are what they are …
-
- How do we decide whether someone is guilty or not?
-
- We cannot minimize both kinds of errors…
-
- We need a criterion for our judgments
  - "Guilty beyond a reasonable doubt"
  - Not "Guilty beyond all doubt"

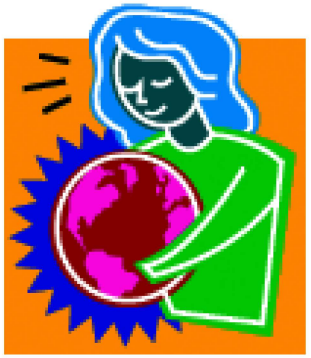


		Jury Decision: Guilty	Jury Decision: Not Guilty
True State	Guilty	Hit	Type II Error
	Innocent	Type I Error	Correct Rejection

Criteria for judgment:

Maximum allowable probability of a Type I error set at:

- 5% - for most basic research
- Much lower % - for medical research or court judgment



True State	Scientist Decision: True Effect	Scientist Decision: No Difference
True Effect	Hit	Type II Error
No Difference	Type I Error	Correct Rejection

False alarm - very costly

Missing a true effect - very unfortunate

The power of replication

- 5% chance of Type I error means 1/20 results could be erroneous…
-
- Chance of a Type I error in Experiment 1: 1/20
- Chance of a Type I error in Experiment 2: 1/20
-
- Chance of a Type I error in both experiments: 1/400 (0.25%)!!!
-

Computer Aided Data Analysis

- Commercial Product
  - SPSS (primarily used by social scientist)
  - SAS (primarily used by medical and clinical trials)
- Freeware (under GNU license)
  - PSPP
  - R
- In this course, we will use PSPP
- Google “PSPP”, you’ll get a copy of the freeware!

Hypothesis Testing

- Before you prove your hypothesis is true, your hypothesis is assumed to be false.
  - Reduce Type I Error.
  - Analogous to the legal principle of “Presumption of Innocence”

- Null Hypothesis H_0
  - The default position
  - A statement of “no effect”, “no difference”, “not better than”, etc
  - The reverse of your proposed hypothesis
- Alternative Hypothesis H_1
  - Your proposed effect

- The Null Hypothesis is usually assumed to be true until you disprove it.
- You suppport your believe by rejecting or disproving the Null Hypothesis H_0.

Null Hypothesis Significance Testing (NHST)

- Null Hypothesis H_0
- Alternative Hypothesis H_1

- Assume that H_0 is correct.
- If your data is not likely to occur by chance (e.g. less than 5% of chance), then you reject the Null Hypothesis

- There are many many types of Null Hypothesis tests:
  - z-test
  - t-test
  - Chi-square test
  - ANOVA (f test)
  - etc …
- Depends on the number of variables (IV and DV), the type of variable (e.g. scale vs. categorical data), paired vs. unpaired data, etc

5 steps for hypothesis proving

1. State the Null Hypothesis H_0 and Alternative Hypothesis H_1.
2. Select the appropriate statistical method.
3. Select a level of significance.
4. Calculate the statistic.
5. Make the decision.

The t-test

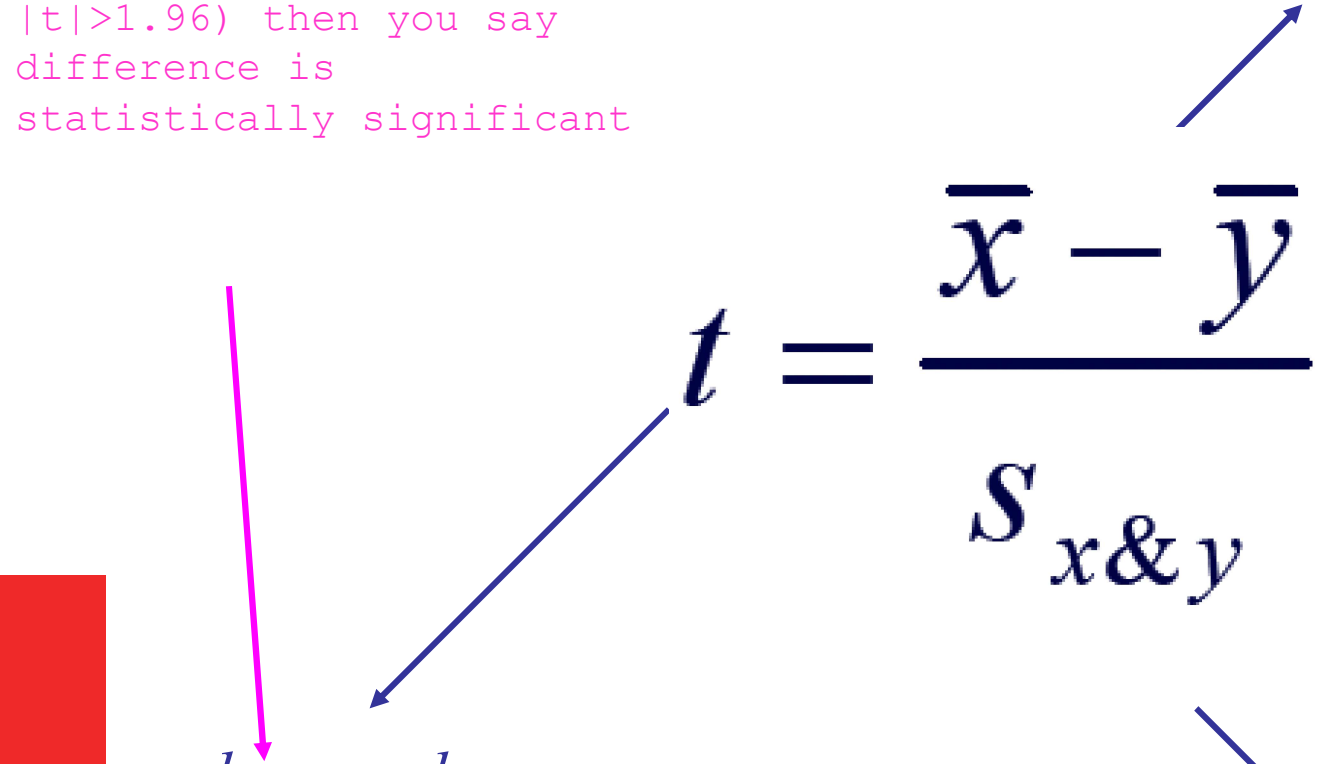
- Originally developed by Gossett for beer quality control (1904)
  - Guiness Brewing Company
  - Variance from the crops is big
    - Unable to create consistent product with same alcoholic content!
  - https://www.youtube.com/watch?v=U9Wr7VEPGXA
- Test hypotheses about population means using small sample sizes
- Used for comparing 2 mean values

Comes in 3 varieties:
- Single sample
- Independent samples
- Dependent samples (paired samples)

t-value

difference between means
(SYSTEMATIC)

if "large enough" (e.g., |t|>1.96) then you say difference is statistically significant



large values indicate statistical significance

variability of both distributions
(ERROR)

difference between means
(SYSTEMATIC)

if "large enough" (e.g., |t|>1.96) then you say difference is statistically significant

$$t = \frac{\bar{x} - \bar{y}}{s_{x\&y}}$$

large values indicate statistical significance

variability of both distributions
(ERROR)

- What is the meaning of a "0" t-value?
  - When t=0; the difference between the population mean and the sample mean is **zero**.
  - => The population mean is exactly equals to the null hypothesis
  - => The null hypothesis is proved! (i.e. Your alternative hypothesis is disproved!)

difference between means
(SYSTEMATIC)

if "large enough" (e.g., |t|>1.96) then you say difference is statistically significant

$$t = \frac{\bar{x} - \bar{y}}{s_{x\&y}}$$

large values indicate statistical significance

variability of both distributions
(ERROR)

- What is the meaning when the absolute value of t-value is **small**?
  - There is a difference between the population mean and the sample mean but it is SMALL. [the nominator]
  - But the variability of both distribution is BIG. [the denominator]
  - => The chance of the null hypothesis is high! (i.e. The chance of your alternative hypothesis is low!)

difference between means
(SYSTEMATIC)

if "large enough" (e.g., |t|>1.96) then you say difference is statistically significant

$$t = \frac{\bar{x} - \bar{y}}{s_{x\&y}}$$

large values indicate statistical significance

variability of both distributions
(ERROR)

- What is the meaning when the absolute value of t-value is **big**?
  - There is a difference between the population mean and the sample mean but it is BIG. [the nominator]
  - But the variability of both distribution is SMALL. [the denominator]
  - => The chance of the null hypothesis is low! (i.e. The chance of your alternative hypothesis is high!)

The *t* Distribution

We use *t* when

1. the population variance is unknown (the usual case), and
2. sample size is small (N<100, the usual case).

The *t* distribution is a short, fat relative of the normal.
The shape of *t* depends on its *df (df = N-1).* As *N* becomes infinitely large, *t* becomes normal.

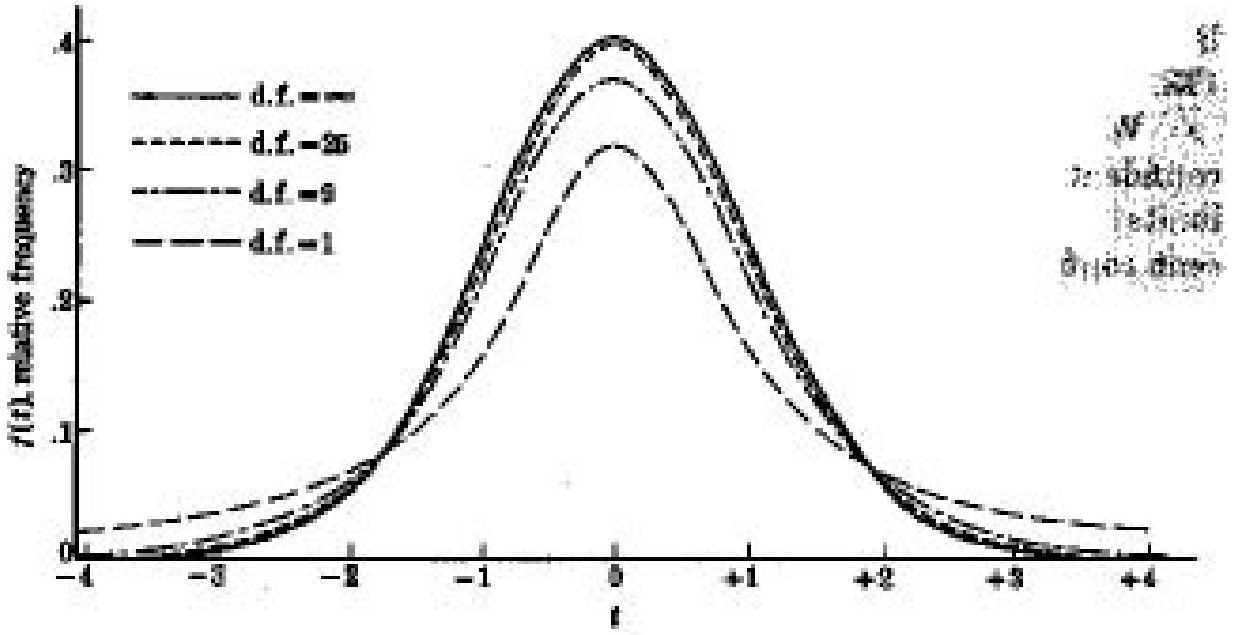
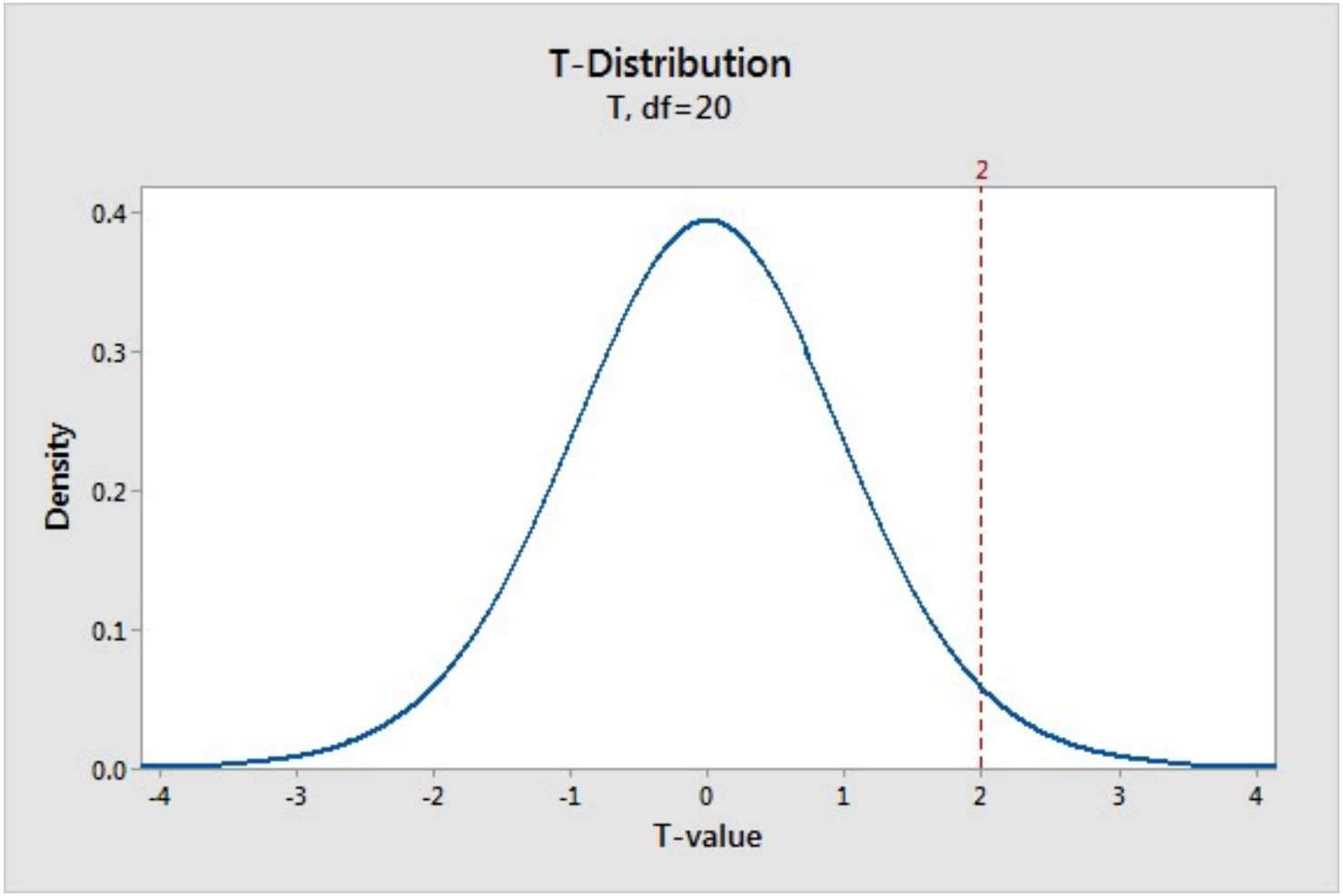


fig. 10.1 Distribution of *t* for various degrees of freedom. *(From D. Lewis, quantitative methods in psychology, McGraw-Hill Book Company, New York, 1960.)*

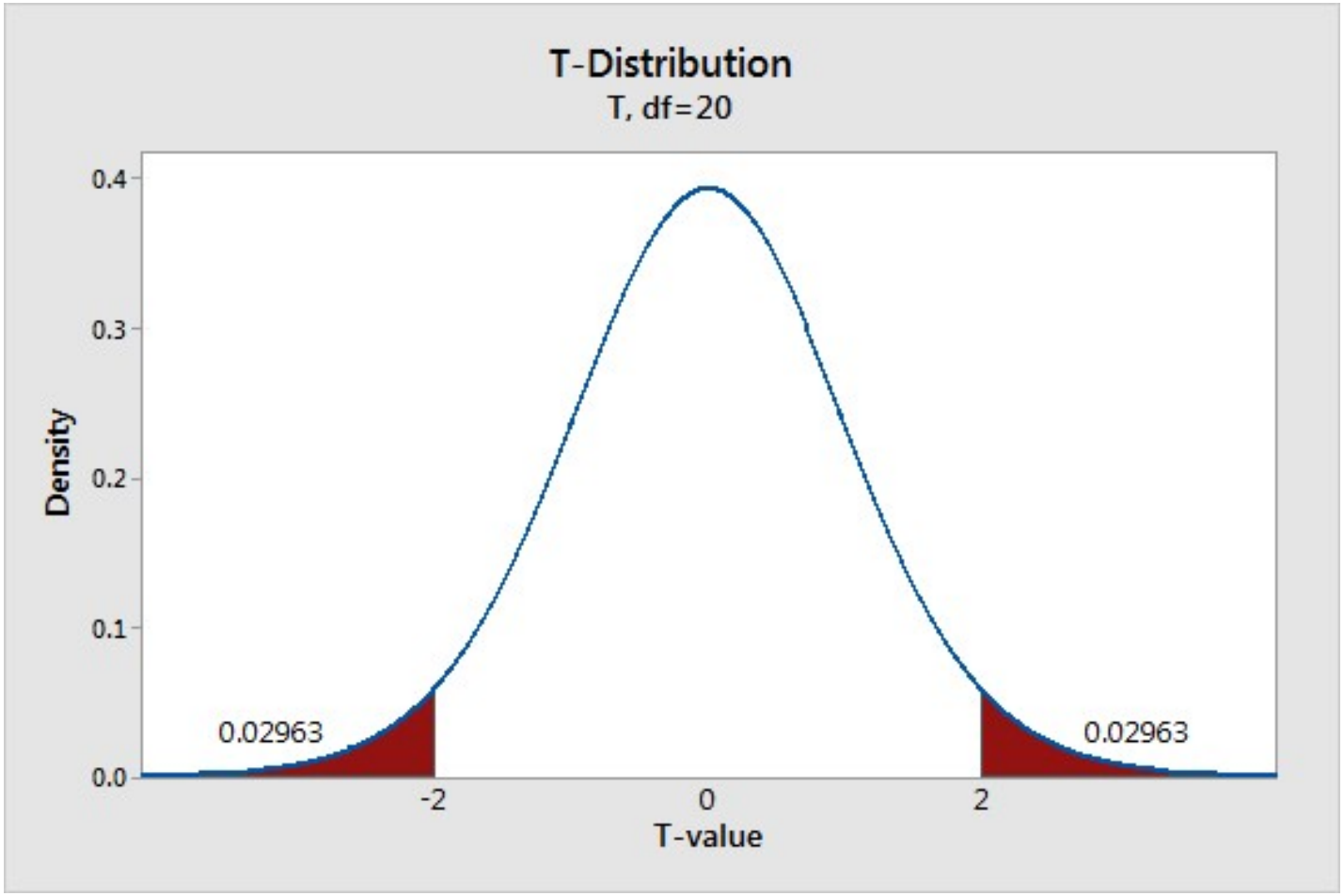
The t-distribution

- What is the meaning when you have a t-value of 2?



The t-distribution

What is the meaning when you have a t-value of 2?

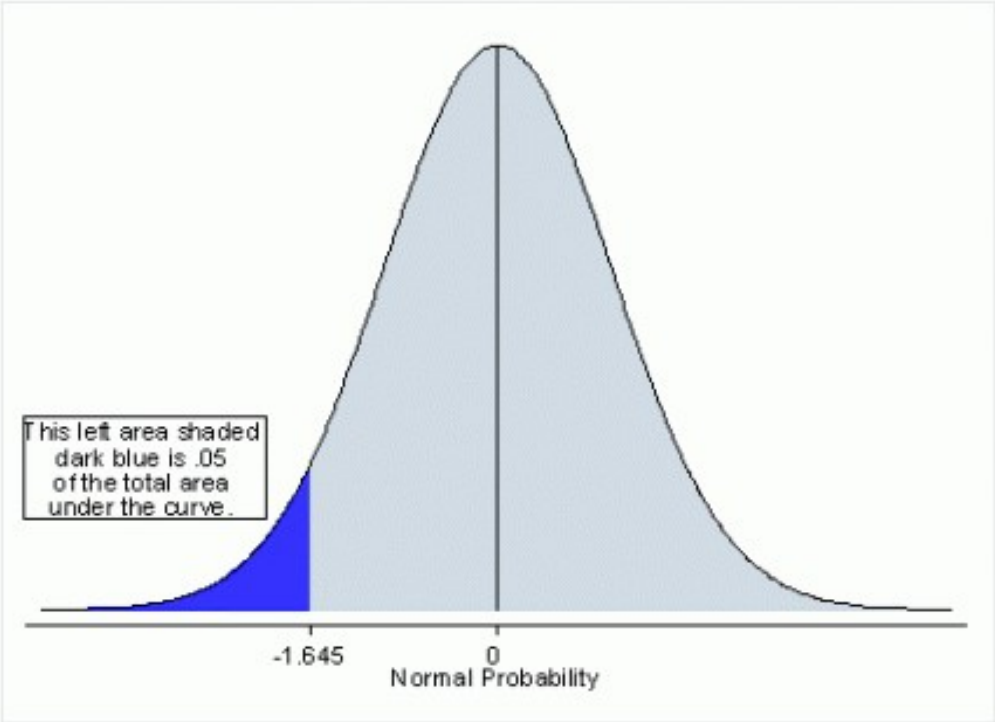


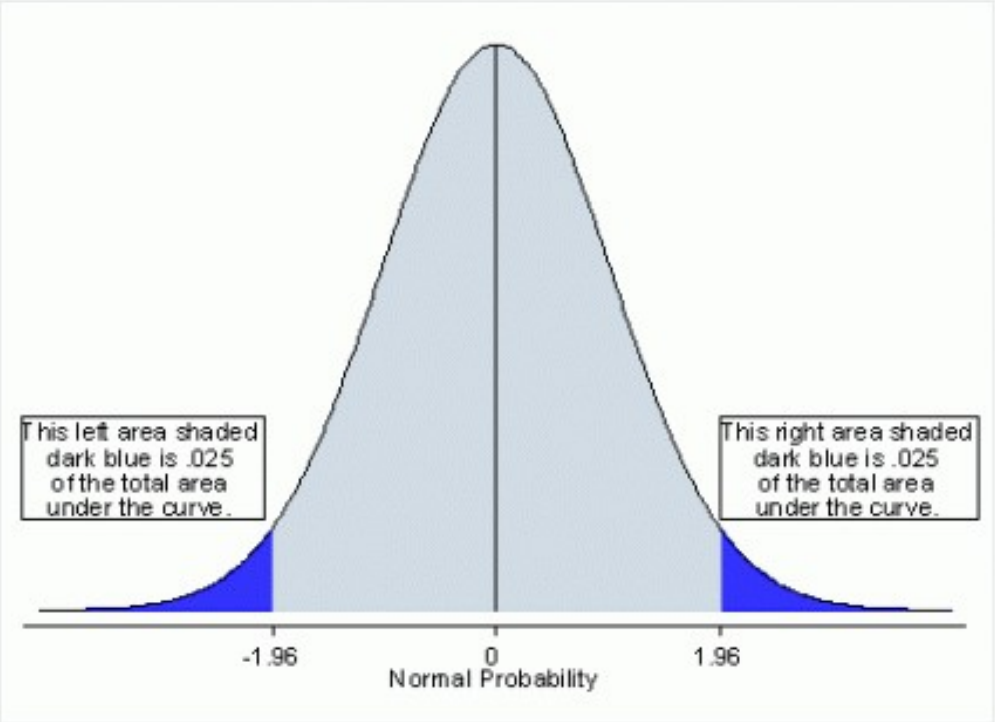
The probability for observing a difference from the null hypothesis that is at least as extreme as the difference present in our sample data while assuming that the null hypothesis is actually true – 5.962%.

This is called the p-value!

1-tailed vs. 2-tailed

- The t-value to achieve a significant level of 0.05 is:
  - 1-tailed – 1.645
  - 2-tailed – 1.96





2-tailed

- When you are comparing if the 2 mean values are the same.

1-tailed

- When you are comparing if one of the mean value significantly bigger/smaller than the other.