Lecture 21: Inferential Statistics

Friday, November 10, 2023

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Lectures: MWF 12:00 PM – 1:00 PM (003); 1:00 PM – 2:00 PM (004); 2:00 PM – 3:00 PM (010)
Office hours: Tuesdays 2:00 PM – 4:00 PM

How to study?

- More retrieval reinforces learning, leads to better recall

- Focus on rereading indicative of emphasizing “encoding” aspect of memory, not the “retrieval” aspect of memory
  - But repeated retrieval actually prevents forgetting due to repeated practice

How to study?

- What we obtained were mean differences between groups
    - How likely are these differences due to chance rather than a real effect of study method?

How to study?

Null Hypothesis

- Mean 1 = Mean 2
- H_0
- **True effect:** Study technique does not affect memory retention
- Differences between groups are most likely **due to random chance**

Research Hypothesis

- Mean 1 ≠ Mean 2
- H_1 or H_A
- **True effect:** Study technique affects memory retention
- Differences between groups are **unlikely to be due to random chance**

Directional vs. Non-directional Hypotheses

Null Hypothesis

- Mean 1 ≤ Mean 2
- H_0
- **True effect**: Repeated retrieval does not lead to better memory retention than solely studying
- **Random chance likely caused** Mean 1 > Mean 2 in our sample

Research Hypothesis

- Mean 1 > Mean 2
- H_1 or H_A
- **True effect:** Repeated retrieval leads to better memory retention than solely studying
- **Random chance is a very *unlikely*** explanation that Mean 1 > Mean 2 in our sample

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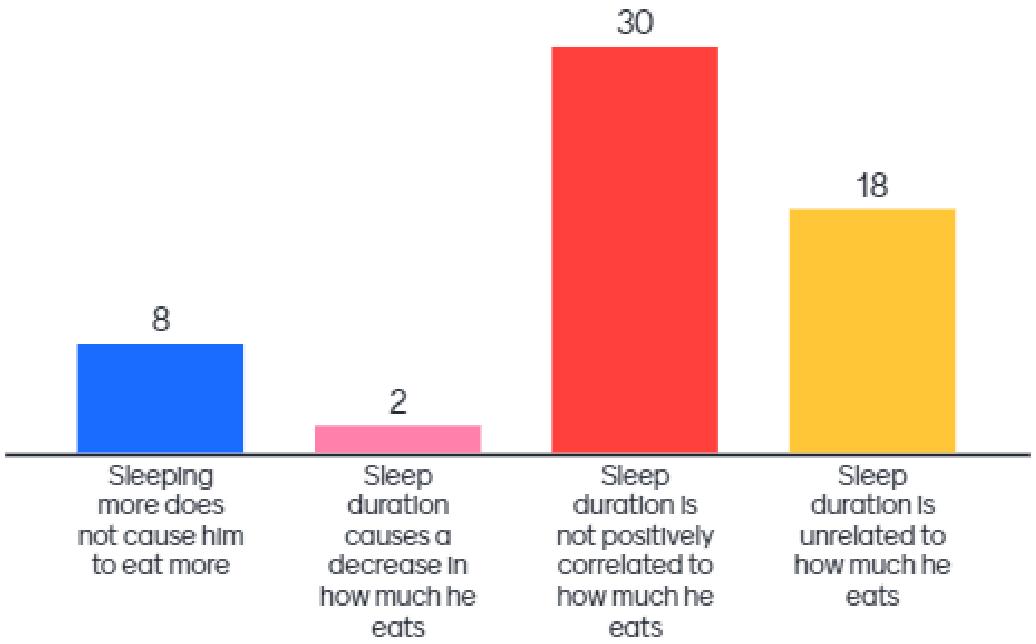
Mentimeter

Charles is doing a study to see if there's a relationship between how much he sleeps and how much food he can eat.



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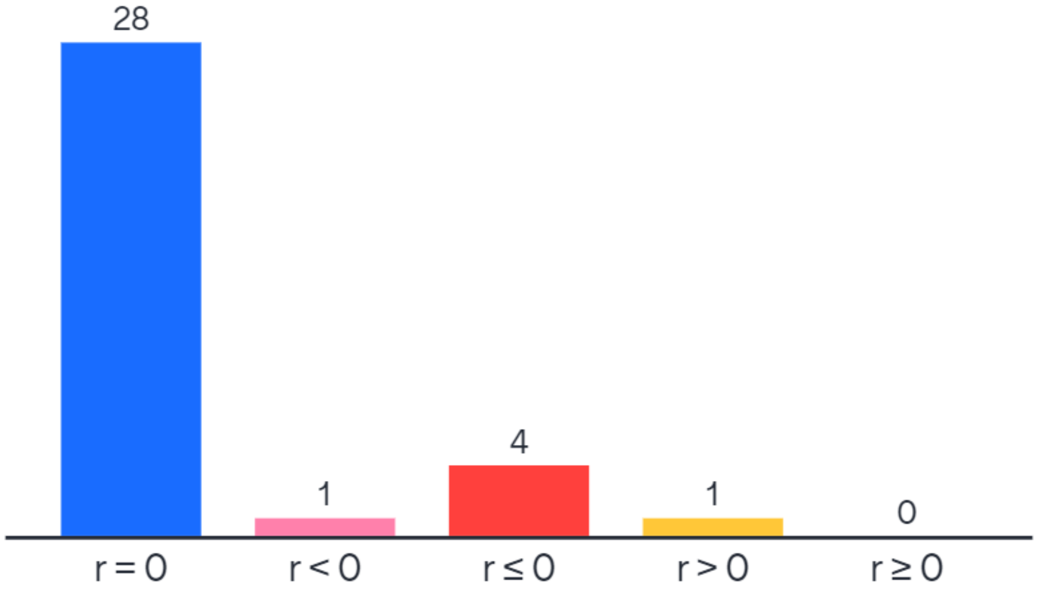
Charles is doing a study to see if there's a relationship between how much he sleeps and how much he can eat.



Due to chance...?

- Key part of interpretation:
  - Was the difference due to chance, or does it reflect a real difference in the population?

- Whether something is due to chance is always the most parsimonious alternative explanation for any research finding
  - When analysing data, start by assuming that the null hypothesis is true
  - Can we reject the null hypothesis?

Learning objectives

- By the end of this class, you'll be able to
  - Explain the relationship between a sample and a population
  - Explain how a sampling distribution is made
  - List the 3 steps in hypothesis testing
  - Explain the logic of the numerator and the denominator in the *t*-ratio
  - Differentiate between Type I and Type II errors

Large vs. small samples

- Small samples subject to more error in estimating population value
- Even with random assignment, problem still remains
- Random assignment works best with large sample sizes
  - Chance plays major role in statistical analysis and research methods!

Precursor for next session: When an effect does not exist in the population, but we conclude that there is an effect → Type 1 error

Statistically significance? Easy as 1-2-3!

1. Calculate a statistic that captures the effect.
   - E.g., % (Chi square), mean difference (*t* or *F* value) , correlation (*r*)…
2. Refer to a sampling distribution for comparison
   - For this sample size, what is an expected statistic value *if there actually is NO effect going on.*
3. Make a decision
   - Is our statistic value sufficiently rare to consider it *significant*?
   - If yes, reject the null hypothesis (LET’S PUBLISH!)
   - If no, retain the null hypothesis (CRY IN A CORNER!)

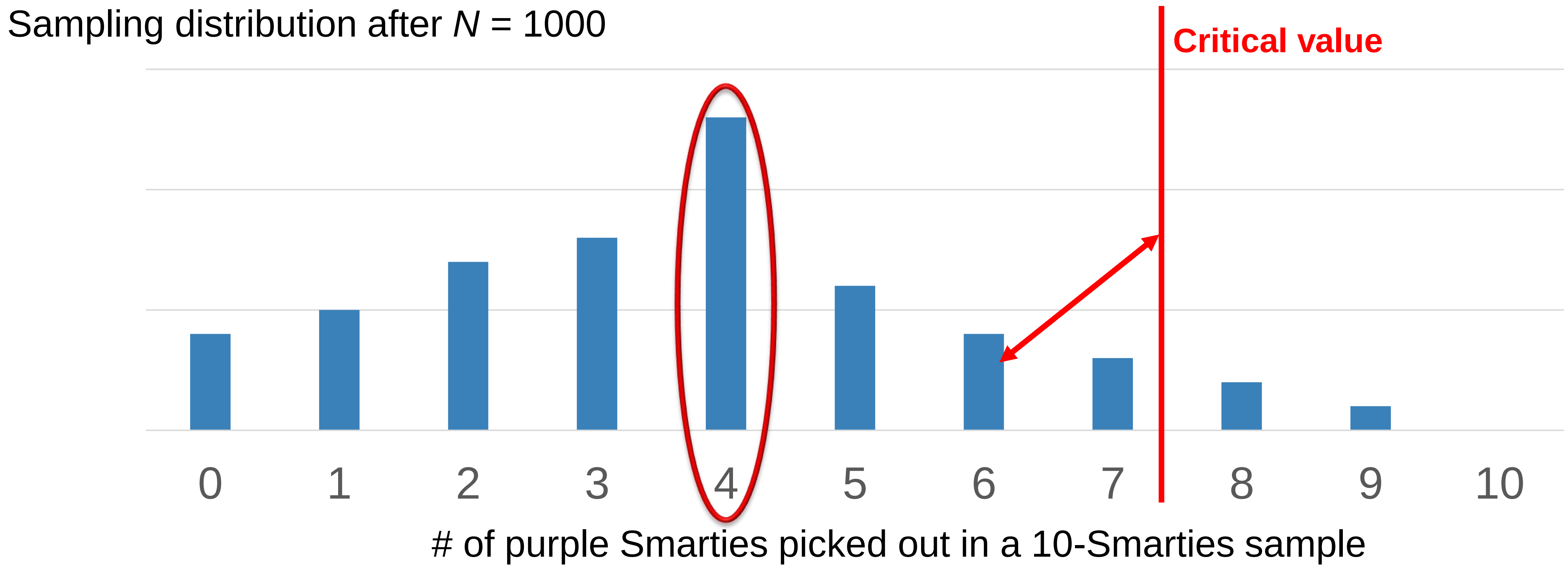
Basics of sampling distribution

- Sampling distribution:
  - Probability distribution of any statistic of interest assuming the null hypothesis is true (i.e. random chance)
  - What it answers: What statistical result would you get from your data if your effects were only due to random chance?

Basics of sampling distribution

- My claim: While blindfolded, I have magical powers that no one else has, so more than half that I pick out will be purple Smarties in a sample of 10 Smarties
- What we need to know: How many purple Smarties would someone pull out at random in 10 Smarties?
- What we want: Sampling distribution for the number of purple Smarties in a sample of 10 Smarties
    1. First: Get 1000 blindfolded students to take samples of 10 Smarties from a giant Smarties bag
    2. Then: Determine how likely it is to pick out any number of purple Smarties by chance

Basics of sampling distribution



- Decide on what's a rare # of purples as threshold = Critical value
- How does my performance compare to critical value?
- Similar to sampling distributions for other statistics

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Get ready, because…

t-test

- A statistical technique: is difference between two means something to be expected from random chance … *if the null hypothesis is true*?

- If <u>*t* obtained</u> exceeds <u>critical *t*</u> value: suggests that the H_0 might not be true

Determining if two means are significantly different from each other

- 1. Find "obtained *t*" value
  - Use formula to convert the mean difference and standard deviation into a *t* value
- 2. Refer to sampling distribution of *t* values
  - Find "critical *t*" value for that df and alpha
  - From the table (Appendix C, Table C.2)
  - *Don't need to find this for 217*
- 3. Make a decision
  - Is our statistic value sufficiently rare to consider it *significant?*
  - Is absolute value of $|t_{obt}| > |t_{crit}|$?
    - If yes, reject the null hypothesis
    - If no, retain the null hypothesis

Inferential Statistics Overview

- Null & Research Hypotheses
- Sampling distribution
- *t*-test logic
- Statistically significant
- Type 1 and Type 2 errors
- Apply your understanding

Finding t_{obt}

Mean of Group 1

Mean of Group 2

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Variance of Group 1

Variance of Group 2

Sample size of Group 1

Sample size of Group 2

Finding t_{obt}

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Numerator:
How big is the difference?

Denominator:
How much variation exists around the means?

Finding t_{obt}

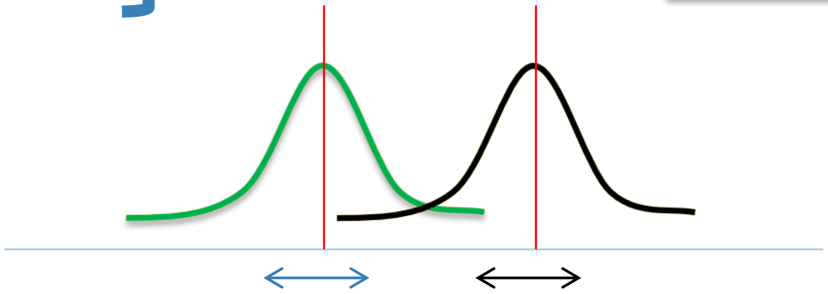
$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

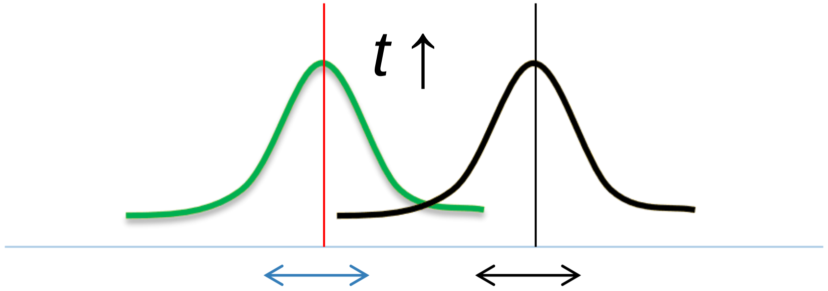
Signal / Effect

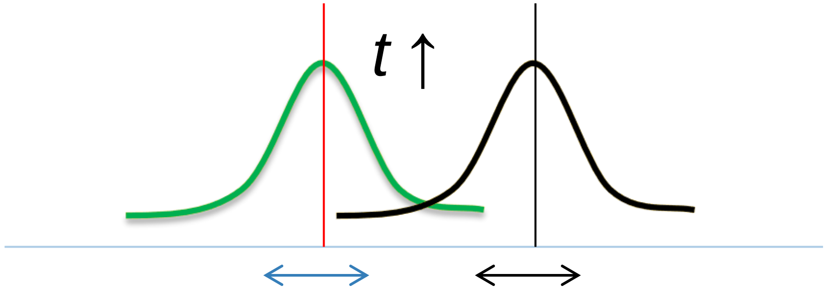
Noise / Error

Between-Group Difference

Within-Group Variability







Rank the following in terms of t(obt) with greatest value being Rank 1