Review of hypothesis tests

Overview

Review of randomization tests for a proportion

Randomization tests for two means using a t-statistic

Parametric tests for two means using a t-statistic (t-test)

Randomization tests for more than two means (if there is time)

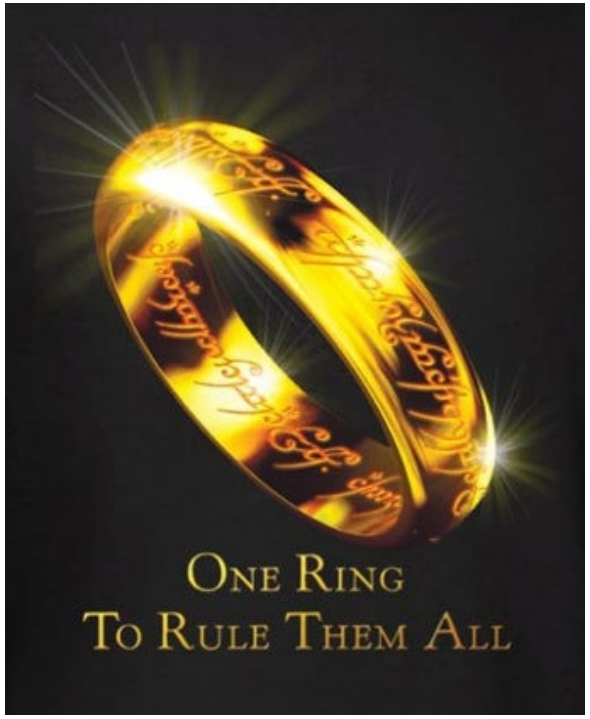
Study groups

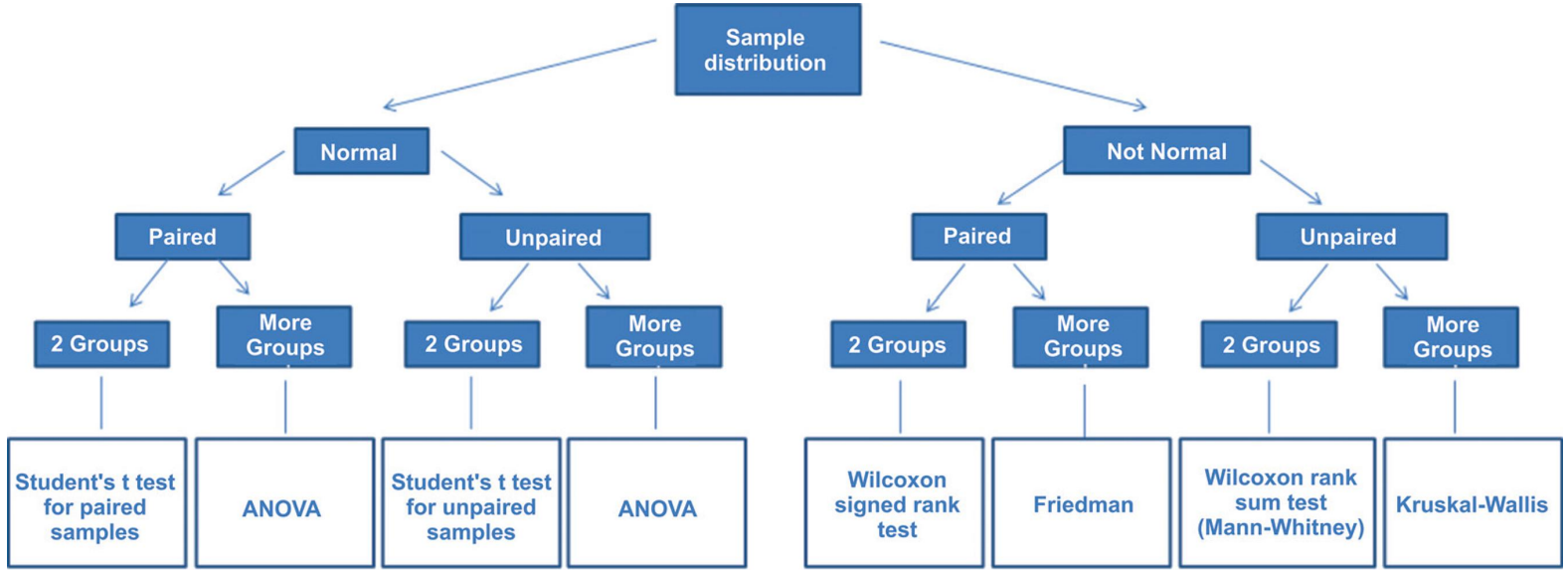
The ULAs are organizing study groups which is opportunity to meet your peers, work on PSETs, and study for exams

- 10-12 students per group

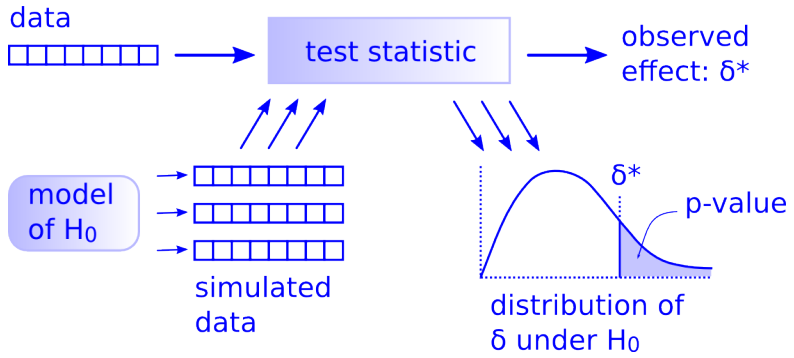
Please sign up by this Friday at 9am:
https://forms.gle/8mXqwhBxa6VoVyZG6

The big picture: There is only one hypothesis test!

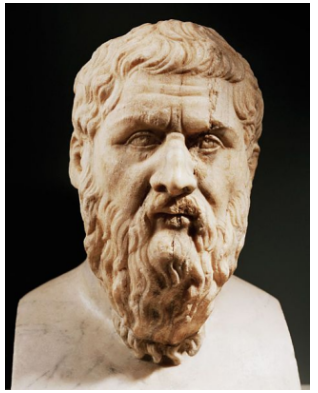




Just need to follow 5 steps!

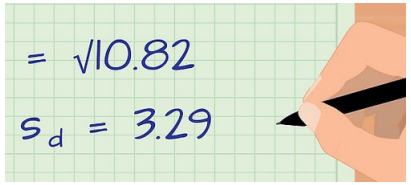


Five steps of hypothesis testing

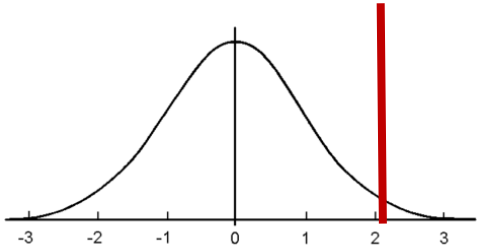


1. State H_0 and H_A
   - Assume Gorgias (H_0) was right
   - α = .05 of the time he will be right, but we will say he is wrong

2. Calculate the actual observed statistic



3. Create a distribution of what statistics would look like if Gorgias is right
   - Create the **null distribution** (that is consistent with H_0)



4. Get the probability we would get a statistic more than the observed statistic from the null distribution
   - p-value

5. Make a judgement
   - Assess whether the results are statistically significant

Review: hypothesis test for a single proportion

Joy Milne claimed to have the ability to smell whether someone had Parkinson's disease

To test this claim researchers gave Joy 6 shirts that had been worn by people who had Parkinson's disease and 6 shirts by people who did not

Joy identified 11 out of the 12 shirts correctly

Were the answers to the survey questions clear?

1. What are the cases in this experiment?

2-3. What is the variable of interest, and is it categorical or quantitative?

4-5. What is the observed statistic - and what symbols should we use to denote it?

6. What is the population parameter we are trying to estimate, and what symbol should we use to denote it?

7. Do you think the results are due to chance?
   - i.e., do you think Joy got 11 correct answers by guessing?

8. Do you believe Joy can really smell whether someone has Parkinson's disease?

Do you think the results are due to chance?

- i.e., do you think Joy got 11 correct answers by guessing?

Yes, I think she was guessing	21 respondents	**25 %**	
No, these results are too unlikely to be due to chance	63 respondents	74 %	

```
obs_stat <- 11/12
flip_sims_prop <- rbinom(10000, 12, .5)/12
p_value <- sum(flip_sims_prop >= obs_stat)/length(flip_sims)
```

p-value is 0.0029

Should we reject H_0?

Do you believe Joy can really smell whether someone has Parkinson's disease?

Yes, I believe she can smell Parkinson's disease!	44 respondents	52 %	
No, I do not believe she can smell Parkinson's disease!	41 respondents	48 %	

What do you currently think about Joy's ability?

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TREATMENTS

Her Incredible Sense Of Smell Is Helping Scientists Find New Ways To Diagnose Disease

March 23, 2020 · 4:45 PM ET

Is the smelling Parkinson's disease study an experiment or observational study?

Parkinson's disease study is observational	49 respondents	58 %	
Parkinson's disease study is an experiment	36 respondents	42 %	

An **experiment** is a study in which the researcher actively controls one or more of the explanatory variables

- Allows one to get at questions of **causation**!

An **observational study** is a study in which the researcher does not actively control the value of any variable but simply observes the values as they naturally exist

How do we feel about hypothesis tests for proportions?

More examples during extra office hours tomorrow

brief communications

Adult persistence of head-turning asymmetry

A neonatal right-side preference makes a surprising romantic reappearance later in life.

A preference in humans for turning the head to the right, rather than to the left, during the final weeks of gestation and for the first six months after birth[1,2] constitutes one of the earliest examples of behavioural asymmetry and is thought to influence the subsequent development of perceptual and motor preferences by increasing visual orientation to the right side[3,4]. Here I show that twice as many adults turn their heads to the right as to the left when kissing, indicating that this head-motor bias persists into adulthood. My finding may be linked to other forms of sidedness (for example, favouring the right foot, ear or

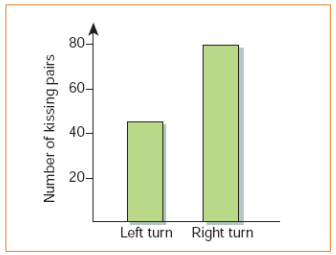
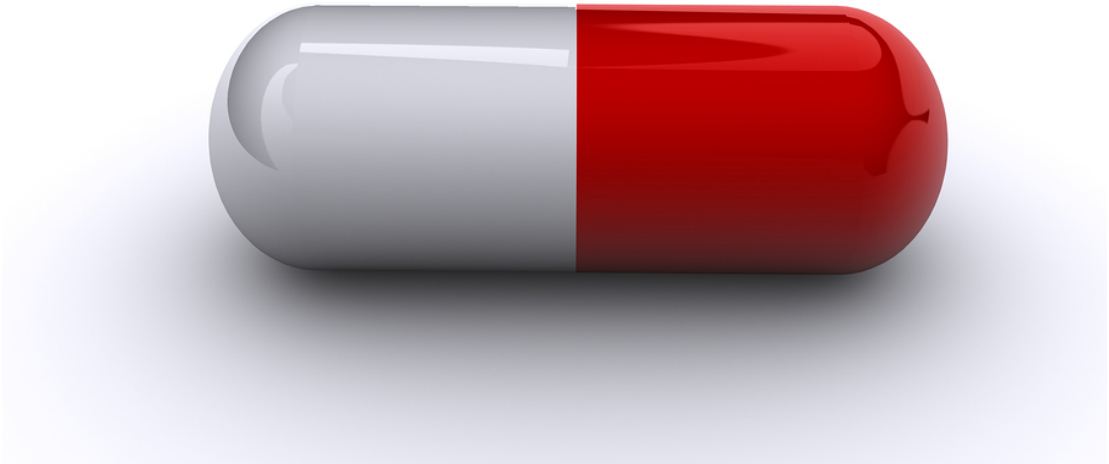


Figure 1 The number of couples who turn their heads to the right rather than to the left when kissing predominates by almost 2:1 (64.5%: 35.5%; $n = 124$ couples).

Hypothesis tests for comparing two means

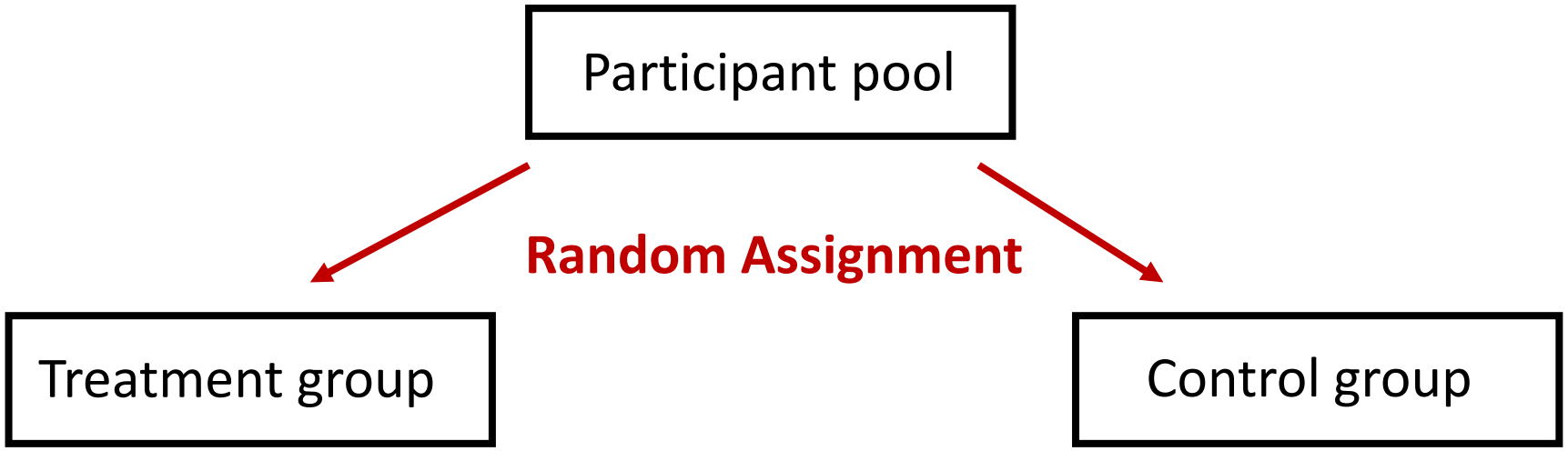


Question: Is this pill effective?

Experimental design

Take a group of participant and ***randomly assign***:

- Half to a *treatment group* where they get the pill
- Half in a *control group* where they get a fake pill (placebo)
- See if there is more improvement in the treatment group compared to the control group



Is this drug study an experiment or observational study?

The drug study observational	7 respondents	8 %	
The drug study is an experiment	69 respondents	81 %	

An **experiment** is a study in which the researcher actively controls one or more of the explanatory variables

- Allows one to get at questions of **causation**!

An **observational study** is a study in which the researcher does not actively control the value of any variable but simply observes the values as they naturally exist

Hypothesis tests for differences in two group means

1. State the null and alternative hypothesis
   - H_0: $\mu_{Treatment} = \mu_{Control}$ or $\mu_{Treatment} - \mu_{Control} = 0$
   - H_A: $\mu_{Treatment} > \mu_{Control}$ or $\mu_{Treatment} - \mu_{Control} > 0$

2. Calculate statistic of interest

The statistic used before: $\bar{x}_{Effect} = \bar{x}_{Treatment} - \bar{x}_{Control}$

Let's try a t-statistic instead: $$t = \frac{\bar{x}_t - \bar{x}_c}{\sqrt{\frac{s_t^2}{n_t} + \frac{s_c^2}{n_c}}}$$

Does calcium reduce blood pressure?

Treatment data (n = 10):

Begin	107	110	123	129	112	111	107	112	136	102
End	100	114	105	112	115	116	106	102	125	104
Decrease	**7**	**-4**	**18**	**17**	**-3**	**-5**	**1**	**10**	**11**	**-2**

Control data (n = 11):

Begin	123	109	112	102	98	114	119	112	110	117	130
End	124	97	113	105	95	119	114	114	121	118	133
Decrease	**-1**	**12**	**-1**	**-3**	**3**	**-5**	**5**	**2**	**-11**	**-1**	**-3**

2. What is the observed statistic of interest?
   - t = 1.604

$$t = \frac{\bar{x}_t - \bar{x}_c}{\sqrt{\frac{s_t^2}{n_t} + \frac{s_c^2}{n_c}}}$$

3. What is step 3?

3. Create the null distribution!

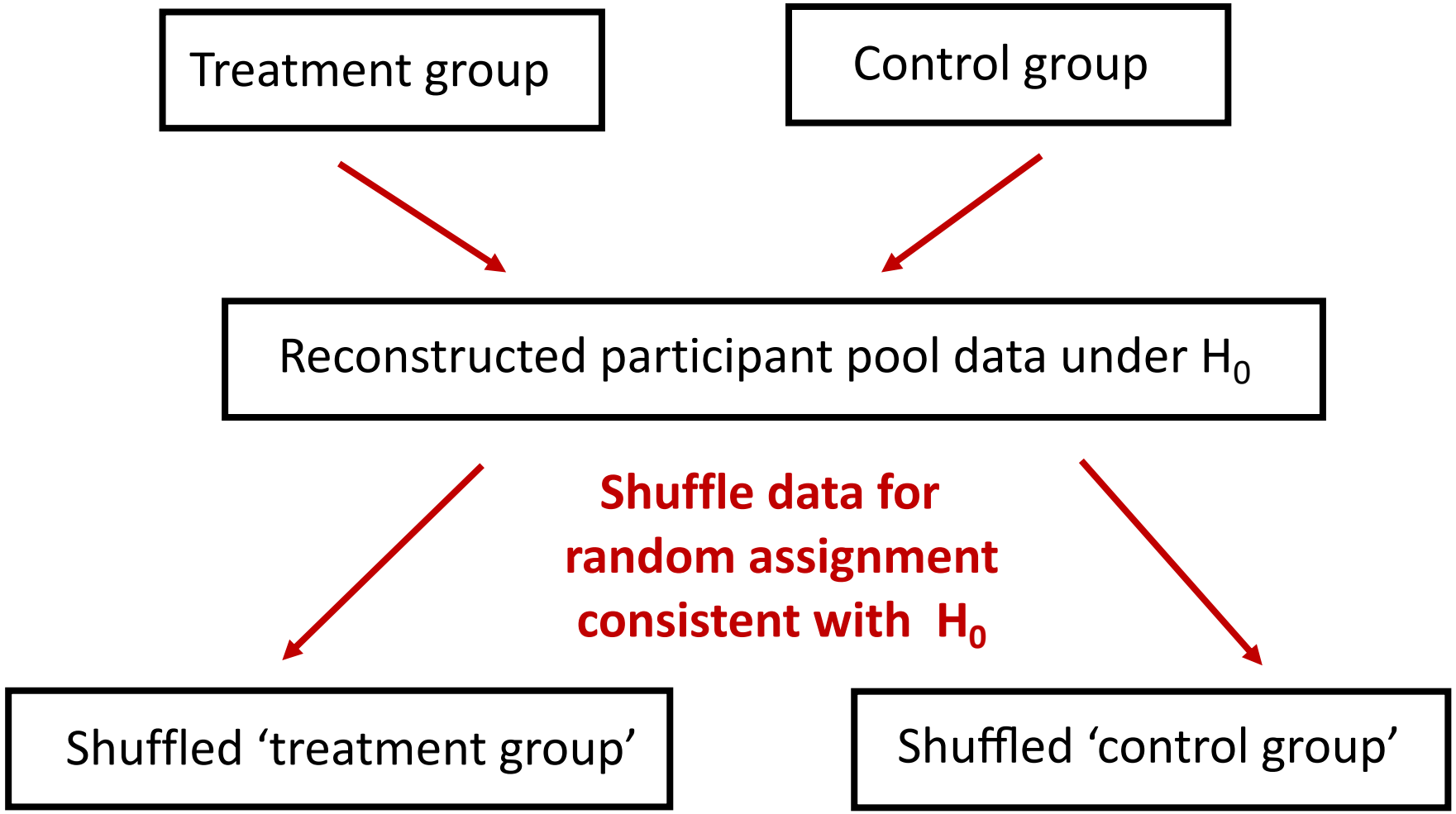
How could we create the null distribution?

Need to generate data consistent with H_0: $\mu_{Treatment} - \mu_{Control} = 0$

- i.e., we need fake t-statistics that are consistent with H_0

How can we could do this?

3. Create the null distribution!



One null distribution statistic: t_{shuff}

3. Create a null distribution

1. Combine data from both groups

2. Shuffle data

3. Randomly select 10 points to be the ‘null’ treatment group

4. Take the remaining 11 points to the ‘null’ control group

5. Compute the statistic of interest on these ‘null’ groups

6. Repeat 10,000 times to get a null distribution

Let’s try the rest of the hypothesis test in R…