In-person session 6

February 17, 2022

PMAP 8521: Program evaluation
Andrew Young School of Policy Studies

Plan for today

Exam 1

FAQs

Confidence intervals, credible intervals, and a crash course on Bayesian statistics

Exam 1

Tell us about Exam 1!

FAQs

Are *p*-values really misinterpreted in published research?

Power calculations and sample size

Won't we always be able to find a significant effect if the sample size is big enough?

Yes!

Math with computers

andhs.co/live

Are the results from p-hacking actually a threat to validity?

Do people actually post their preregistrations?

Yes!

OSF

See this and this for examples

As Predicted

See this

Do you have any tips for identifying the threats to validity in articles since they're often not super clear?

Especially things like spillovers, Hawthorne effects, and John Henry effects?

Using a control group of some kind seems to be the common fix for all of these issues.

What happens if you can't do that? Is the study just a lost cause?

Confidence intervals, credible intervals, and a crash course on Bayesian statistics

In the absence of p-values, I'm confused about how we report... significance?

Imbens and p-values

Nobody really cares about p-values

**Decision makers want to know
a number or a range of numbers—
some sort of effect and uncertainty**

**Nobody cares how likely a number would be
in an imaginary null world!**

Imbens's solution

Report point estimates and some sort of range

> "It would be preferable if reporting standards emphasized confidence intervals or standard errors, and, even better, Bayesian posterior intervals."

Point estimate

The single number you calculate (mean, coefficient, etc.)

Uncertainty

A range of possible values

Greek, Latin, and extra markings

Statistics: use a sample to make inferences about a population

Greek

Letters like β_1 are the ***truth***

Letters with extra markings like $\hat{\beta}_1$ are our ***estimate*** of the truth based on our sample

Latin

Letters like X are ***actual data*** from our sample

Letters with extra markings like $\bar{X}$ are ***calculations*** from our sample

Estimating truth

Data → Calculation → Estimate → Truth

Data	X
Calculation	$\bar{X} = \frac{\sum X}{N}$
Estimate	$\hat{\mu}$
Truth	μ

$$\bar{X} = \hat{\mu}$$

$$X \rightarrow \bar{X} \rightarrow \hat{\mu} \xrightarrow{\text{🤞 hopefully 🤞}} \mu$$

Population parameter

Truth = Greek letter

An single unknown number that is true for the entire population

Proportion of left-handed students at GSU

Median rent of apartments in NYC

Proportion of red M&Ms produced in a factory

ATE of your program

Samples and estimates

We take a sample and make a guess

This single value is a *point estimate*

(This is the Greek letter with a hat)

Variability

**You have an estimate,
but how different might that
estimate be if you take another sample?**

Left-handedness

You take a random sample of 50 GSU students and 5 are left-handed.

If you take a different random sample of 50 GSU students, how many would you expect to be left-handed?

3 are left-handed. Is that surprising?

40 are left-handed. Is that surprising?

Nets and confidence intervals

How confident are we that the sample picked up the population parameter?

Confidence interval is a net

We can be X% confident that our net is picking up that population parameter

If we took 100 samples, at least 95 of them would have the true population parameter in their 95% confidence intervals

> A city manager wants to know the true average property value of single-value homes in her city. She takes a random sample of 200 houses and builds a 95% confidence interval. The interval is ($180,000, $300,000).

We're 95% confident that the interval ($180,000, $300,000) captured the true mean value

WARNING

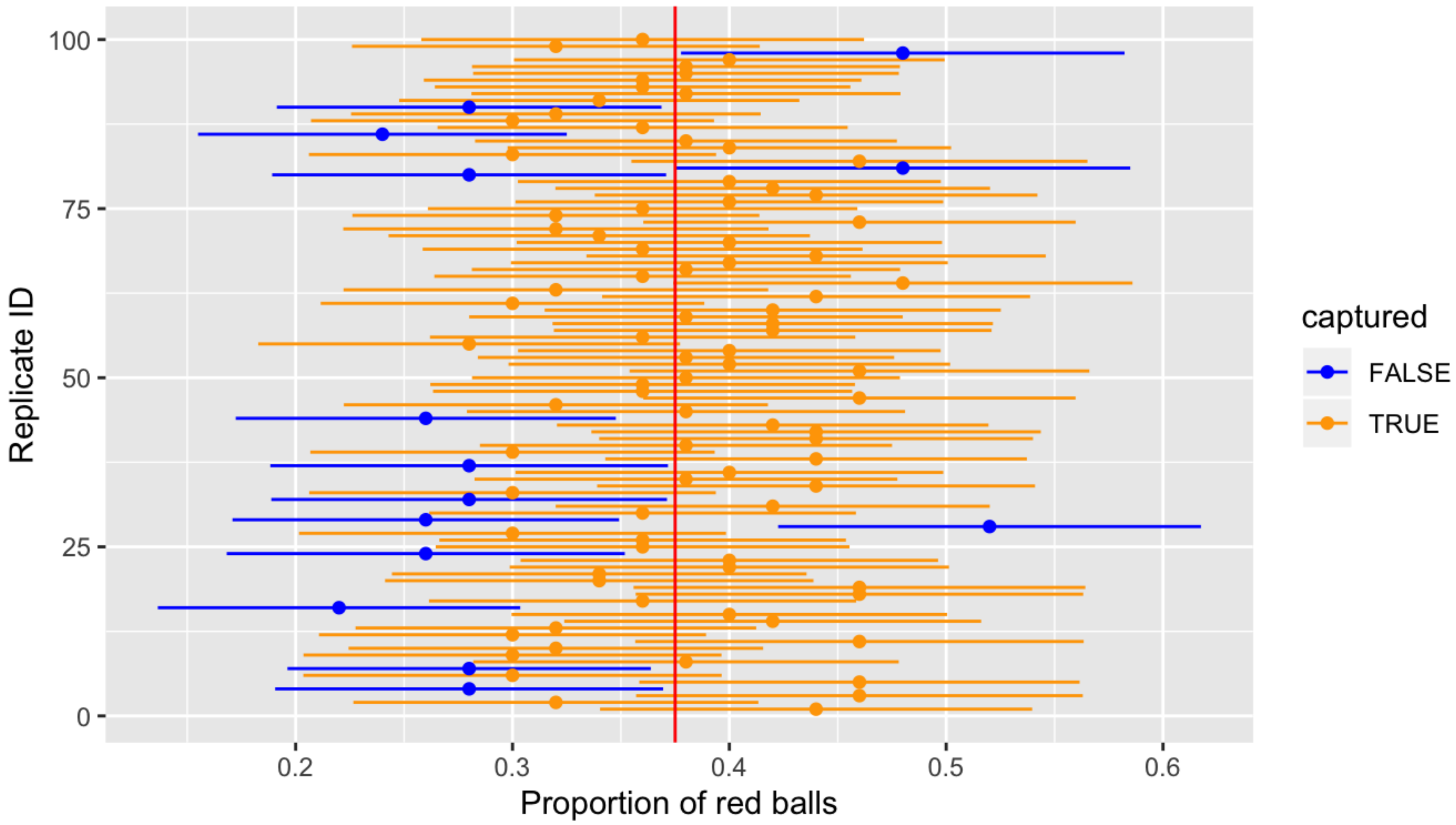
It is way too tempting to say "We're 95% sure that the population parameter is X"

People do this all the time! People with PhDs!

YOU will try to do this too

Nets

**If you took lots of samples,
95% of their confidence intervals
would have the single true value in them**


100
75
50
25
0
Replicate ID
0.2
0.3
0.4
0.5
0.6
Proportion of red balls
captured
FALSE
TRUE

Frequentism

This kind of statistics is called "frequentism"

The population parameter θ is fixed and singular while the data can vary

$$P(\text{Data} \mid \theta)$$

You can do an experiment over and over again; take more and more samples and polls

Frequentist confidence intervals

"We are 95% confident that this net captures the true population parameter"

~~"There's a 95% chance that the true value falls in this range"~~

Weekends and restaurant scores

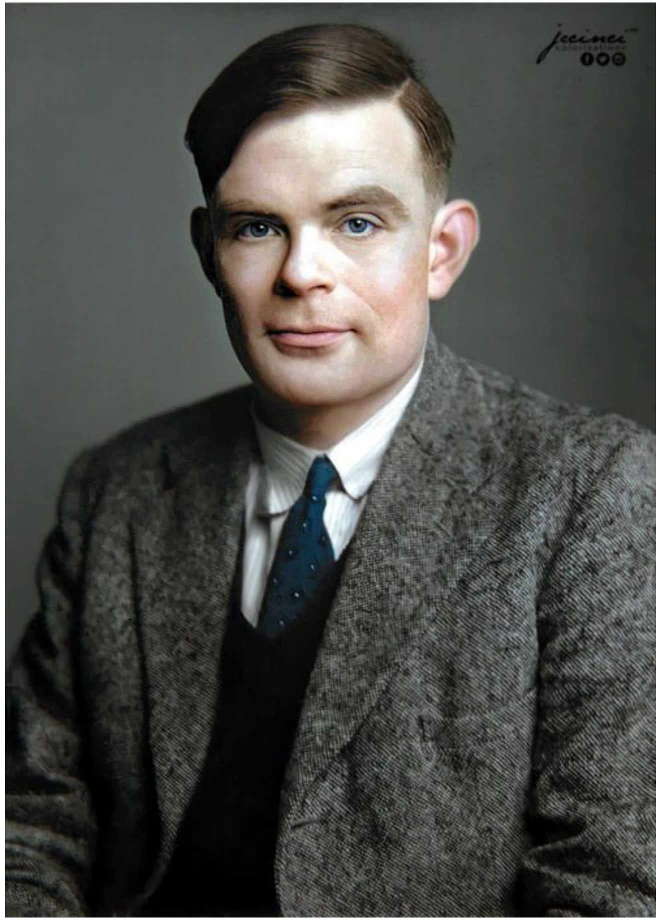
Bayesian statistics

Rev. Thomas Bayes

$$P(\theta \mid \text{Data})$$

$$P(\text{H} \mid \text{E}) = \frac{P(\text{H}) \times P(\text{E} \mid \text{H})}{P(\text{E})}$$

Bayesianism in WWII



Alan Turing

An enigma machine

$$P(\mathrm{H} \mid \mathrm{E}) = \frac{P(\mathrm{H}) \times P(\mathrm{E} \mid \mathrm{H})}{P(\mathrm{E})}$$

$$P(\text{Hypothesis} \mid \text{Evidence}) = \frac{P(\text{Hypothesis}) \times P(\text{Evidence} \mid \text{Hypothesis})}{P(\text{Evidence})}$$

$$P(\mathrm{H} \mid \mathrm{E}) = \frac{P(\mathrm{H}) \times P(\mathrm{E} \mid \mathrm{H})}{P(\mathrm{E})}$$

▼

$$\overbrace{P(\text{Unknown} \mid \text{Data})}^{\text{Posterior}} = \frac{\overbrace{P(\text{Unknown})}^{\text{Prior}} \times \overbrace{P(\text{Data} \mid \text{Unknown})}^{\text{Likelihood}}}{\underbrace{P(\text{Data})}_{\text{Average likelihood}}}$$

$$\overbrace{P(\text{Unknown} \mid \text{Data})}^{\text{Posterior}} = \frac{\overbrace{P(\text{Unknown})}^{\text{Prior}} \times \overbrace{P(\text{Data} \mid \text{Unknown})}^{\text{Likelihood}}}{\underbrace{P(\text{Data})}_{\text{Average likelihood}}}$$

▼

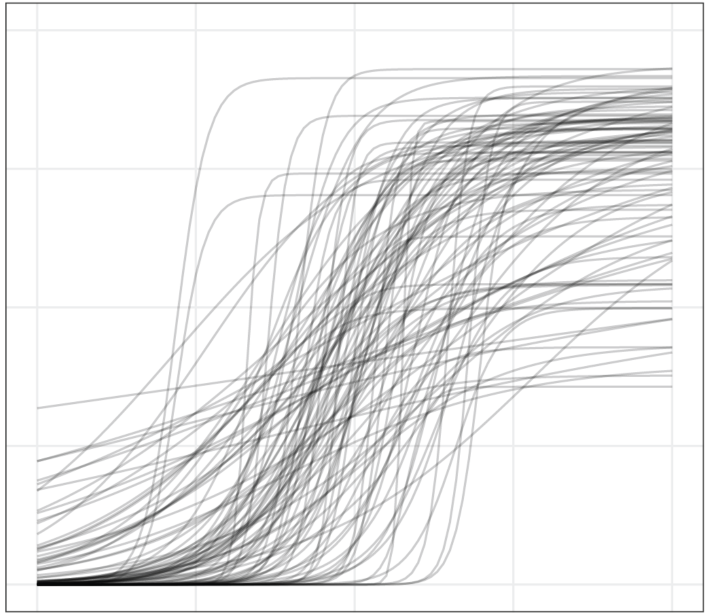
$$\overbrace{P(\text{Unknown})}^{\text{Prior}} \times \overbrace{P(\text{Data} \mid \text{Unknown})}^{\text{Likelihood}} \propto \overbrace{P(\text{Unknown} \mid \text{Data})}^{\text{Posterior}}$$

Bayesian statistics and more complex questions

$$\overbrace{P(\text{Unknown})}^{\text{Prior}} \times \overbrace{P(\text{Data} \mid \text{Unknown})}^{\text{Likelihood}} \propto \overbrace{P(\text{Unknown} \mid \text{Data})}^{\text{Posterior}}$$

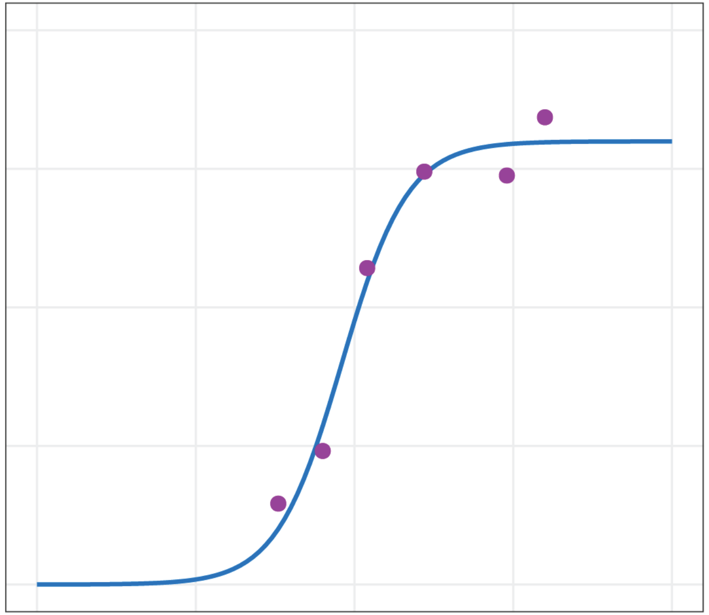
Plausible curves before seeing the data

The prior: **P(Unknown)**



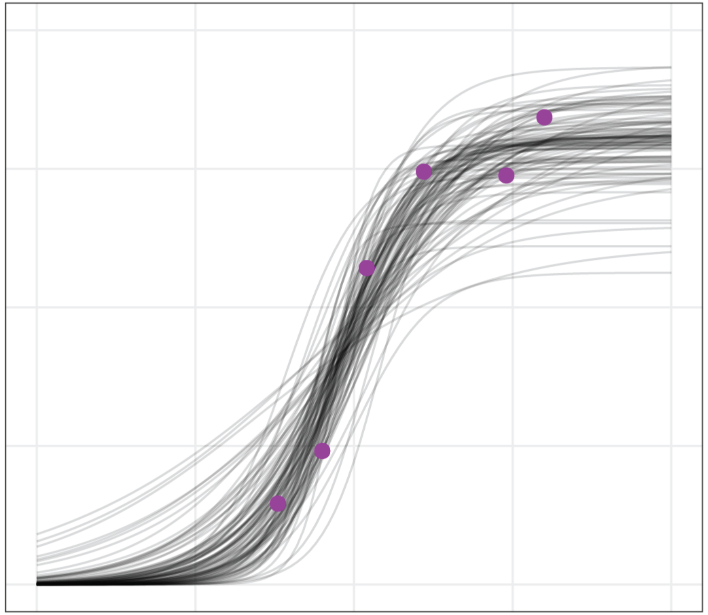
How well the curves fit the data

The likelihood: **P(Data | Unknown)**



Plausible curves after seeing the data

The posterior: **P(Unknown | Data)**



But the math is too hard!

So we simulate!

(Monte Carlo Markov Chains, or MCMC)

Weekends and restaurant scores again

Bayesianism and parameters

In the world of frequentism, there's a fixed population parameter and the data can hypothetically vary

$$P(\text{Data} \mid \theta)$$

In the world of Bayesianism, the data is fixed (you collected it just once!) and the population parameter can vary

$$P(\theta \mid \text{Data})$$

Bayesian credible intervals

(AKA posterior intervals)

"Given the data, there is a 95% probability that the true population parameter falls in the credible interval"

Intervals

Frequentism

There's a 95% probability that the range contains the true value

Probability of the range

Few people naturally think like this

Bayesianism

There's a 95% probability that the true value falls in this range

Probability of the actual value

People *do* naturally think like this!

Thinking Bayesianly

We all think Bayesianly,
even if you've never heard of Bayesian stats

Every time you look at a confidence interval, you inherently think that the parameter is around that value, but that's wrong!

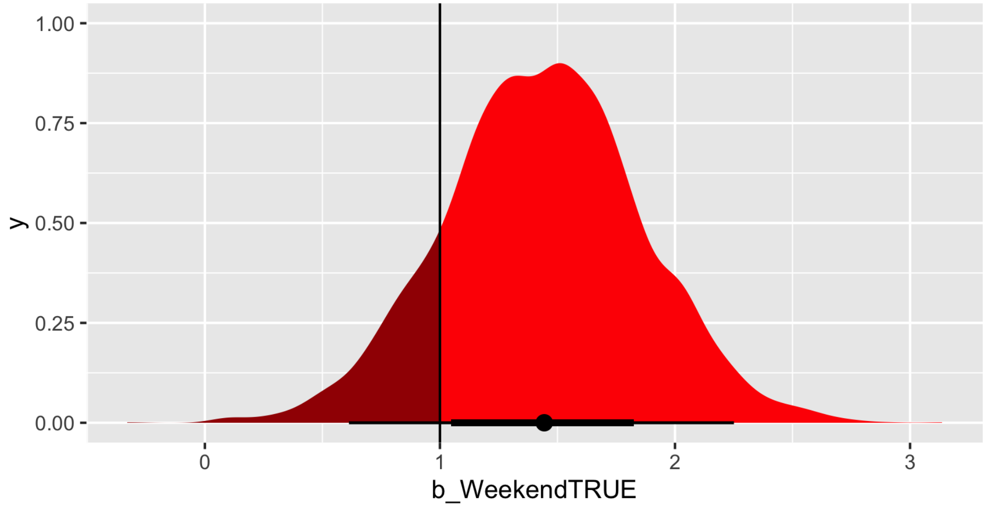
BUT Imbens cites research that that's actually generally okay

Often credible intervals are super similar to confidence intervals

Bayesian inference

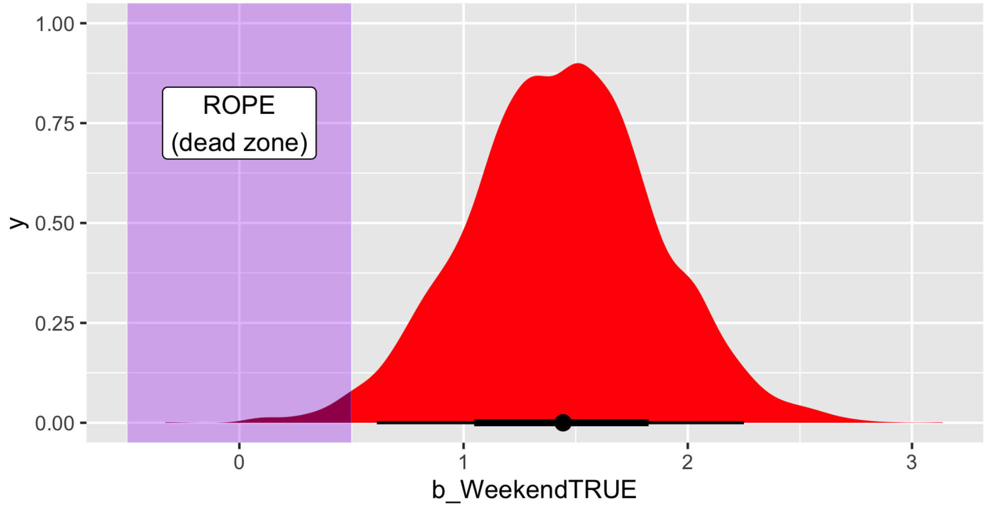
What do you do without p-values then?

Probability of direction



Point shows median value;
thick black bar shows 66% credible interval;
thin black bar shows 95% credible interval

Region of practical equivalence (ROPE)



Point shows median value;
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Weekends and restaurant scores once more