

# 431 Class 21

Thomas E. Love

2017-11-09

# Today's Agenda

- Answer Sketches for the Airline Etiquette Exercises
- A little more on the problems with  $p$  values
  - Statistical Significance doesn't have to be about  $p$  values
  - Confidence intervals as a partial solution journals like
  - Researcher Degrees of Freedom
  - The Garden of Forking Paths
- Two “Exciting” New Results worth a closer look
  - Stents
  - Advil + Tylenol in the ED for acute pain

# Today's R Setup

```
library(Epi); library(magrittr)
library(forcats); library(tidyverse)

fly <- fivethirtyeight::flying %>%
  select(id = respondent_id, recline_frequency,
         recline_rude, unruly_child,
         have_kids = children_under_18) %>%
  mutate(have_kids = factor(have_kids)) %>%
  filter(complete.cases(.))

source("Love-boost.R")
```

# Airplane Etiquette Survey: My Answers

# Airplane Etiquette Survey

<https://fivethirtyeight.com/features/airplane-etiquette-recline-seat/>

```
summary(select(fly, unruly_child, have_kids,  
               recline_rude, recline_frequency))
```

unruly_child	have_kids	recline_rude
No :146	FALSE:657	No :498
Somewhat:348	TRUE :188	Somewhat:279
Very :351		Very : 68

recline_frequency
Never :166
Once in a while :254
About half the time:116
Usually :175
Always :134

# Exercise 1

- 1 Estimate a 90% confidence interval for the proportion of people answering either “Somewhat” or “Very” to the question of whether it is rude to knowingly bring an unruly child on a plane. What is the margin of error?

```
fly %$% table(unruly_child) %>% addmargins
```

```
unruly_child
      No Somewhat      Very      Sum
146      348      351      845
```

Our sample probability of (“Somewhat” or “Very”) is  $(348 + 351) / 845 = 699 / 845 = 0.827$ .

## Exercise 1 (continued)

We could use `binom.test` to calculate the 90% CI.

```
prop.test(x = 699, n = 845, conf.level = 0.90)
```

1-sample proportions test with continuity  
correction

```
data: 699 out of 845, null probability 0.5
X-squared = 360.6, df = 1, p-value < 2.2e-16
alternative hypothesis: true p is not equal to 0.5
90 percent confidence interval:
 0.8041724 0.8481192
sample estimates:
      p
0.8272189
```

## Exercise 1 (continued)

In fact, we know of at least three reasonable approaches.

Approach	90% CI	half-width
<code>prop.test</code>	(0.804, 0.848)	0.022
<code>binom.test</code>	(0.804, 0.848)	0.022
<code>saifs.ci</code>	(0.805, 0.849)	0.022

In each case, the confidence interval's width is 0.044, and so the margin for error is approximately 0.022 (note that the confidence intervals we've fit aren't symmetric around the point estimate.)



## Exercise 2

- 2 Does the proportion of people who feel it is “Somewhat” or “Very” rude to knowingly bring an unruly child on a plane show a significant association with whether or not they themselves have children under 18 years of age?

```
fly %>% table(have_kids, unruly_child) %>% addmargins
```

	unruly_child			
have_kids	No	Somewhat	Very	Sum
FALSE	96	251	310	657
TRUE	50	97	41	188
Sum	146	348	351	845

We'd like to rearrange this by collapsing the “Somewhat” and “Very” categories and moving the result left, and it might be nice to move “TRUE” to the top row, so as to approximate standard epidemiological format.

## Exercise 2 (data reshaping)

So, some data reshaping...

```
fly1 <- fly %>%  
  mutate(kid_rude =  
    fct_collapse(unruly_child,  
                  yes = c("Somewhat", "Very"),  
                  no = "No"),  
    kid_rude = fct_relevel(kid_rude, "yes"),  
    have_kids = fct_relevel(have_kids,  
                            "TRUE"))
```

## Exercise 2 (revised table)

```
fly1 %>% table(have_kids, kid_rude) %>% addmargins
```

	kid_rude		
have_kids	yes	no	Sum
TRUE	138	50	188
FALSE	561	96	657
Sum	699	146	845

Now, we apply the `twoby2` function from `Epi...`

```
twoby2(fly1 %>% table(have_kids, kid_rude))
```

## Exercise 2 (twoby2 results)

2 by 2 table analysis:

-----  
Outcome : yes

Comparing : TRUE vs. FALSE

	yes	no	P(yes)	95% conf. interval
TRUE	138	50	0.7340	0.6663 0.7923
FALSE	561	96	0.8539	0.8248 0.8789

		95% conf. interval
Relative Risk:	0.8597	0.7844 0.9422
Sample Odds Ratio:	0.4723	0.3200 0.6971
Conditional MLE Odds Ratio:	0.4728	0.3153 0.7139
Probability difference:	-0.1198	-0.1917 -0.0550

Exact P-value: 3e-04

Asymptotic P-value: 2e-04  
-----

## Exercise 3

- 3 Given the actual data, what can you conclude about the true proportion of people who feel it is rude to recline your seat on a plane?

```
fly %>% count(recline_rude)
```

```
# A tibble: 3 x 2
  recline_rude      n
    <fctr> <int>
1         No    498
2   Somewhat    279
3        Very     68
```

It looks like 347 ( $279 + 68$ ) respondents are in the “Somewhat” or “Very” category. That’s 41.1% of the 845 respondents.

## Exercise 3 (SAIFS and other confidence intervals)

```
saifs.ci(x = 347, n = 845)
```

Sample Proportion	0.025	0.975
0.411	0.377	0.445

The 95% CI from the `prop.test` and `binom.test` (without Bayesian augmentation) are also (0.377, 0.445)

## Exercise 4

- 4 Is there an association between how often you recline and your feelings about how rude it is?

```
fly %$% table(recline_rude, recline_frequency) %>% addmargins
```

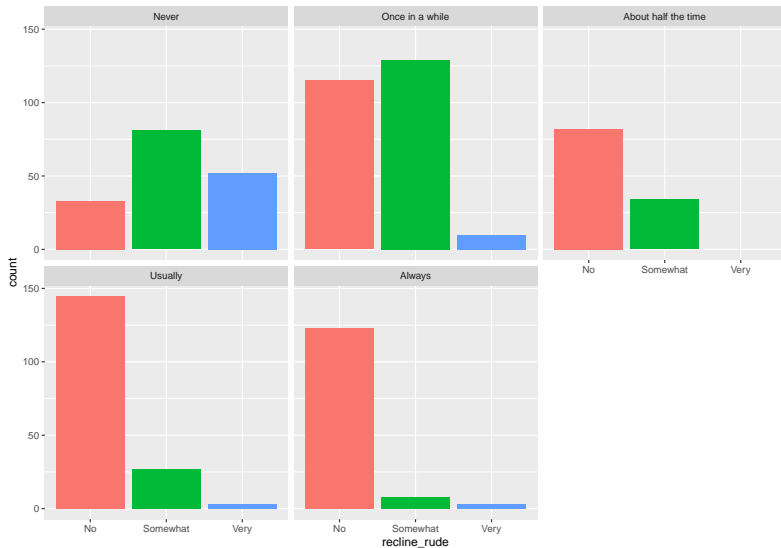
recline\_frequency

recline_rude	Never	Once in a while	About half the time
No	33	115	82
Somewhat	81	129	34
Very	52	10	0
Sum	166	254	116

recline\_frequency

recline_rude	Usually	Always	Sum
No	145	123	498
Somewhat	27	8	279
Very	3	3	68
Sum	175	134	845

# Exercise 4 (graph)





## Exercise 4 (initial chi-square test)

```
fly %$% table(recline_rude, recline_frequency) %>% chisq.test
```

Pearson's Chi-squared test

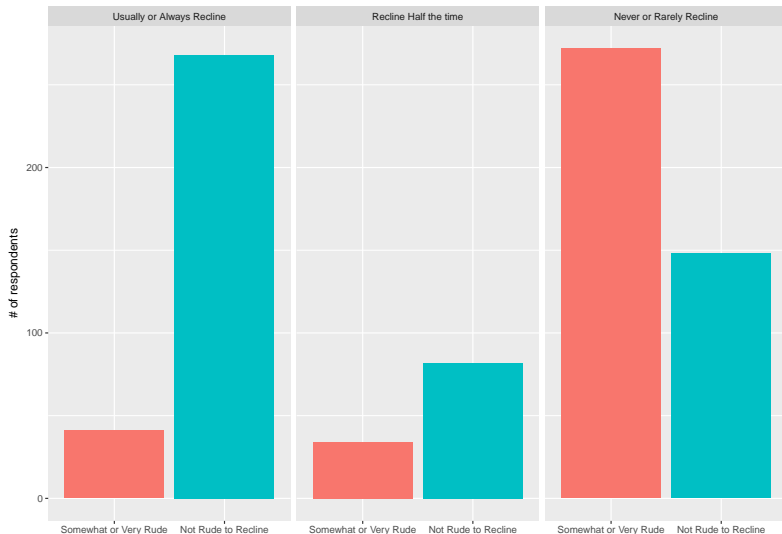
data: .

X-squared = 319.42, df = 8, p-value < 2.2e-16

## Exercise 4 (collapsing the table)

```
fly3 <- fly %>%  
  mutate(rude =  
    fct_collapse(recline_rude,  
      "Somewhat or Very Rude" = c("Somewhat", "Very"),  
      "Not Rude to Recline" = "No"),  
    rude = fct_relevel(rude, "Somewhat or Very Rude"),  
    behavior = fct_collapse(recline_frequency,  
      "Usually or Always Recline" = c("Usually", "Always"),  
      "Recline Half the time" = "About half the time",  
      "Never or Rarely Recline" =  
        c("Never", "Once in a while")),  
    behavior = fct_relevel(behavior,  
      "Usually or Always Recline",  
      "Recline Half the time"))
```

# Exercise 4 (graph, after collapsing)



## Exercise 4 (table, after collapsing)

```
fly3 %>% table(behavior, rude) %>% addmargins
```

	rude
behavior	Somewhat or Very Rude
Usually or Always Recline	41
Recline Half the time	34
Never or Rarely Recline	272
Sum	347

	rude	
behavior	Not Rude to Recline	Sum
Usually or Always Recline	268	309
Recline Half the time	82	116
Never or Rarely Recline	148	420
Sum	498	845

OK - we're ready for a chi-square test.

## Exercise 4 (chi-square test)

```
fly3 %$% table(behavior, rude) %>% chisq.test
```

Pearson's Chi-squared test

data: .

X-squared = 202.72, df = 2, p-value < 2.2e-16

## Exercise 5

Suppose we wish to estimate the power a study will have to estimate the difference in proportion of people who feel that waking someone up to go for a walk is very or somewhat rude, comparing taller people to shorter people. Suppose we propose a new study, where we will collect data from 1200 tall and 1200 short people, and we look to declare as important any observed difference where one group is at 73% or more, while the other is at 70% or less.

- 5 Using a 10% significance level, what power will we have?

Two-sample comparison of proportions power calculation

```
n = 1200
p1 = 0.7
p2 = 0.73
sig.level = 0.1
power = 0.4932237
```

## Exercise 5 Result

```
power.prop.test(n = 1200, p1 = 0.70, p2 = 0.73,  
               sig.level = 0.10)
```

Two-sample comparison of proportions power calculation

```
      n = 1200  
     p1 = 0.7  
     p2 = 0.73  
sig.level = 0.1  
   power = 0.4932237  
alternative = two.sided
```

NOTE: n is number in *each* group

## Exercise 6

- ⑥ To obtain at least 80% power, how big a sample would we need?

```
power.prop.test(p1 = 0.70, p2 = 0.73,  
               sig.level = 0.10, power = 0.80)
```

Two-sample comparison of proportions power calculation

```
      n = 2798.621  
      p1 = 0.7  
      p2 = 0.73  
sig.level = 0.1  
  power = 0.8  
alternative = two.sided
```

NOTE: n is number in *each* group



## Two “New” Clinical Results Worth a Closer Look

# A Double-blind RCT of Cardiac Stents (The Lancet 2017-11-02)

## Percutaneous coronary intervention in stable angina (ORBITA): a double-blind, randomised controlled trial

Rasha Al-Lamee, MRCP, David Thompson, MRCPI, Hakim-Moulay Dehbi, PhD, Sayan Sen, MRCP, Kare Tang, FRCP, John Davies, MRCP, Thomas Keeble, MRCP, Michael Mielewicz, PhD, Raffi Kaprielian, FRCP, Iqbal S Malik, FRCP, Sukhjinder S Nijjer, MRCP, Ricardo Petraco, MRCP, Christopher Cook, MRCP, Yousif Ahmad, MRCP, James Howard, MRCP, Christopher Baker, FRCP, Andrew Sharp, FRCP, Robert Gerber, FRCP, Suneel Talwar, MRCP, Ravi Assomull, MRCP, Prof Jamil Mayet, FRCP, Roland Wensel, MRCP, David Collier, PhD, Matthew Shun-Shin, MRCP, Prof Simon A Thom, FRCP, Dr Justin E Davies, MRCP  , Prof Darrel P Francis, FRCP on behalf of the  ORBITA investigators<sup>†</sup>

A procedure used to relieve chest pain in hundreds of thousands of heart patients each year is useless for many of them, researchers reported on Wednesday.

Their study focused on the insertion of stents, tiny wire cages, to open blocked arteries. The devices are lifesaving when used to open arteries in patients in the throes of a heart attack.

But they are most often used in patients who have a blocked artery and chest pain that occurs, for example, walking up a hill or going up stairs. Sometimes patients get stents when they have no pain at all, just blockages.

For the study, Dr. Justin E. Davies, a cardiologist at Imperial College London, and his colleagues recruited 200 patients with a profoundly blocked coronary artery and chest pain severe enough to limit physical activity, common reasons for inserting a stent.

All were treated for six weeks with drugs to reduce the risk of a heart attack, like aspirin, a statin and a blood pressure drug, as well as medications that relieve chest pain by slowing the heart or opening blood vessels.

Then the subjects had a procedure: a real or fake insertion of a stent. This is one of the few studies in cardiology in which a sham procedure was given to controls who were then compared to patients receiving the actual treatment.

In both groups, doctors threaded a catheter through the groin or wrist of the patient and, with X-ray guidance, up to the blocked artery. Once the catheter reached the blockage, the doctor inserted a stent or, if the patient was getting the sham procedure, simply pulled the catheter out.

Neither the patients nor the researchers assessing them afterward knew who had received a stent. Following the procedure, both groups of patients took powerful drugs to prevent blood clots.

The stents did what they were supposed to do in patients who received them. Blood flow through the previously blocked artery was greatly improved.

When the researchers tested the patients six weeks later, both groups said they had less chest pain, and they did better than before on treadmill tests.

But there was no real difference between the patients, the researchers found. Those who got the sham procedure did just as well as those who got stents.

Stenting is so accepted that American cardiologists said they were amazed ethics boards agreed to a study with a sham control group.

But in the United Kingdom, said Dr. Davies, getting approval for the study was not so difficult. Neither was it difficult to find patients.

“There are many people who are open to research, and if you tell them you are exploring a question, people agree,” he said. Nonetheless, it took him three and a half years to find the subjects for his study.

Ethics boards at many American hospitals probably would resist, since giving such patients fake procedures “flies in the face of guidelines,” Dr. Boden said.

# Advil + Tylenol in the ED for acute pain (JAMA 2017-11-07)

November 7, 2017

## **Effect of a Single Dose of Oral Opioid and Nonopioid Analgesics on Acute Extremity Pain in the Emergency Department** **A Randomized Clinical Trial**

Andrew K. Chang, MD, MS<sup>1</sup>; Polly E. Bijur, PhD<sup>2</sup>; David Esses, MD<sup>2</sup>; [et al](#)

## *New York Times* (2017-11-08) by Nicholas Bakalar

Researchers studied 416 men and women who arrived in the E.R. with moderate to severe pain in their arms or legs from sprains, strains, fractures or other injuries. They randomly assigned them to an oral dose of acetaminophen (Tylenol) with either ibuprofen (Advil) or the opioids oxycodone, hydrocodone or codeine.

Two hours later, they questioned them using an 11-point pain scale (higher scores = more pain).

- The average score was 8.7 before taking medicine.
- That score decreased by:
  - 4.3 points with ibuprofen and Tylenol,
  - 4.4 with oxycodone and Tylenol,
  - 3.5 with hydrocodone and Tylenol, and
  - 3.9 with codeine and Tylenol.

In other words, there was no significant difference, either statistically or clinically, among any of the four regimens.



## p values

# George Cobb's Questions (with Answers)

In February 2014, George Cobb, Professor Emeritus of Mathematics and Statistics at Mount Holyoke College, posed these questions to an ASA discussion forum:

- Q: Why do so many colleges and grad schools teach  $p = 0.05$ ?

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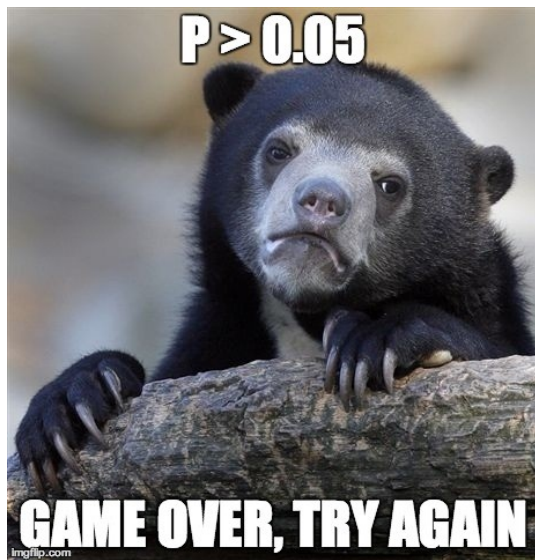
- Q: Why do so many colleges and grad schools teach  $p = 0.05$ ?
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- Q: Why do so many people still use  $p = 0.05$ ?

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- Q: Why do so many colleges and grad schools teach  $p = 0.05$ ?
- A: Because that's still what the scientific community and journal editors use.
- Q: Why do so many people still use  $p = 0.05$ ?
- A: Because that's what they were taught in college or grad school.

Now what?



So sad...

# Gelman on Statistical Significance

"... we use the term statistically significant in the conventional way, to mean that an estimate is **at least two standard errors away** from some "null hypothesis" or prespecified value that would indicate no effect present. An estimate is statistically insignificant if the observed value could reasonably be explained by simple chance variation, much in the way that a sequence of 20 coin tosses might happen to come up 8 heads and 12 tails; we would say that this result is not statistically significantly different from chance. More precisely, the observed proportion of heads is 40 percent but with a standard error of 11 percent - thus, the data are less than two standard errors away from the null hypothesis of 50 percent, and the outcome could clearly have occurred by chance. Standard error is a measure of the variation in an estimate and gets smaller as a sample size gets larger, converging on zero as the sample increases in size."

Gelman's blog (2017-10-28)

# The Value of a $p$ -Valueless Paper

Jason T. Connor (2004) *American J of Gastroenterology* 99(9): 1638-40.

Abstract: As is common in current bio-medical research, about 85% of original contributions in *The American Journal of Gastroenterology* in 2004 have reported  $p$ -values. However, none are reported in this issue's article by Abraham et al. who, instead, rely exclusively on effect size estimates and associated confidence intervals to summarize their findings. **Authors using confidence intervals communicate much more information in a clear and efficient manner than those using  $p$ -values. This strategy also prevents readers from drawing erroneous conclusions caused by common misunderstandings about  $p$ -values.** I outline how standard, two-sided confidence intervals can be used to measure whether two treatments differ or test whether they are clinically equivalent.

DOI: 10.1111/j.1572-0241.2004.40592.x



# Why Dividing Data Comparisons into Categories based on Significance Levels is Terrible.

*The common practice of dividing data comparisons into categories based on significance levels is terrible, but it happens all the time. . . . so it's worth examining the prevalence of this error.*

Link to Andrew Gelman's blog, 2016-10-15

# Gelman on $p$ values, 1

Let me first briefly explain why categorizing based on  $p$ -values is such a bad idea. Consider, for example, this division:

- “really significant” for  $p < .01$ ,
- “significant” for  $p < .05$ ,
- “marginally significant” for  $p < .1$ , and
- “not at all significant” otherwise.

Now consider some typical  $p$ -values in these ranges: say,  $p = .005$ ,  $p = .03$ ,  $p = .08$ , and  $p = .2$ .

Translate these two-sided  $p$ -values back into  $z$ -scores, which we can do in R via `qnorm(c(.005, .03, .08, .2)/2, lower.tail = FALSE)`

## Gelman on $p$ values, 2

Description	really sig.	sig.	marginally sig.	not at all sig.
$p$ value	0.005	0.03	0.08	0.20
$Z$ score	2.8	2.2	1.8	1.3

The seemingly yawning gap in  $p$ -values comparing the not at all significant  $p$ -value of .2 to the really significant  $p$ -value of .005, is only 1.5.

If you had two independent experiments with  $z$ -scores of 2.8 and 1.3 and with equal standard errors and you wanted to compare them, you'd get a difference of 1.5 with a standard error of 1.4, which is completely consistent with noise.

**The key point:** The difference between statistically significant and NOT statistically significant is not, generally, statistically significant.

From a **statistical** point of view, the trouble with using the  $p$ -value as a data summary is that the  $p$ -value is only interpretable in the context of the null hypothesis of zero effect, and (much of the time), nobody's interested in the null hypothesis. Indeed, once you see comparisons between large, marginal, and small effects, the null hypothesis is irrelevant, as you want to be comparing effect sizes.

From a **psychological** point of view, the trouble with using the  $p$ -value as a data summary is that this is a kind of deterministic thinking, an attempt to convert real uncertainty into firm statements that are just not possible (or, as we would say now, just not replicable).

# p Hacking and “Researcher Degrees of Freedom”

# Hack Your Way To Scientific Glory

<https://fivethirtyeight.com/features/science-isnt-broken>

## Hack Your Way To Scientific Glory

You're a social scientist with a hunch: **The U.S. economy is affected by whether Republicans or Democrats are in office.** Try to show that a connection exists, using real data going back to 1948. For your results to be publishable in an academic journal, you'll need to prove that they are "statistically significant" by achieving a low enough p-value.

### 1 CHOOSE A POLITICAL PARTY

Republicans

Democrats

### 2 DEFINE TERMS

Which politicians do you want to include?

- ☐ Presidents
- ☒ Governors
- ☐ Senators
- ☐ Representatives

How do you want to measure economic performance?

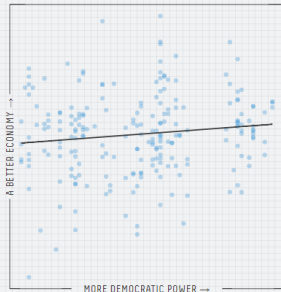
- ☐ Employment
- ☒ Inflation
- ☒ GDP
- ☒ Stock prices

Other options

- ☒ Factor in power  
Weight more powerful positions more heavily
- ☒ Exclude recessions  
Don't include economic recessions

### 3 IS THERE A RELATIONSHIP?

Given how you've defined your terms, does the economy do better, worse or about the same when more Democrats are in power? Each dot below represents one month of data.



### 4 IS YOUR RESULT SIGNIFICANT?

If there were no connection between the economy and politics, what is the probability that you'd get results at least as strong as yours? That probability is your p-value, and by convention, you need a p-value of 0.05 or less to get published.



### Result: Almost

Your 0.06 p-value is close to the 0.05 threshold. Try tweaking your variables to see if you can push it over the line!

If you're interested in reading real (and more rigorous) studies on the connection between politics and the economy, see the work of Larry Bartels and Alan Blinder and Mark Watson.

Data from The @unitedstates Project, National Governors Association, Bureau of Labor Statistics, Federal Reserve Bank of St. Louis and Yahoo Finance.

# What can you get?

I was able to get

- $p < 0.01$  (positive effect of Democrats on economy)
- $p = 0.01$  (negative effect of Democrats)
- $p = 0.03$  (negative effect of Democrats)
- $p = 0.03$  (positive effect of Democrats)

but also . . .

- $p = 0.05, 0.06, 0.07, 0.09, 0.17, 0.19, 0.20, 0.22, 0.23, 0.47, 0.51$

without even switching parties, exclusively by changing my definitions of terms (section 2 of the graphic.)

# “Researcher Degrees of Freedom”, 1

*[I]t is unacceptably easy to publish “statistically significant” evidence consistent with any hypothesis.*

*The culprit is a construct we refer to as **researcher degrees of freedom**. In the course of collecting and analyzing data, researchers have many decisions to make: Should more data be collected? Should some observations be excluded? Which conditions should be combined and which ones compared? Which control variables should be considered? Should specific measures be combined or transformed or both?*

Simmons et al. [link](#)



## “Researcher Degrees of Freedom”, 2

*... It is rare, and sometimes impractical, for researchers to make all these decisions beforehand. Rather, it is common (and accepted practice) for researchers to explore various analytic alternatives, to search for a combination that yields statistical significance, and to then report only what worked. The problem, of course, is that the likelihood of at least one (of many) analyses producing a falsely positive finding at the 5% level is necessarily greater than 5%.*

For more, see

- Gelman's blog [2012 – 11 – 01](#) “Researcher Degrees of Freedom”,
- Paper by [Simmons](#) and others, defining the term.

# And this is really hard to deal with...

**The garden of forking paths:** Why multiple comparisons can be a problem, even when there is no fishing expedition or p-hacking and the research hypothesis was posited ahead of time

*Researcher degrees of freedom can lead to a multiple comparisons problem, even in settings where researchers perform only a single analysis on their data. The problem is there can be a large number of potential comparisons when the details of data analysis are highly contingent on data, without the researcher having to perform any conscious procedure of fishing or examining multiple p-values. We discuss in the context of several examples of published papers where data-analysis decisions were theoretically-motivated based on previous literature, but where the details of data selection and analysis were not pre-specified and, as a result, were contingent on data.*

- [Link](#) to the paper from Gelman and Loken

# Benjamin et al 2017 Redefine Statistical Significance

We propose to change the default P-value threshold for statistical significance for claims of new discoveries from 0.05 to 0.005.

- 0.005 is stringent enough to “break” the current system - makes it very difficult for researchers to reach threshold with noisy, useless studies.

Visit the main [article](#). Visit an explanatory piece in [Science](#).

## Lakens et al. Justify Your Alpha

“In response to recommendations to redefine statistical significance to  $p \leq .005$ , we propose that researchers should transparently report and justify all choices they make when designing a study, including the alpha level.” Visit [link](#).

# Quiz 2 Setup

- Quiz 2 will be yours by 5 PM today.
  - It's now due Tuesday Nov 14 at **8 AM**.