GENERAL ASSEMBLY

STATISTICS FUNDAMENTALS, PART 2

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Data Scientist @ Critical Juncture

STATISTICS FUNDAMENTALS, PART 2

LEARNING OBJECTIVES

- Explain the difference between causation and correlation
- Test a hypothesis within a sample case study
- Validate your findings using statistical analysis (p-values, confidence intervals)

COURSE

PRE-WORK

PRE-WORK REVIEW

- Explain the difference between variance and bias

- Use descriptive statistics to understand your data

OPENING

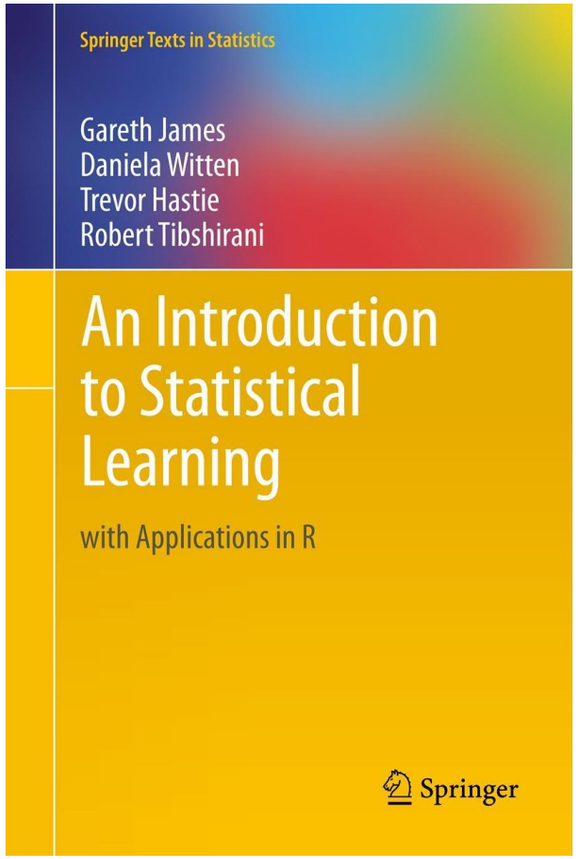
STATISTICS FUNDAMENTALS, PART 2

LAST SESSION

- Any questions from last class?
- Exit tickets

DATA SOURCE

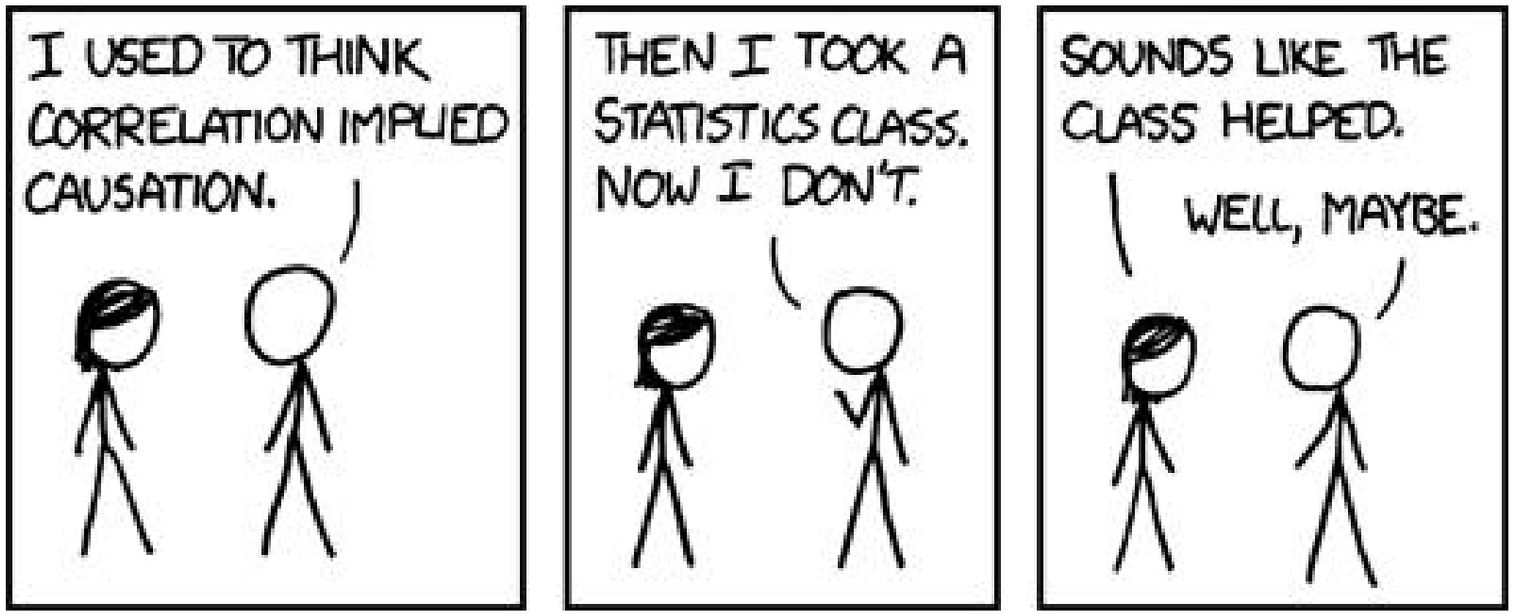
- Today, we'll use advertising data from an example in *An Introduction to Statistical Learning*



INTRODUCTION

CAUSATION AND CORRELATION

CAUSATION AND CORRELATION



https://xkcd.com/552/

CAUSATION AND CORRELATION

- If an association is observed, the first question to ask should always be… is it real?
- Think of various examples you've seen in the media related to food

Home >

HEALTH NEWS

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A few cups of coffee may lower colon cancer risk

Posted: 01 August 2007 1708 hrs

TOKYO : Drinking a few cups of coffee a day may lower the risk of advanced colon cancer, at least for women, Japanese researchers said Wednesday.

The study, supported by Japan's health ministry, showed women who drink more than three cups of coffee a day were 56 percent less likely to develop advanced colon cancer than those who drink no coffee at all.

"Drinking coffee sustains the secretion of bile acid and keeps down cholesterol levels, the mechanisms thought to prevent colon cancer," the report said.

But unfortunately the effect was not seen in men, the medical research team said.

Many men smoke and drink alcohol more than women, and those habits probably offset the effect of coffee, the study said.

The research team tracked down about 96,000 people in Japan aged from 40 to 69 between the early 1990s and 2002, of whom 726 men and 437 wom
suffered colon cancer.

Photos 1 of 1

Causal claims are often
inconsistent
and contradictory!

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Rectal Cancer News

Coffee Does Not Decrease Risk of Colorectal Cancer

Researchers from the Harvard School of Public Health have reported that, contrary to the results of several previous studies, coffee consumption does not appear to reduce the risk of colorectal cancer. The details of this study were reported in the April 1, 2009 issue of the *International Journal of Cancer*.[1]

Habitual coffee drinking has been associated with a reduced risk of mortality and chronic diseases, including cancer. Current evidence suggests that coffee consumption is associated with a reduced risk of liver, kidney, and to a lesser extent, premenopausal breast cancer and colorectal cancer; coffee consumption has no association with prostate, pancreas, and ovarian cancers.

Some studies have indicated that coffee may have a protective effect against colon cancer; however, researchers continue to evaluate this link in an effort to establish more direct evidence. In order to examine the relationship between coffee consumption and colorectal cancer, researchers from Harvard conducted a review of 12 studies that included 646,846 participants and 5,403 cases of colorectal cancer.

They evaluated high versus low coffee consumption and found no significant effect of coffee consumption on colorectal cancer risk. The review included four studies in the United States, five in Europe, and three in Japan. The data from each country was very similar. There were no significant differences by gender or site of cancer; however, there was a slight inverse relationship between coffee consumption and colon cancer for women, which was even more pronounced among Japanese women (21% for total study, 38% for Japanese women).

The researchers observed that inverse associations between coffee consumption and colorectal cancer "were slightly stronger in studies that controlled for smoking and alcohol and in studies with shorter follow-up times."

They concluded that coffee is "unlikely to have a strong protective effect on colorectal cancer risk"; however, they also note that it does not appear to increase the risk of colorectal cancer either.

August 31, 2007

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Drinking and Dementia: Is There a Link?

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Study Shows Drinkers With Genetic Predisposition to Alzheimer's Disease at Higher Risk

By Salynn Boyles
WebMD Medical News

Sept. 2, 2004 -- Drinking alcohol in middle age may increase the risk of late-life dementia in people who are genetically predisposed to develop Alzheimer's disease, according to findings from a Scandinavian study.

Researchers from Stockholm's Karolinska Institute reported that infrequent drinkers have a twofold increase in the risk of dementia in old age among carriers of a gene that has been linked to Alzheimer's. Gene carriers who frequently drink had a threefold increase in risk.

But the findings also show a protective effect for infrequent drinkers who did not have the genetic risk factor. Low-risk teetotalers and frequent drinkers in the study were twice as likely to experience mild cognitive declines later in life as infrequent drinkers.

The findings are reported in the Sept. 4 issue of the *BMJ* (formerly the *British Medical Journal*).

BBC NEWS

You are in: Health

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Friday, 25 January, 2002, 12:13 GMT

Alcohol 'could reduce dementia risk'

Moderate alcohol consumption could be beneficial

Small amounts of alcohol could reduce the risk of dementia in older people regardless of the type of alcoholic drink consumed, research suggests.

It is known that light-to-moderate consumption lessens the risk of coronary heart disease and stroke, but Dutch scientists think it could be good for mental health.

See also:

- 17 Apr 01 | Health
  Alcohol 'protects old against heart failure'
- 01 Feb 01 | Health
  £6bn bill for alcohol abuse
- 06 Dec 00 | Health
  Alcohol 'improves IQ'
- 15 Apr 01 | Health
  Why alcohol affects women more
- 06 Jan 01 | Health
  Alcohol 'cuts strokes in women'
- 18 Dec 00 | Health
  Beer 'keeps cataracts away'
- 30 Oct 00 | Health
  Alcoholic liver disease linked to genes

Internet links:

- British Heart Foundation
- The Lancet
- Alzheimer's Society

CAUSATION AND CORRELATION

- Why is this?
- Sensational headlines?

CAUSATION AND CORRELATION

- There is neglect of a robust data analysis

CAUSATION AND CORRELATION

- There is also often a lack of understanding of the difference between *causation* and *correlation*
- Understanding this difference is critical in the data science workflow, especially when **Identifying** and **Acquiring** data
- We need to fully articulate our question and use the right data to answer it, including any *confounding variables*

CAUSATION AND CORRELATION

- Additionally, this comes up when we **Present** our results to stakeholders
- We don't want to *overstate* what our model measures
- Be careful not to say "caused" when you really mean "associated with" or "related to"

LECTURE

CAUSATION VS CORRELATION

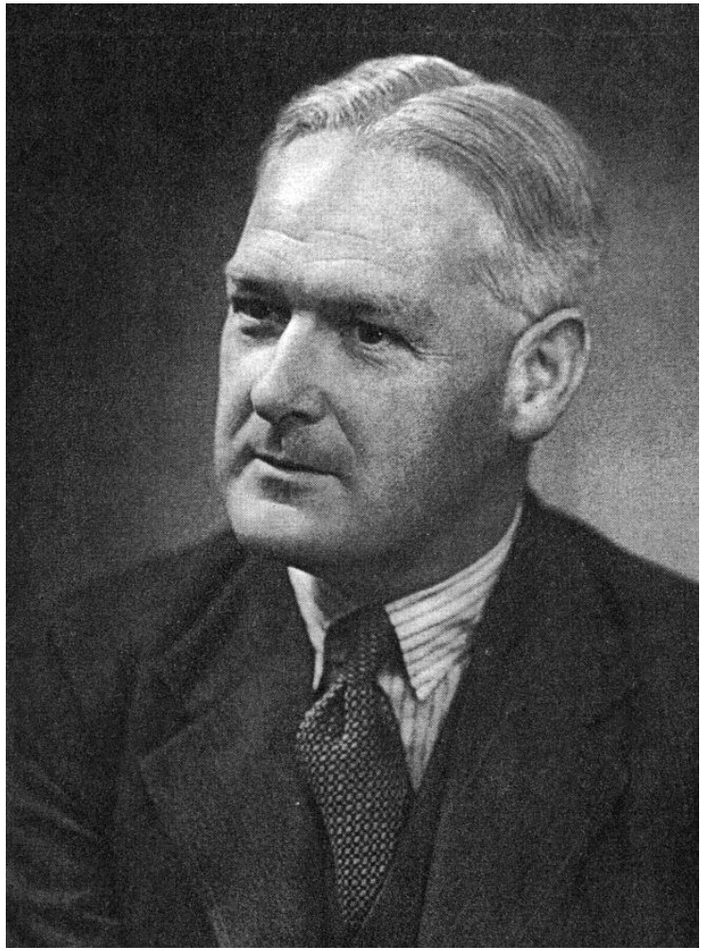
CAUSAL CRITERIA

- Causal criteria is one approach to assessing causal relationships
- However, it's ***very hard to define*** universal causal criteria
- One attempt that is commonly used in the medical field is based on work by Bradford Hill

CAUSAL CRITERIA

He developed a list of “tests” that an analysis must pass in order to indicate a causal relationship:

1. Temporal Relationship
2. Strength
3. Dose-Response Relationship
4. Consistency
5. Plausibility
6. Alternate Explanations
7. Experiment
8. Specificity
9. Coherence



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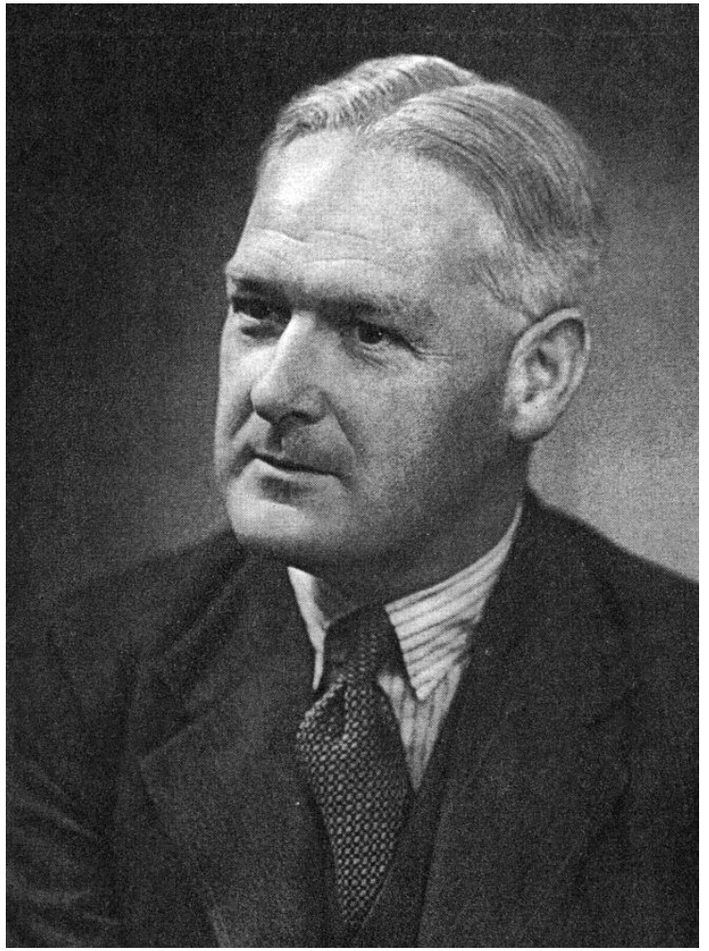


CAUSAL CRITERIA

- This is not an exhaustive checklist, but it's useful for understanding that your predictor/exposure **must have occurred before your outcome**
- For example, in order for smoking to cause cancer, one must have started smoking prior to getting cancer

CAUSAL CRITERIA

- Most commonly, we find an *association* between two variables
  - This means there is an observed **correlation** between the variables
- We may not fully understand the causal direction (e.g. does smoking cause cancer or does cancer cause smoking?)
- We also might not understand *other* factors influencing the outcome

ACTIVITY: KNOWLEDGE CHECK

ANSWER THE FOLLOWING QUESTIONS

1. What is the difference between ***causation*** and ***association***?
2. Why is ***causation*** harder to prove than ***correlation***?

DELIVERABLE

Answers to the above questions

INTRODUCTION

CONFOUNDING AND DAGS

CONFOUNDING

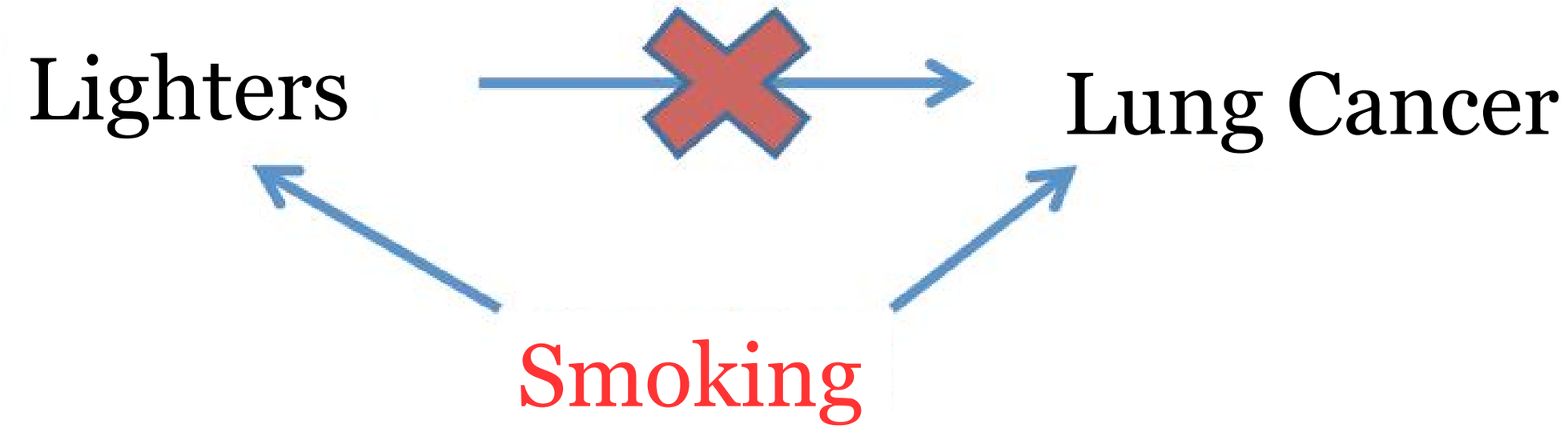
Often times, associations may be influenced by another *confounding* factor

Let's say we did an analysis to understand what causes lung cancer

We find that people who carry cigarette lighters are 2.4 times more likely to contract lung cancer as people who don't carry lighters

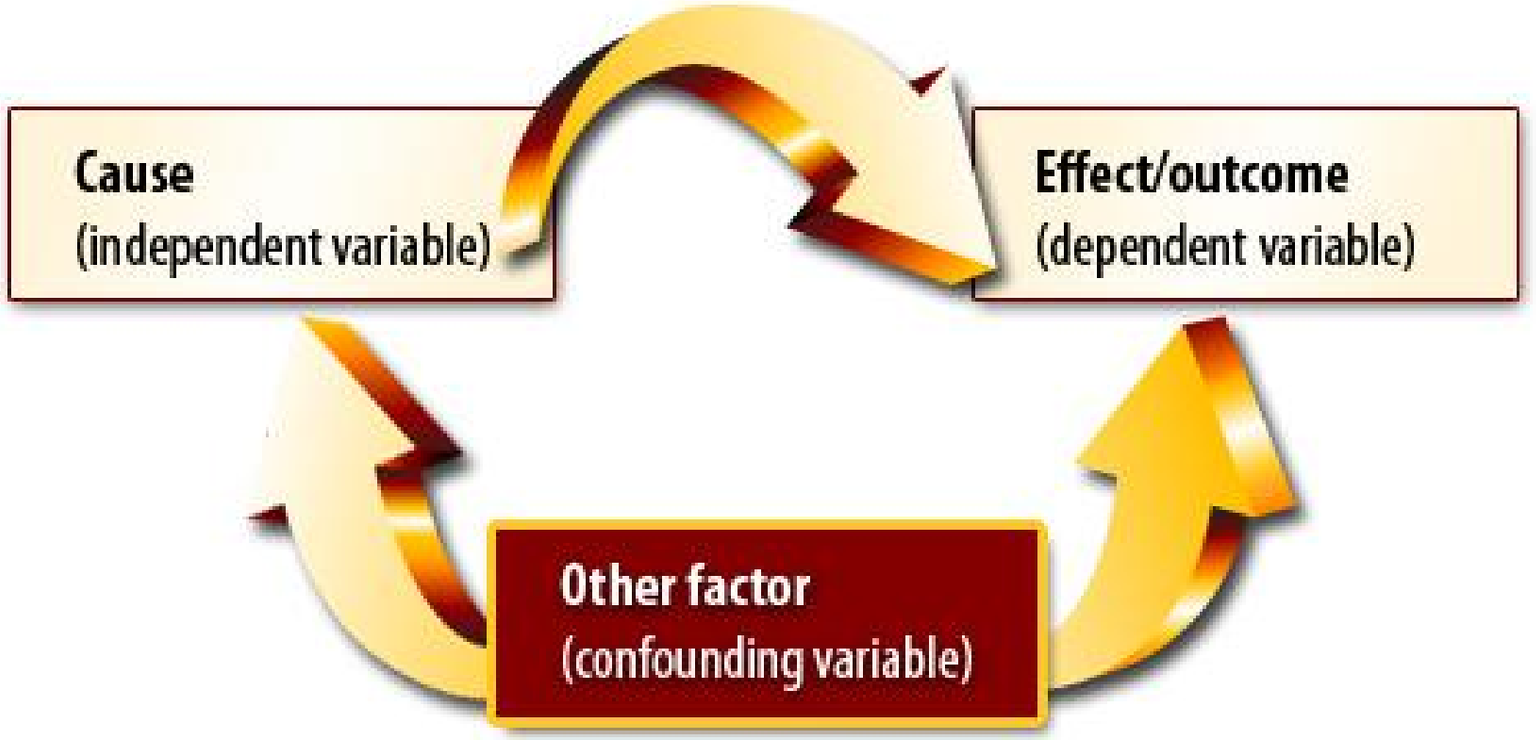
Does this mean that the lighters are causing cancer?

CONFOUNDING



CONFOUNDING

Confounding variables often hide the true association between causes and outcomes



ACTIVITY: KNOWLEDGE CHECK

ANSWER THE FOLLOWING QUESTIONS

How might we test for these?

DELIVERABLE

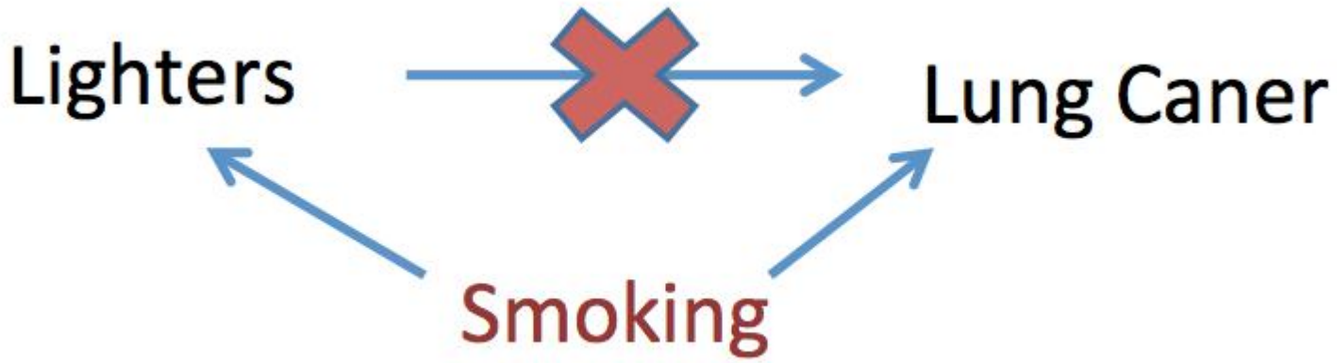
Answers to the above questions

DIRECTED ACYCLIC GRAPH

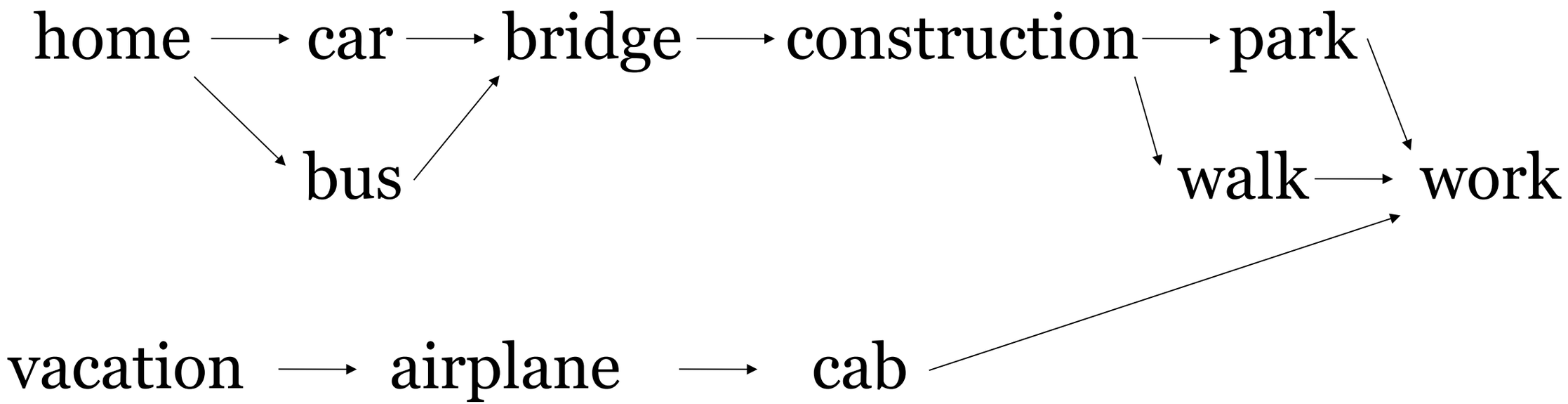
A *Directed Acyclic Graph* (DAG) can help determine which variables are most important for your model

It helps visually demonstrate the logic of your models

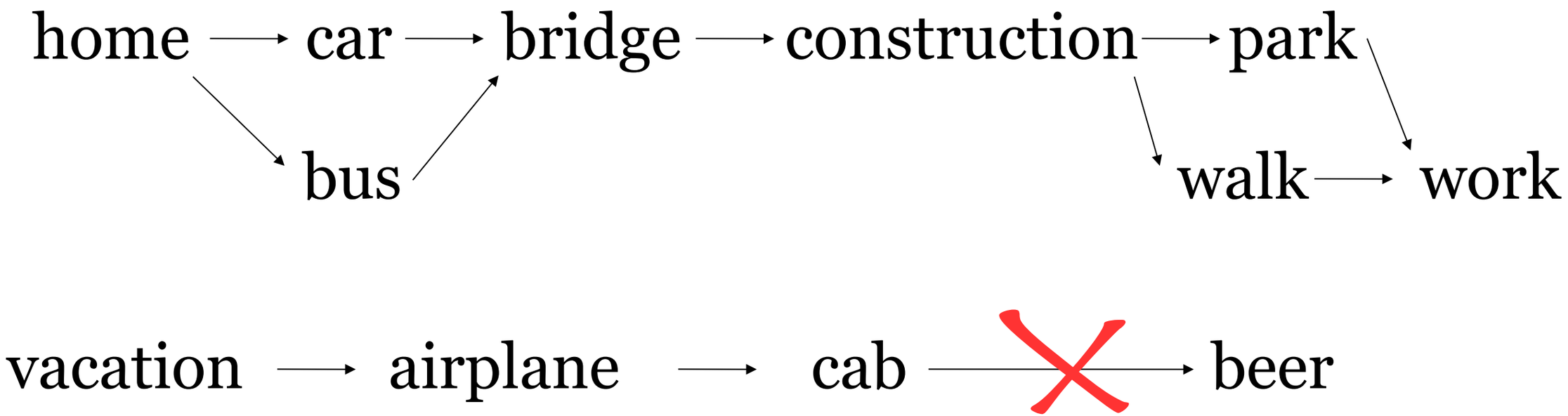
A DAG always includes at least one exposure/predictor and one outcome



DIRECTED ACYCLIC GRAPH



DIRECTED ACYCLIC GRAPH



DIRECTED ACYCLIC GRAPH

Suppose we have the following output from a model:

Dep. Variable:	Sales	**R-squared:**	0.612
Model:	OLS	**Adj. R-squared:**	0.610
Method:	Least Squares	**F-statistic:**	312.1
Date:	Thu, 03 Sep 2015	**Prob (F-statistic):**	1.47e-42
Time:	18:58:58	**Log-Likelihood:**	-519.05
No. Observations:	200	**AIC:**	1042.
Df Residuals:	198	**BIC:**	1049.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[95.0% Conf. Int.]**
Intercept	7.0326	0.458	15.360	0.000	6.130 7.935
TV	0.0475	0.003	17.668	0.000	0.042 0.053

Omnibus:	0.531	**Durbin-Watson:**	1.935
Prob(Omnibus):	0.767	**Jarque-Bera (JB):**	0.669
Skew:	-0.089	**Prob(JB):**	0.716
Kurtosis:	2.779	**Cond. No.**	338.

DIRECTED ACYCLIC GRAPH

The exposure/predictor is TV ads, associated with the outcome: sales

We can measure the strength to demonstrate a strong association

What other factors may increase sales?

What other types of ads?

DIRECTED ACYCLIC GRAPH

The DAG for this might look like the following:

THINK, PAIR, SHARE

DAGS

ACTIVITY: DAGS

DIRECTIONS

Let's say we want to evaluate which type of ad is associated with higher sales

Draw a basic DAG on your table or on the board
This DAG should show the relationship between ads and higher sales
Discuss your DAGs in small groups and be ready to share one or two examples with the class

DELIVERABLE

Example DAG

SEASONALITY

Suppose…

TV ads were run in November/December (peak buying season)

Google ads were run during February/March (low buying season)

If we compare the two, we'll reach the **wrong conclusion**

Seasonal trends are affecting our associations

This is an example of ***bias***

TV ads aren't better than Google ads…

November/December is a better buying season than February/March, an *inherent bias*

SEASONALITY

Let’s take a look at the association between TV Ads and Sales while taking into account *seasonality* (recurring regular patterns over time)

What are some examples of seasonality with relation to sales?

SEASONALITY

A DAG incorporating seasonality might look like this

ACTIVITY: KNOWLEDGE CHECK

ANSWER THE FOLLOWING QUESTIONS

1. What is bias?
2. What is confounding?
3. What could we do differently in this example to avoid these elements?

DELIVERABLE

Answers to the above questions

A FEW KEY TAKEAWAYS

It is important to have deep subject area knowledge to be aware of biases in your field, in addition to statistical techniques

A DAG can be a useful tool for thinking through the logic of your model

There is a difference between causation and correlation

Statistics usually show *correlation*, not *causation*

Good data is important!

Your analysis is only as good as your understanding of the problem and the data you have to work with

INTRODUCTION

HYPOTHESIS TESTING

HYPOTHESIS TESTING

How can we tell the difference between two groups of observations (e.g. smokers vs. non-smokers)?

Imagine we are testing the health of smokers vs. non-smokers - results may show that smokers are marginally healthier than non-smokers

Are they healthier due to random chance or is there a statistically significant difference?

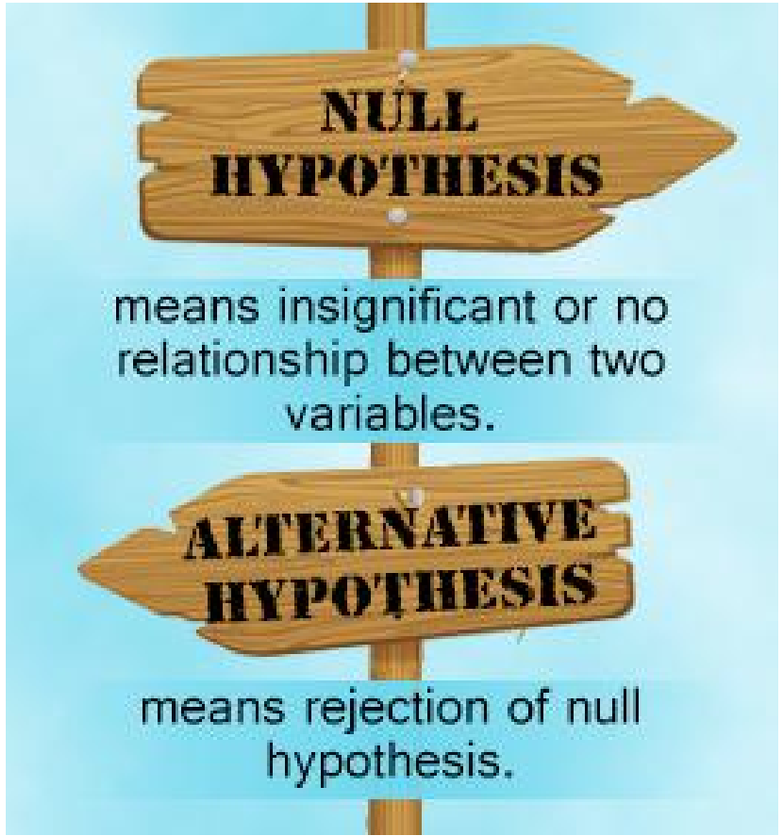
Smoking triathletes and non-smoking couch potatoes?

This is where hypothesis testing can help

HYPOTHESIS TESTING STEPS

First, you need a hypothesis to test (i.e. a *null hypothesis)*

The opposite of it would be the *alternative hypothesis*



HYPOTHESIS TESTING STEPS

For example, if we want to test the relationship between gender and sales, we may have the following hypotheses:

Null hypothesis: There **IS NOT** a relationship between Gender and Sales

Alternative hypothesis: There **IS** a relationship between Gender and Sales

HYPOTHESIS TESTING STEPS

Once you have your hypotheses, you can check whether the data:

supports rejecting the null hypothesis

-OR-

fails to reject the hypothesis

Note: Failing to reject the null is **NOT** the same as accepting the null

While the alternative hypothesis **might** be true, we don't have enough data to support that claim specifically

Keep this in mind so you don't overstate your findings

DEMO

HYPOTHESIS TESTING CASE STUDY

HYPOTHESIS TESTING CASE STUDY

We're going to walk through Part 1 of the demo-starter-code-4 notebook in the class repo

There are several questions to answer

Answer those questions in small groups and then discuss with the class

ACTIVITY: KNOWLEDGE CHECK

ANSWER THE FOLLOWING QUESTIONS

1. What is the null hypothesis?
2. Why is this important to use?

DELIVERABLE

Answers to the above questions

VALIDATE YOUR FINDINGS

VALIDATE YOUR FINDINGS

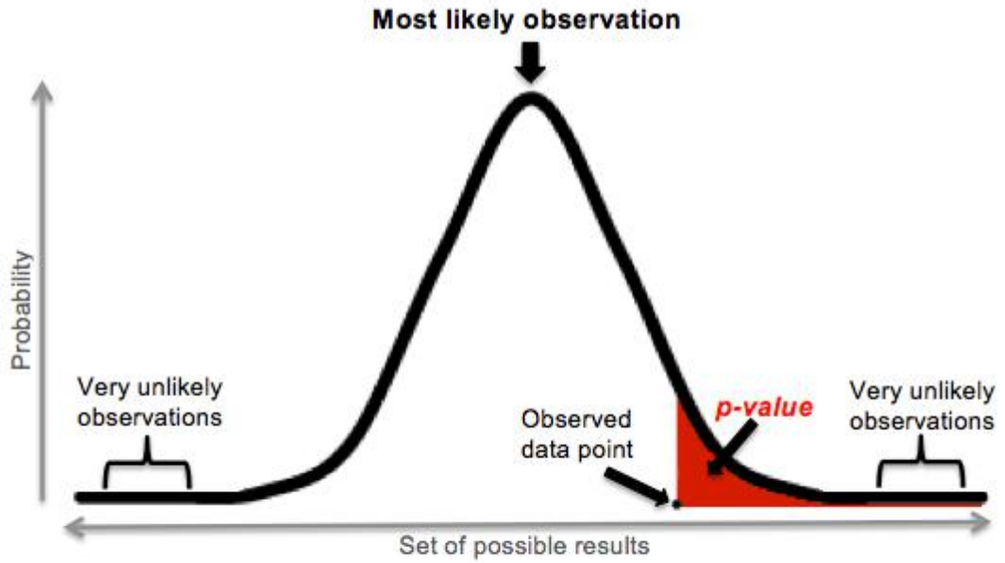
How do we tell if the association we found is *statistically significant*?

Statistical significance: likelihood that a result or relationship is caused by something other than random chance

Statistical hypothesis testing is traditionally employed to determine if a result is statistically significant or not

VALIDATE YOUR FINDINGS

Typically, a cut point of 5% is used.
i.e. something is “statistically significant”
if there is a <5% chance that it's due to random chance alone



A *p-value* (shaded red area) is the probability of an observed (or more extreme) result arising by chance

VALIDATE YOUR FINDINGS

TABLE 1

Relationship between Common Language and Hypothesis Testing

COMMON LANGUAGE	STATISTICAL STATEMENT	CONVENTIONAL TEST THRESHOLD
"Statistically significant" "Unlikely due to chance"	The null hypothesis was rejected.	$P < 0.05$
"Not significant" "Due to chance"	The null hypothesis could not be rejected.	$P > 0.05$

VALIDATE YOUR FINDINGS

When we present results, we say we found something “significant” using “X” criteria

Lets dive into p-values and confidence intervals with an example

DEMO

P-VALUES AND CONFIDENCE INTERVALS CASE STUDY

P-VALUES AND CONFIDENCE INTERVALS CASE STUDY

We’re now going to walk through Part 2 of the demo-starter-code-4 notebook in the class repo

There are several questions to answer

Answer questions in small groups and then we'll discuss with the class

ACTIVITY: KNOWLEDGE CHECK

ANSWER THE FOLLOWING QUESTIONS

1. What does a 95% confidence interval indicate?

DELIVERABLE

Answers to the above questions

INDEPENDENT PRACTICE

INTERPRETING RESULTS

ACTIVITY: INTERPRETING RESULTS

DIRECTIONS (35 minutes)

1. Use the lab-starter-code-4, you'll look through a variety of analyses and interpret the findings
2. You'll be presented with a series of outputs and tables from a published analysis
3. Read the outputs and determine if the findings are statistically significant or not

DELIVERABLE

Answers to the questions in the notebook

CONCLUSION

LAB REVIEW

LAB REVIEW

Let’s review the answers to the questions in the labs

Any other questions?

COURSE

BEFORE NEXT CLASS

BEFORE NEXT CLASS

DUE DATE

Project: Unit Project 2 due **4/3** (next Tuesday)!

LESSON

Q & A

LESSON

EXIT TICKET

DON’T FORGET TO FILL OUT YOUR EXIT TICKET