Implementing GAISE Recommendations for Teaching Introductory Statistics

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GAISE

- Guidelines for Assessment and Instruction in Statistics Education
- Recommendations for teaching introductory statistics at college level
  - Comparable guidelines at PreK-12 level
- Developed by American Statistical Association
  - Originally in 2005, revised in 2016
- www.amstat.org/education/gaise

GAISE recommendations

1. Teach statistical thinking.
2. Focus on conceptual understanding.
3. Integrate real data with a context and purpose.
4. Foster active learning.
5. Use technology to explore concepts and analyze data.
6. Use assessments to improve and evaluate student learning.

Outline

- Six recommendations
  - Multiple examples for each
- Two new emphases
  - One example for each
- Four interludes interspersed throughout (just for fun)

1. Teach statistical thinking

- Example: Sex discrimination?

	Men	Women
Accepted	533	113
Denied	665	336
Total	1198	449

- Men: 533/1198 ≈ .445 were accepted
- Women: 113/449 ≈ .252 were accepted
- Does this provide evidence of discrimination against women?

1. Teach statistical thinking

	Men		Women	
	Accepted	Denied	Accepted	Denied
Program A	511	314	89	19
Program F	22	351	24	317
Total	533	665	113	336

- Program A
  - Men: 511/825 ≈ .619
  - Women: 89/108 ≈ .824
- Program F:
  - Men: 22/373 ≈ .059
  - Women: 24/341 ≈ .070

1. Teach statistical thinking

- Engage in proportional reasoning
  - Take sample sizes into account
- Think about alternative explanations
  - Confounding variables
- Consider where the data came from
  - Observational vs. experimental

1. Teach statistical thinking

- Example: Cancer pamphlets

Researchers investigated whether pamphlets containing information for cancer patients are written at a level that the patients can understand

Patients' reading levels	< 3	3	4	5	6	7	8	9	10	11	12	> 12	Total
Count (number of patients)	6	4	4	3	3	2	6	5	4	7	2	17	63

Pamphlets' readability levels	6	7	8	9	10	11	12	13	14	15	16	Total
Count (number of pamphlets)	3	3	8	4	1	1	4	2	1	2	1	30

1. Teach statistical thinking

- Think in terms of distributions of data
- Be sure to address motivating question

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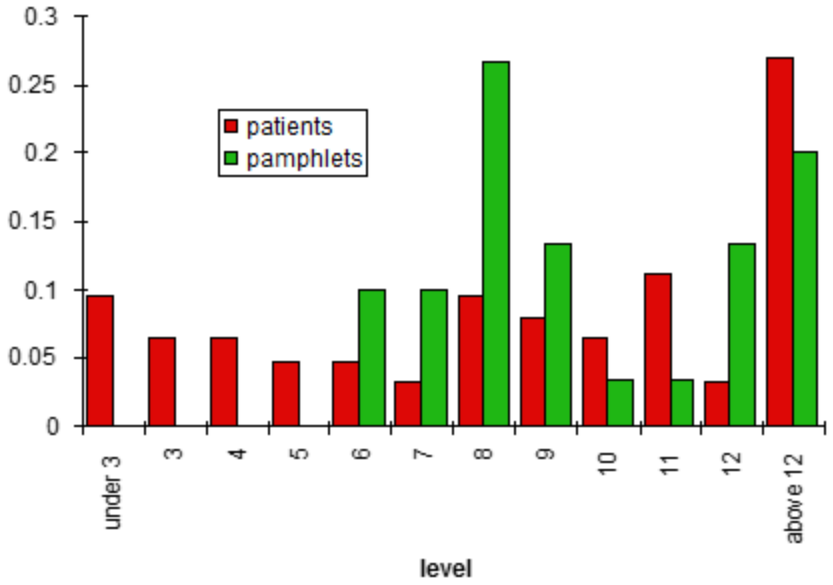
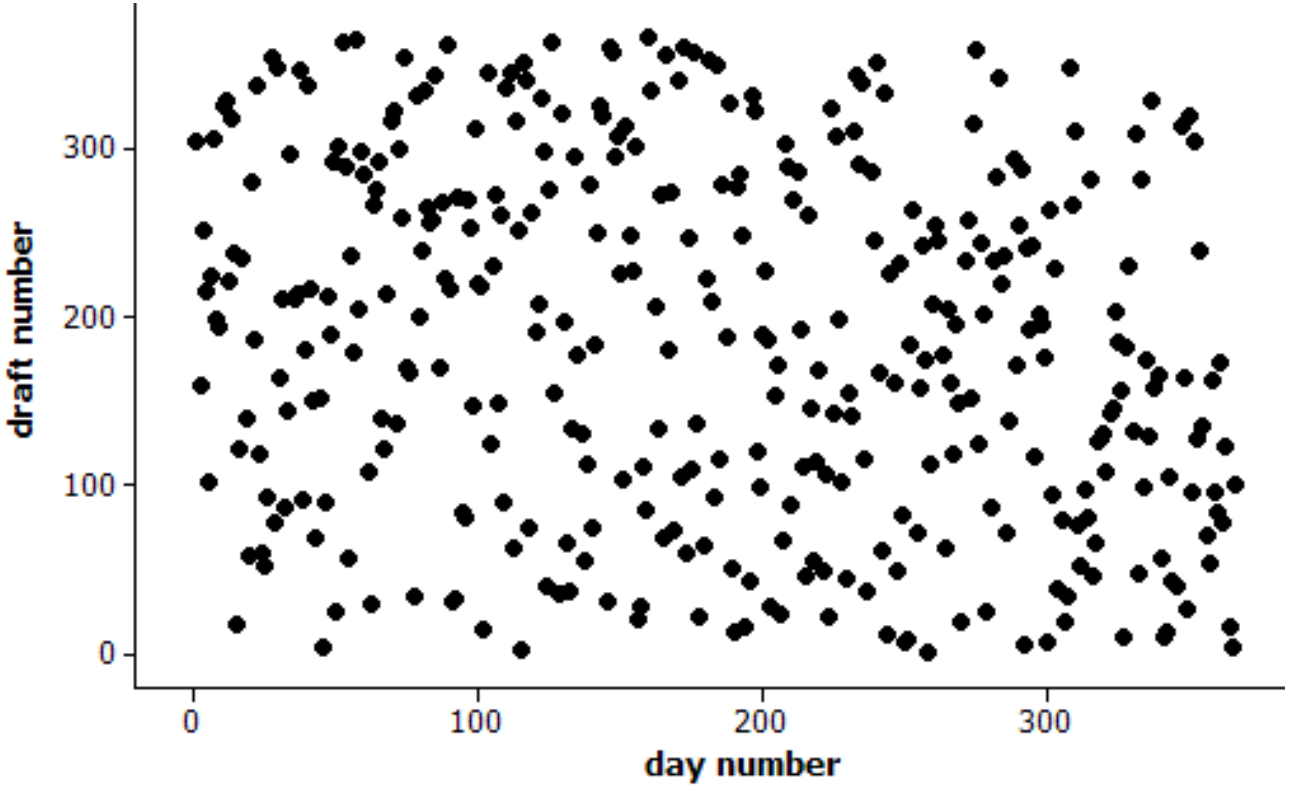
- Think in terms of distributions of data
- Be sure to address motivating question
- Do not underestimate value of simple graphs



1. Teach statistical thinking

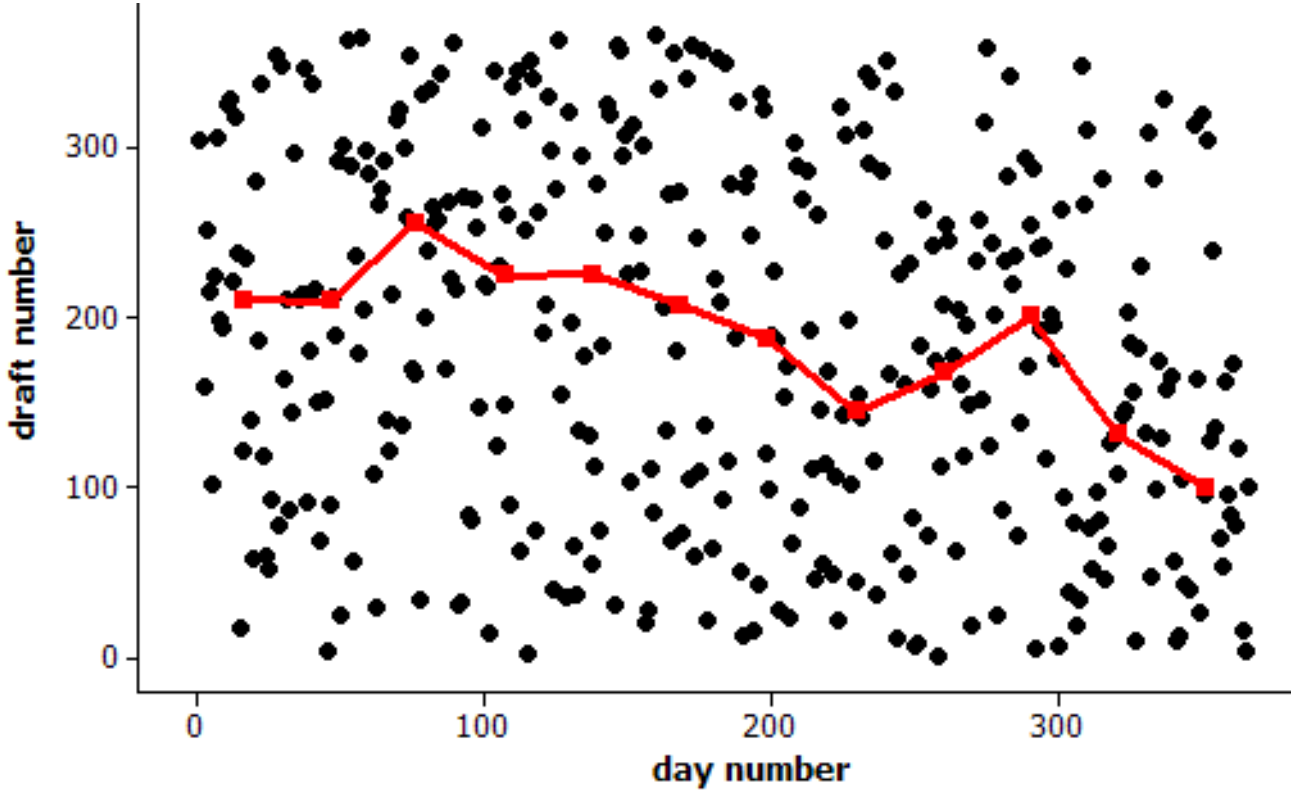
- Example: 1970 Draft Lottery



- Any reason to doubt randomness?

1. Teach statistical thinking

- Example: 1970 Draft Lottery



- Any reason to doubt randomness?

Interlude 1: Intro stat enrollments

- 2015 CBMS Survey

TABLE S.2 Total enrollment (in 1000s), including distance-learning enrollment, by course level in undergraduate mathematics, statistics, and computer science courses taught in mathematics and statistics departments at four-year colleges and universities, and in mathematics programs at two-year colleges in fall 2000, 2005, 2010, and 2015.

	Mathematics Departments				Statistics Departments				Two-Year College Mathematics Programs			
Course level	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015
Probability and Statistics courses												
Introductory level	136	148	231	253	54	54	81	94	74	117	137	280
Upper level	35	34	32	60	20	24	27	50	0	0	0	0

- Look at this growth! Especially at TYCs
- Also 222K took AP Statistics exam in 2018

2. Focus on conceptual understanding

- Example: Variability/SD

Suppose that Abby records the ages of customers at The Avenue (on-campus snack bar) from 11am-2pm today, while Mary records ages of customers at McDonald's (near freeway).

Who will have the larger standard deviation of customer ages: Abby or Mary? Explain.

2. Focus on conceptual understanding

- Example: Variability/SD (from USCOTS presentation)

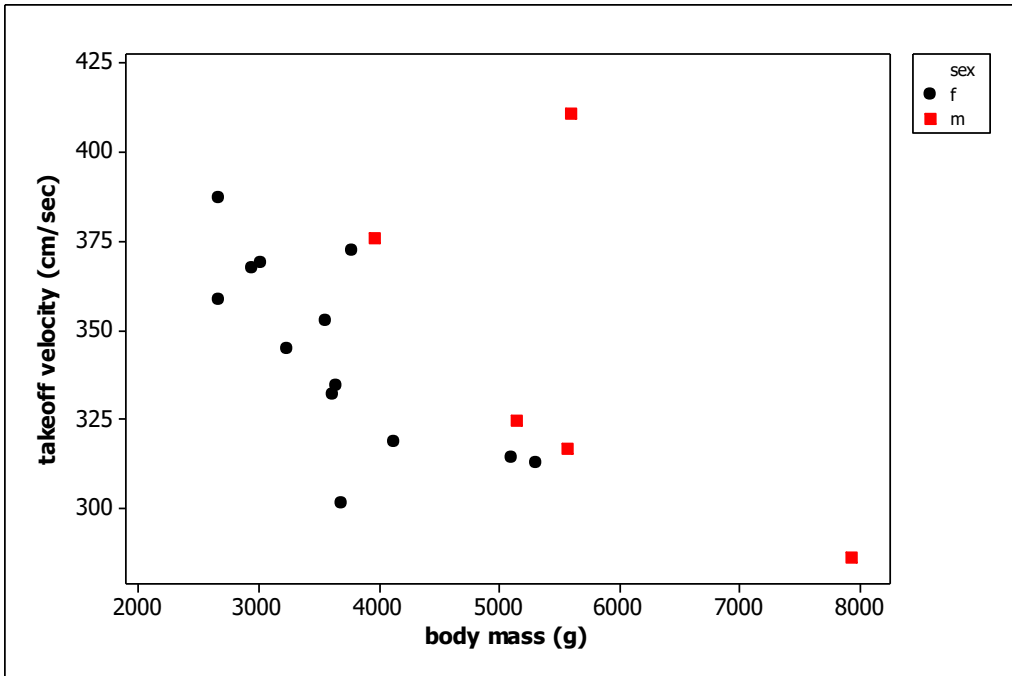
Draw four rectangles so that the standard deviation of the heights is greater than the standard deviation of the widths.

3. Integrate real data

The Journal of Experimental Biology 205, 3877–3889 (2002)
Printed in Great Britain © The Company of Biologists Limited 2002
JEB4511

The relationship between maximum jumping performance and hind limb morphology/physiology in domestic cats (*Felis silvestris catus*)

Michelle A. Harris[1,*] and Karen Steudel[2]



Interlude 2: My cats

3. Integrate real data

- Example: Anchoring
  - Group 1: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 16 years old when he died?
    - Make a guess for how old he was when he died.

3. Integrate real data

- Example: Anchoring
  - Group 2: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 160 years old when he died?
    - Make a guess for how old he was when he died.

3. Integrate real data

- Example: Anchoring
  - Group 1: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 16 years old when he died?
    - Make a guess for how old he was when he died.
  - Group 2: Nelson Mandela was the first president of South Africa following apartheid.
    - Do you think he was older or younger than 160 years old when he died?
    - Make a guess for how old he was when he died.

3. Integrate real data

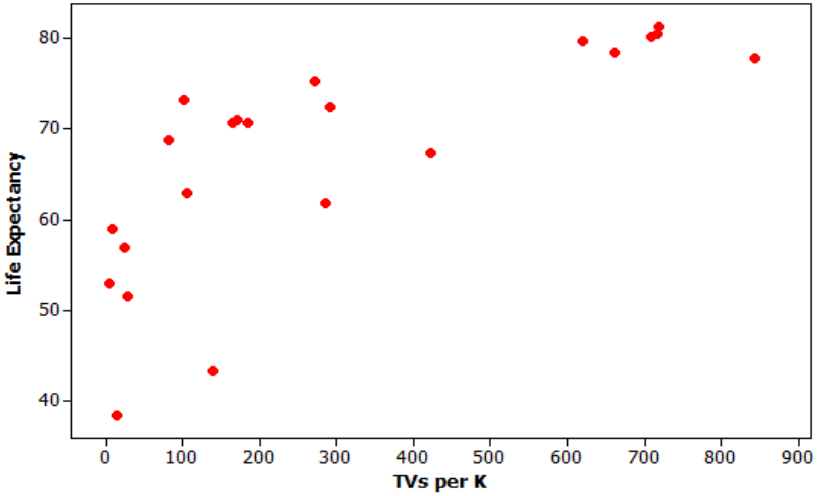
- Example: Facial prototyping

Do people tend to associate names with faces? (Lea, Thomas, Lamkin, & Bell, 2007)

Who is on the left: Bob or Tim?

4. Foster active learning

- Example: Televisions and life expectancy



- Is there an association?
- Can we infer causation?
- Could we make predictions?

4. Foster active learning

- Example: Gettysburg Address

- Select a sample of 10 words from the population of 268 words in the Gettysburg Address. (Just circle 10 words.)
- Record the length (# of letters) of each word.
- Calculate the average length for your sample.
- Produce graph of sample averages.

4. Foster active learning

- Example: Gettysburg Address
- Is this a reasonable sampling method?

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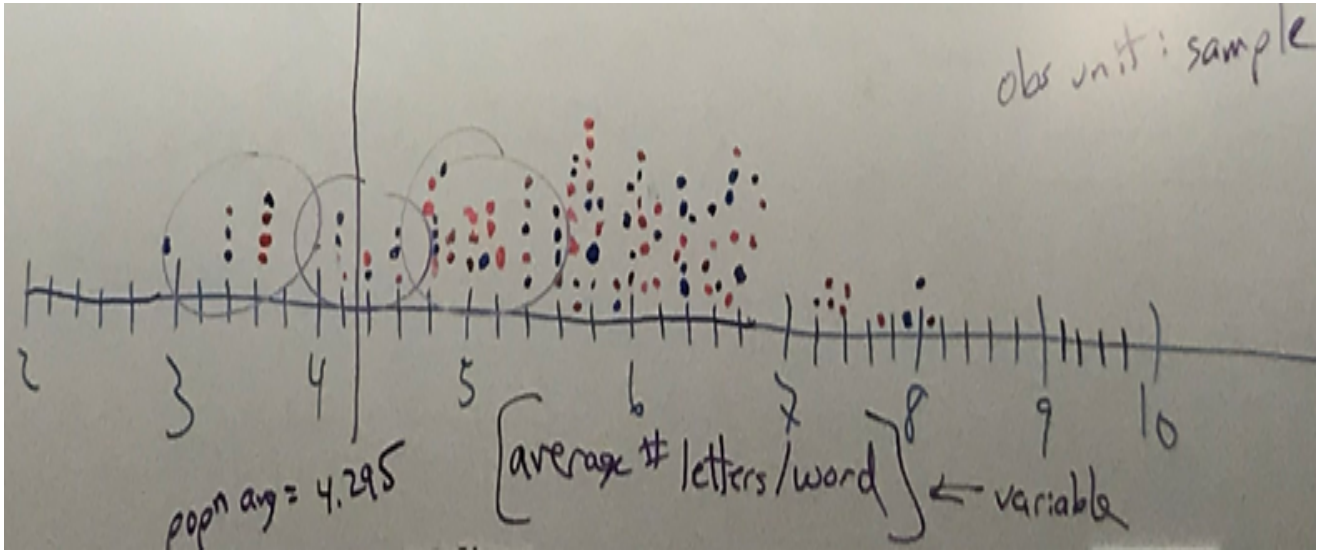
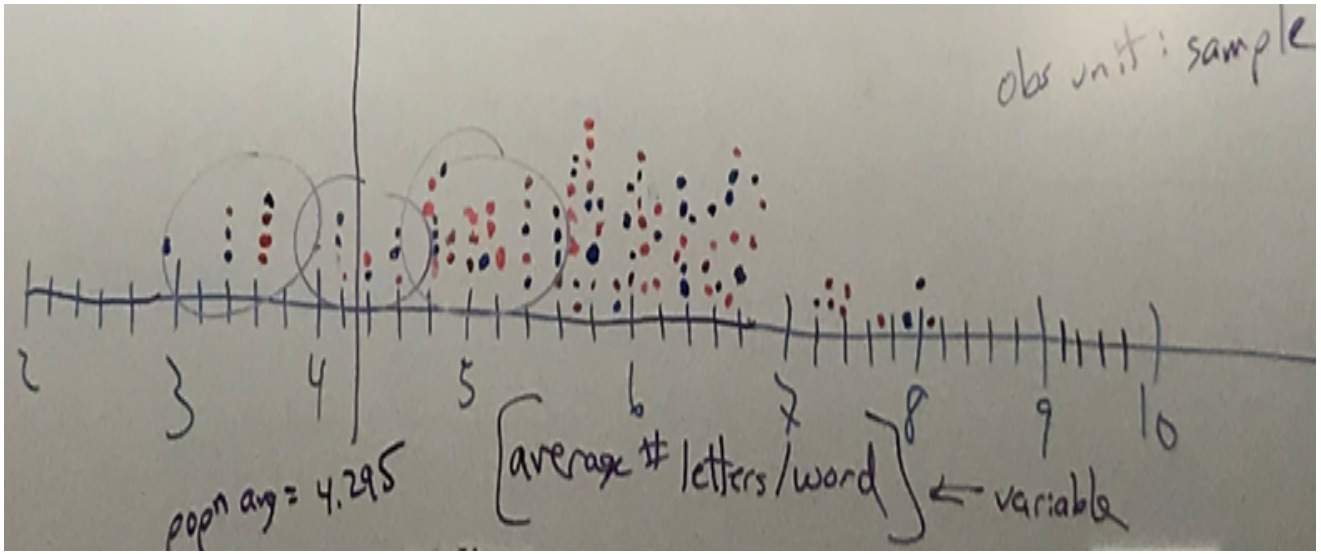


4. Foster active learning

- Example: Gettysburg Address

- How does this graph indicates sampling bias?



- Would closing eyes and pointing be unbiased?

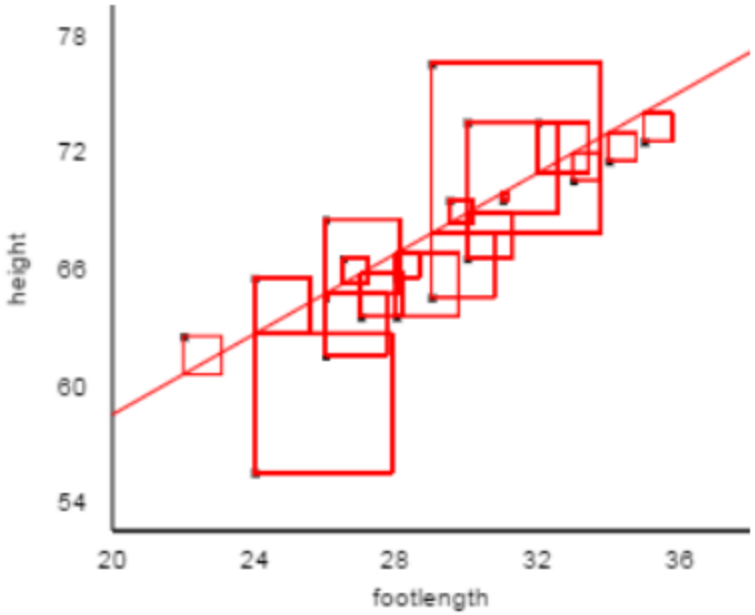
4. Foster active learning

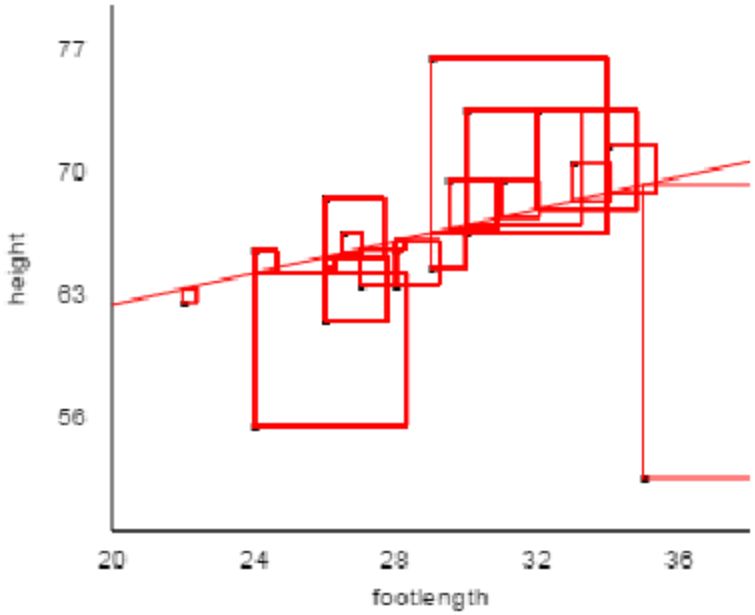
Example: Facial prototyping (cont)

- 36 of 46 students put Tim on the left
  - What are two possible explanations for our observed sample result?
  - Which explanation can we investigate/model? How?
  - How often would such an extreme sample result occur by chance alone (if there were no facial prototyping)?
  - Have students flip coins to investigate

5. Use technology to explore concepts

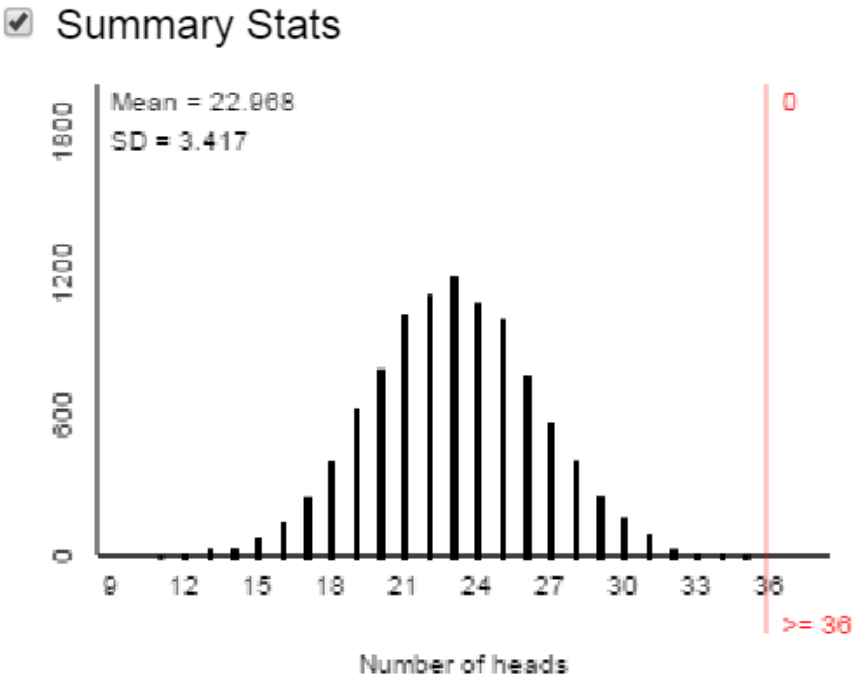
- Example: Effect of outlier on “least squares” regression line





5. Use technology to explore concepts

- Facial prototyping: 10,000 simulated samples of 46 students



- Very strong evidence: people tend to put Tim on left

6. Use assessments to improve learning

- Example: Anchoring (Mandela's age)

a) What are the observational units in this study?

b) What are the variables in this study? Which type is which variable? Which variable plays which role?

c) Did this study make use of random sampling, random assignment, both, or neither?

d) Is this an observational study or an experiment?

6. Use assessments to improve learning

- Example: Anchoring (Mandela's age)

e) Summarize your conclusion from the (approximate) p-value.

f) Estimate magnitude of effect with confidence interval.

g) Is it reasonable to draw a cause-and-effect conclusion? Explain why or why not.

h) Is it reasonable to generalize the results to all people? Explain why or why not.

6. Use assessments to improve learning

- Example: Halloween treats

Among 283 trick-or-treaters in a Connecticut study, 148 chose candy and 135 chose toys

a) Conduct a test of whether the data provide strong evidence that trick-or-treaters have a genuine preference for one kind of treat.

b) How would test statistic, p-value, confidence interval, conclusion change if you analyzed the proportion who chose *toys* rather than candy?

6. Use assessments to improve learning

- Example (probability):
  - A recent survey revealed that 48% of households in the U.S. have a pet dog, and 37% have a pet cat.
  - Does it follow that 48% + 37% = 85% of households in the U.S. have a pet dog *or* a pet cat? Explain why or why not.

6. Use assessments to improve learning

- Example (adapted from Jay Lehmann):

a) Which would be larger – the mean weight of 10 randomly selected people or the mean weight of 1000 randomly selected cats? Explain briefly.

b) Which would be larger – the standard deviation of the weights of 1000 randomly selected people or the standard deviation of the weights of 10 randomly selected cats? Explain briefly.

Interlude 3: My teaching philosophy

- What's the key to being a successful singer?
  - Sing Good Songs

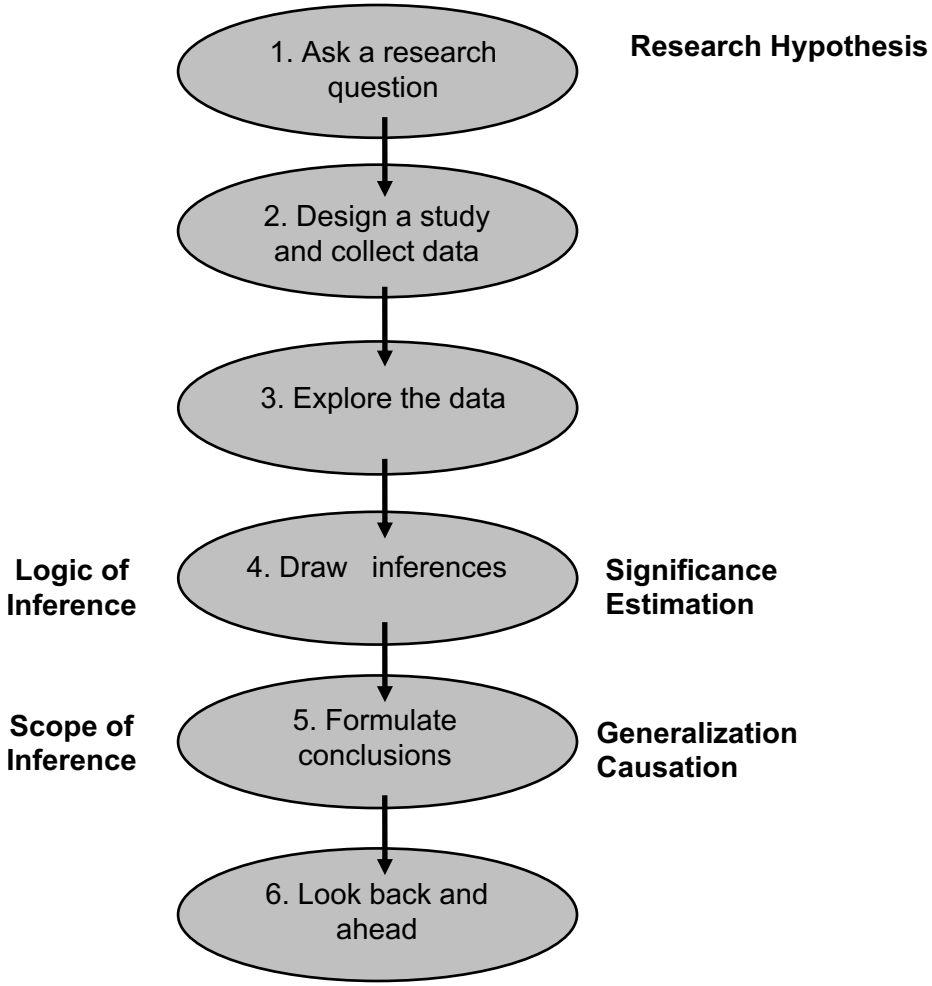
Interlude 3: My teaching philosophy

- What's the key to effective teaching?
  - Ask Good Questions
  - https://askgoodquestions.blog

New emphases in GAISE revision

1. Teach statistical thinking
   a) Teach statistics as investigative process of problem-solving and decision-making
   b) Give students experience with multivariable thinking

1a. Investigative process



1a. Investigative process

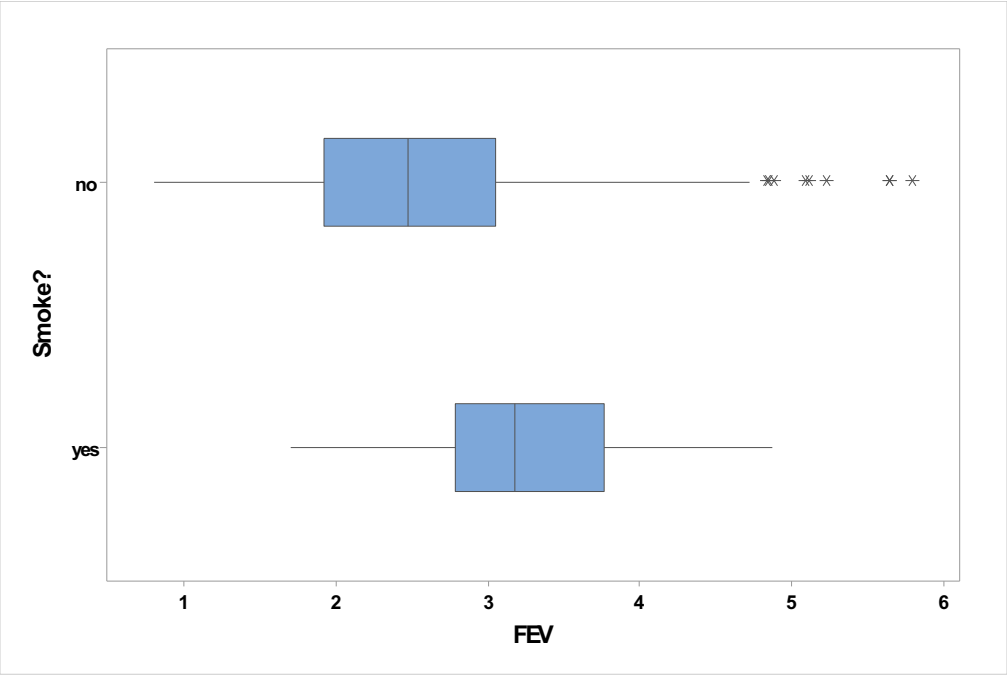
1a. Investigative process

- Assessment example: Collect data on transactions at campus snack bar – student/not, day of week, amount of transaction, waiting time
  - State a research question for which a two-sample *t*-test would be appropriate
  - State a research question for which two-proportion *z*-test would be appropriate
  - State a research question for which one-sample *t*-interval would be appropriate

1b. Multivariable thinking

- Example: Lung capacity and smoking

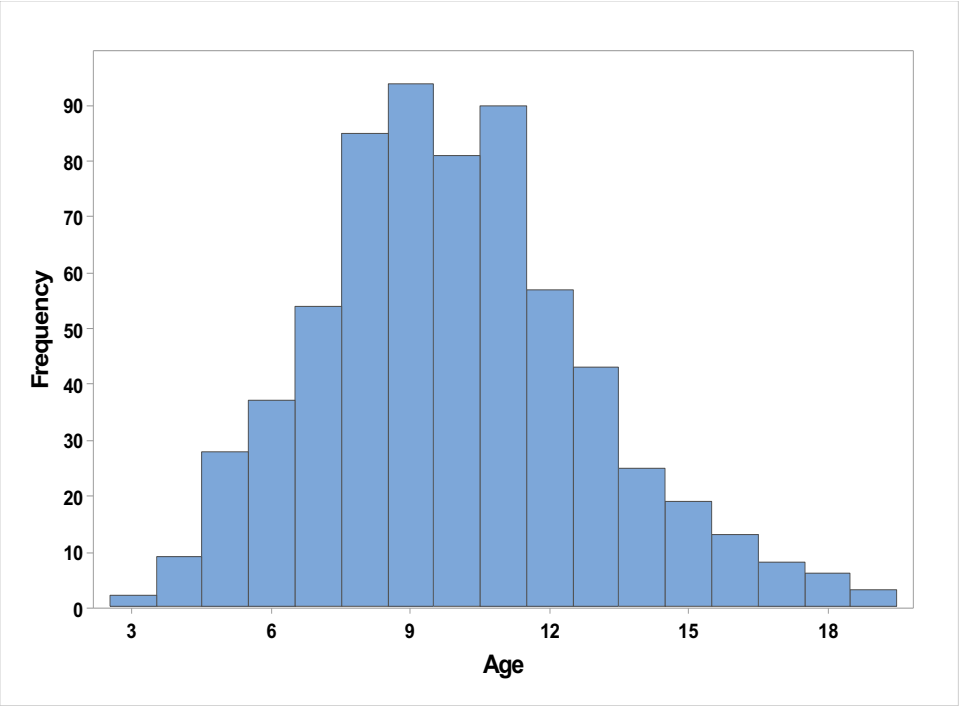
- $t = 7.15$
- p-value ≈ .0000



- What's going on here???

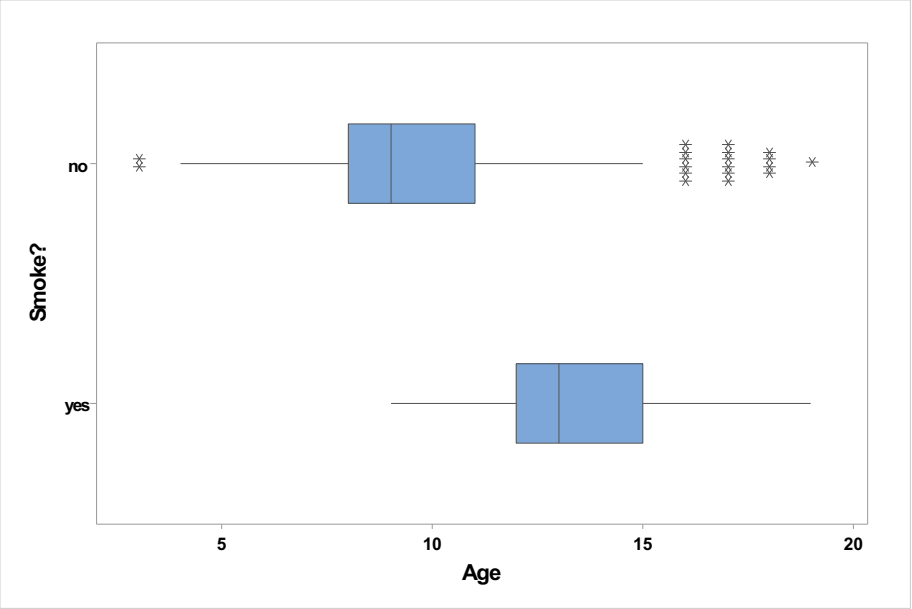
1b. Multivariable thinking (cont)

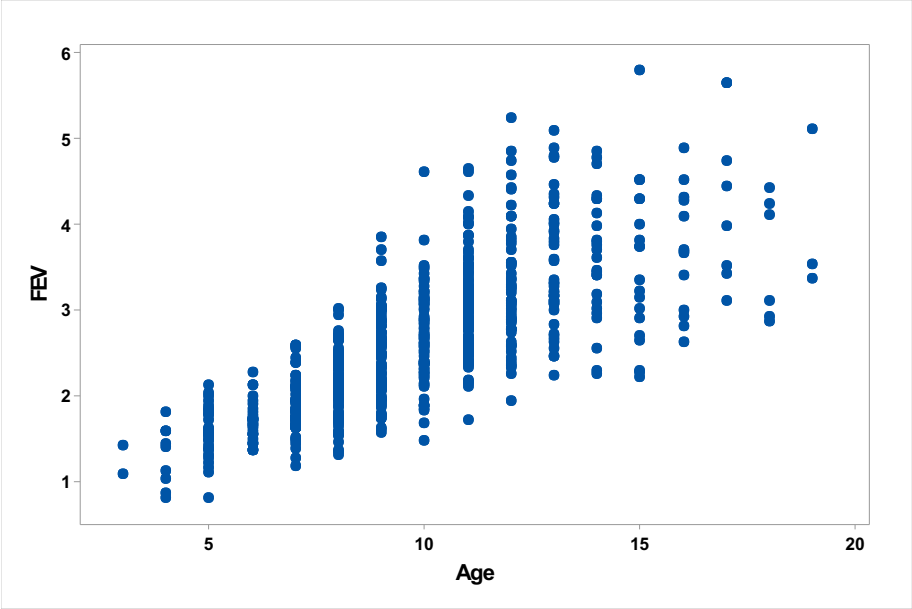
- Confounding variable
- These data are from children aged 3 – 19
- How does age explain why smokers have significantly larger lung capacities than non-smokers?



1b. Multivariable thinking (cont)

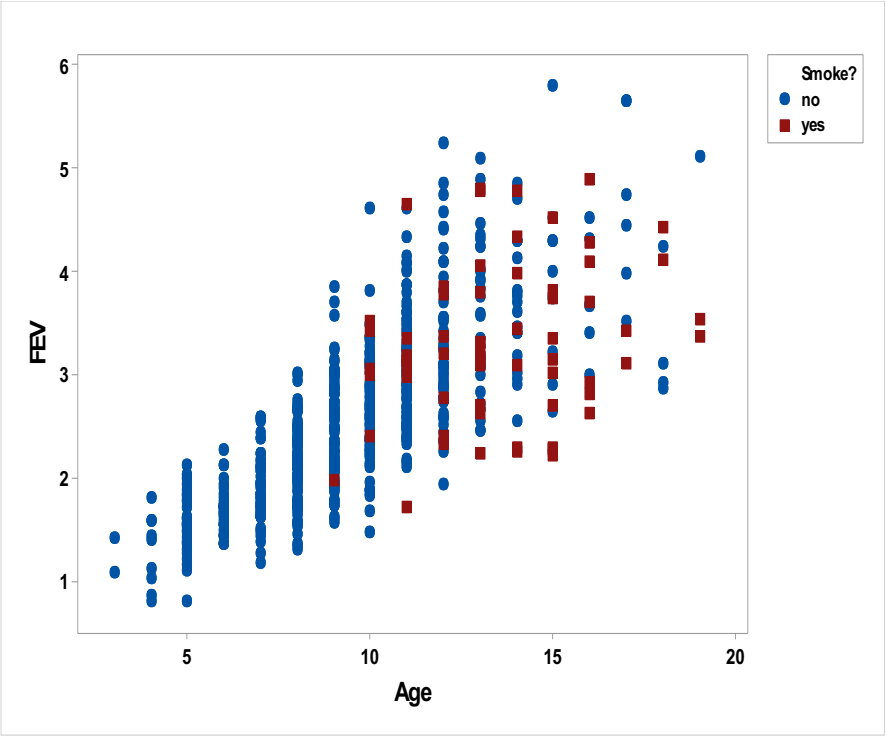
- Age is associated with both smoking status and lung capacity





1b. Multivariable thinking (cont)

- Let's look at all three variables together



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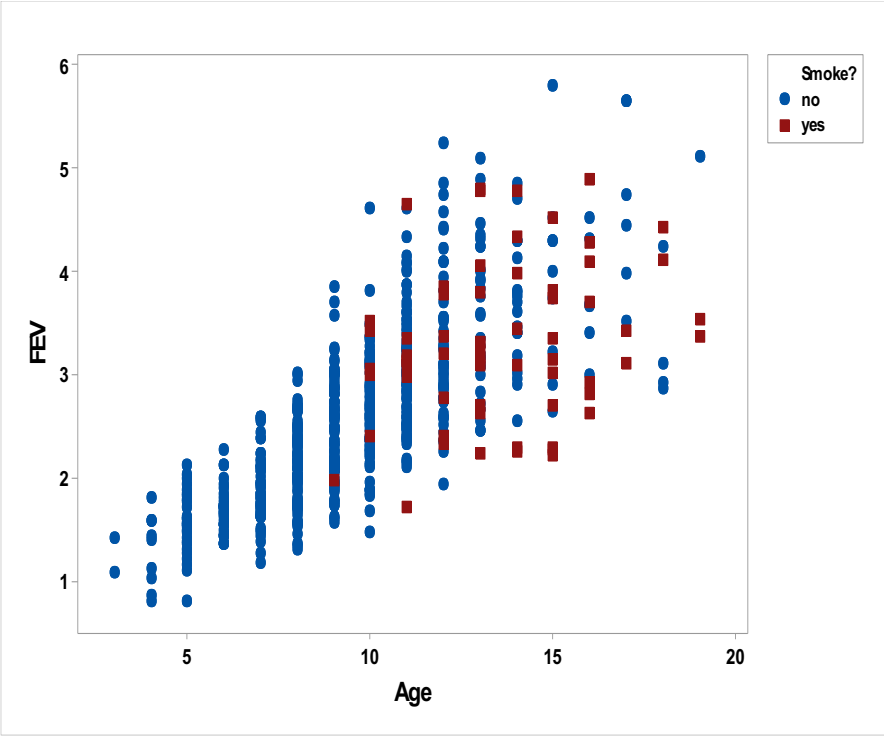
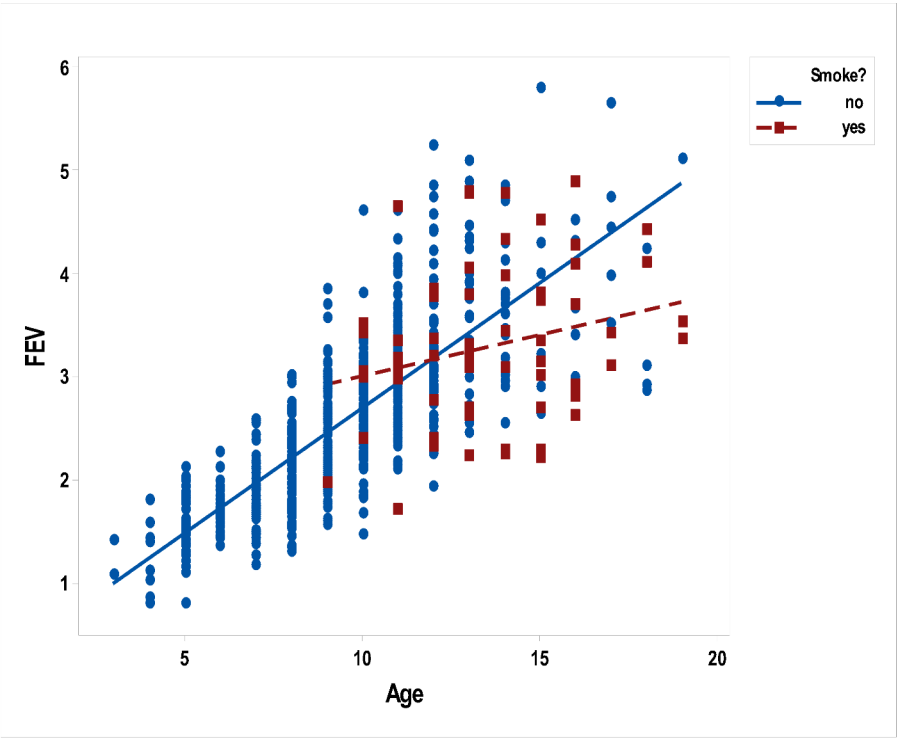
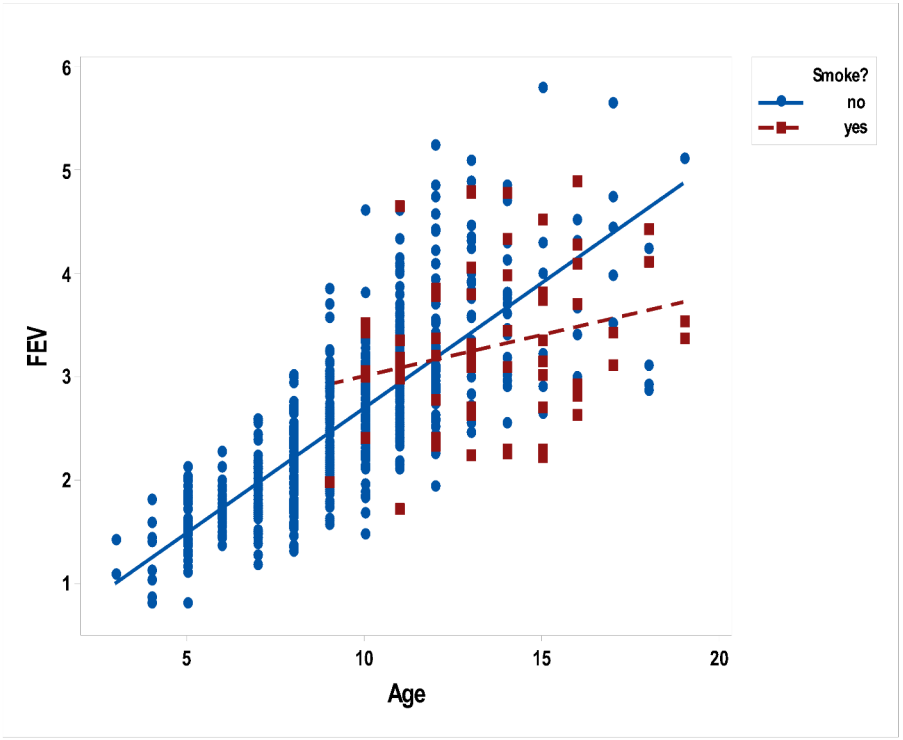




1b. Multivariable thinking (cont)

- After controlling for age, smokers have smaller lung capacity than non-smokers (12 or older)
- Rate of increase in lung capacity per year of age is smaller for smokers than for non-smokers



Interlude 4: My “accent”

- Where do you think I’m from?
  - Ireland?
  - Scotland?
  - Scandanavia?
  - Canada?
  - Minnesota?
  - …?

Thanks very much!

www.amstat.org/education/gaise

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