

Unit 1: Introduction to data

1. Data Collection + Observational studies & experiments

Sta 104 - Summer2015

Duke University, Department of Statistical Science

May 15, 2015

1. Housekeeping

2. Main ideas

1. Always start your exploration with a visualization
2. When describing numerical distributions discuss shape, center, spread, and unusual observations
3. Robust statistics are not easily affected by outliers and extreme skew
4. Use box plots to display quartiles, median, and outliers
5. Use mosaic plots for visualizing relationship between two categorical variables
6. Be aware of Simpson's paradox
7. Use side-by-side box plots to visualize relationships between numerical and categorical variables

3. Summary

- ▶ Piazza participation
- ▶ Lab 1 due Sunday night
- ▶ PS 1 due Monday night
- ▶ Bring deck of cards to class on Monday

Application exercise: 1.1 Scientific studies in the press

See course website for details: <http://bit.ly/sta104su15>
(10 minutes)

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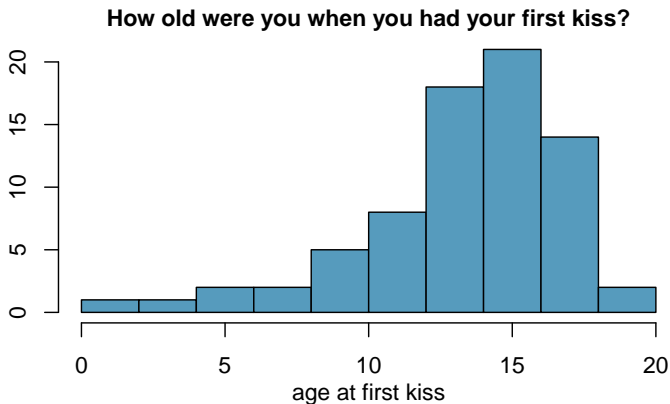
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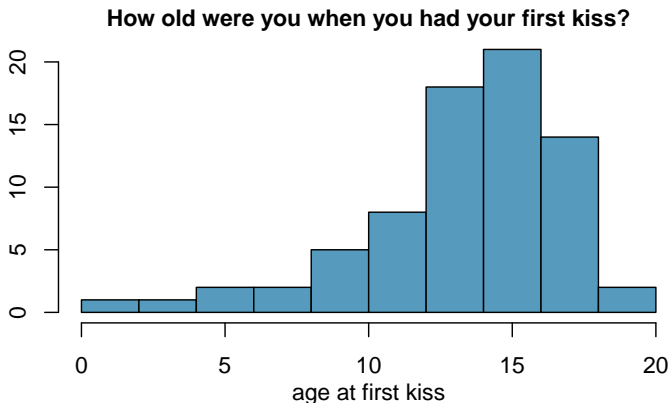
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Do you see anything out of the ordinary?

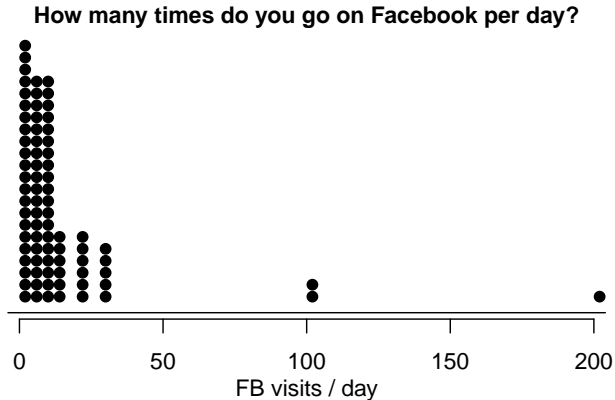


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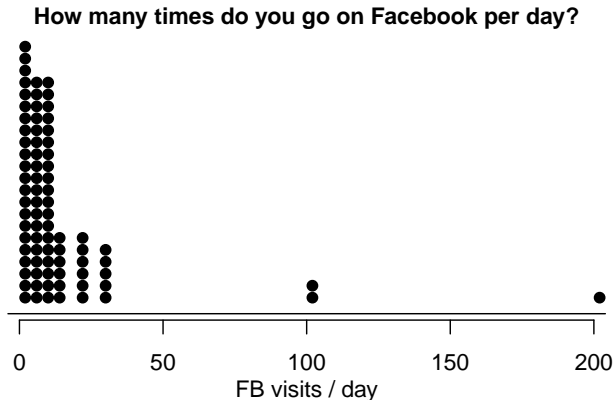


Some people reported very low ages, which might suggest the survey question wasn't clear: romantic kiss or any kiss?

How are people reporting lower vs. higher values of FB visits?

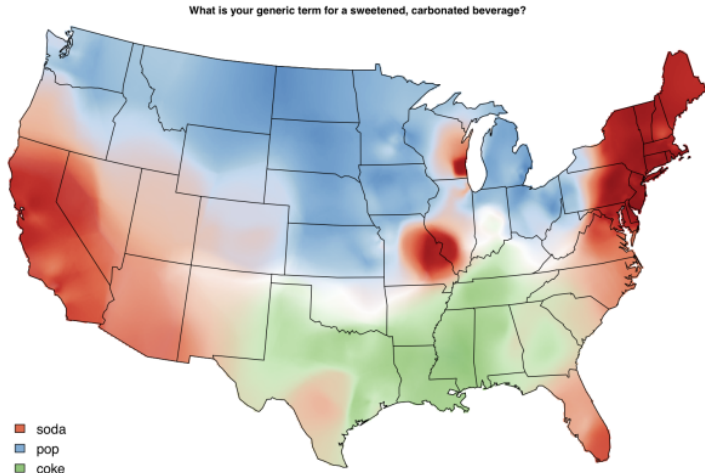


How are people reporting lower vs. higher values of FB visits?



Finer scale for lower numbers.

Describe the spatial distribution of preferred sweetened carbonated beverage drink.



Map by Joshua Katz, Department of Statistics, NC State University
Based on survey data from Bert Vaux, Department of Linguistics, University of Cambridge

What is missing in this visualization?



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3. Summary

- ▶ *Shape*: skewness, modality
- ▶ *Center*: an estimate of a *typical* observation in the distribution (mean, median, mode, etc.)
 - Notation: μ : population mean, \bar{x} : sample mean
- ▶ *Spread*: measure of variability in the distribution (standard deviation, IQR, range, etc.)
- ▶ *Unusual observations*: observations that stand out from the rest of the data that may be suspected outliers

Clicker question

Which of these is most likely to have a roughly symmetric distribution?

- (a) salaries of a random sample of people from North Carolina
- (b) weights of adult females
- (c) scores on an well-designed exam
- (d) last digits of phone numbers

Clicker question

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- (a) salaries of a random sample of people from North Carolina
- (b) *weights of adult females*
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Clicker question

How do the mean and median of the following two datasets compare?

Dataset 1: 30, 50, 70, 90

Dataset 2: 30, 50, 70, 1000

- (a) $\bar{x}_1 = \bar{x}_2$, $median_1 = median_2$
- (b) $\bar{x}_1 < \bar{x}_2$, $median_1 = median_2$
- (c) $\bar{x}_1 < \bar{x}_2$, $median_1 < median_2$
- (d) $\bar{x}_1 > \bar{x}_2$, $median_1 < median_2$
- (e) $\bar{x}_1 > \bar{x}_2$, $median_1 = median_2$

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- ▶ Most commonly used measure of variability is the *standard deviation*, which roughly measures the average deviation from the mean
 - Notation: σ : population standard deviation, s : sample standard deviation
- ▶ Calculating the standard deviation, for a population (rarely, if ever) and for a sample:

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (x_i - \mu)^2}{n}} \qquad s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

- ▶ Square of the standard deviation is called the *variance*.

Why divide by $n - 1$ instead of n when calculating the sample standard deviation?

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Why divide by $n - 1$ instead of n when calculating the sample standard deviation?

Lose a “degree of freedom” for using an estimate (the sample mean, \bar{x}), in estimating the sample variance/standard deviation.

Why do we use the squared deviation in the calculation of variance?

- ▶ To get rid of negatives so that observations equally distant from the mean are weighed equally.
- ▶ To weigh larger deviations more heavily.

Clicker question

True / False: The range is always at least as large as the IQR for a given dataset.

- (a) Yes
- (b) No

Clicker question

True / False: The range is always at least as large as the IQR for a given dataset.

(a) Yes

(b) No

$$\text{Range} = \max - \min, \text{IQR} = Q3 - Q1$$

Clicker question

True / False: The range is always at least as large as the IQR for a given dataset.

(a) Yes

(b) No

$$\text{Range} = \max - \min, \text{IQR} = Q3 - Q1$$

Is the range or the IQR more robust to outliers?

Clicker question

True / False: The range is always at least as large as the IQR for a given dataset.

(a) Yes

(b) No

$$\text{Range} = \max - \min, \text{IQR} = Q3 - Q1$$

Is the range or the IQR more robust to outliers?

IQR

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3. Summary

- ▶ Mean and standard deviation are easily affected by extreme observations since the value of each data point contributes to their calculation.
- ▶ Median and IQR are more robust.
- ▶ Therefore we choose median&IQR (over mean&SD) when describing skewed distributions.

Application exercise: 1.2 Distributions of numerical variables

See course website for details: <http://bit.ly/sta104su15>
(15 minutes)

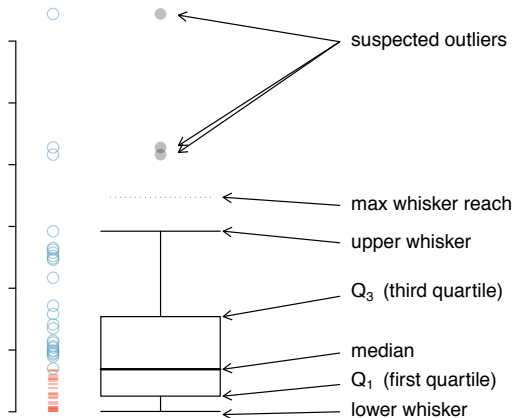
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A *box plot* visualizes the median, the quartiles, and suspected outliers. An *outlier* is defined as an observation more than $1.5 \times \text{IQR}$ away from the quartiles.



Application exercise: 1.3 Boxplots

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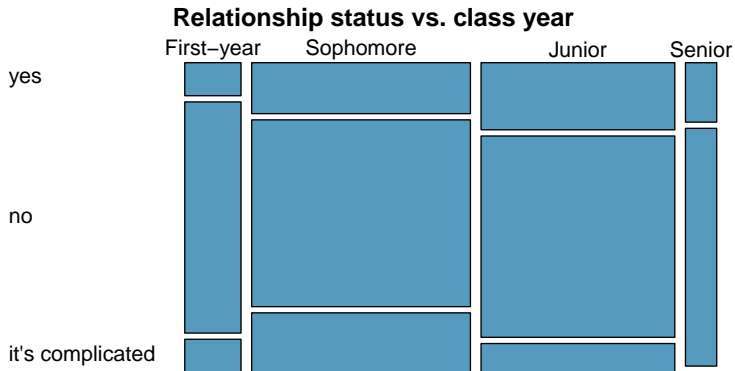
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What do the widths of the bars represent? What about the heights of the boxes? Is there a relationship between class year and relationship status? What other tools could we use to summarize these data?



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A 1991 study by Radelet and Pierce on race and death-penalty (DP) sentences gives the following table:

Defendant's race	DP	No DP	Total	% DP
Caucasian	53	430	483	
African American	15	176	191	
Total	68	606	674	

Adapted from Subsection 2.3.2 of A. Agresti (2002), *Categorical Data Analysis*, 2nd ed., and

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Same data, taking into consideration victim's race:

Victim's race	Defendant's race	DP	No DP	Total	% DP
Caucasian	Caucasian	53	414	467	
Caucasian	African American	11	37	48	
African American	Caucasian	0	16	16	
African American	African American	4	139	143	
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Same data, taking into consideration victim's race:

Victim's race	Defendant's race	DP	No DP	Total	% DP
Caucasian	Caucasian	53	414	467	11.3%
Caucasian	African American	11	37	48	
African American	Caucasian	0	16	16	
African American	African American	4	139	143	
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Victim's race	Defendant's race	DP	No DP	Total	% DP
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Who is more likely to get the death penalty?

- ▶ People of one race are more likely to murder others of the same race, murdering a Caucasian is more likely to result in the death penalty, and there are more Caucasian defendants than African American defendants in the sample.

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- ▶ People of one race are more likely to murder others of the same race, murdering a Caucasian is more likely to result in the death penalty, and there are more Caucasian defendants than African American defendants in the sample.
- ▶ Controlling for the victim's race reveals more insights into the data, and changes the direction of the relationship between race and death penalty.
- ▶ This phenomenon is called *Simpson's Paradox*: An association, or a comparison, that holds when we compare two groups can disappear or even be reversed when the original groups are broken down into smaller groups according to some other feature (a confounding/lurking variable).

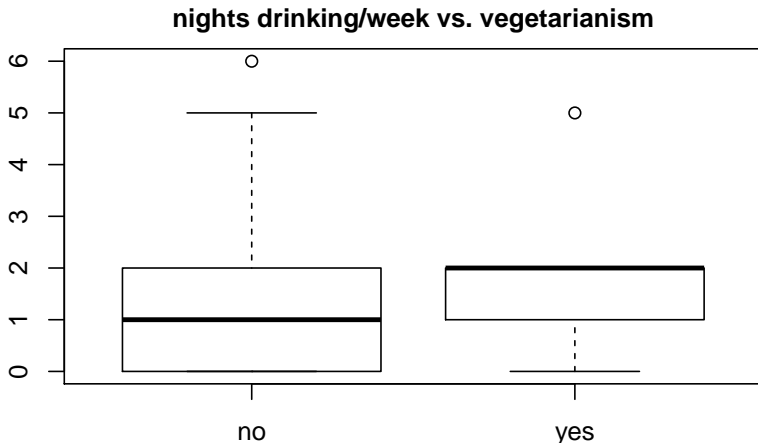
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How do drinking habits of vegetarian vs. non-vegetarian students compare?



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