Summarizing Data

Ryan Miller

Why summarize?

A restaurant server wanting to understand their income collects data on every table they serve. Data from 20 tables are displayed below. What do these data tell you?

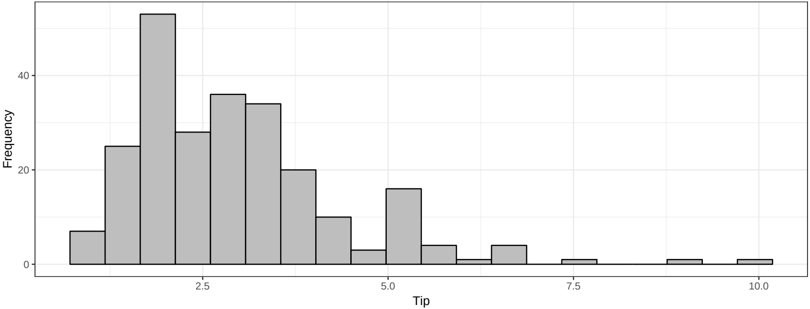
total_bill	tip	sex	smoker	day	time	size
12.69	2.00	Male	No	Sat	Dinner	2
13.13	2.00	Male	No	Sun	Dinner	2
11.87	1.63	Female	No	Thur	Lunch	2
14.07	2.50	Male	No	Sun	Dinner	2
26.59	3.41	Male	Yes	Sat	Dinner	3
24.55	2.00	Male	No	Sun	Dinner	4
21.01	3.50	Male	No	Sun	Dinner	3
19.49	3.51	Male	No	Sun	Dinner	2
25.00	3.75	Female	No	Sun	Dinner	4
11.69	2.31	Male	No	Thur	Lunch	2
16.21	2.00	Female	No	Sun	Dinner	3
8.52	1.48	Male	No	Thur	Lunch	2
20.08	3.15	Male	No	Sat	Dinner	3
13.27	2.50	Female	Yes	Sat	Dinner	2
3.07	1.00	Female	Yes	Sat	Dinner	1
19.81	4.19	Female	Yes	Thur	Lunch	2
15.69	3.00	Male	Yes	Sat	Dinner	3
20.29	3.21	Male	Yes	Sat	Dinner	2
13.94	3.06	Male	No	Sun	Dinner	2
34.81	5.20	Female	No	Sun	Dinner	4

Why summarize?

- Presenting data without any *summarization* is rarely useful
  - Human's simply aren't good at processing that much information
- Summarization reduces the data to a single number (or a small set of numbers)
  - In this class, we will focus on **univariate** summaries (those involving a single variable) and **bivariate** summaries (those involving two variables)

Distributions

- For a single variable, we often want to know how the variable is *distributed*
  - A variable's **distribution** describes values that are possible and how frequently they occur
- Below is a **histogram**, one way of showing a distribution of a quantitative variable
  - \$2-3 tips are most common, larger tips of \$5+ do occasionally occur, tips over \$10 almost never occur



Distributions

- Distributions aren't actually a summary, but they help us understand summarization
    - The *most common* tips could be more precisely characterized using the **mean** or **median**
    - The *less common larger tips* could be more precisely characterized using the **maximum** or **90% percentile**
- Each of the four bolded terms is a different *univariate* summary measure
    - Lab #1 will go into further detail on these summary measures

Variability

- Distributions also display **variation** in the data, a fundamental concept in statistics
  - Variation is most commonly measured by the **standard deviation**, which roughly corresponds to the *average distance of each data-point from the mean*
  - Lab #1 will provide a more precise, mathematical definition of standard deviation

The 68-95-99 Rule

For symmetric, bell-shaped distributions, the standard deviation is related to the percentage of cases within a certain distance of the mean

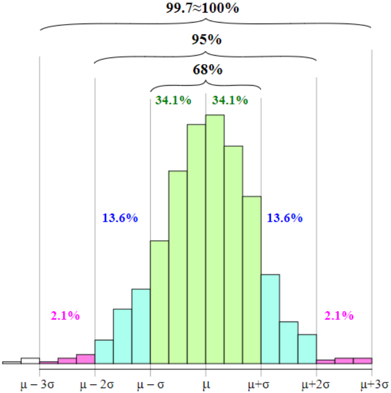


Image Source: https://en.wikipedia.org/wiki/68-95-99.7_rule

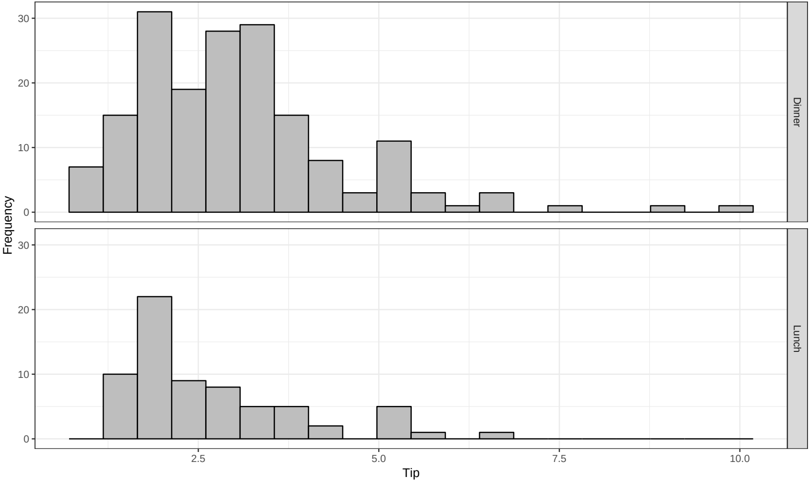
Association

- Most things we'd like to learn from our data involve two (or more) variables
- Two variables are **associated** if certain values of one variable tend to correspond with certain values of the other variable
- For example, the **two-way frequency table** below suggests "table size" and "time of day" *are associated*
  - 76.5% of lunches have size = 2, while only 59.1% of dinners have size = 2

Size	Dinner	Lunch
1	2	2
2	104	52
3	33	5
4	32	5
5	4	1
6	1	3

Practice

Using the graph below, are the variables “time” and “tip” associated? Be prepared to explain why or why not.

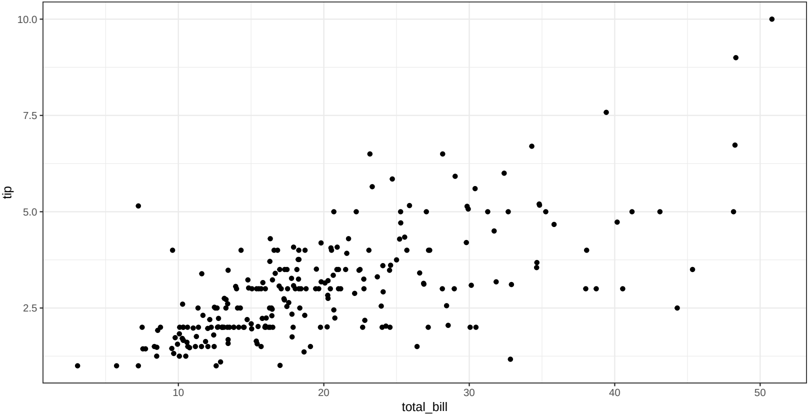


Explanatory and Response Variables

- When discussing association, we tend to think about *cause and effect*
  - "time" could influence "tip", but "tip" couldn't possibly influence "time"
- In this spirit, an **explanatory variable** is one that is used to understand or predict a **response variable**
  - Not every two-variable relationship requires the designation of explanatory and response variables
  - Systolic blood pressure is strongly associated with diastolic blood pressure, but neither "explains" the other
- We will revisit *cause and effect* soon, for now we'll use the general term "association" when discussing relationships between variables, and we'll avoid reading too much into *why* associations exist (a key topic for the rest of the semester)

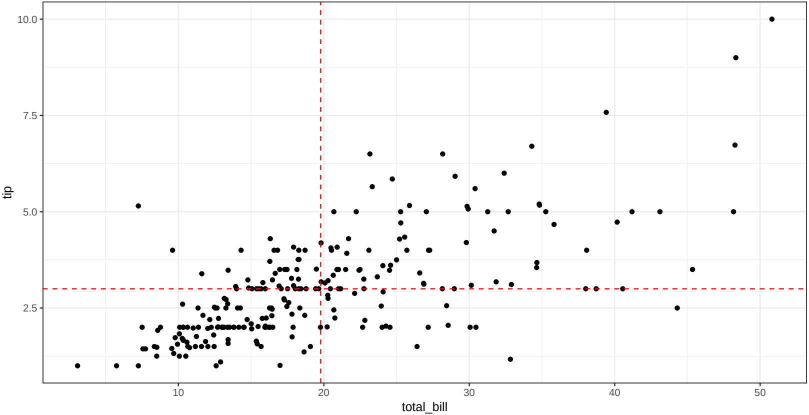
Practice

Using the scatterplot below, are the variables “total_bill” and “tip” associated? Why or why not? Which variable makes more sense to consider as an explanatory variable?



Practice - Solution

Dividing the scatterplot into quadrants (using each variable's mean), an association is evidenced by the abundance of data in the upper-right and lower-left quadrants.



Measuring Association

- Association can be quantified numerically depending upon the types of the variables in question
- For two categorical variables, association can be measured using **differences in proportions**
    - The proportion of tables with exactly 2 patrons is 0.174 higher for lunches than for dinners
- For one quantitative and one categorical variable, it can be measured using **differences in means**
    - The mean tip is $1.6 higher for dinners than it is for lunches
- For two quantitative variables, it can be measured using the **correlation coefficient**
    - The correlation between tip and total bill is 0.676, suggesting higher bills are associated with higher tips
    - More info on the correlation coefficient is coming in Lab #1

Foreshadowing

- For the time being, we're going to focus on measuring and describing associations *in the data we are analyzing*
- For much of the remainder of this course we'll learn about how to properly generalize associations using statistical methods to help us make broader conclusions

Conclusion

Right now, you should:

1. Understand the usefulness in summarizing data
2. Know the definition of association, how to identify when variables are associated, and how to quantify an association

If you want more information:

- Read Ch 2.1-2.4
- Read the Bradford Hill criteria (link) for causation