Chapter 7 – Scatterplots, Association, and Correlation

1. Association.

a) Either weight in grams or weight in ounces could be the explanatory or response variable. Greater weights in grams correspond with greater weights in ounces. The association between weight of apples in grams and weight of apples in ounces would be positive, straight, and perfect. Each apple's weight would simply be measured in two different scales. The points would line up perfectly.

b) Circumference is the explanatory variable, and weight is the response variable, since one-dimensional circumference explains three-dimensional volume (and therefore weight). For apples of roughly the same size, the association would be positive, straight, and moderately strong. If the sample of apples contained very small and very large apples, the association's true curved form would become apparent.

c) There would be no association between shoe size and GPA of college freshmen.

d) Number of miles driven is the explanatory variable, and gallons remaining in the tank is the response variable. The greater the number of miles driven, the less gasoline there is in the tank. If a sample of different cars is used, the association is negative, straight, and moderate. If the data is gathered on different trips with the same car, the association would be strong.

2. Association.

a) Price for each T-Shirt is the explanatory variable, and number of T-Shirts sold is the response variable. The association would be negative, straight (until the price became too high to sell *any* shirts), and moderate. A very low price would likely lead to very high sales, and a very high price would lead to low sales.

b) Depth of the water is the explanatory variable, and water pressure is the response variable. The deeper you dive, the greater the water pressure. The association is positive, straight, and strong. For every 33 feet of depth, the pressure increases by one atmosphere (14.7 psi).

c) Depth of the water is the explanatory variable, and visibility is the response variable. The deeper you dive, the lower the visibility. The association is negative, possibly straight, and moderate if a sample of different bodies of water is used. If the same body of water has visibility measured at different depths, the association would be strong.

d) At first, it appears that there should be no association between weight of elementary school students and score on a reading test. However, with weight as the explanatory variable and score as the response variable, the association is positive, straight, and moderate. Students who weigh more are likely to do better on reading tests because of the lurking variable of age. Certainly, older students generally weigh more and generally are better readers. Therefore, students who weigh more are likely to be better readers. This does not mean that weight causes higher reading scores.

3. Association.

a) Altitude is the explanatory variable, and temperature is the response variable. As you climb higher, the temperature drops. The association is negative, straight, and strong.

b) At first, it appears that there should be no association between ice cream sales and air conditioner sales. When the lurking variable of temperature is considered, the association becomes more apparent. When the temperature is high, ice cream sales tend to increase. Also, when the temperature is high, air conditioner sales tend to increase. Therefore, there is likely to be an increase in the sales of air conditioners whenever there is an increase in the sales of ice cream. The association is positive, straight, and moderate. Either one of the variables could be used as the explanatory variable.

c) Age is the explanatory variable, and grip strength is the response variable. The association is neither negative nor positive, but is curved, and moderate in strength, due to the variability in grip strength among people in general. The very young would have low grip strength, and grip strength would increase as age increased. After reaching a maximum (at whatever age physical prowess peaks), grip strength would decline again, with the elderly having low grip strengths.

d) Blood alcohol content is the explanatory variable, and reaction time is the response variable. As blood alcohol level increase, so does the time it takes to react to a stimulus. The association is positive, probably curved, and strong. The scatterplot would probably be almost linear for low concentrations of alcohol in the blood, and then begin to rise dramatically, with longer and longer reaction times for each incremental increase in blood alcohol content.

4. Association.

a) Time spent talking on the phone is the explanatory variable, and cost of the call is the response variable. The longer you spend talking, the more the call costs. The association is positive, straight, and moderately strong, since some long distance companies charge more than others.

b) Distance from lightning is the explanatory variable, and time delay of the thunder is the response variable. The farther away you are from the strike, the longer it takes the thunder to reach your ears. The association is positive, straight, and fairly strong, since the speed of sound is not a constant. Sound travels at a rate of around 770 miles per hour, depending on the temperature.

c) Distance from the streetlight is the explanatory variable, and brightness is the response variable. The further away from the light you are, the less bright it appears. The association is negative, curved, and strong. Distance and light intensity follow an inverse square relationship. Doubling the distance to the light source reduces the intensity by a factor of four.

d) There is likely very little association between the weight of the car and the age of the owner. However, some might say that older drivers tend to drive larger cars. (Anyone who has seen my grandfather's car can attest to this!) If that is the case, there may be a positive, straight, and very weak association between weight of a car and the age of its owner.

5. Scatterplots.

a) None of the scatterplots show little or no association, although # 4 is very weak.

b) #3 and #4 show negative association. Increases in one variable are generally related to decreases in the other variable.

c) #2, #3, and #4 each show a straight association.

d) #2 shows a moderately strong association.

e) #1 and #3 each show a very strong association. #1 shows a curved association and #3 shows a straight association.

6. Scatterplots.

a) #1 shows little or no association.

b) #4 shows a negative association.

c) #2 and #4 each show a straight association.

d) #3 shows a moderately strong, curved association.

e) #2 and #4 each show a very strong association, although some might classify the association as merely "strong".

7. Performance IQ scores *vs.* brain size.

The scatterplot of IQ scores *vs.* Brain Sizes is scattered, with no apparent pattern. There appears to be little or no association between the IQ scores and brain sizes displayed in this scatterplot.

8. Kentucky derby 2006.

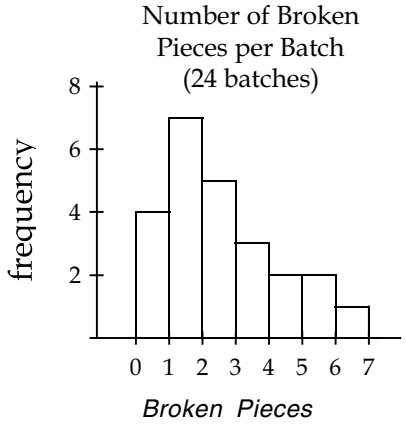
Winning speeds in the Kentucky Derby have generally increased over time. The association between year and speed is moderately strong, and seems slightly curved, with a greater rate of increase in winning speed before 1950 and a smaller rate of increase after 1950, suggesting that winning speeds have leveled off over time.

9. Firing pottery.

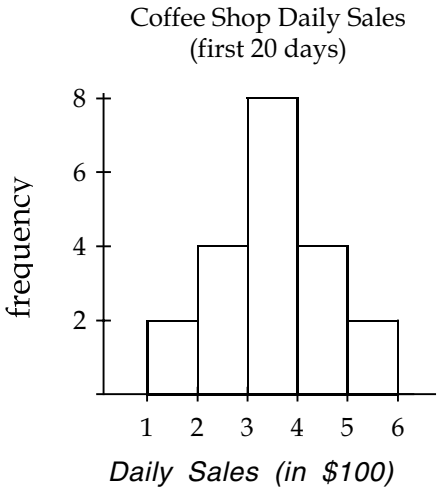
a) A histogram of the number of broken pieces is at the right.

b) The distribution of the number broken pieces per batch of pottery is skewed right, centered around 1 broken piece per batch. Batches had from 0 and 6 broken pieces. The scatterplot does not show the center or skewness of the distribution.

c) The scatterplot shows that the number of broken pieces increases as the batch number increases. If the 8 daily batches are numbered sequentially, this indicates that batches fired later in the day generally have more broken pieces. This information is not visible in the histogram.



10. Coffee sales.



a) A histogram of daily sales is at the right.

b) The scatterplot shows that, in general, the sales have been increasing over time. The histogram does not show this.

c) The histogram shows that the mean of the daily sales for the coffee shop was between $300 and $400, and that this happened on 8 days. The scatterplot does not show this.

11. Matching.

a) 0.006 **b)** 0.777 **c)** - 0.923 **d)** - 0.487

12. Matching.

a) - 0.977 **b)** 0.736 **c)** 0.951 **d)** - 0.021

13. Politics.

The candidate might mean that there is an **association** between television watching and crime. The term correlation is reserved for describing linear associations between quantitative variables. We don't know what type of variables "television watching" and "crime" are, but they seem categorical. Even if the variables are quantitative (hours of TV watched per week, and number of crimes committed, for example), we aren't sure that the relationship is linear. The politician also seems to be implying a cause-and-effect relationship between television watching and crime. Association of any kind does not imply causation.

14. Car thefts.

It might be reasonable to say that there is an **association** between the type of car you own and the risk that it will be stolen. The term correlation is reserved for describing linear associations between quantitative variables. Type of car is a categorical variable.

15. Roller Coasters.

a) It is appropriate to calculate correlation. Both height of the drop and speed are quantitative variables, the scatterplot shows an association that is straight enough, and there are not outliers.

b) There is a strong, positive, straight association between drop and speed; the greater the height of the initial drop, the higher the top speed.

16. Antidepressants.

a) It is appropriate to calculate correlation. Both placebo improvement and treated improvement are quantitative variables, the scatterplot shows an association that is straight enough, and there are not outliers.

b) There is a strong, positive, straight association between placebo and treated improvement. Experiments that showed a greater placebo effect also showed a greater mean improvement among patients who took an antidepressant.

17. Hard water.

It is not appropriate to summarize the strength of the association between water hardness and pH with a correlation, since the association is curved, not Straight Enough.

18. Traffic headaches.

It is not appropriate to summarize the strength of the association between highway speed and total delay with a correlation. The scatterplot shows evidence of outliers, and the main cluster of data is not Straight Enough.

19. Cold nights.

The correlation is between the number of days since January 1 and temperature is likely to be near zero. We expect the temperature to be low in January, increase through the spring and summer, then decrease again. The relationship is not Straight Enough, so correlation is not an appropriate measure of strength.

20. Association.

The researcher should have plotted the data first. A strong, curved relationship may have a very low correlation. In fact, correlation is only a useful measure of the strength of a linear relationship.

21. Prediction units.

The correlation between prediction error and year would not change, since the correlation is based on z-scores. The z-scores are the same whether the prediction errors are measured in nautical miles or miles.

22. More predictions.

The correlation between prediction error and year would not change, since the correlation is based on z-scores. The z-scores of the prediction errors are not changed by adding or subtracting a constant.

23. Correlation errors.

a) If the association between GDP and infant mortality is linear, a correlation of –0.772 shows a moderate, negative association. Generally, as GDP increases, infant mortality rate decreases.

b) Continent is a categorical variable. Correlation measures the strength of linear associations between quantitative variables.

24. More correlation errors.

a) Correlation must be between –1 and 1, inclusive. Correlation can never be 1.22.

b) A correlation, no matter how strong, cannot prove a cause-and-effect relationship.

25. Height and reading.

a) Actually, this *does* mean that taller children in elementary school are better readers. However, this does *not* mean that height causes good reading ability.

b) Older children are generally both taller and are better readers. Age is the lurking variable.

26. Cellular telephones and life expectancy.

a) No. It simply means that in countries where cell phone use is high, the life expectancy tends to be high as well.

b) General economic conditions of the country could affect both cell phone use and life expectancy. Richer countries generally have more cell phone use and better health care. The economy is a lurking variable.

27. Correlations conclusions I.

a) No. We don't know this from correlation alone. The relationship between age and income may be non-linear, or the relationship may contain outliers.

b) No. We can't tell the form of the relationship between age and income. We need to look at the scatterplot.

c) No. The correlation between age and income doesn't tell us anything about outliers.

d) Yes. Correlation is based on *z*-scores, and is unaffected by changes in units.

28. Correlation conclusions II.

a) No. We don't know this from correlation alone. The relationship between fuel efficiency and price may be non-linear, or the relationship may contain outliers.

b) No. We can't tell the form of the relationship between fuel efficiency and price. We need to look at the scatterplot.

c) No. The correlation between fuel efficiency and price doesn't tell us anything about outliers.

d) No. Correlation is based on *z*-scores, and is unaffected by changes in units.

29. Baldness and heart disease.

Even though the variables baldness and heart disease were assigned numerical values, they are categorical. Correlation is only an appropriate measure of the strength of linear association between quantitative variables. Their conclusion is meaningless.

30. Sample survey.

Even though zipcodes are numbers, they are categorical variables representing different geographic areas. Likewise, even thought the variable *datasource* has numerical values, it is also categorical, representing the source from which the data were acquired. Correlation is only an appropriate measure of the strength of linear association between quantitative variables.

31. Income and housing.

a) There is a positive, moderately strong, linear relationship between *Housing Cost Index* and *Median Family Income*, with several states whose *Housing Cost Index* seems high for their *Median Family Income*, and one state whose *Housing Cost Index* seems low for their *Median Family Income*.

b) Correlation is based on *z*-scores. The correlation would still be 0.65.

c) Correlation is based on *z*-scores, and is unaffected by changes in units. The correlation would still be 0.65.

d) Washington D.C. would be a moderately high outlier, with *Housing Cost Index* high for its *Median Family Income*. Since it doesn't fit the pattern, the correlation would decrease slightly if Washington D.C. were included.

e) No. We can only say that higher *Housing Cost Index* scores are associated with higher *Median Family Income*, but we don't know why. There may be other variables at work.

32. Interest rates and mortgages.

a) There is a negative, strong, linear relationship between *Total Mortgages* and *Interest Rate*. There are no outliers in the relationship.

b) Correlation is based on *z*-scores. The correlation would still be –0.84.

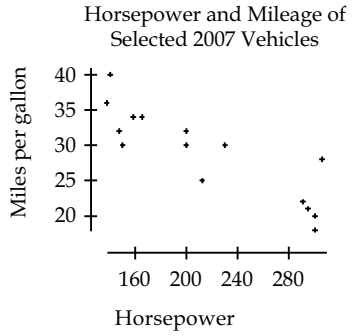
c) Correlation is based on *z*-scores, and is unaffected by changes in units. The correlation would still be –0.84.

d) The given year has a very high mortgage rate for an interest rate that is that high. It doesn't fit the overall pattern, so the correlation would weaken (get closer to zero).

e) No. We can only say that lower interest rates are associated with larger mortgage amounts, but we don't know why. There may be other economic variables at work.

33. Fuel economy 2007.

a) A scatterplot of average fuel economy vs. horsepower ratings is at the right.



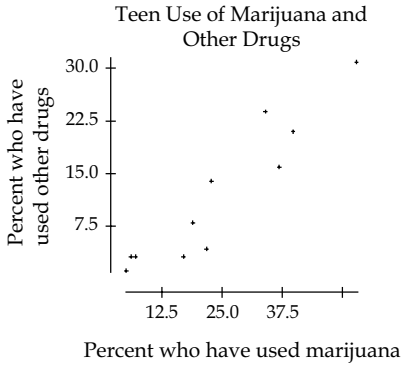
b) There is a strong, negative, straight association between horsepower and mileage of the selected vehicles. There don't appear to be any outliers. All of the cars seem to fit the same pattern. Cars with more horsepower tend to have lower mileage.

c) Since the relationship is linear, with no outliers, correlation is an appropriate measure of strength. The correlation between horsepower and mileage of the selected vehicles is $r = -0.869$.

d) There is a strong linear relationship in the negative direction between horsepower and highway gas mileage. Lower fuel efficiency is associated with higher horsepower.

34. Drug abuse.

a) A scatterplot of percentage of teens who have used other drugs vs. percentage who have used marijuana in the U.S. and 10 Western European countries is at the right.



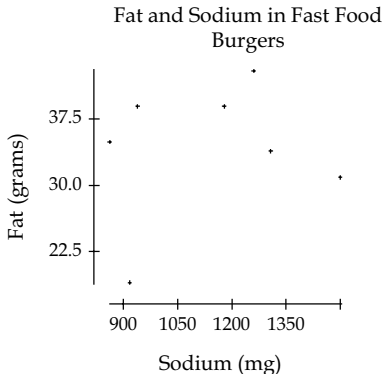
b) The correlation between the percent of teens who have used marijuana and the percent of teens who have used other drugs is $r = 0.934$.

c) The association between the percent of teens who have used marijuana and the percent of teens who have used other drugs is positive, strong, and straight. Countries with higher percentages of teens who have used marijuana tend to have higher percentages of teens that have used other drugs.

d) These results do not confirm that marijuana is a "gateway drug". An association exists between the percent of teens that have used marijuana and the percent of teens that have used other drugs. This does not mean that one caused the other.

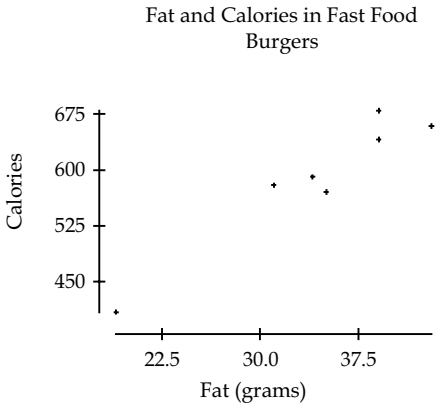
35. Burgers.

There is no apparent association between the number of grams of fat and the number of milligrams of sodium in several brands of fast food burgers. The correlation is only $r = 0.199$, which is close to zero, an indication of no association. One burger had a much lower fat content than the other burgers, at 19 grams of fat, with 920 milligrams of sodium. Without this (comparatively) low fat burger, the correlation would have been even lower.



36. Burgers II.

The correlation between the number of calories and the number of grams of fat in several fast food burgers is $r = 0.961$. The association between the number of calories and the number of grams of fat in several fast food burgers is positive, straight, and strong. Typically, burgers with higher fat content have more calories. Even if the outlier at 410 calories and 19 grams of fat is set aside, the correlation is still quite strong at 0.837.



37. Attendance 2006.

a) Number of runs scored and attendance are quantitative variables, the relationship between them appears to be straight, and there are no outliers, so calculating a correlation is appropriate.

b) The association between attendance and runs scored is positive, straight, and moderate in strength. Generally, as the number of runs scored increases, so does attendance.

c) There is evidence of an association between attendance and runs scored, but a cause-and-effect relationship between the two is not implied. There may be lurking variables that can account for the increases in each. For example, perhaps winning teams score more runs and also have higher attendance. We don't have any basis to make a claim of causation.

38. Second inning 2006.

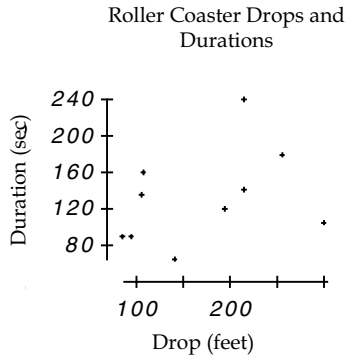
a) Winning teams generally enjoy greater attendance at their home games. The association between home attendance and number of wins is positive, somewhat straight, and moderately strong.

b) The association between winning and home attendance has the strongest correlation, with $r = 0.697$, but it is only slightly higher than the association between home attendance and scoring runs, at $r = 0.667$.

c) The correlation between number of runs scored and number of wins is $r = 0.605$, indicating a possible moderate association. However, since there is no scatterplot of wins vs. runs provided, we can't be sure the relationship is straight. Correlation may not be an appropriate measure of the strength of the association.

39. Thrills.

The scatterplot at the right shows that the association between *Drop* and *Duration* is straight, positive, and weak, with no outliers. Generally, rides on coasters with a greater initial drop tend to last somewhat longer. The correlation between *Drop* and *Duration* is 0.35, indicating a weak association.

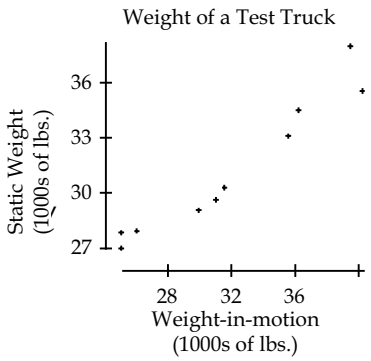


40. Vehicle weights.

a) A scatterplot of the Static Weight vs. Weight-in-Motion of the test truck is at the right.

b) The association between static weight and weight-in-motion is positive, strong, and roughly straight. There may be a hint of a curve in the scatterplot.

c) As the static weight of the test truck increased, so did the weight-in-motion, but the relationship appears weaker for heavier trucks.



d) The correlation between static weight and weight-in-motion is $r = 0.965$.

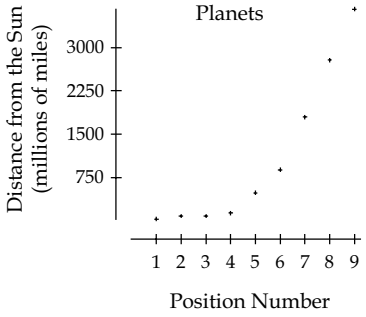
e) Weighing the trucks in kilograms instead of pounds would not change the correlation. Correlation, like z-score, has no units. It is a numerical measure of the degree of linear association between two variables.

f) When the test truck weighed approximately 35,500 pounds, it weighed higher in motion. The scale may need to be recalibrated. If the scale were calibrated exactly, we would expect the points to line up perfectly, with no curve, and no deviations from the pattern.

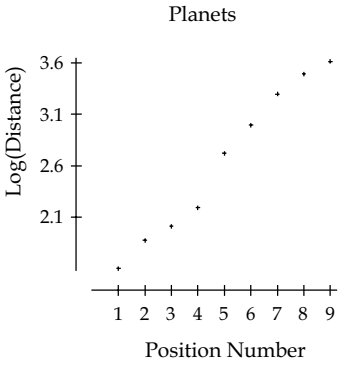
41. Planets (more or less).

a) The association between Position Number of each planet and its distance from the sun (in millions of miles) is very strong, positive and curved. The scatterplot is at the right.

b) The relationship between Position Number and distance from the sun is not linear. Correlation is a measure of the degree of *linear* association between two variables.



c) The scatterplot of the logarithm of distance versus Position Number (shown at the right) still shows a strong, positive relationship, but it is straighter than the previous scatterplot. It still shows a curve in the scatterplot, but it is straight enough that correlation may now be used as an appropriate measure of the strength of the relationship between logarithm of distance and Position Number, which will in turn give an indication of the strength of the association.



42. Flights.

a) The correlation between the year and the number of flights is 0.828.

b) There is a positive, curved association between the year and the number of flights. There is one low outlier in the year 2001.

c) The plot is not straight and has an outlier. Either violation would disqualify the correlation. It isn't unusual for growth in a business to be faster than linear. The outlier in 2001 is due to the drop in airline flights after the 9/11 attacks.