Scatterplots, Association, Correlation

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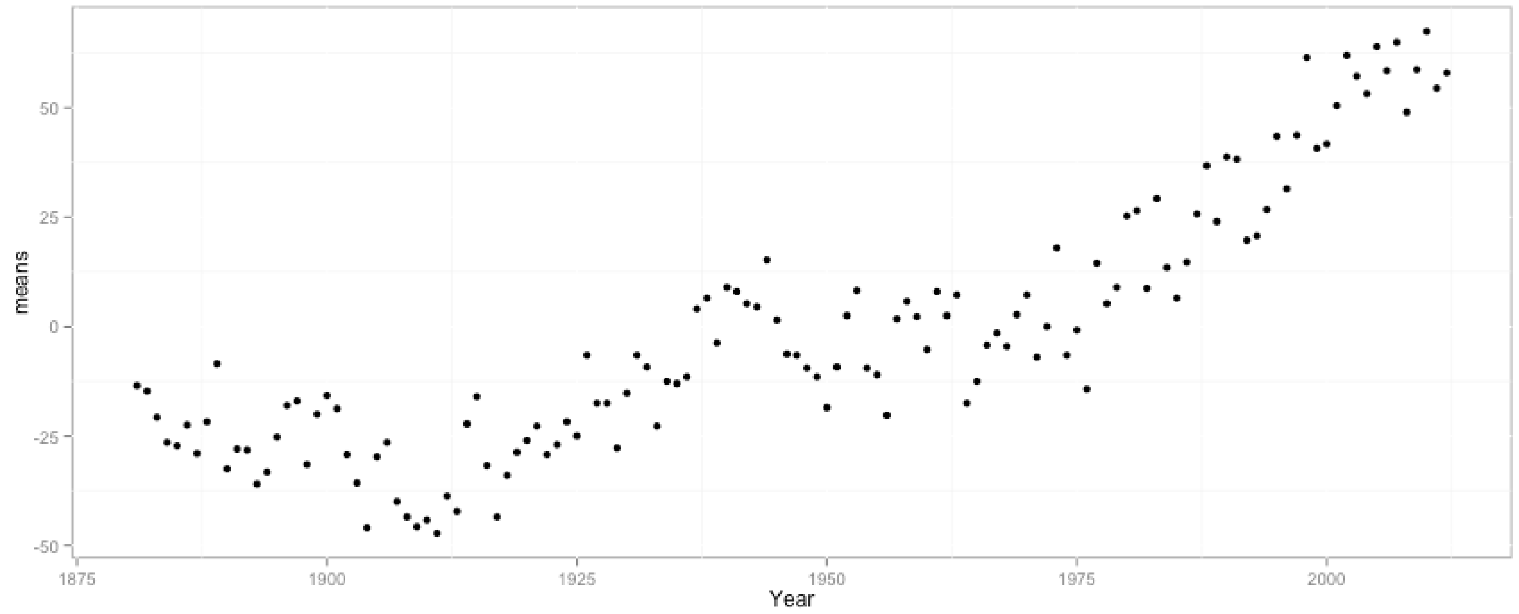
Scatterplots

- Scatterplots exhibit the relationship between two variables.
- Used for detecting patterns, trends, relationships, and extraordinary values.

```
ggplot(temp, aes(x=Year, y=means)) + geom_point()
```



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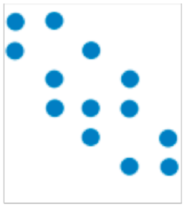
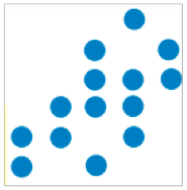
Scatterplots

Direction of Association

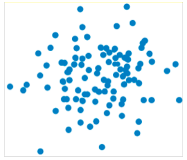
- Negative Direction: As one goes up, the other goes down.



- Positive Direction: As one goes up, the other goes up also.

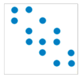


- No Direction

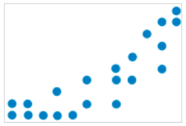


Form

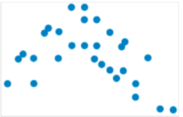
- Linear: The points cluster near a line.



- Gently curves in a direction. May be able to straighten with a transformation.

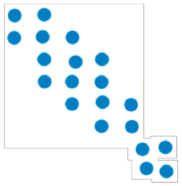


- Curves up and down. Difficult to straighten

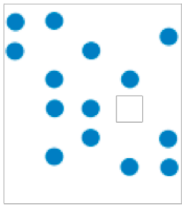


Strength of Relationship

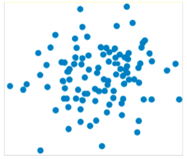
- Strong linear relationship



- Moderate linear relationship



- No linear relationship



Variables

- **Response Variable** (y): The variable of interest. It is what we want to predict.
- **Explanatory or Predictor Variable** (x): The variable that we use to provide information or a prediction of the response variable.
- Choosing the response variable and the explanatory variable depends on how we think about the problem.

For example:

- Do baseball teams that score more runs also sell more tickets?
  Tickets = Response (y), Runs = Explanatory (x)
- Do students with higher SAT scores get better grades?
  Grades = Response (y), SAT score = Explanatory (x)
- Can we estimate a person's BMI by measuring their wrist size?
  BMI = Response (y), Wrist Size = Explanatory (x)

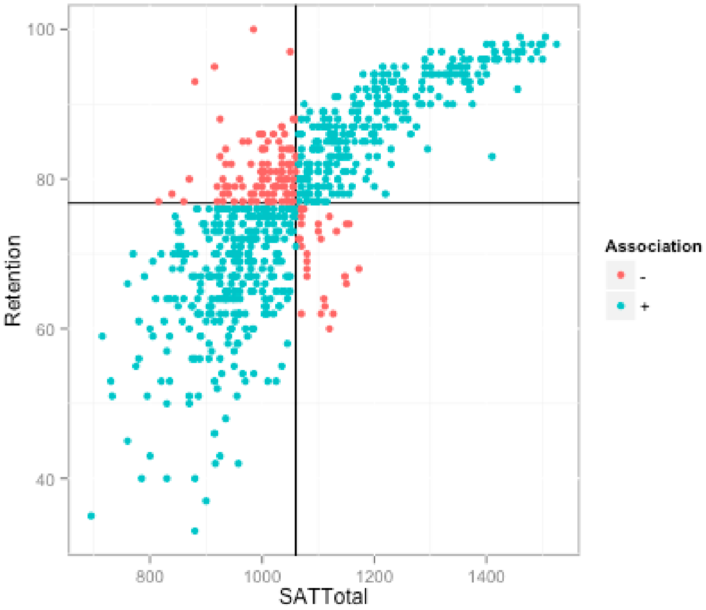
Correlation

- How strong is the relationship between SAT scores and full-time retention?
- For the green dots: z-scores have the same sign, so multiplying the z-scores produces a positive value.
- For the red dots: z-scores have opposite signs, so multiplying the z-scores produces a negative value.
- Define the correlation coefficient by an almost average product of the z-scores:

$$r = \frac{\sum z_x z_y}{n-1}$$

```
meanSAT = mean(ipedsSAT$SATTotal)
meanRetention = mean(ipedsSAT$Retention)
```

```
ggplot(ipedsSAT, aes(x=SATTotal,
     y=Retention, color=Association)) +
     geom_vline(xintercept=meanSAT) +
     geom_hline(yintercept=meanRetention) +
     geom_point()
```



Assumptions and Conditions for Correlation

- To use r, there must be a true underlying linear relationship between the two variables.
- The variables must be quantitative.
- The pattern for the points of the scatterplot must be reasonably straight.
- Outliers can strongly affect the correlation. Look at the scatterplot to make sure that there are no strong outliers.

Calculating correlation in R

```
cor(ipedsSAT$SATTotal, ipedsSAT$Retention)
```

```
[1] 0.7909
```

Properites of Correlation

- $r > 0$ → positive association
- $r < 0$ → negative association
- $-1 < r < 1$, with $r = -1$ only if the points all lie exactly on a negatively sloped line and $r = 1$ only if the points all lie exactly on a positively sloped line.
- Interchanging x and y does not change the correlation.
- r has no units.
- Changing the units of x or y does not affect r.
- Measuring in dollars, cents, or Euros will all produce the same correlation.
- Correlation measures the strength of the linear association between the two variables.
- Correlation is sensitive to outliers. An extreme outlier can cause a dramatic change in r.
- The adjectives weak, moderate, and strong can describe correlation, but there are no agreed upon boundaries.

Correlation DOES NOT mean causation

- Causation is a possibility, but more must be done to prove causation.
- The causation could be in reverse (y causes x)
- A lurking variable may cause both.

Guidelines for Re-Expressions

- Scatterplot bends downwards → y^2
- Scatterplot is linear → No change
- For data that is a count → $y^{\frac{1}{y}}$
- For data that is always positive → $log(y)$
- If nothing else seems to work try → $y^{-\frac{1}{2}}$
- For ratios such as miles per gallon → $\frac{1}{y}$