Visualizing Distributions & Missing Data

PSC7475: Week 4

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Concepts and measurement

- Social science is about understanding **causal relationships**
  - Does minimum wage change levels of employment
  - Does outgroup contact influence views on immigration?
- Relationships are between **concepts**:
  - Minimum wage, unemployment, outgroup contact, views on immigration
  - We took these for granted when talking about causality
- Important to consider how we **measure** these concepts
  - Some straightforward: what is your age?
  - Others more complicated: what does it mean to "be liberal"?
  - **Operational definition**: mapping of concept to numbers in our data

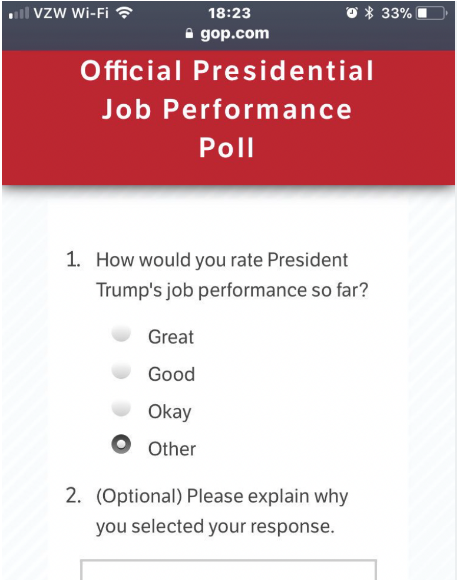
Example

- Concept: presidential approval
- Conceptual definition:
  - Extent to which US adults support the actions and policies of the current US president
- Operational definition:
  - "On a scale from 1 to 5, where 1 is least supportive and 5 is most supportive, how much would you say you support the job that Donald Trump is doing as president?"

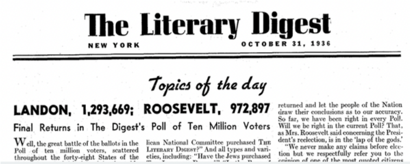
Measurement error

- **Measurement error**: chance variation in our measurements
  - individual measurement = exact value + chance error
  - chance errors tend to cancel out when we take averages
- No matter how careful we are, chance error can always affect a measurement.
  - Panel study of 19,000 respondents: 20 reported being a citizen in 2010 and then a non-citizen in 2012
  - Data entry errors
- **Bias**: systematic errors for all units in the same direction.
  - individual measurement = exact value + bias + chance error
  - "What did you eat yesterday?" $\rightsquigarrow$ underreporting

A biased poll?



1936 Literary Digest Poll



The Literary Digest

NEW YORK OCTOBER 31, 1936

Topics of the day

LANDON, 1,293,669; ROOSEVELT, 972,897

Final Returns in The Digest's Poll of Ten Million Voters

Well, the great battle of the ballots in the Poll of ten million voters, scattered throughout the forty-eight States of the

lican National Committee purchased The Literary Digest?" And all types and varieties, including: "Have the Jews purchased

returned and let the people of the Nation draw their conclusions as to our accuracy. So far, we have been right in every Poll. Will we be right in the current Poll? That, as Mrs. Roosevelt said concerning the President's reelection, is in the 'lap of the gods.'

"We never make any claims before election but we respectfully refer you to the

- Literary Digest predicted elections using mail-in polls
- Source of addresses: automobile registrations, phone books, etc.
- In 1936, sent out 10 million ballots, over 2.3 million returned
- George Gallup used only 50,000 respondents

	FDR's vote share
Literary Digest	43
George Gallup	56

Poll fail

	FDR %
Literary Digest	43
George Gallup	56
Actual Outcome	62

- **Selection bias**: ballots skewed toward the wealthy (with cars, phones)
  - Only 1 in 4 households had a phone in 1936
- **Nonresponse bias**: respondents differ from nonrespondents
  - $\leadsto$ when selection procedure is biased, adding more units won't help!

1948 Election

The Polling Disaster

	Truman	Dewey	Thurmond	Wallace
Crossley	45	50	2	3
Gallup	44	50	2	4
Roper	38	53	5	4
Actual Outcome	50	45	3	2

- **Quota sampling**: fixed quota of certain respondents for each interviewer
  - If Black women make up 5% of the population, stop interviewing them once they make up 5% of your sample
- Sample resembles the population on these characteristics
- Potential unobserbed confounding $\rightsquigarrow$ **selection bias**
- Republicans easier to find within quotas (phones, listed addresses)

Sample surveys

- **Probability sampling** to ensure representativeness
  - Definition: every unit in the population has a known, non-zero probability of being selected into sample
- **Simple random sampling**: every unit has an equal selection probability.
- Random digit dialing:
  - Take a particular area code + exchange: 310-495-XXXX.
  - Randomly choose each digit in XXXX to call a particular phone
  - Every phone in the US has an equal chance of being included in sample

Sampling lingo

- **Target population**: set of people we want to learn about
  - Example: people who will vote in the next election
- **Sampling frame**: list of people from which we will actually sample
  - Frame bias: list of registered voters (frame) might include nonvoters!
- **Sample**: set of people contacted
- **Respondents**: subset of sample that acutally responds to the survey
  - Unit non-response: sample $\neq$ respondents
  - Not everyone picks up their phone
- **Completed items**: subset of questions that respondents answer
  - Item non-response: refusing to disclose their vote preference

Difficulties of sampling

- Problems of telephone survey
  - Cell phones (double countring for the wealthy)
  - Caller ID screening (unit non-response)
  - Response rates down to 9%
- An alternative: internet surveys
  - Opt-in panels, respondent-driven sampling $\rightsquigarrow$ **non-probability sampling**
  - Cheaper, but non-representative
  - Digital divide: rich vs. poor, young vs. old
  - Correct for potential sampling bias via stastical methods

Effect of assasination attempts

```r
library(tidyverse)
data(leaders, package = "qss")
head(leaders[,1:7])
```

```
##   year     country       leadername age politybefore
## 1 1929 Afghanistan Habibullah Ghazi  39           -6
## 2 1933 Afghanistan       Nadir Shah  53           -6
## 3 1934 Afghanistan      Hashim Khan  50           -6
## 4 1924     Albania             Zogu  29            0
## 5 1931     Albania             Zogu  36           -9
## 6 1968     Algeria      Boumedienne  41           -9
##   polityafter interwarbefore
## 1   -6.000000              0
## 2   -7.333333              0
## 3   -8.000000              0
## 4   -9.000000              0
## 5   -9.000000              0
## 6   -9.000000              0
```

Contingency tables

- With two categorical variables, we can create **contingency tables**
  - Also known as **cross-tabs**
  - Rows are the values of one variable, columns the other

```
leaders %>%
  group_by(civilwarbefore,civilwarafter) %>%
  count() %>%
  spread(civilwarafter, n)
```

```
## # A tibble: 2 x 3
## # Groups:   civilwarbefore [2]
##   civilwarbefore   `0`   `1`
##            <int> <int> <int>
## 1              0   177    19
## 2              1    27    27
```

- Quick summary how the two variables "go together"

Cross-tabs with proportions

```
leaders %>%
  group_by(civilwarbefore,civilwarafter) %>%
  count() %>%
  ungroup() %>%
  mutate(prop = n/ sum(n)) %>%
  select(-n) %>%
  spread(civilwarafter, prop, drop = T)
```

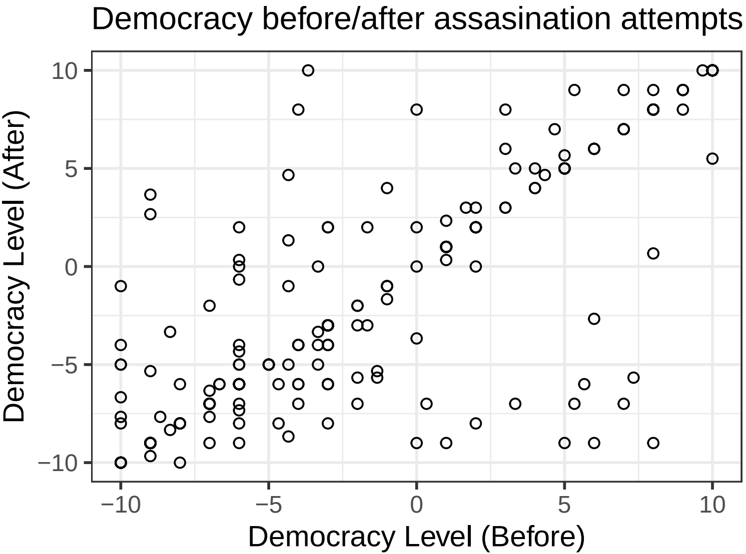
```
## # A tibble: 2 x 3
##   civilwarbefore   `0`   `1`
##            <int> <dbl> <dbl>
## 1              0 0.708 0.076
## 2              1 0.108 0.108
```

Cross-tabs with proportions (by row)

```
leaders %>%
  group_by(civilwarbefore,civilwarafter) %>%
  count() %>%
  ungroup() %>%
  group_by(civilwarbefore) %>%
  mutate(prop = n/ sum(n)) %>%
  select(-n) %>%
  spread(civilwarafter, prop, drop = T)
```

```
## # A tibble: 2 x 3
## # Groups:   civilwarbefore [2]
##   civilwarbefore   `0`    `1`
##            <int> <dbl>  <dbl>
## 1              0 0.903 0.0969
## 2              1 0.5   0.5
```

Scatterplot



Scatterplot

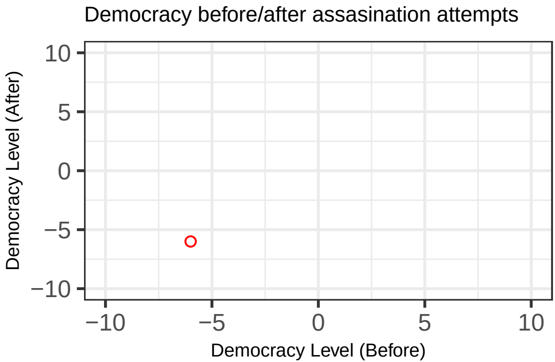
- Each point on the scatterplot (x_i, y_i)
- Use `geom_point()` function in ggplot

```
leaders %>%
  ggplot(aes(x = politybefore, y = polityafter)) +
  geom_point(shape = 21) +
  labs(title = "Democracy before/after assasination attempts",
       x = "Democracy Level (Before)",
       y = "Democracy Level (After)") +
  theme_bw() +
  theme(plot.title = element_text(size=12))
```

Scatterplot

```
leaders[1, c("politybefore","polityafter")]
```

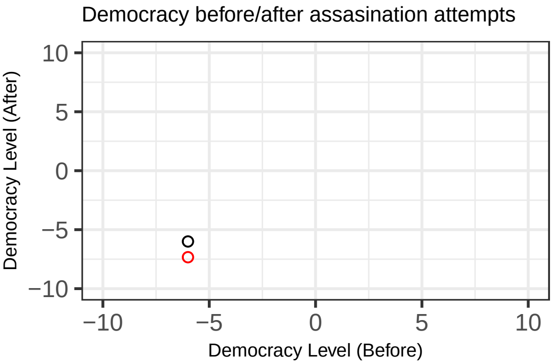
```
##   politybefore polityafter
## 1           -6          -6
```



Scatterplot

```r
leaders[2, c("politybefore","polityafter")]
```

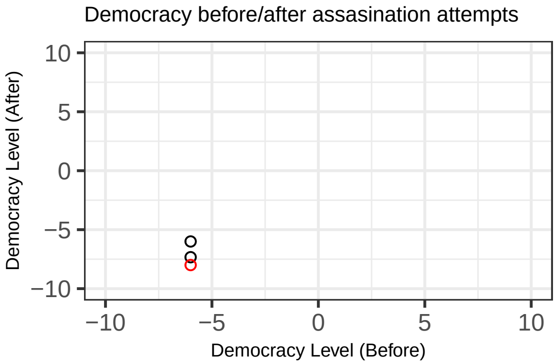
```
##   politybefore polityafter
## 2           -6   -7.333333
```



Scatterplot

```r
leaders[3, c("politybefore","polityafter")]
```

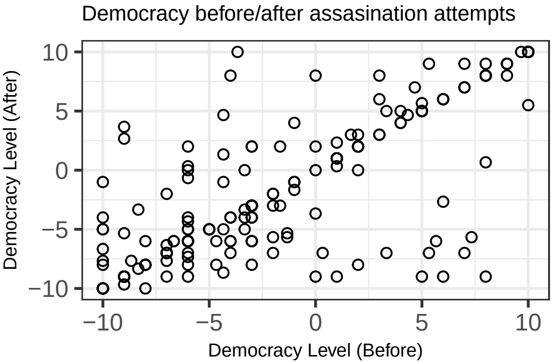
```
##   politybefore polityafter
## 3           -6          -8
```



Scatterplot

```r
leaders[3, c("politybefore","polityafter")]
```

```
##   politybefore polityafter
## 3           -6          -8
```



How big is big?

- Would be nice to have a standard summary of how similar variables are
  - Problem: variables on different scales!
  - Needs a way to put any variable on common units
  - **z-score** to the rescue!

$$\text{z-score of } x_i = \frac{x_i - \text{mean of } x}{\text{standard deviation of } x}$$

  - Crucial property: z-scores don't depend on units

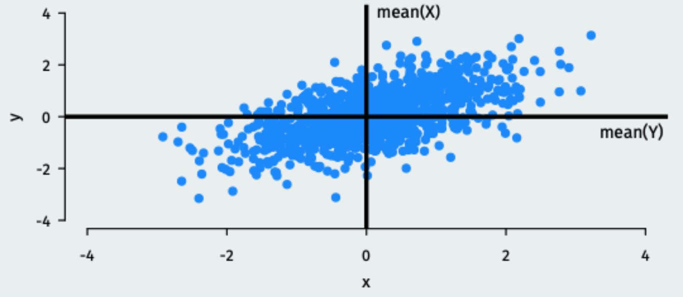
$$\text{z-score of } (ax_i + b) = \text{z-score of } x_i$$

Correlation

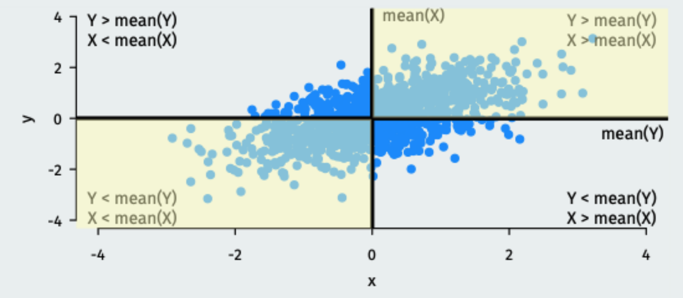
- How do variables move together on average?
- When x_i is big, what is y_i likely to be?
  - Positive correlation: when x_i is big, y_i is also big
  - Negative correlation: when x_i is big, y_i is small
  - High magnitude of correlation: data cluster tightly around a line
- The technical definition of the **correlation coefficient**:

$$\frac{1}{n-1}\sum_{i=1}^{n}\left[(\text{z-score for } x_i) \times (\text{z-score for } y_i)\right]$$

Correlation intuition:

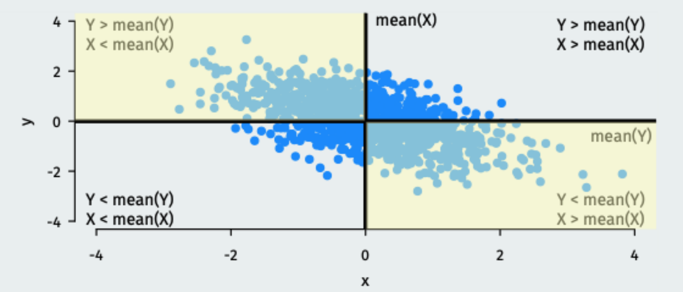


Correlation intuition:



- Large values of X tend to occur with large values of Y
  - (z-score for x_i) $\times$ (z-score for y_1) $=$ (pos. num.) $\times$ (pos. num.) $= +$
- Small values of X tend to occur with small values of Y
  - (z-score for x_i) $\times$ (z-score for y_1) $=$ (neg. num.) $\times$ (neg. num.) $= +$
- If these dominate $\rightsquigarrow$ positive correlation

Correlation intuition:



- Large values of X tend to occur with small values of Y
  - (z-score for x_i) $\times$ (z-score for y_1) $=$ (pos. num.) $\times$ (neg. num.) $= -$
- Small values of X tend to occur with large values of Y
  - (z-score for x_i) $\times$ (z-score for y_1) $=$ (neg. num.) $\times$ (pos. num.) $= -$
- If these dominate $\rightsquigarrow$ negative correlation

Properties of correlation coefficient

- Correlation measures **linear** association.
- Interpretation:
  - Correlation is between -1 and 1
  - Correlation of 0 means no linear association
  - Positive correlations $\rightsquigarrow$ positive associations
  - Negative correlations $\rightsquigarrow$ negative associations
  - Closer to -1 or 1 means stronger association
- Order doesn't matter: `cor`(x,y) = `cor`(y,x)
- Not affected by changes of scale:
  - `cor`(x,y) = `cor`(ax+b, cy+d)
  - Celsius vs. Fahrenheit; dollars vs. pesos; cm vs. in.

Correlation in R

- Use the `cor()` function

```
leaders %>%
  select(politybefore, polityafter) %>%
  cor()
```

```
##              politybefore polityafter
## politybefore    1.0000000   0.8283237
## polityafter     0.8283237   1.0000000
```

- Very highly correlated!

Assassination attempts

- See the possible attempt results

```r
unique(leaders$result)
```

```
##  [1] "not wounded"
##  [2] "dies within a day after the attack"
##  [3] "survives, whether wounded unknown"
##  [4] "wounded lightly"
##  [5] "plot stopped"
##  [6] "hospitalization but no permanent disability"
##  [7] "dies between a day and a week"
##  [8] "dies, timing unknown"
##  [9] "survives but wounded severely"
## [10] "dies between a week and a month"
```

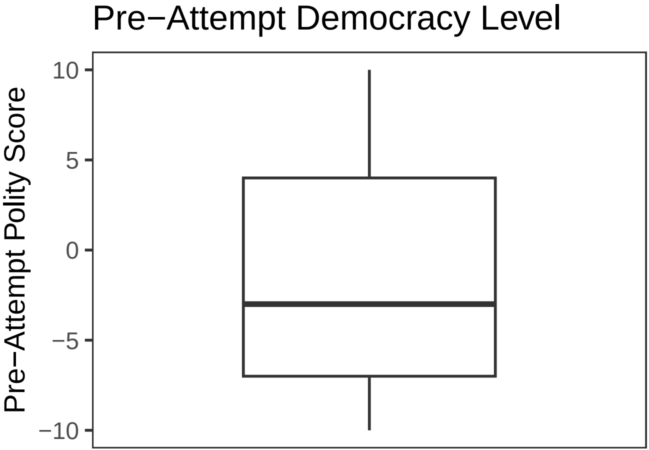
Creating an attempt fatal variable

- use `ifelse` to create a `fatal` variable

```r
## create new vector of unique results of "result"
lev <- unique(leaders$result)
leaders <- leaders %>%
  mutate(fatal = ifelse(result %in% lev[c(2,7,8,10)], 1,0))
leaders %>%
  summarize(mean(fatal))
```

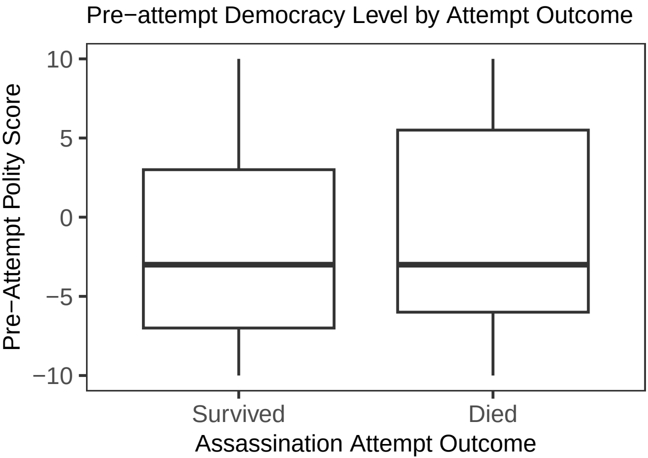
```
##   mean(fatal)
## 1       0.216
```

Remember boxplots?



Comparing distribution with the boxpot

- What if we want to know how the distribution varies by success?



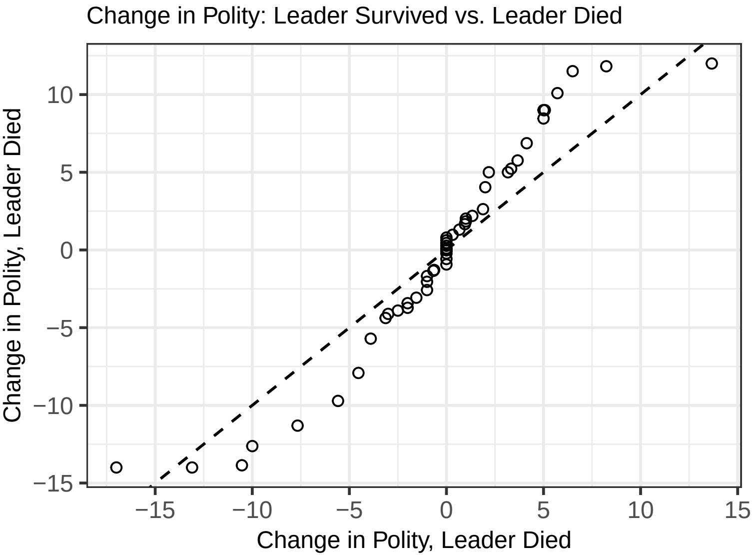
Boxplot comparisons in R

```
leaders %>%
  ggplot(aes(y = politybefore,
             x = factor(fatal,labels = c("Survived", "Died"))
  geom_boxplot() +
  scale_y_continuous(breaks = seq(-10, 10,by = 5)) +
  labs(title = "Pre-attempt Democracy Level by Attempt Outcome
       y = "Pre-Attempt Polity Score",
       x = "Assassination Attempt Outcome") +
  theme_bw() +
  theme(plot.title = element_text(size=9),
        axis.title.x = element_text(size = 9),
        axis.title.y = element_text(size = 9),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())
```

Quantile-Quantile Plot

- How do we compare distributions of two variables that are not in the same dataset?
  - Could use boxplots, but it's only a crude summary of the distributions.
- **Quantile-quantile plot (Q-Q plot)**: scatterplot of **quantiles**
  - (min of X, min of Y)
  - (median of X, median of Y)
  - (25th percentile of X, 25th percentile of Y)
- Intuitions:
  - If distributions are the same $\rightsquigarrow$ all points on a 45-degree line
  - Points above 45° line $\rightsquigarrow$ y-axis variable has larger value of the quantile
  - Point below 45° line $\rightsquigarrow$ x-axis variable has larger value of the quantile
  - Steeper slope than 45° line $\rightsquigarrow$ y-axis variable has more spread
  - Flatter slope than 45° line $\rightsquigarrow$ x-axis variable has more spread

QQ-plot example



QQ-plot example (setup)

```
## calculate change in polity
leaders <- leaders %>%
  mutate(polity_change = polityafter - politybefore)

## set quantile vectors
quantile_probs <- seq(from = 0, to = 1, by = 0.01)
quantile_names <- as.character(quantile_probs)

## generate dataframe for plot
quantiles <- leaders %>%
  group_by(fatal) %>%
  summarize(politychng_quantile = quantile(polity_change, probs = qu
            quantile = quantile_names) %>%
  pivot_wider(names_from = fatal,
              values_from = politychng_quantile)
```

QQ-plot example (plot)

```
quantiles %>%
  ggplot(aes(x = `0`, y = `1`)) +
  geom_point(shape = 1) +
  geom_abline(intercept = 0, slope = 1, linetype = "dashed") +
  scale_y_continuous(breaks = seq(-20, 15,by = 5)) +
  scale_x_continuous(breaks = seq(-20, 15,by = 5)) +
  labs(title = "Change in Polity: Leader Survived vs. Leader Died",
       y = "Change in Polity, Leader Died",
       x = "Change in Polity, Leader Died") +
  theme_bw() +
  theme(plot.title = element_text(size=9),
        axis.title.x = element_text(size = 9),
        axis.title.y = element_text(size = 9))
```