Lecture 3 - GGR376

Spatial Data Science II

Dr. Adams

Today's Lecture

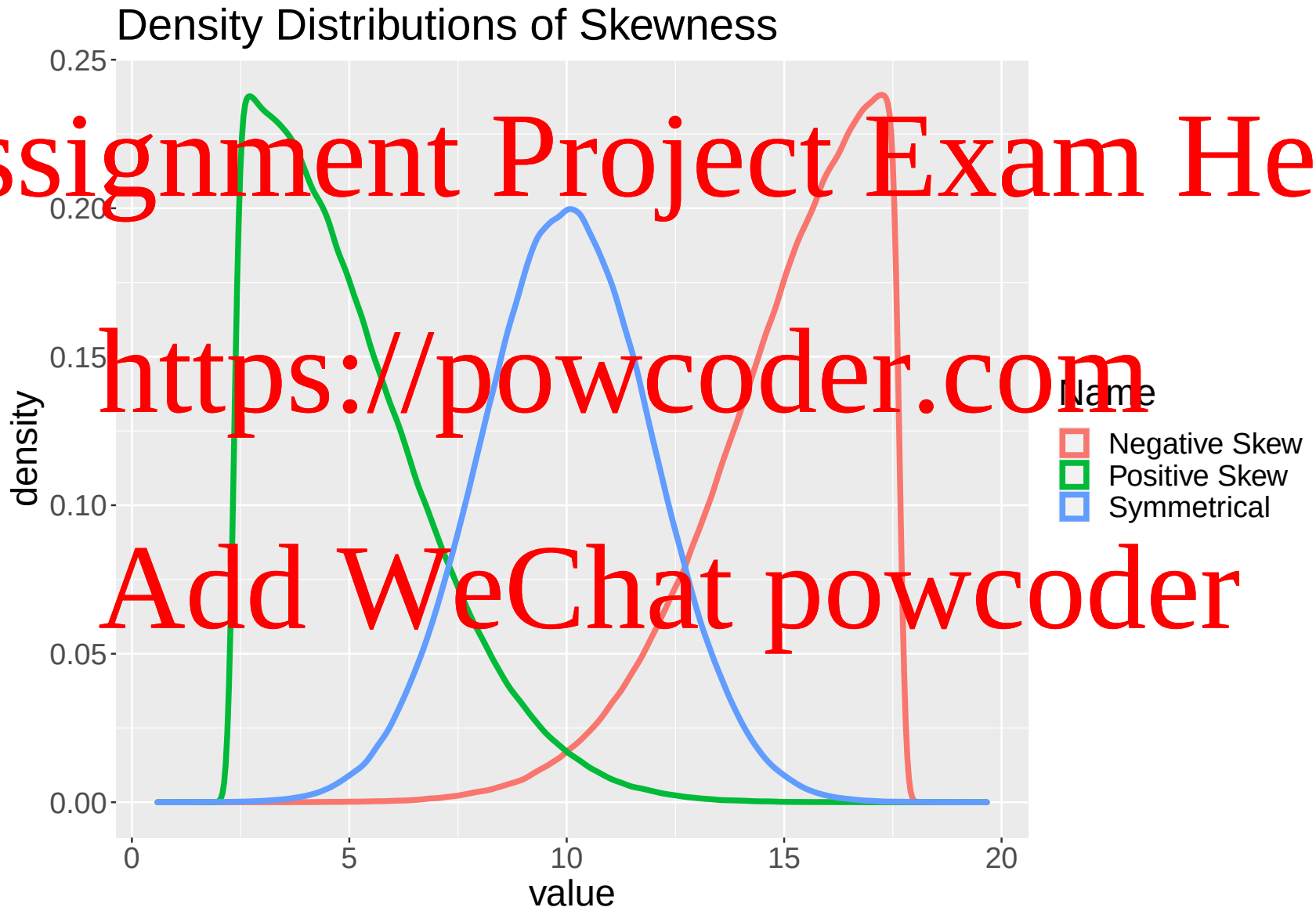
- Skewness & Kurtosis
- Visualization
- ggplot2

Skewness and Kurtosis

Skewness

- Rightward / Positive Skew
  - Long tail of high value numbers
  - mean $>$ median $>$ mode
- Leftward / Negative Skew
  - Long tail of low value numbers
  - mean $<$ median $<$ mode
- Symmetric
  - When there is no skewness in the data.

Skewness Visual



Skewness Calculations

Pearson's moment coefficient of skewness

$$Sk = \frac{\sum(x_i - \overline{x})^3/N}{Var(x)^{1.5}}$$

Many skewness formulas exist, generally though:

- Sk $= 0$, Symmetrical
- Sk < 0, Negative Skewness
- Sk > 0, Positive Skewness

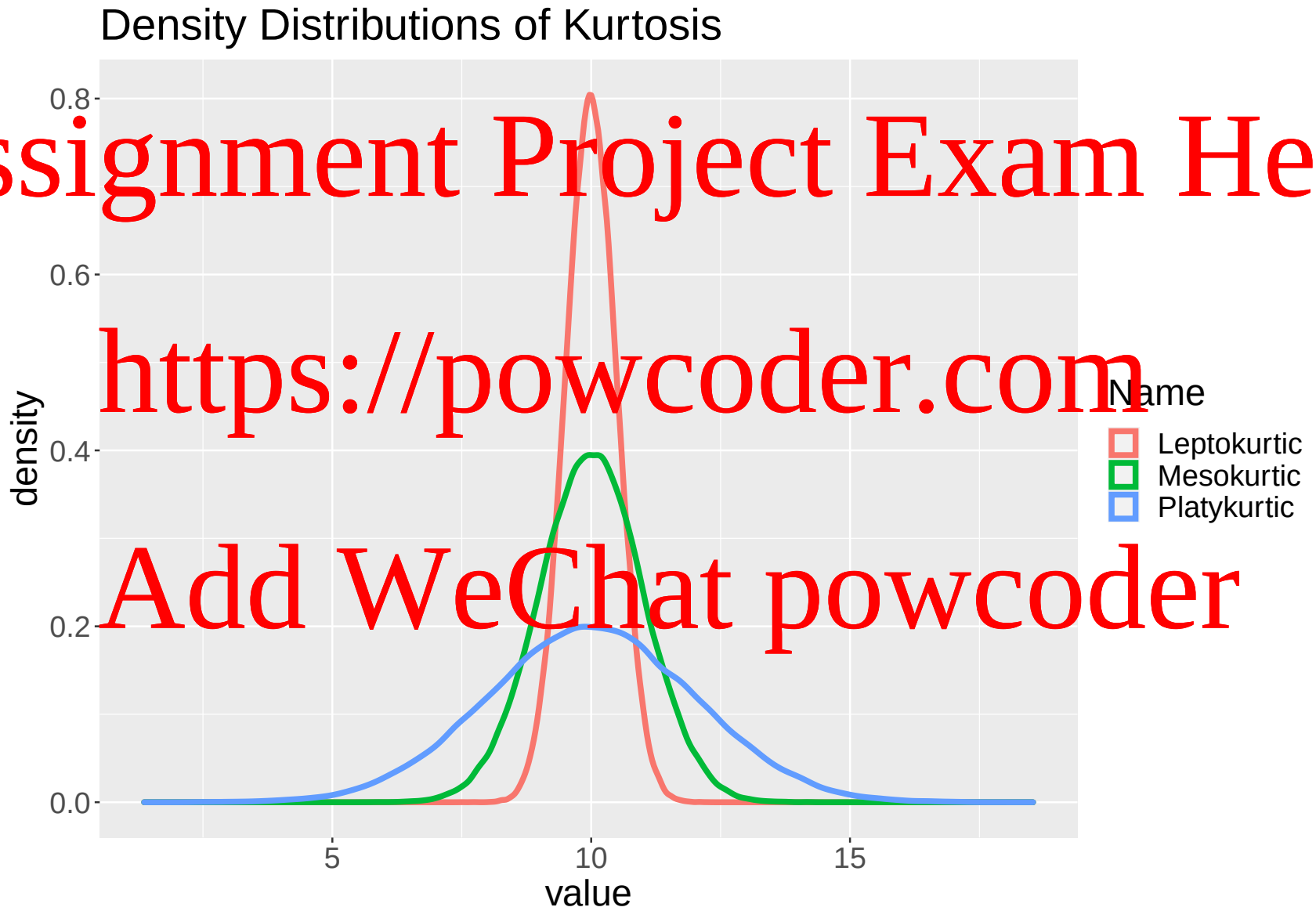
```
# Need to load a package with a skewness function
library(moments)

moments::skewness()
```

Kurtosis

Kurtosis

- Sharpness of the peak of a frequency-distribution curve
- Leptokurtic
  - High central peak
- Mesokurtic
  - Medium central peak
  - Standard normal curve
- Platykurtic
  - Low central peak

Kurtosis Visual



Kurtosis Calculations

Pearson's measure of kurtosis

$$Ku = \frac{\sum(x_i - \overline{x})^4/N}{Var(x)^2}$$

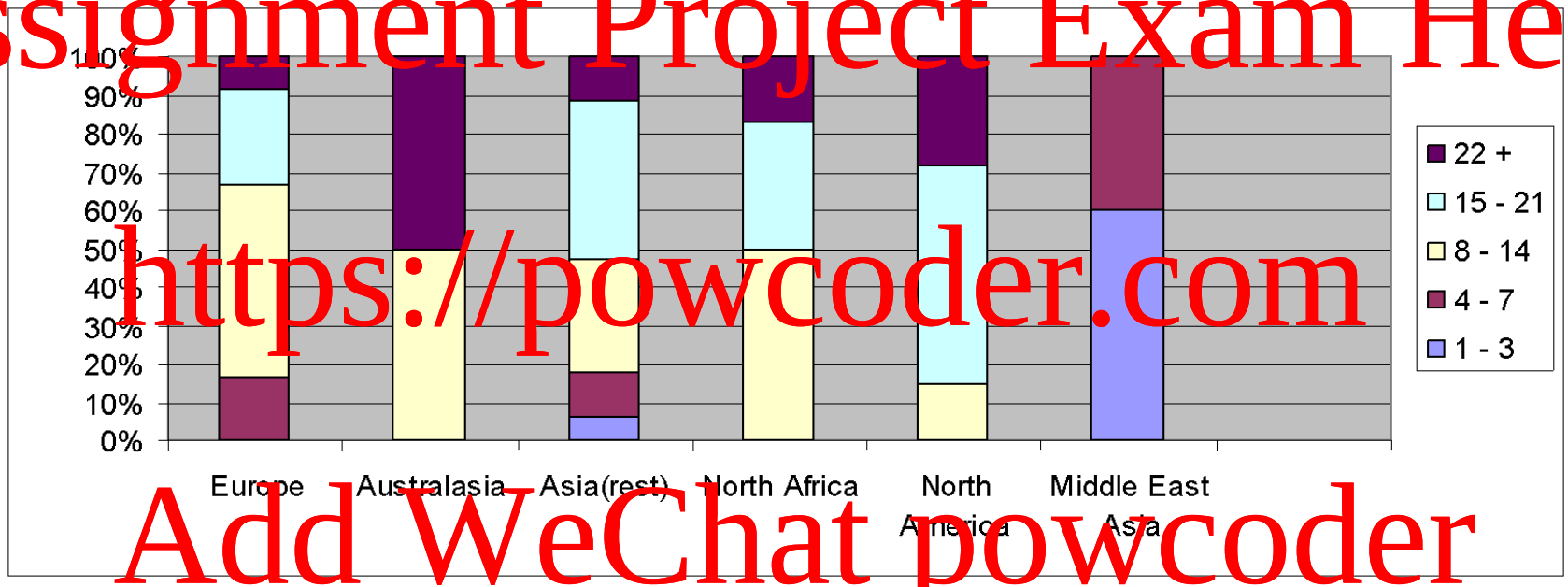
Units are not meaningful (as with skewness):

- Ku $\sim$ 0, Mesokurtic
- Ku $>>$ 0 and up to infinity, Leptokurtic
- Ku $<$ 0 to -2.75, Platykurtic

```
# Need to load a package with a kurtosis function
library(moments)

moments::kurtosis()
```

Visualization

No more ulgy plots.



markedbyteachers.com/

The simple graph has brought more information to the data analyst's mind than any other device.
- John Tukey

Memorable Visualizations

What makes a memorable (effective) visualization?
(M. A. Borkin et al. 2015)

1. Titles and supporting text need to convey the message of a visualization
2. Pictograms may be included to improve recognition, unlikely to hinder understanding.
3. Redundancy helps effectively communicate the message.

"A memorable visualization is often also an effective one."

Why do we use visualizations?

Alcohol use and long-term cognitive decline

The relationship between alcohol use and long-term cognitive decline in middle and late life: a longitudinal analysis using UK Biobank

Giovanni Piumatti, Simon C Moore, Damon M Berridge, Chinmoy Sarkar, John Gallacher

Journal of Public Health, https://doi.org/10.1093/pubmed/fdx186

Research Question

Explain the causal (not correlation) between cognitive decline and alcohol intake in middle and older aged adults in the UK.

- UK Department of Health, drinkers should not consume more than 16 g/day to minimize the risk of alcohol to health.

Methods

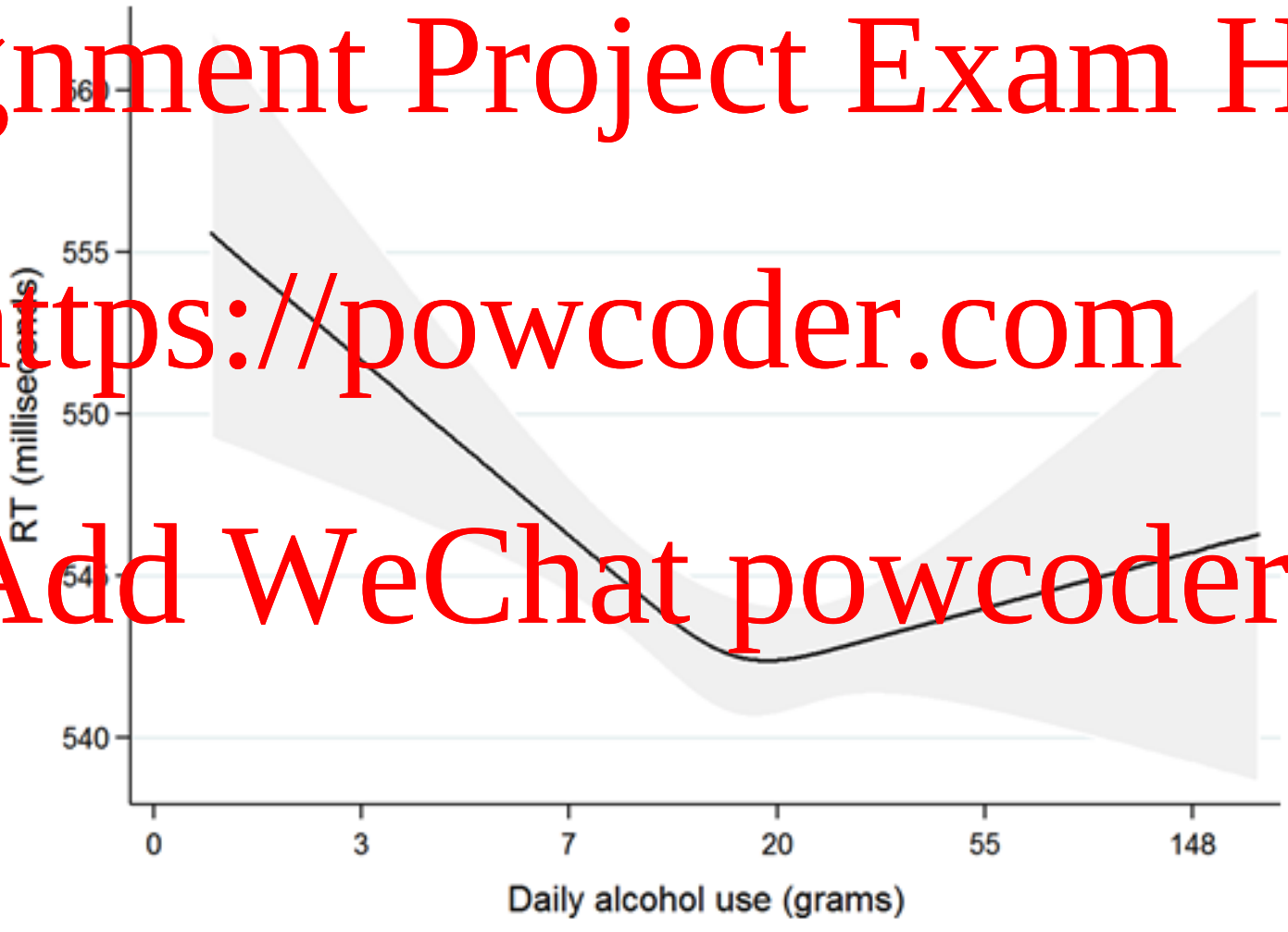
- Data from 13,342 men and women, aged between 40 and 73 years.
- How often and how much alcohol was consumed.
- Regression analysis testing the functional relationship and impact of alcohol on cognitive performance.
- Performance was measured in response of card matching (do a pair of cards match?).
- Covariates included body mass index, physical activity, tobacco use, socioeconomic status, education and baseline cognitive function.
  - Additional variables that may be predictive of the outcome
    - Direct interest or it may be a confounding or interacting variable

Conclusions

"UK department of Health guidelines are that drinkers should not consume more than 16 g/day to minimize the risk of alcohol to health. Our findings suggest that to preserve cognitive performance **10 g/day** is a more appropriate upper limit."

Results - To preserve cognitive performance 10 g/day limit

Fig. 1

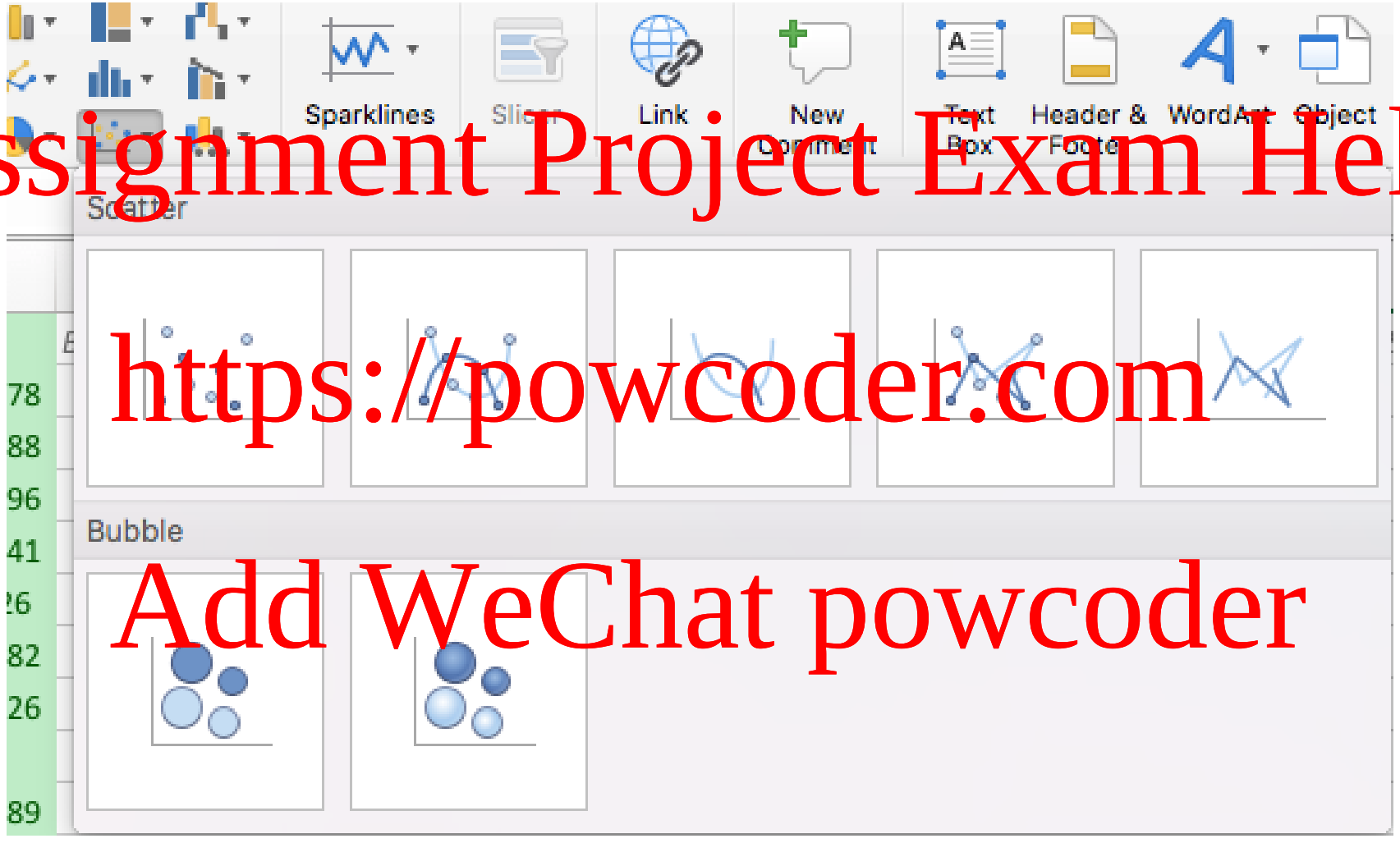


A Layered Grammar of Graphics

"What is a graphic? How can we succinctly describe a graphic? And how can we create the graphics that we have described?" (Wickham, 2010)

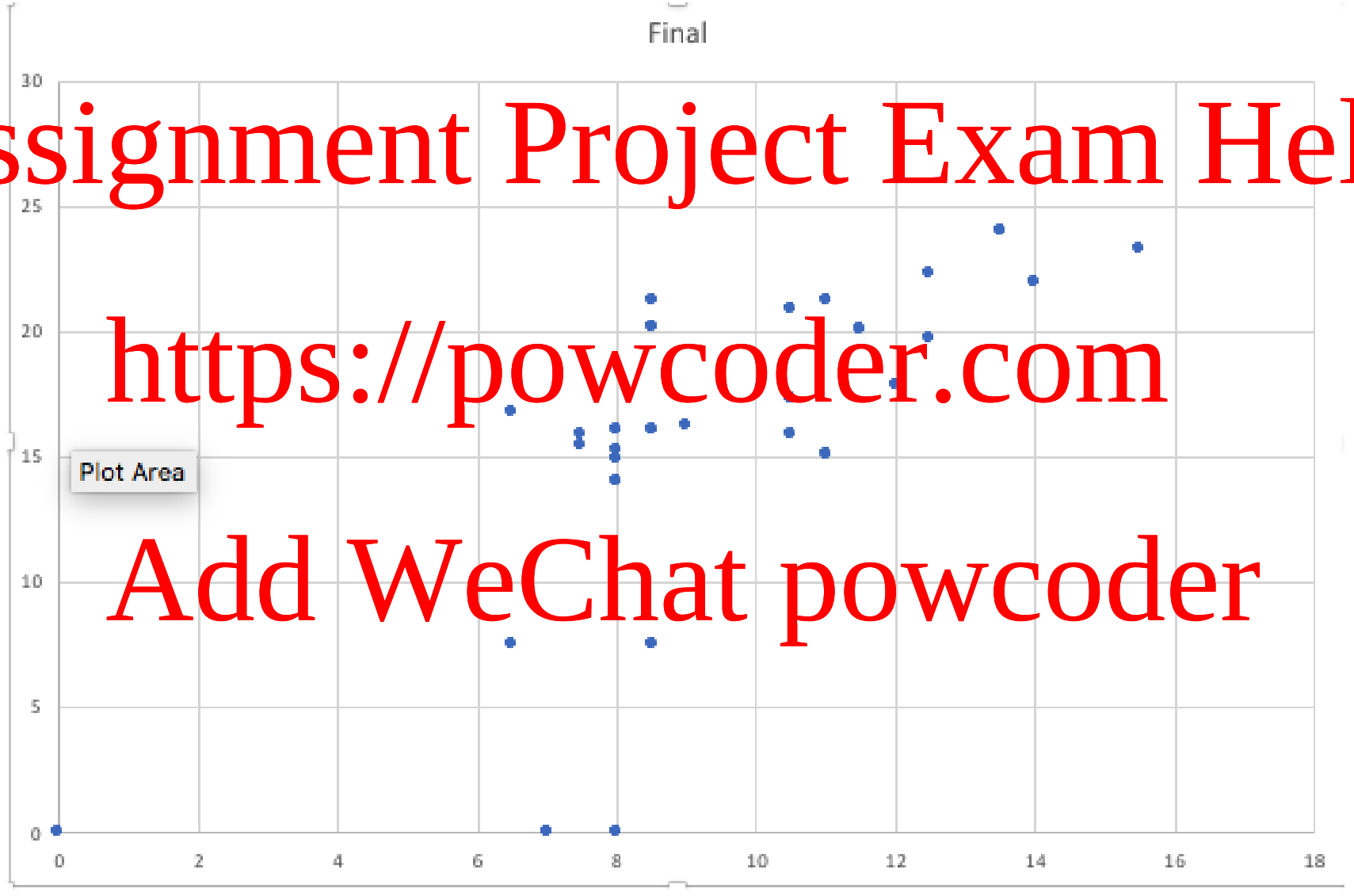
One answer to these was questions was to develop a grammar of graphics. - Grammar referring to a set of rules or constructs to govern the process.

What is different about the grammar of graphics?

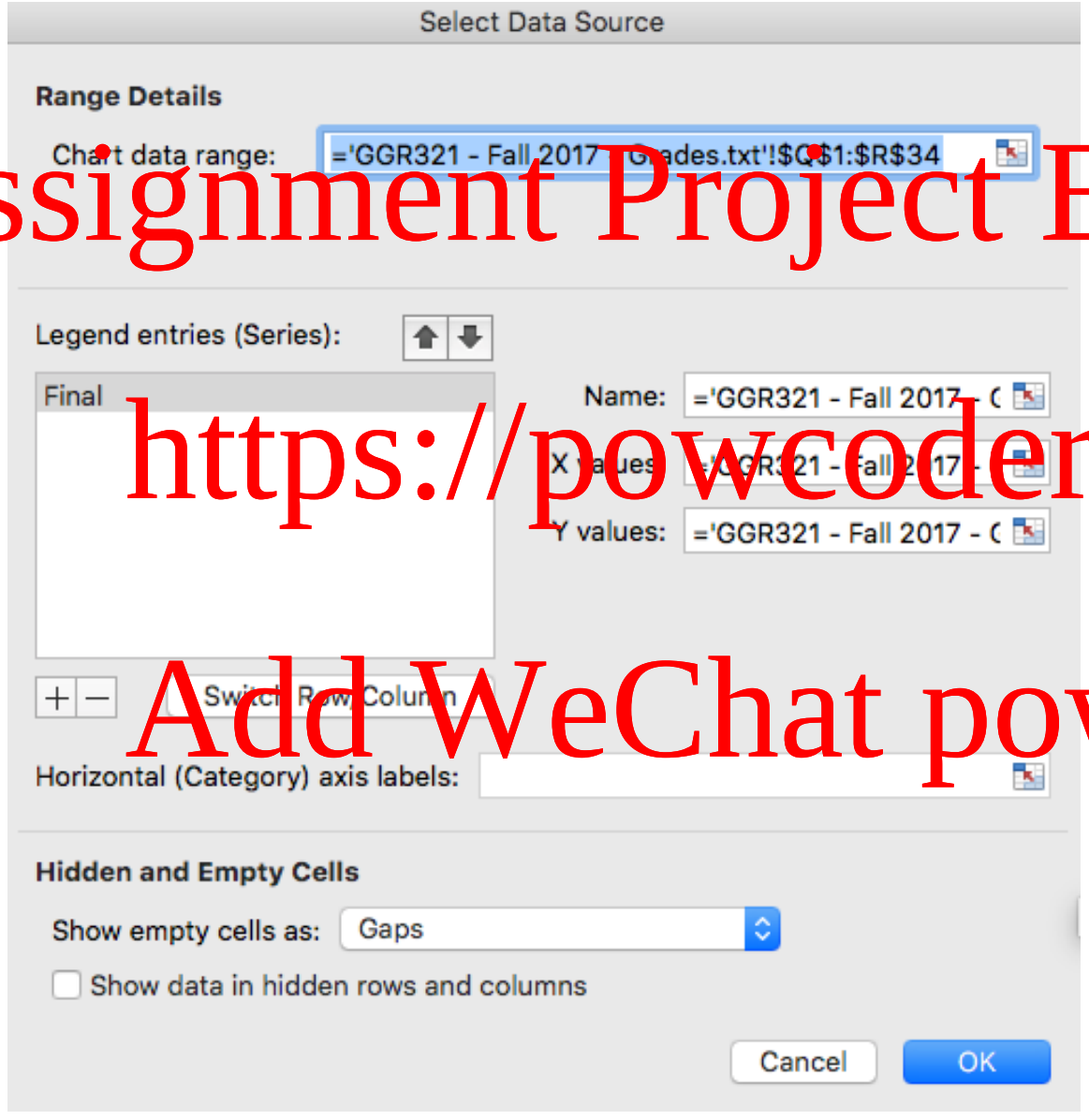


Traditionally, you will select the plot by name.

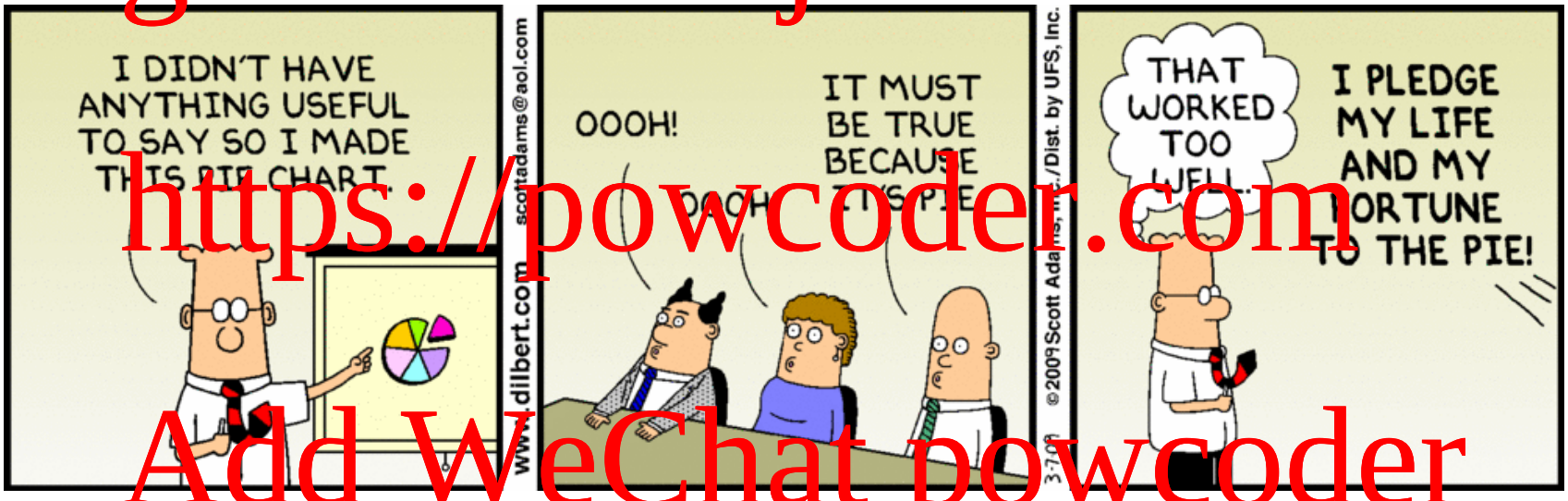
Produce a Plot



And try your best to modify the plot



We can do better



ggplot: The pieces

- A dataset and the mapping of those data to aesthetics
- At least one layer, including:
  - geometric object
  - statistical transformation
- A scale for each aesthetic mapping
- A coordinate system for the plot
- Faceting

How are plots constructed?

Using the grammar of graphics we construct our plots one component at a time.

Updating Plots

Using a grammar of graphics, we can adjust each piece in isolation.

Gapminder example

gapminder: Data from Gapminder

An excerpt of the data available at Gapminder.org. For each of 142 countries, the package provides values for life expectancy, GDP per capita, and population, every five years, from 1952 to 2007.


```
library(gapminder)
colnames(gapminder::gapminder)[1:3]
```

```
## [1] "country"   "continent" "year"
```

```
colnames(gapminder::gapminder)[4:6]
```

```
## [1] "lifeExp"   "pop"       "gdpPercap"
```

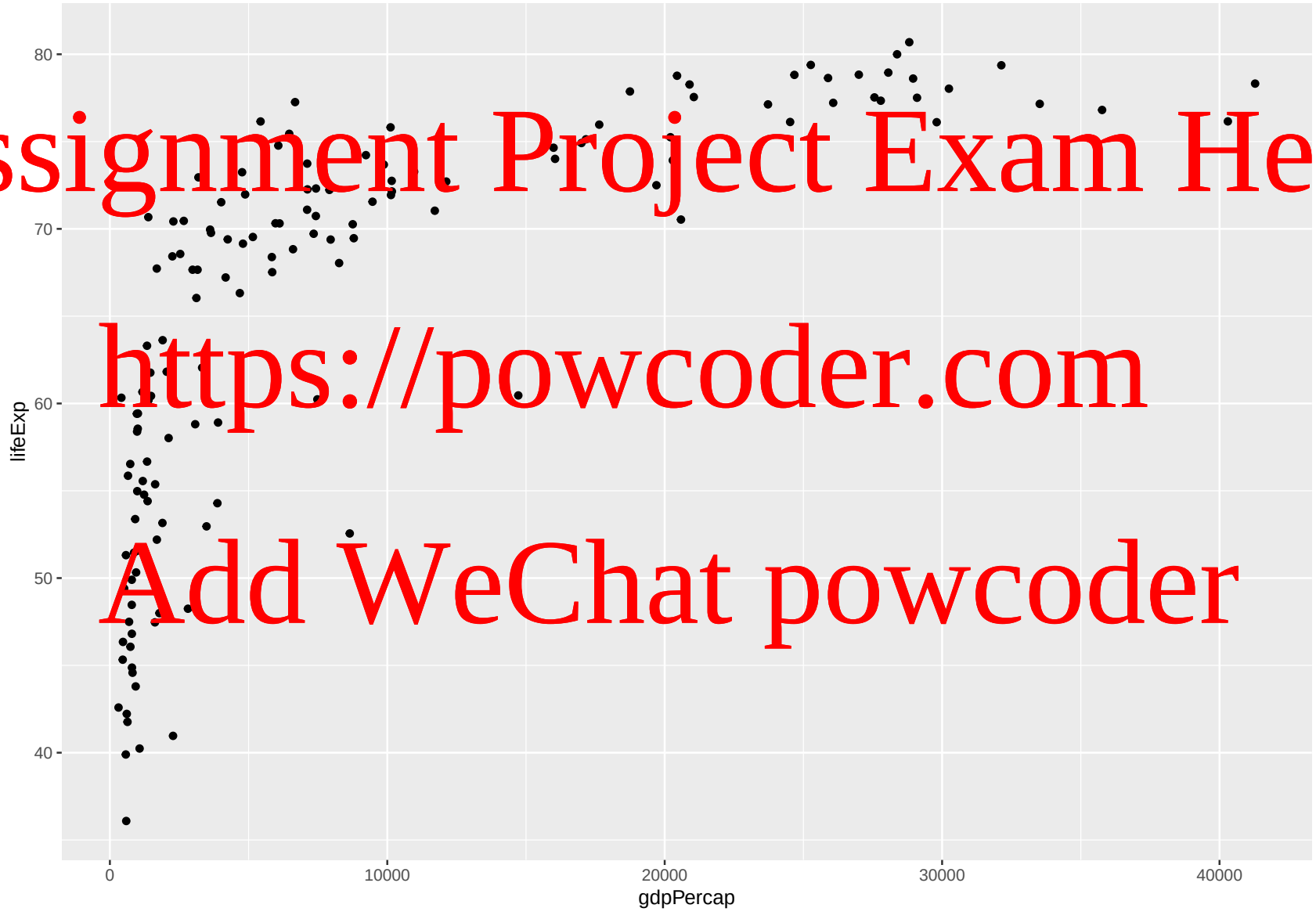
Subset the data to 2002


```
gap <- gapminder::gapminder %>%
  dplyr::filter(year == 1997)
```

Review the subset

```
    continent        year         lifeExp          pop
 Africa  :52   Min.   :1997   Min.   :36.09   Min.   :1.456
 Americas:25   1st Qu.:1997   1st Qu.:55.63   1st Qu.:3.770
 Asia    :33   Median :1997   Median :69.39   Median :9.735
 Europe  :30   Mean   :1997   Mean   :65.01   Mean   :3.884
 Oceania : 2   3rd Qu.:1997   3rd Qu.:74.17   3rd Qu.:2.431
               Max.   :1997   Max.   :80.69   Max.   :1.230

   gdpPercap
 Min.   :  312.2
 1st Qu.: 1366.8
 Median : 4781.8
 Mean   : 9090.2
 3rd Qu.:12022.9
 Max.   :41283.2
```

Examine Life Expectancy and GDP



ggplot template


```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

GEOM_FUNCTION

- Geometric objects include points, lines, and polygons (similar to our vector data model).

The grammar of graphics requires that we specify the geometric feature that wil be used to render the plot.

In ggplot they are known as geoms (geometric objects).

- Every geom is related with a certain statistic.
- The geom_histogram uses the bin statistic
  - Counts by bins values
- The same is true for each statistic, it has an associated geom

geom_histogram & stat_bin

geom_histogram(mapping = NULL, data = NULL, **stat = "bin"**, position = "stack", ..., binwidth = NULL, bins = NULL, na.rm = FALSE, show.legend = NA, inherit.aes = TRUE)

Using stats is an alternative approach to creating the layer

stat_bin(mapping = NULL, data = NULL, **geom = "bar"**, position = "stack", ..., binwidth = NULL, bins = NULL, center = NULL, boundary = NULL, breaks = NULL, closed = c("right", "left"), pad = FALSE, na.rm = FALSE, show.legend = NA, inherit.aes = TRUE)

mapping = **aes()**

aes()

"Aesthetics, things that we can perceive on the graphic." (Wickham 2010)

- x-location (x)
- y-location (y)
- alpha
- colour
- fill
- group
- linetype
- size
- weight

mapping = aes()

mapping =

Defining how we associate each element (variable) to an aesthetic (visual element of the plot).

One Variable geoms

Continuous Variables

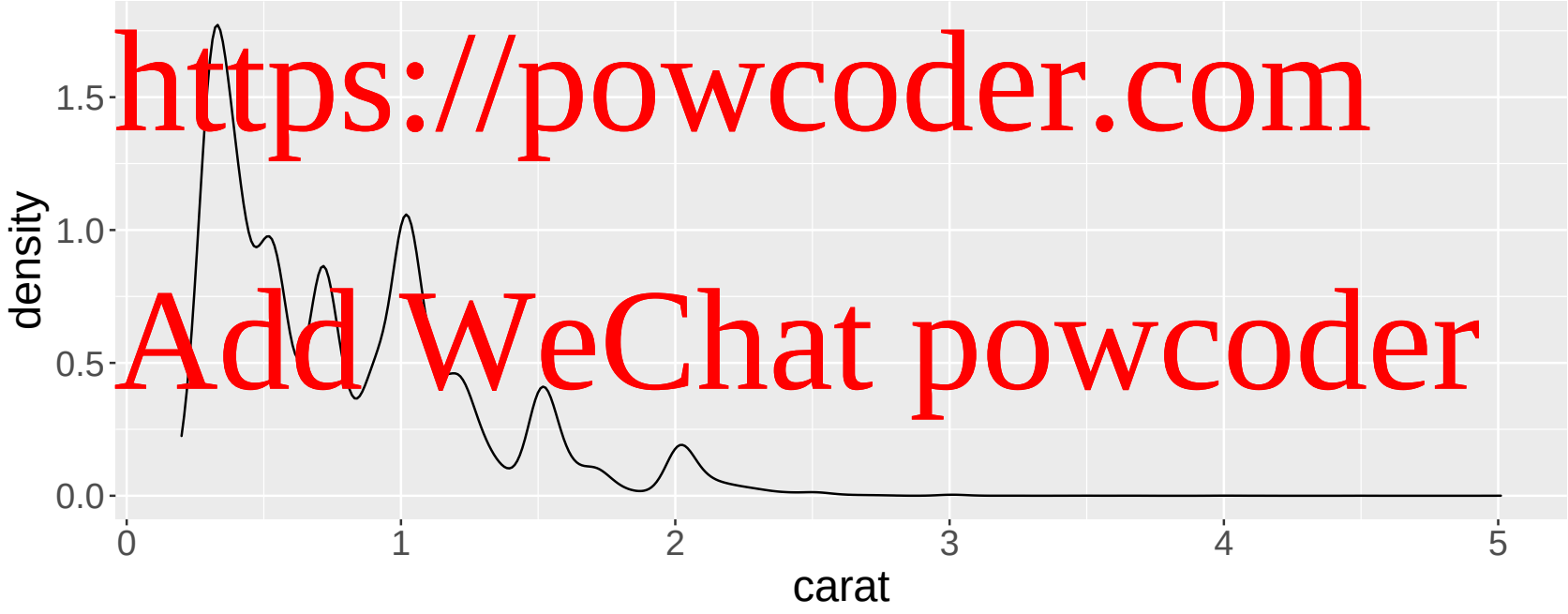
- Kernal Density (smooth histogram)
  - geom_density()
    - Useful if data come from a smooth distribution
- Dot-plot
  - geom_dotplot()
- Histogram
  - geom_histogram()

Discrete Variable

- Bar
  - geom_bar()

geom_density()

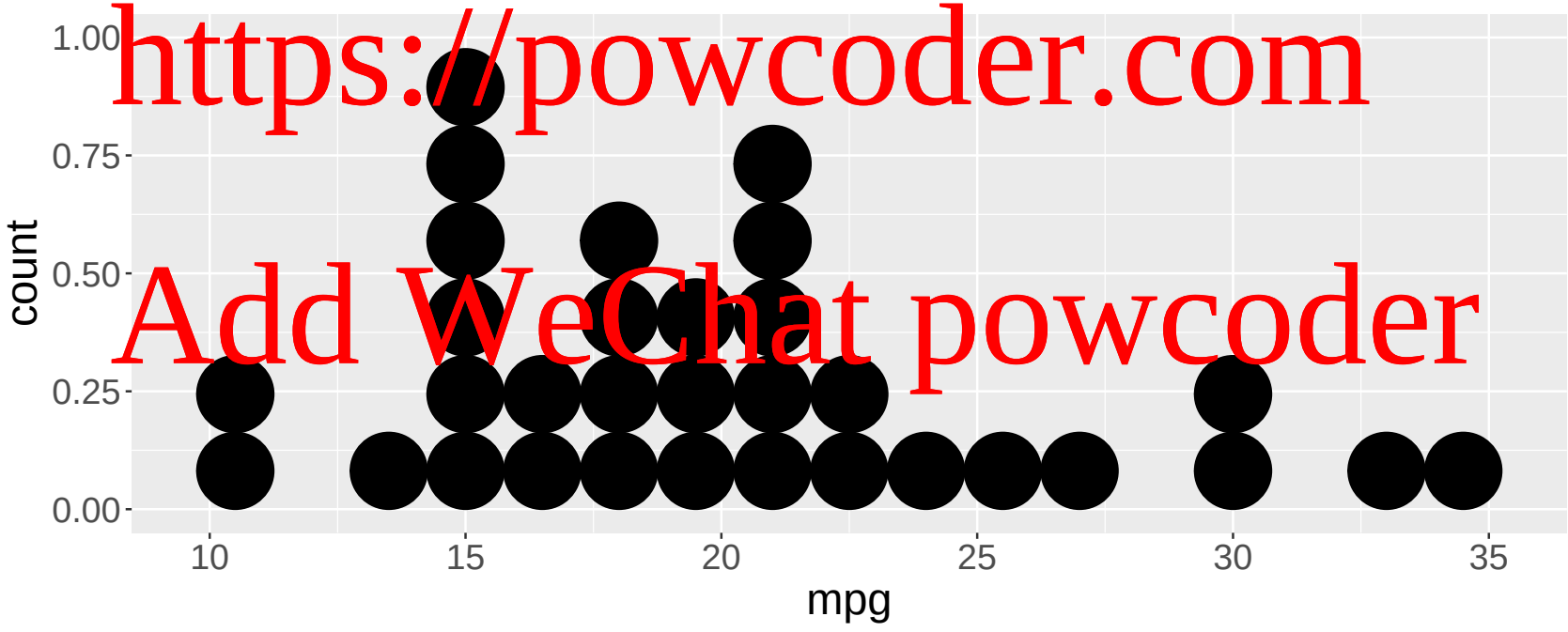
```
ggplot(diamonds, aes(carat)) +
  geom_density() +
  theme(text = element_text(size=20))
```

stat_density()

geom_dotplot()

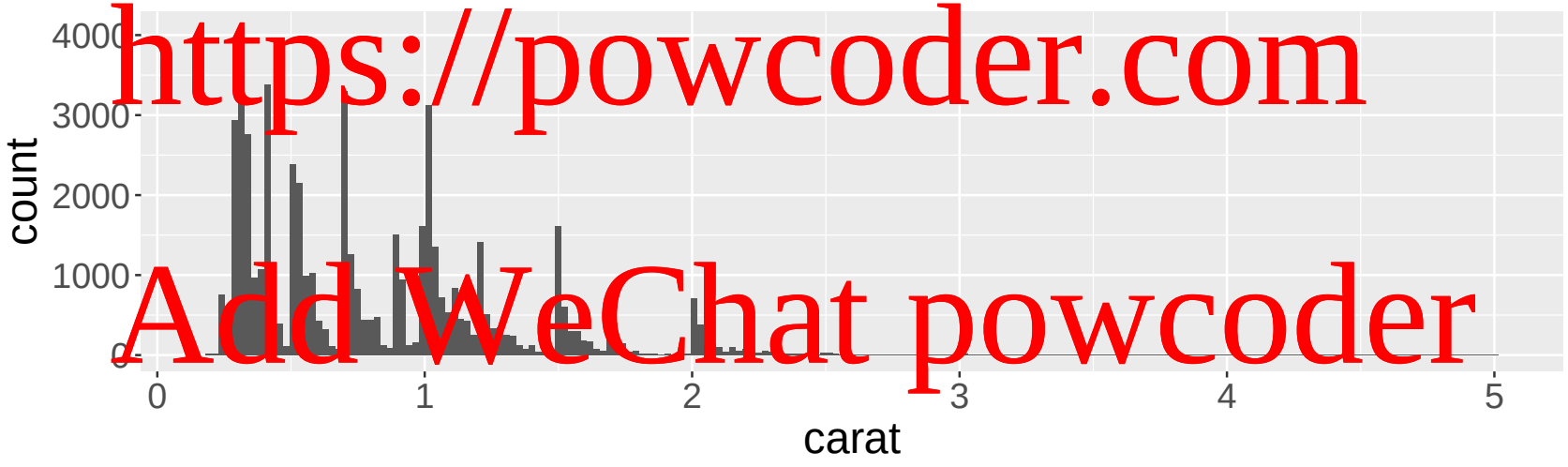
```
# Use fixed-width bins
ggplot(mtcars, aes(x = mpg)) +
  geom_dotplot(method="histodot", binwidth = 1.5) +
  theme(text = element_text(size=20))
```

stat_identity() - The identity statistic leaves the data unchanged.

geom_histogram()

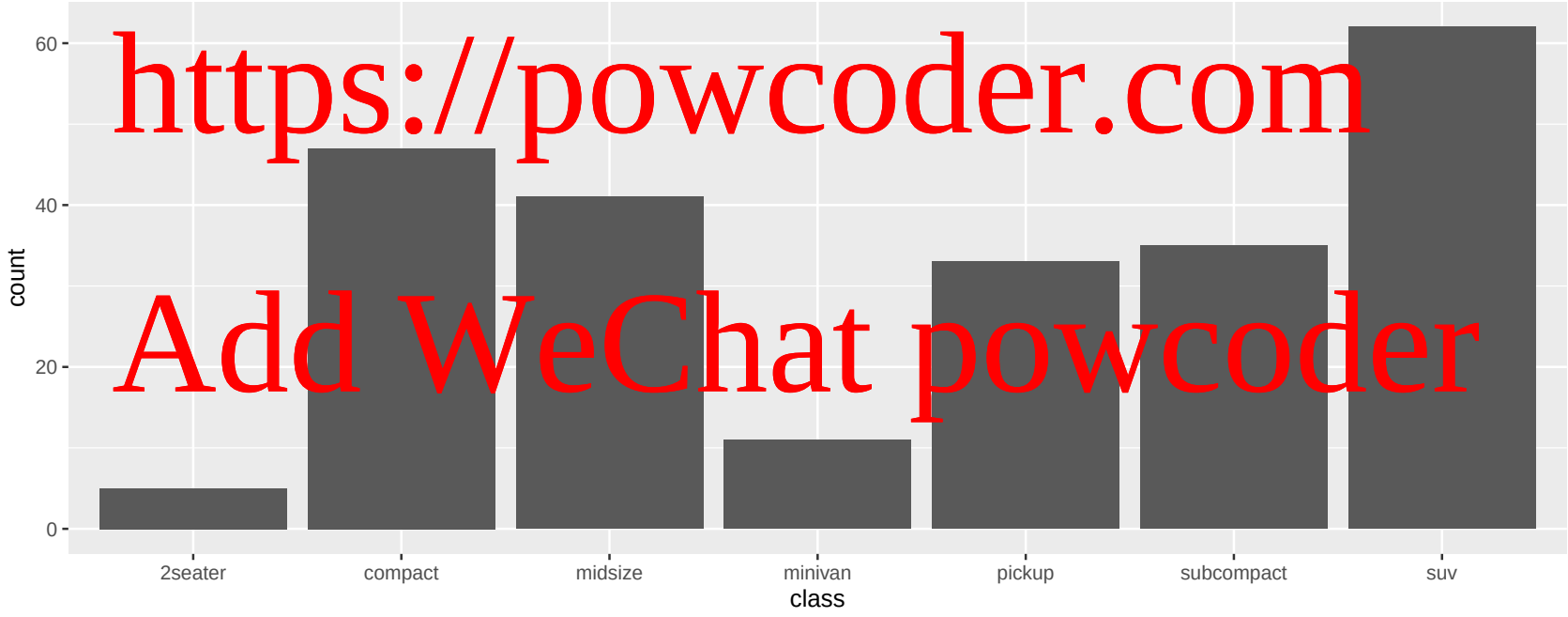
```
ggplot(diamonds, aes(carat)) +
  geom_histogram(bins = 200) +
  theme(text = element_text(size=20))
```



stat_bin(. . . , binwidth = NULL, bins = NULL, . . .) - Continuous data, count values by bins

geom_bar()

```
# Car counts per class
ggplot(mpg, aes(class))+
  geom_bar()
```

stat_count() - Count observations by grouping (discrete)

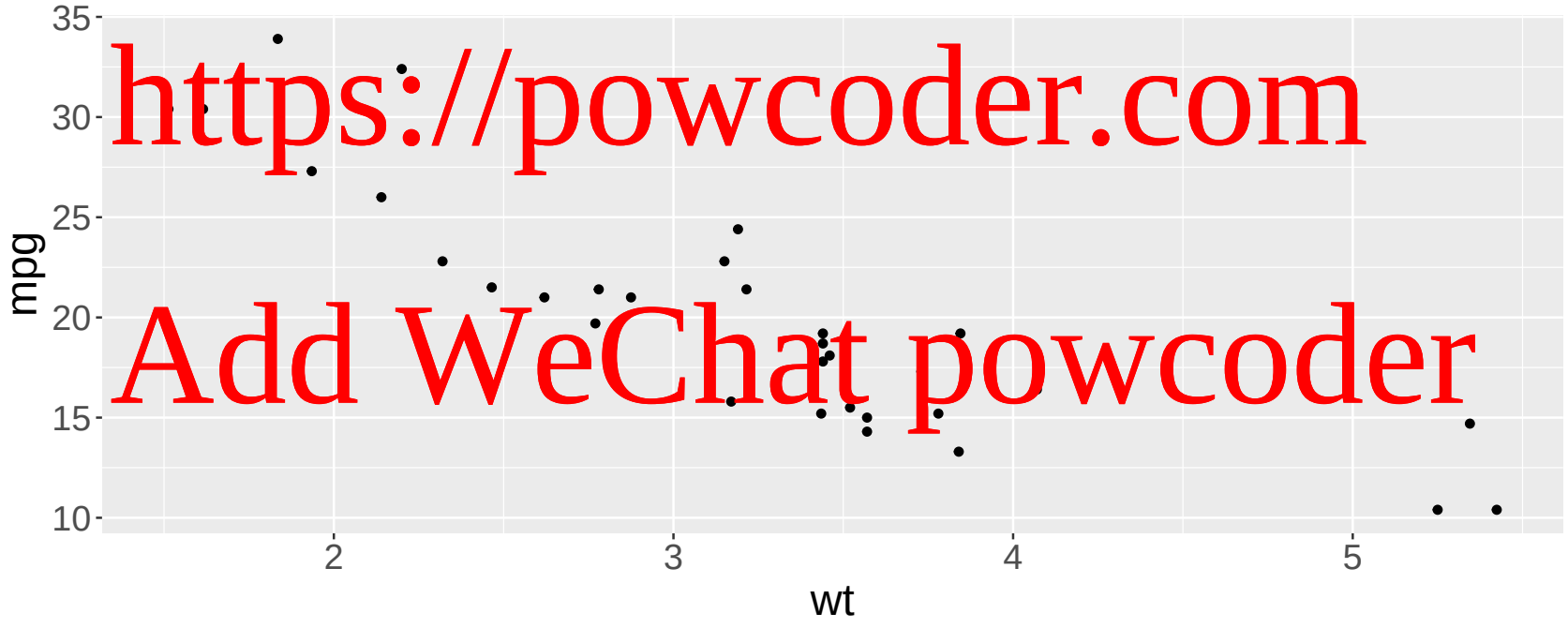
Common two variable geoms

- Points
  - geom_point()
- Points with a little noise
  - geom_jitter()
- Quantile lines
  - geom_quantile()
    - Performs quantile regression and draws the fitted quantiles with lines

- Smoothed conditional means
  - geom_smooth()
  - Include standard errors

geom_point()

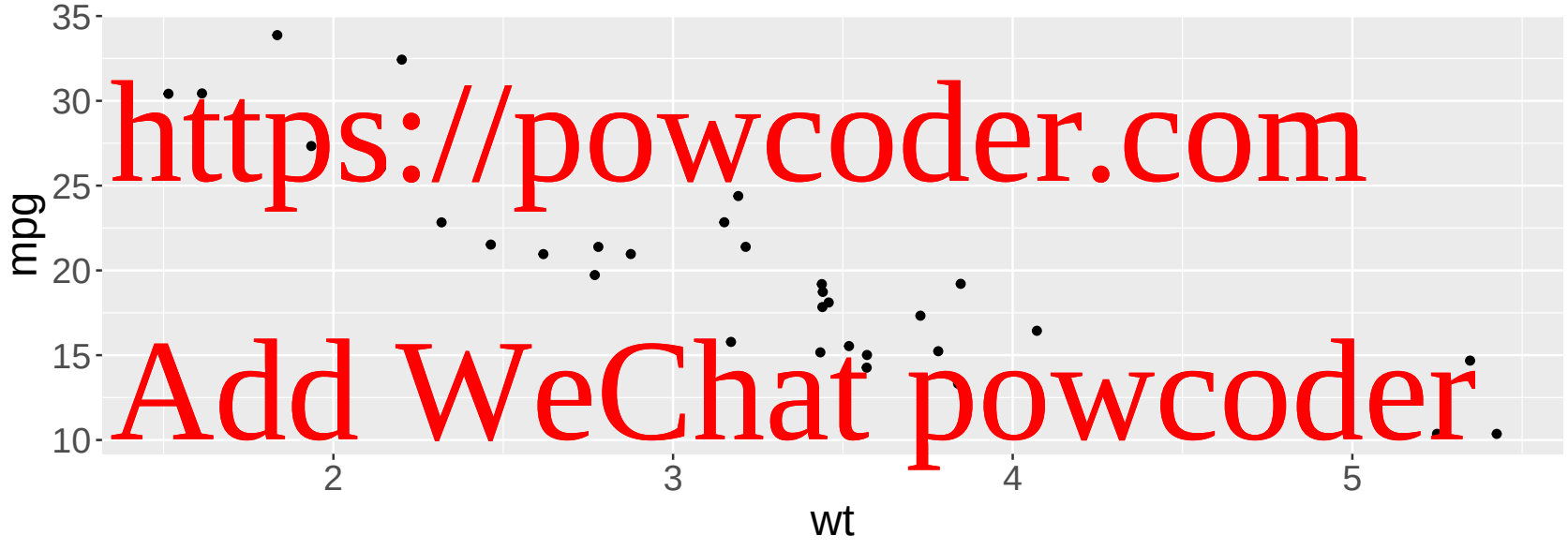
```
ggplot(mtcars, aes(wt, mpg))+
  geom_point()+
  theme(text = element_text(size=20))
```

stat_identity()

geom_jitter()

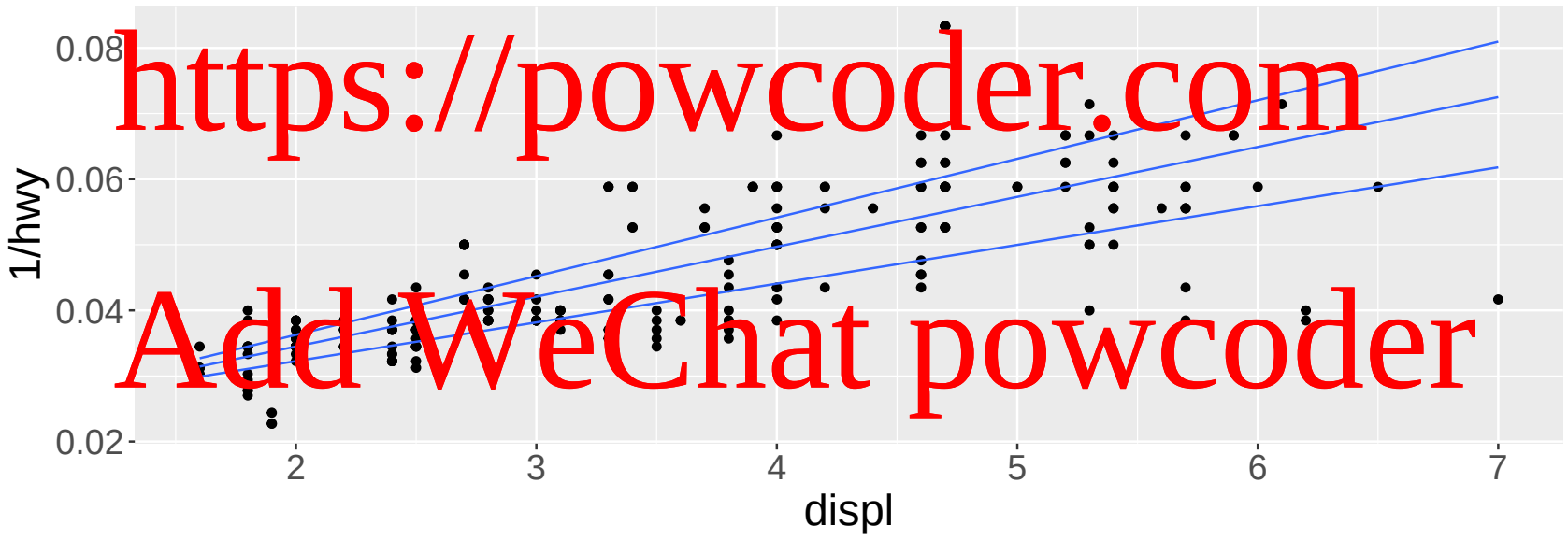
```
ggplot(mtcars, aes(wt, mpg))+
  geom_jitter()+
  theme(text = element_text(size=20))
```

- Used for handling overplotting caused by discreteness in smaller datasets
  stat_identity()

geom_quantile()

```
ggplot(mpg, aes(displ, 1 / hwy)) + geom_point()+
  geom_quantile()+
  theme(text = element_text(size=20))
```

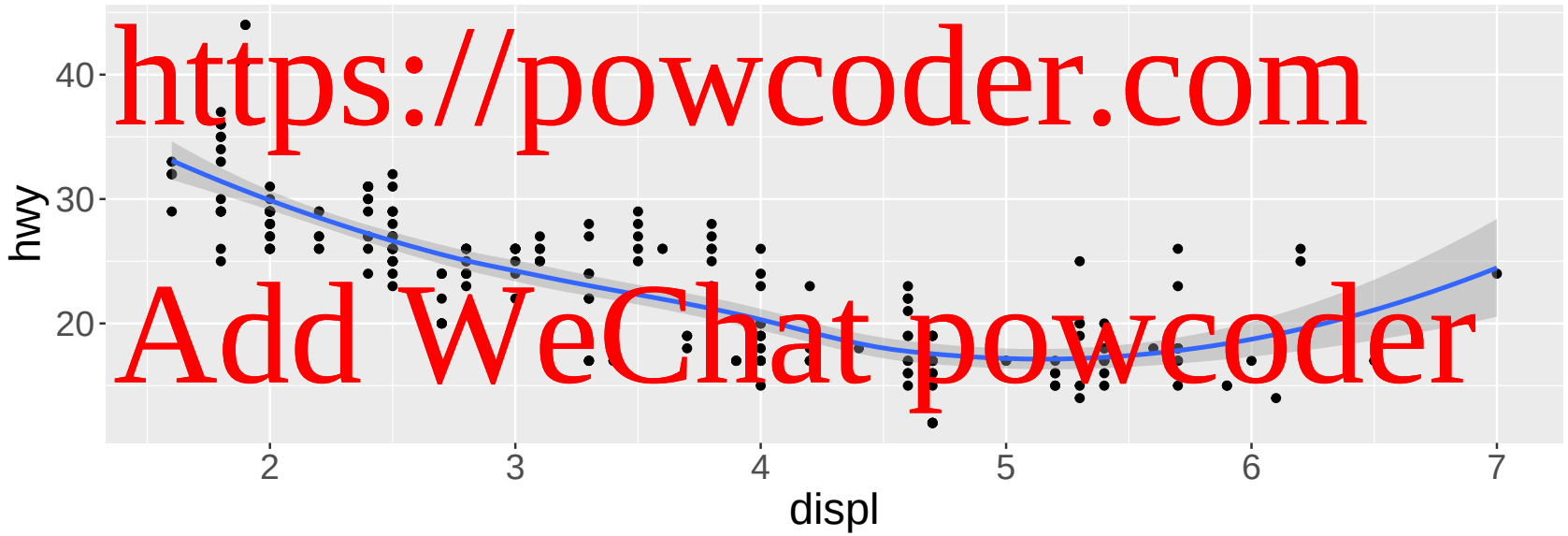



stat_quantile(. . . , quantiles = c(0.25, 0.5, 0.75),. . .)

- Quantile regression

geom_smooth()

```
ggplot(mpg, aes(displ, hwy)) +  geom_point() +
  geom_smooth() +
  theme(text = element_text(size=20))
```

stat_smooth(. . . , level = 0.95, . . .)

- Conditional mean

ggplot requires that we specify either a geom_* or a stat_* when we construct our plots.

Scales

Scales are used to determine how each aesthetic will appear. - Where in graphical space should the points occur? - What is the necessary range in colours? - What is the range in size of points?

As you progress you may begin customizing scales, but not at this time.

Coordinate Systems

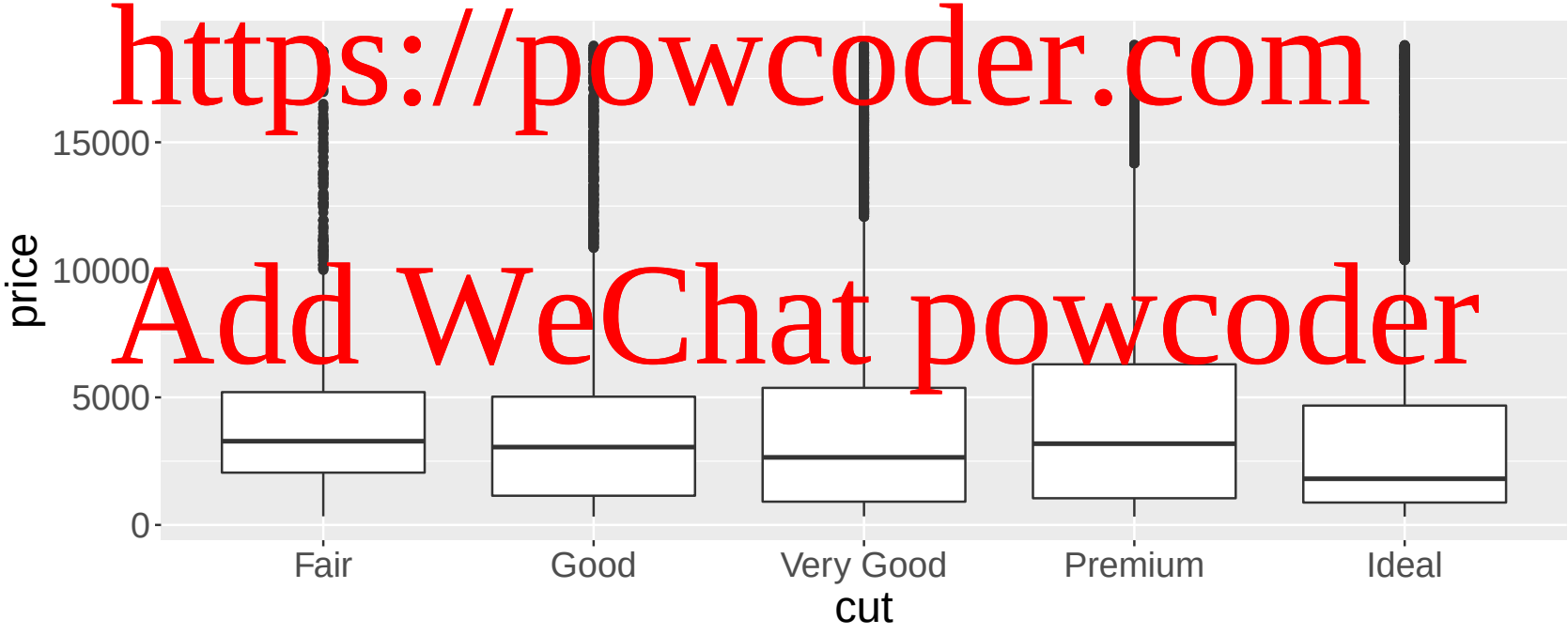
Known as coord in ggplot, maps the position of objects in graphical space.

They affect how geoms look in the plot. Changing the coord from coord_cartesian to coord_polar for a geom_bar changes the geometry to a circle.

coord_cartesian()
Cartesian coordinate system specifies each point uniquely in a plane by a pair of numerical coordinates (x, y) which are the signed distances to the point from two fixed perpendicular directed lines (0,0), measured in the same unit of length.

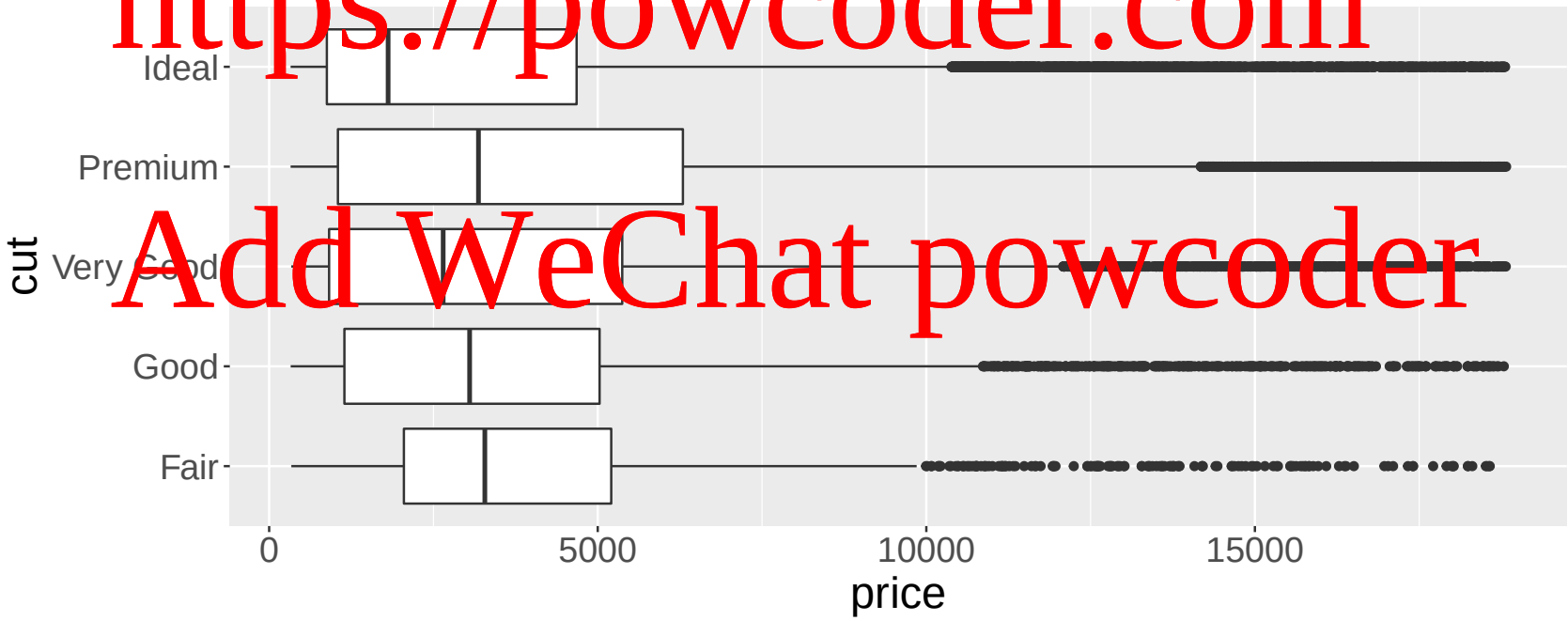
geom_boxplot()

```
ggplot(diamonds, aes(cut, price))+
  geom_boxplot()+
  theme(text = element_text(size=20))
```

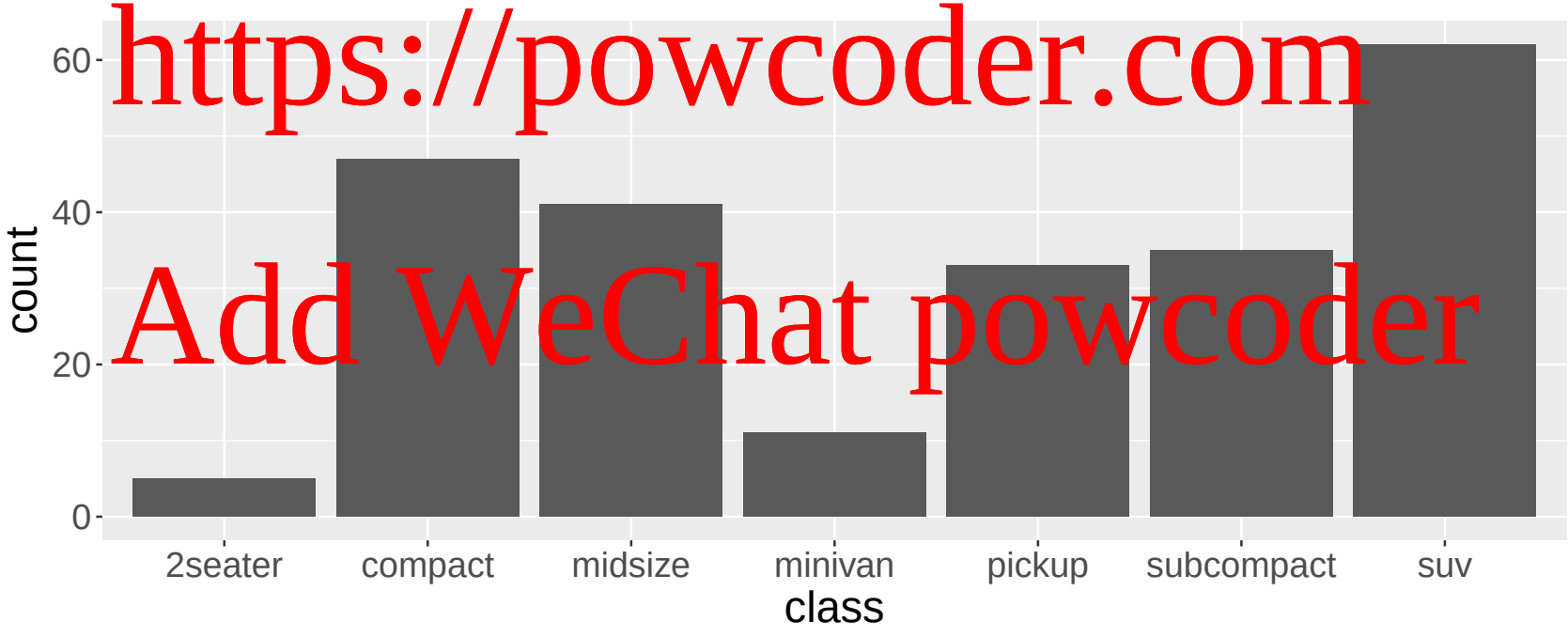
geom_boxplot()+coord_flip()

```
ggplot(diamonds, aes(cut, price))+
  geom_boxplot()+
  coord_flip()+
  theme(text = element_text(size=20))
```

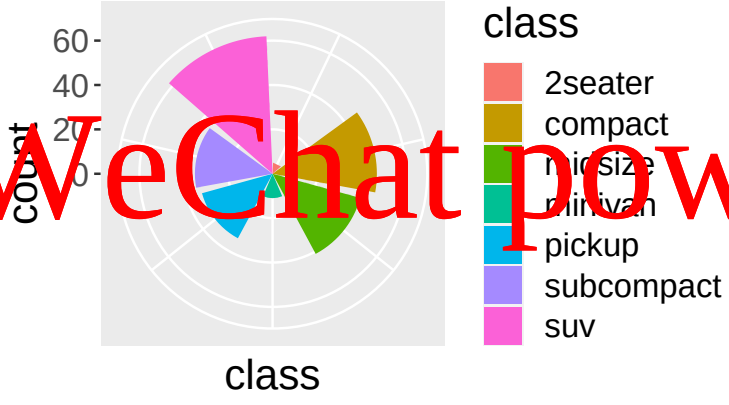
geom_bar

```
ggplot(mpg, aes(class))+
  geom_bar()+
  theme(text = element_text(size=20))
```



geom_bar + coord_polar()


```
ggplot(mpg)+
  geom_bar(mapping = aes(x = class, fill = class))+
  theme(axis.text.x = element_blank(), text = element_text(
  coord_polar()
```

Multiple Variables

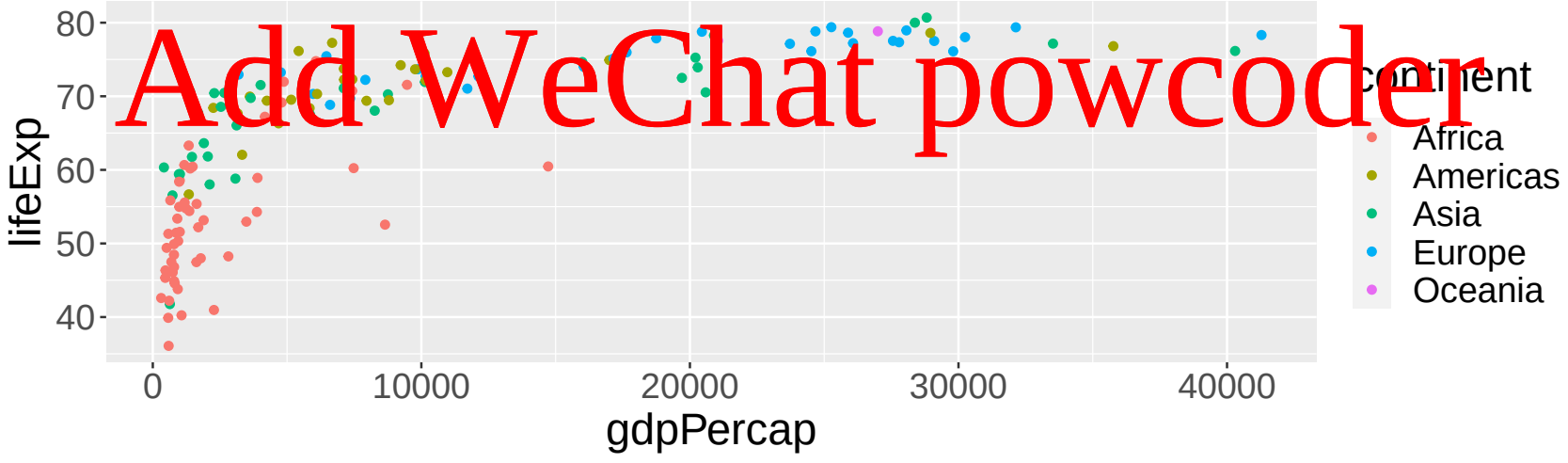
Three variables is the maximum recommended number of variables that should be visualized with a single plot.

- Two variables visualized by position.
- One variable by another aesthetic

More than three leads us to using facets

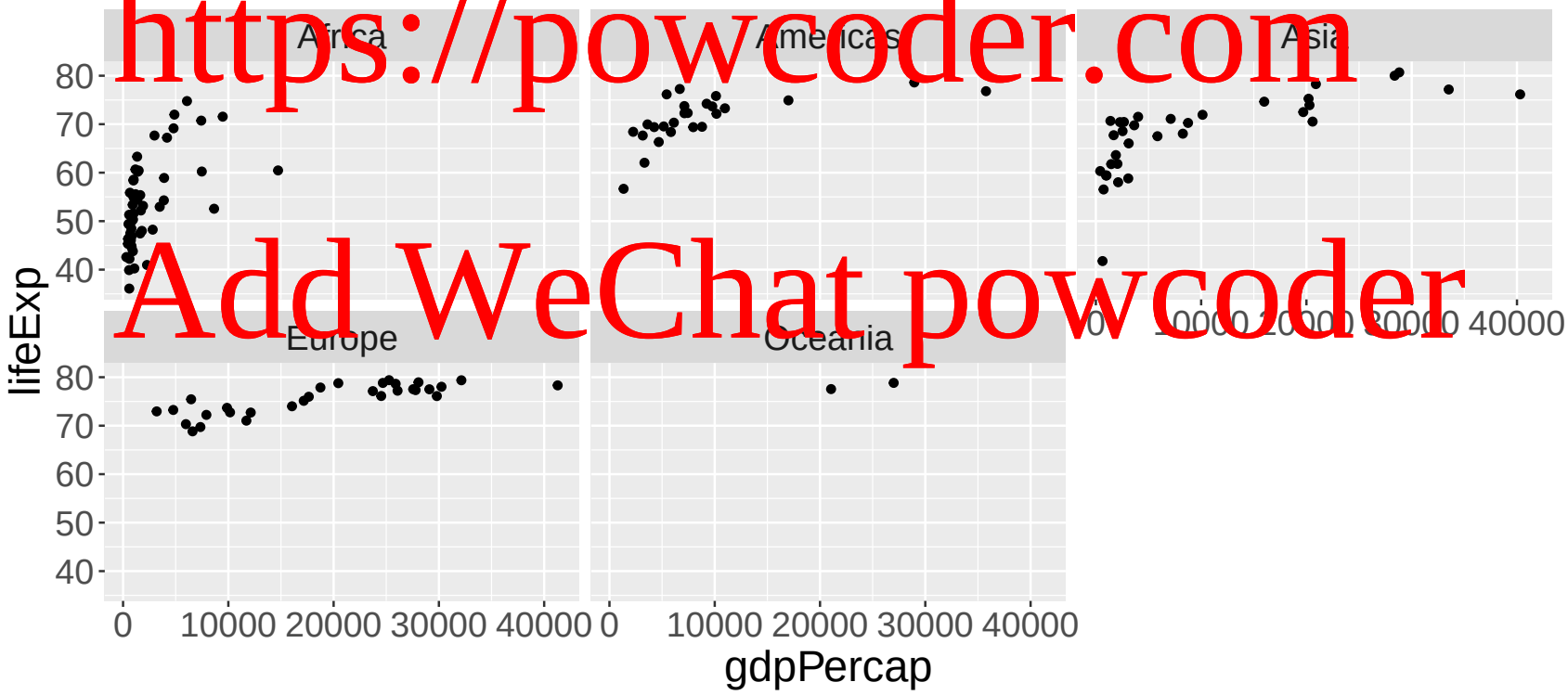
- Creating subplots
- Facet based on one variable, facet_wrap()
- Facet based on two variables, facet_grid()


```
ggplot(data = gap)+
  geom_point(mapping = aes(gdpPercap, lifeExp,
                           colour = continent))+ theme(text
```

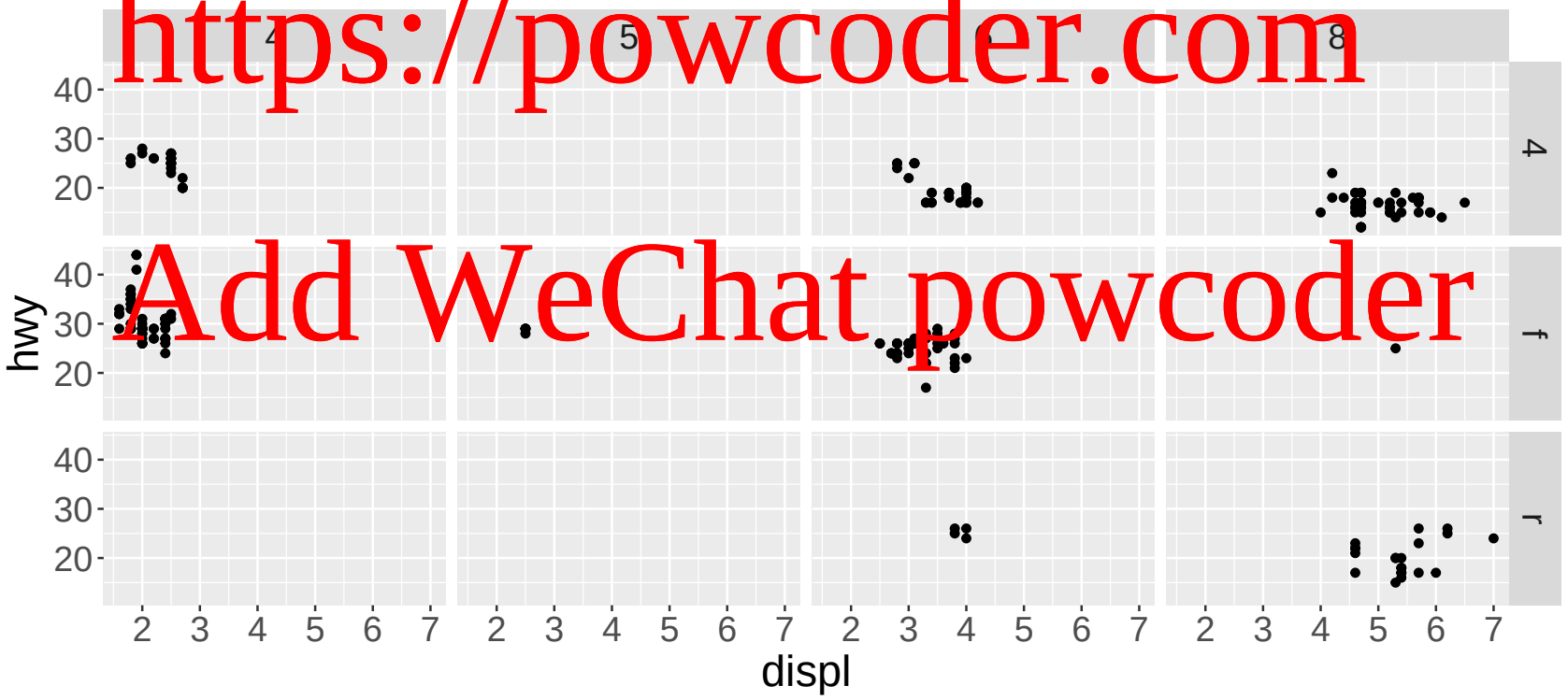
facet_wrap()

```
ggplot(data = gap)+
  geom_point(mapping = aes(gdpPercap, lifeExp))+
  facet_wrap(~continent, nrow = 2)+
  theme(text = element_text(size=20))
```

facet_grid()

```
ggplot(data = mpg)+
  geom_point(mapping = aes(x = displ, y = hwy))+
  facet_grid(drv~cyl)+
  theme(text = element_text(size=20))
```

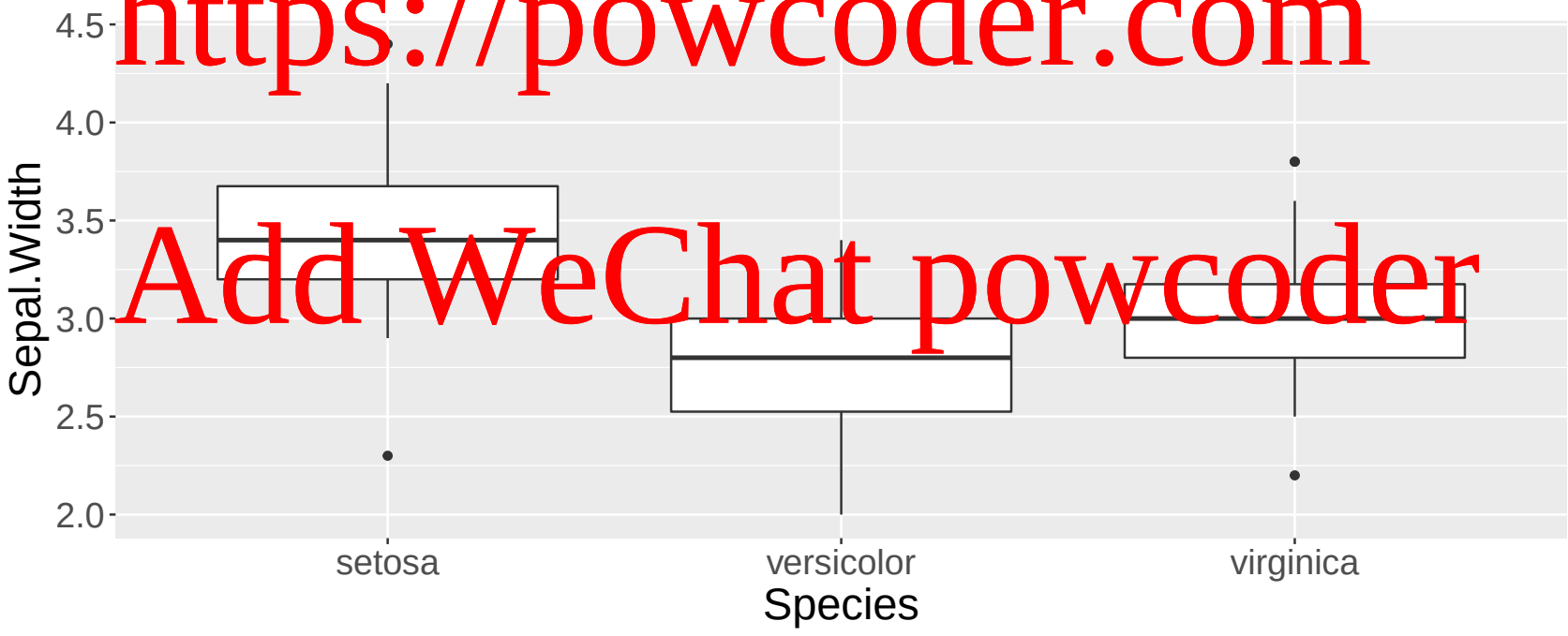



General issues with plots

- Too many variables, which can be overcome through facets
- Overplotting (discrete outcomes), we can jitter the values
- Alphabetical ordering, we can define our order using factors or by mean/median values
- Polar coordinates, you must be careful when using these as humans struggle during interpretation

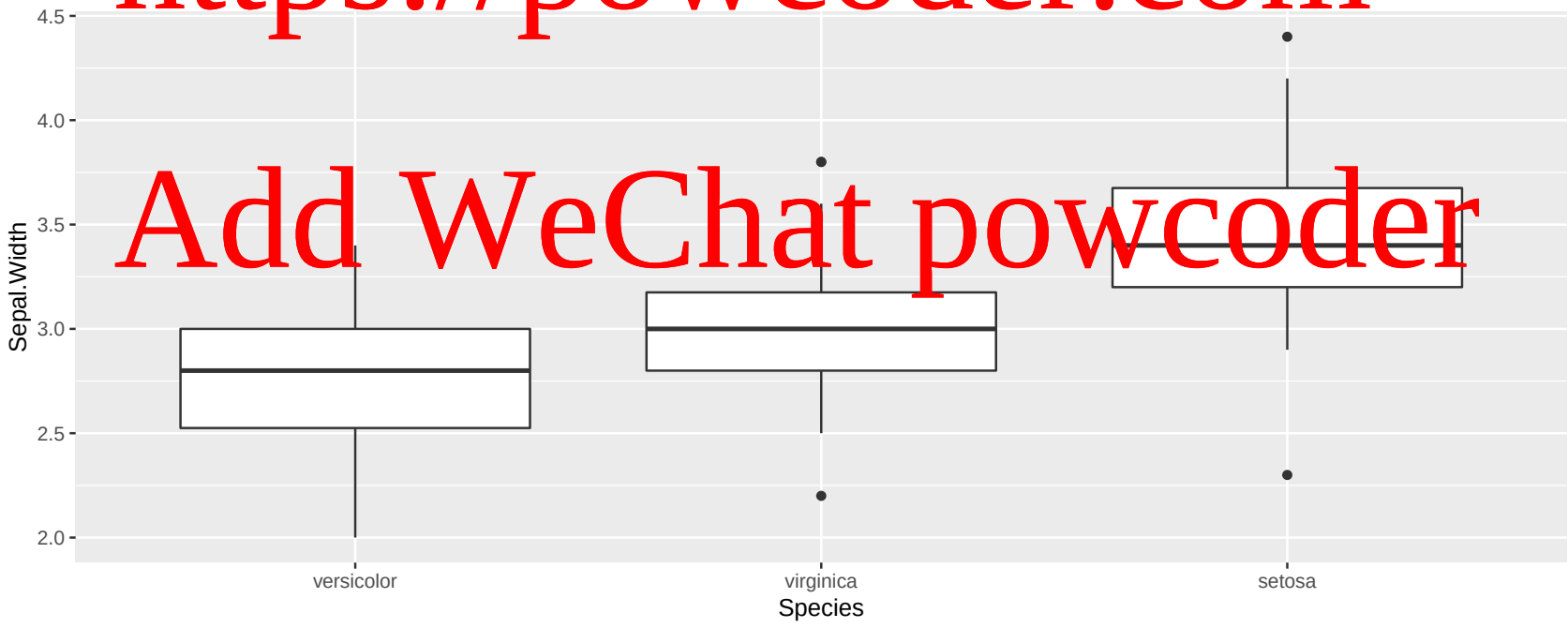
Ordering demo

```
# Default order is alphabetical
ggplot(iris, aes(x = Species, y = Sepal.Width)) +
  geom_boxplot()+
  theme(text = element_text(size=20))
```



Order by median

```
ggplot(iris, aes(x =
  reorder(Species, Sepal.Width,FUN = median),
  y = Sepal.Width)) +
  geom_boxplot()+
  xlab("Species")
```

Homework

Read: Chapters 2 & 3, R4DS

References

Borkin, Michelle A, Zoya Bylinskii, Nam Wook Kim, Constance May Bainbridge, Chelsea S Yeh, Daniel Borkin, Hanspeter Pfister, Senior Member, and Aude Oliva. 2015. "Beyond Memorability: Visualization Recognition an," 1–10. papers3://publication/uuid/9AD97C06-BAC3-414A-8B6E-C951EE2CB7EB.

Groeneveld, RA, and G Meeden. 1984. "Measuring Skewness and Kurtosis." *Journal of the Royal Statistical Society. Series D (the Statistician)* 33 (4): 391–99.

Wickham, Hadley. 2010. "A Layered grammar of graphics." *Journal of Computational and Graphical Statistics* 19 (1): 3–28. doi:10.1198/jcgs.2009.07098.