Statistical Methods and Data Analysis I

Lecture 2: Data Fundamentals

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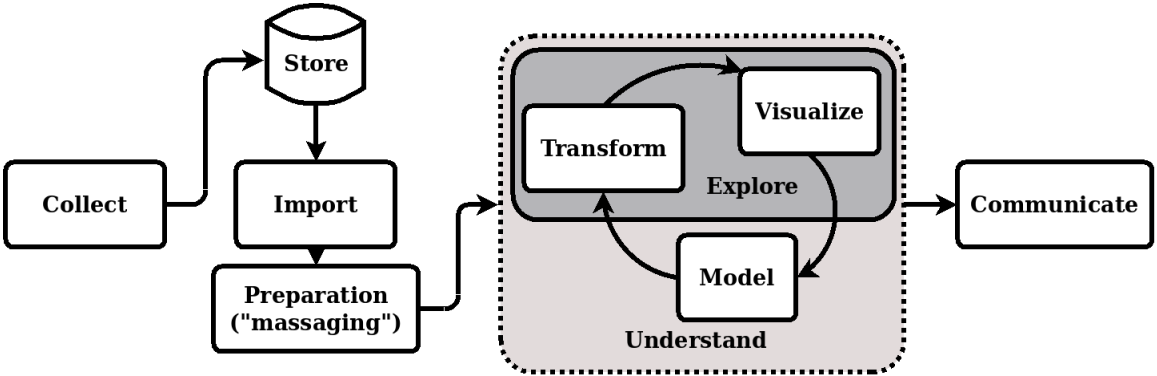
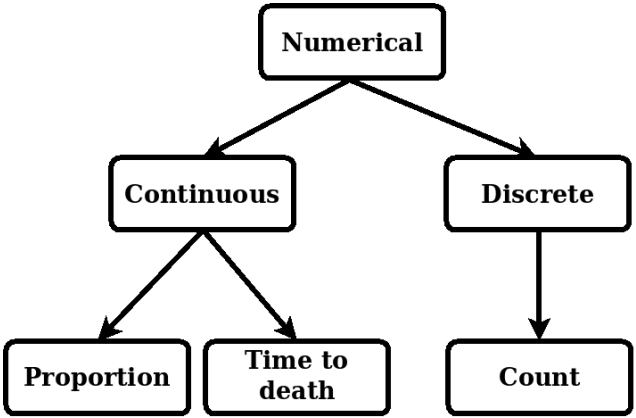
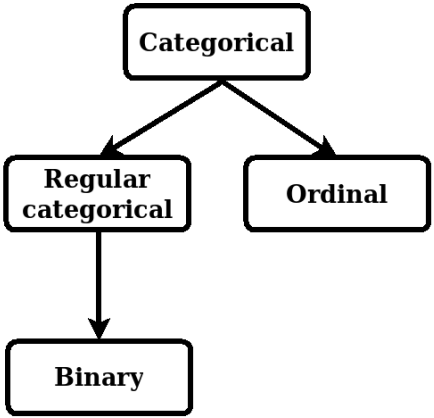
Data Lifecycle



Data Types


Numerical
Continuous
Discrete
Proportion
Time to death
Count


Categorical
Regular categorical
Ordinal
Binary

Data Types: Intuition

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- Budget/balance sheet?

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Data Types: Example

The `ggplot2::mpg` data set (file `loadmpg.R`)

```
library(tidyverse)
mpg %>% print(n=Inf,width=Inf) # use options(width=120) if needed
```

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```

↓ variable

```
    manufacturer model                displ  year   cyl trans      drv     cty   hwy fl    class
    <chr>        <chr>                <dbl> <int> <int> <chr>      <chr> <int> <int> <chr> <chr>
...
  7 audi         a4                     3.1  2008     6 auto(av)   f        18    27 p     compact
  8 audi         a4 quattro             1.8  1999     4 manual(m5) 4        18    26 p     compact
...
 23 chevrolet    c1500 suburban 2wd     6    2008     8 auto(l4)   r        12    17 r     suv
 24 chevrolet    corvette               5.7  1999     8 manual(m6) r        16    26 p     2seater
...
150 nissan       maxima                 3.5  2008     6 auto(av)   f        19    25 p     midsize
151 nissan       pathfinder 4wd         3.3  1999     6 auto(l4)   4        14    17 r     suv
...
173 subaru       impreza awd            2.5  2008     4 manual(m5) 4        20    27 r     compact
...
198 toyota       corolla                1.8  2008     4 auto(l4)   f        26    35 r     compact
199 toyota       land cruiser wagon 4wd 4.7  1999     8 auto(l4)   4        11    15 r     suv
...
221 volkswagen   jetta                  2.8  1999     6 manual(m5) f        17    24 r     compact
222 volkswagen   new beetle             1.9  1999     4 manual(m5) f        35    44 d     subcompact
...
234 volkswagen   passat                 3.6  2008     6 auto(s6)   f        17    26 p     midsize
```

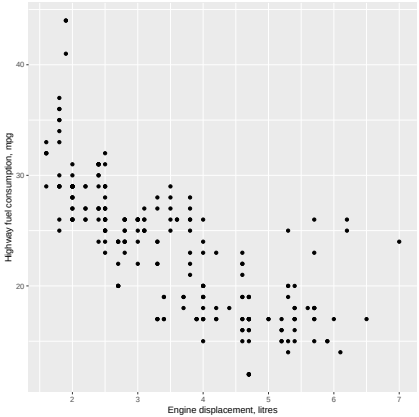
← observation

Independent and Associated variables

- When two variables show some connection with one another, they are called *associated* or *dependent* variables.
- If two variables are not associated, i.e. there is no evident connection between the two, then they are said to be *independent*.
- There are techniques to determine association (or independence, as the case may be) between variables and we will study them.

Relationship Between Variables

Is highway fuel consumption associated with engine displacement?



How to get this graph

```
library(tidyverse)

p <- ggplot(data = mpg) +
    geom_point(mapping = aes(x=displ,y=hwy)) +
    xlab('Engine displacement, litres') +
    ylab('Highway fuel consumption, mpg')

ggsave(plot=p,filename='fig/mpg_assoc_displ_hwy_1.pdf',device='pdf')

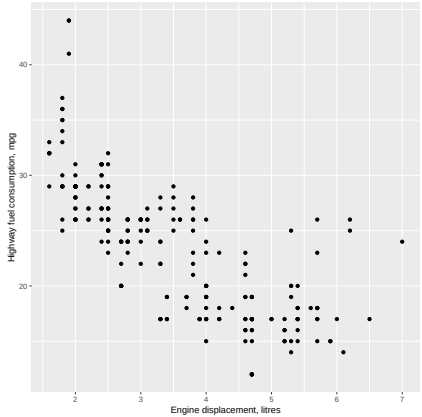
p <- p + geom_smooth(mapping = aes(x=displ,y=hwy))

ggsave(plot=p,filename='fig/mpg_assoc_displ_hwy_2.pdf',device='pdf')
```

Relationship Between Variables

Is highway fuel consumption associated with engine displacement?

Seems that cars with larger engines use more fuel — negative association...



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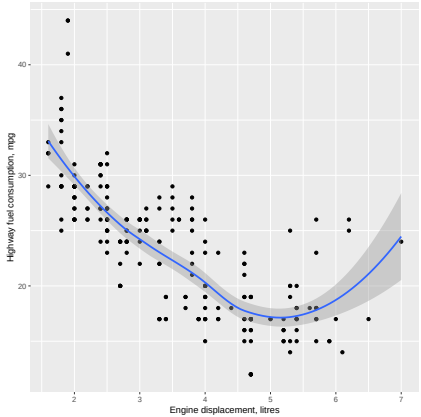
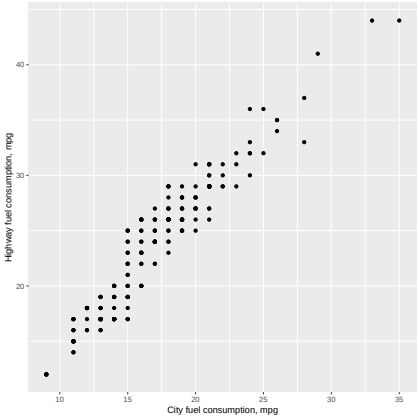


Relationship Between Variables

Is highway fuel consumption associated with city performance?



How to get this graph

```
library(tidyverse)

p <- ggplot(data = mpg) +
    geom_point(mapping = aes(x=cty,y=hwy)) +
    xlab('City fuel consumption, mpg') +
    ylab('Highway fuel consumption, mpg')

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p <- p + geom_smooth(mapping = aes(x=cty,y=hwy))

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Relationship Between Variables

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It rather stands to reason that these two are positively associated...

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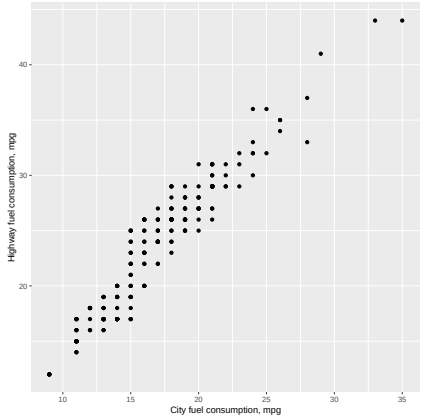

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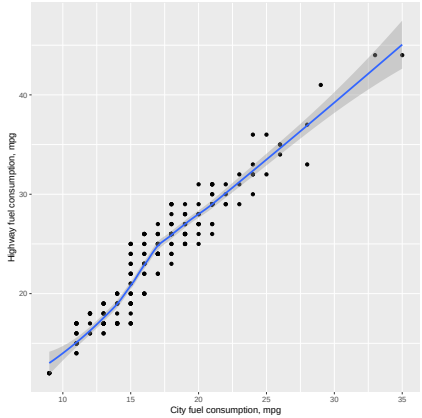
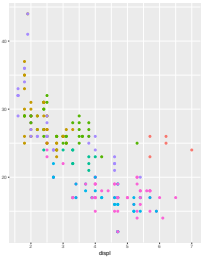
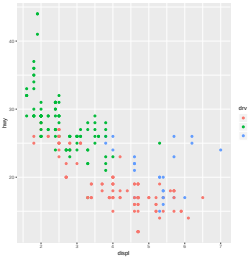
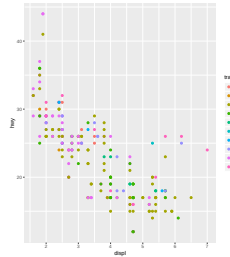
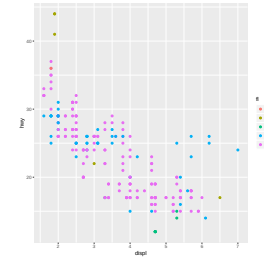


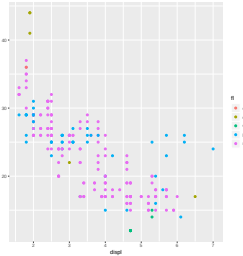
Exploring The mpg Data Set

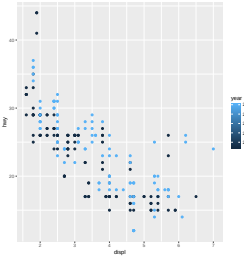


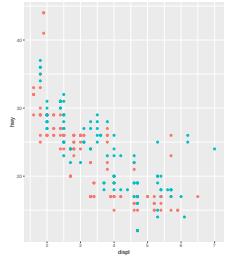


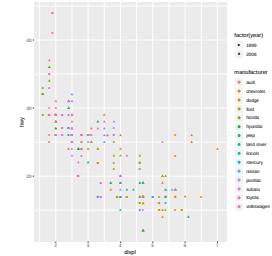












Toolkit: How To Get The Graphs On The Previous slide

Exploring `ggplot2::mpg` (file `explore_mpg.R`)

```
library(tidyverse)

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=class))
ggsave(plot=p,filename='fig/explore_mpg_class.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=drv))
ggsave(plot=p,filename='fig/explore_mpg_drv.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=trans))
ggsave(plot=p,filename='fig/explore_mpg_trans.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=manufacturer))
ggsave(plot=p,filename='fig/explore_mpg_manufacturer.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=fl))
ggsave(plot=p,filename='fig/explore_mpg_fl.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=year))
ggsave(plot=p,filename='fig/explore_mpg_year.pdf',device='pdf')

p <- ggplot(data=mpg) + geom_point(mapping=aes(x=displ,y=hwy,color=factor(year)))
ggsave(plot=p,filename='fig/explore_mpg_fyear.pdf',device='pdf')

p <- ggplot(data=mpg) +
    geom_point(mapping=aes(x=displ,y=hwy,shape=factor(year),color=manufacturer))
ggsave(plot=p,filename='fig/explore_mpg_maker_year.pdf',device='pdf')
```

Explanatory and Response Variables

Given 2 variables, identify which of the two is **suspected** of affecting the other:

$$\text{explanatory variable} \xrightarrow{\textit{might affect}} \text{response variable}$$

Labeling variables as explanatory and response does not indicate a causal relationship between them, even if there is an observed association between the two variables.

(NB: we will discuss correlation and causation later on.)

Such labeling reflects an assumption, often implicit, and certainly not a known fact. It may be regarded a **hypothesis** or may be considered a part of a **model**.

Observations and Experiments

- Observational studies
  - Researchers collect data in ways that do not interfere with how the data are generated. In other words, they merely “observe”.
  - Observational studies can only establish associations between explanatory and observed variables.
- Experimental studies
  - Researchers assign subjects to various “treatments” and study the “effects”.
  - “Treatments” are designed to manipulate explanatory variables, and the “effects” correspond to changes in the response variables.
  - Various techniques related to such assignment (randomization, blind and double-blind studies, etc.) will be studied later.
  - So will techniques of performing “controlled experiments” (changing only one explanatory variable at a time, etc.).
  - The intent is to attempt to establish a causal relationship (or lack thereof) between explanatory and response variables.
  - This may or may not succeed. Various pitfalls will also be discussed in this course.

Prospective and Retrospective Studies

- A *prospective* study identifies subjects and collects information on an ongoing basis.
  - Example: the Nurses' Health Study has been recruiting registered nurses and then collecting data from them using questionnaires since 1976.
- A *retrospective* study collects data *post factum*, after relevant events have taken place.
  - Example: researchers may review past medical records.

The Most Important Meal of the Day

New study sponsored by General Mills says that eating breakfast makes girls thinner

Study: Breakfast Helps Girls Stay Slim
I love these studies....and finding out who sponsored them!

By ALEX DOMINGUEZ, Associated Press

Girls who regularly ate breakfast, particularly one that includes cereal, were slimmer than those who skipped the morning meal, according to a study that tracked nearly 2,400 girls for 10 years.

Girls who ate breakfast of any type had a lower average body mass index, a common obesity gauge, than those who said they didn't. The index was even lower for girls who said they ate cereal for breakfast, according to findings of the study conducted by the Maryland Medical Research Institute. The study received funding from the National Institutes of Health and cereal-maker General Mills.

"Not eating breakfast is the worst thing you can do, that's really the take-home message for teenage girls," said study author Bruce Barton, the Maryland institute's president and CEO.

The fiber in cereal and healthier foods that normally accompany cereal, such as milk and orange juice, may account for the lower body mass index among cereal eaters, Barton said.

The results were gleaned from a larger NIH survey of 2,379 girls in California, Ohio and Maryland who

Breakfast Study: Analysis

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The study was sponsored by General Mills, a Minnesota-based manufacturer of branded foods, including Yoplait, Pillsbury, Häagen-Dazs, Cheerios, Trix, Cocoa Puffs, and Lucky Charms.

Cereals are good for you, eh?

Possible Explanations

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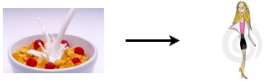
1. Eating breakfast causes girls to be thinner.



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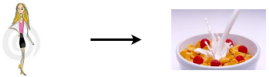

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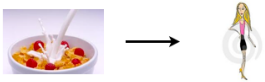

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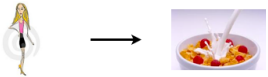
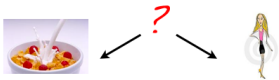


3. There may be a common cause — a *confounding* variable that affects both the explanatory and the response variable and that makes it seem like there is a relationship between the two.



Source: https://github.com/OpenIntroOrg/openintro-statistics-slides.git

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  People call each other when it rains.

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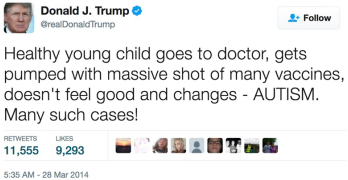

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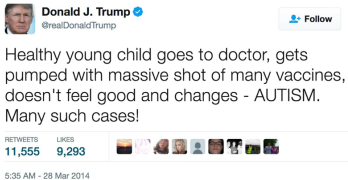

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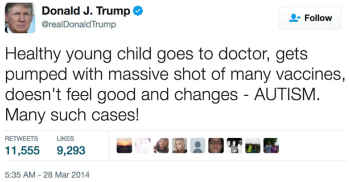

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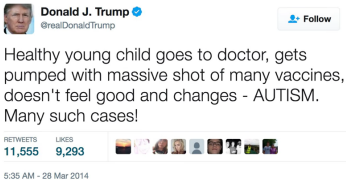

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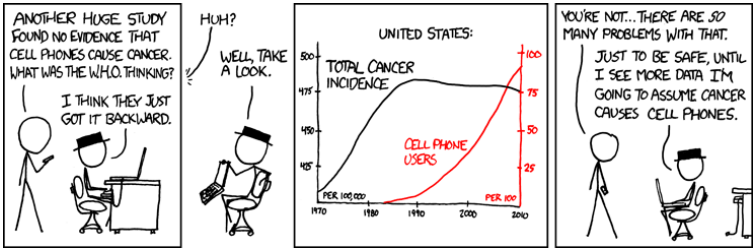

Credit: https://xkcd.com/925/