YData: Introduction to Data Science

Class 02: Introduction to Python

Overview

Very quick review of the history of data science

Quick Discussion of the reading from “Everybody Lies”

Observational and Experimental data

Intro to Python

- Expressions
- Names
- Call expressions (functions)
- Data types
  - Numbers and strings

- If there is time
  - Lists
  - Dictionaries

Let's test the YCRC Jupyter notebook server...

Before we get started, let's test the YCRC Jupyter notebook server

A link to the server is at the top of the class Canvas page

The history of Data Science

(a very incomplete list)

Data

Ishango bone

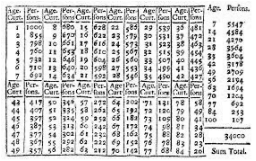
(20,000 BCE)

Cuneiform tablets

(4,000 BCE)

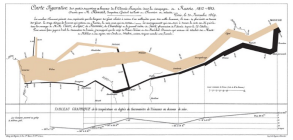
Quipus in South America

(1100-1500)



Demographics

(1600's)



Golden age of data visualization

(1850-1900)

Big data

(now)

Probability

Key Take Away

Probability models dominated data analysis prior to using computational methods

Initial development

(1600's)

"Small data"

Probability in Statistics

(1820's – 1950's)

Math Stats dominates

(1900-1960's)

"Big data"

Computers

Abacus

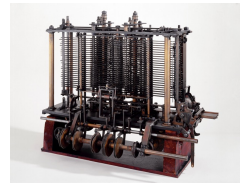
(2400 BCE)

Antikythera mechanism

(100 BCE)

Analytical Engine

(1800's)



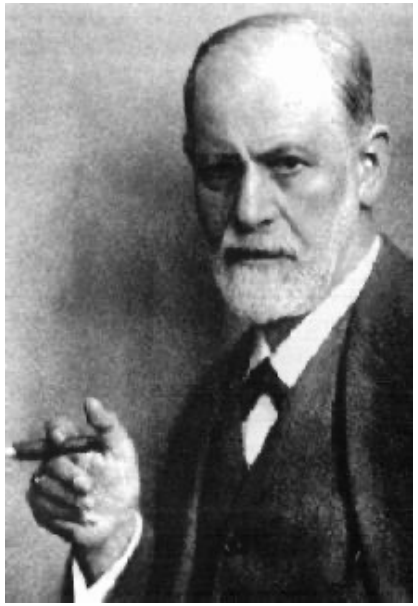
Hollerith Tabulating Machine

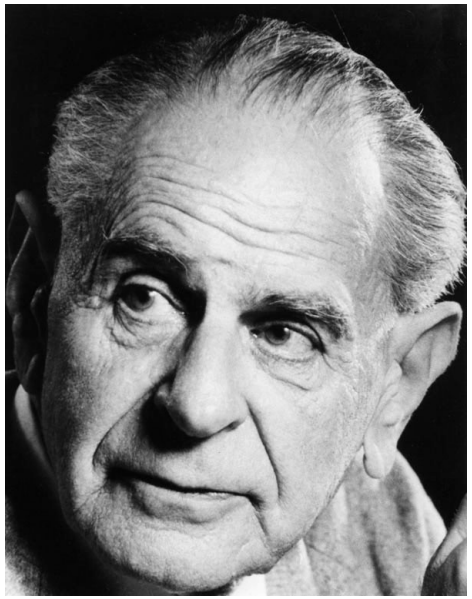
(1890)

Mainframes, PCs, Internet, etc.

(1950-present)

Thoughts on the reading from Everybody Lies?





Let's take ~3 minutes to discuss the paper in groups of 3-4 people

Observational and Experimental Studies

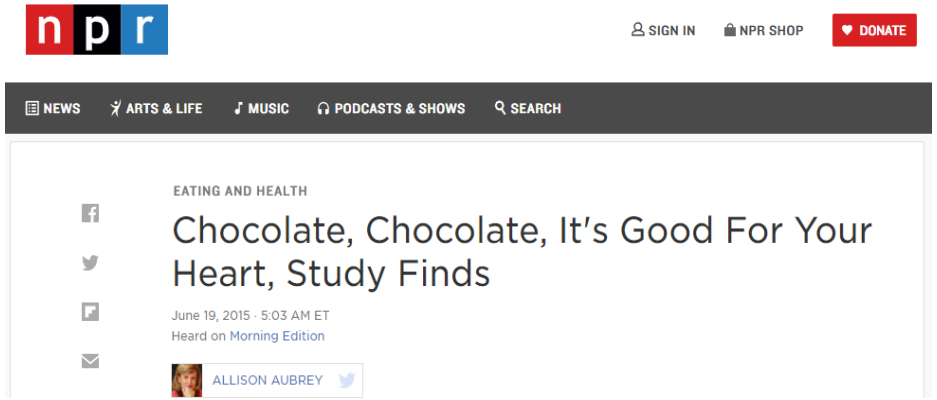
Association vs. causation

An association is the presence of a reliable relationship between the treatments an outcome

- E.g., people who eat chocolate have lower rates of heart disease

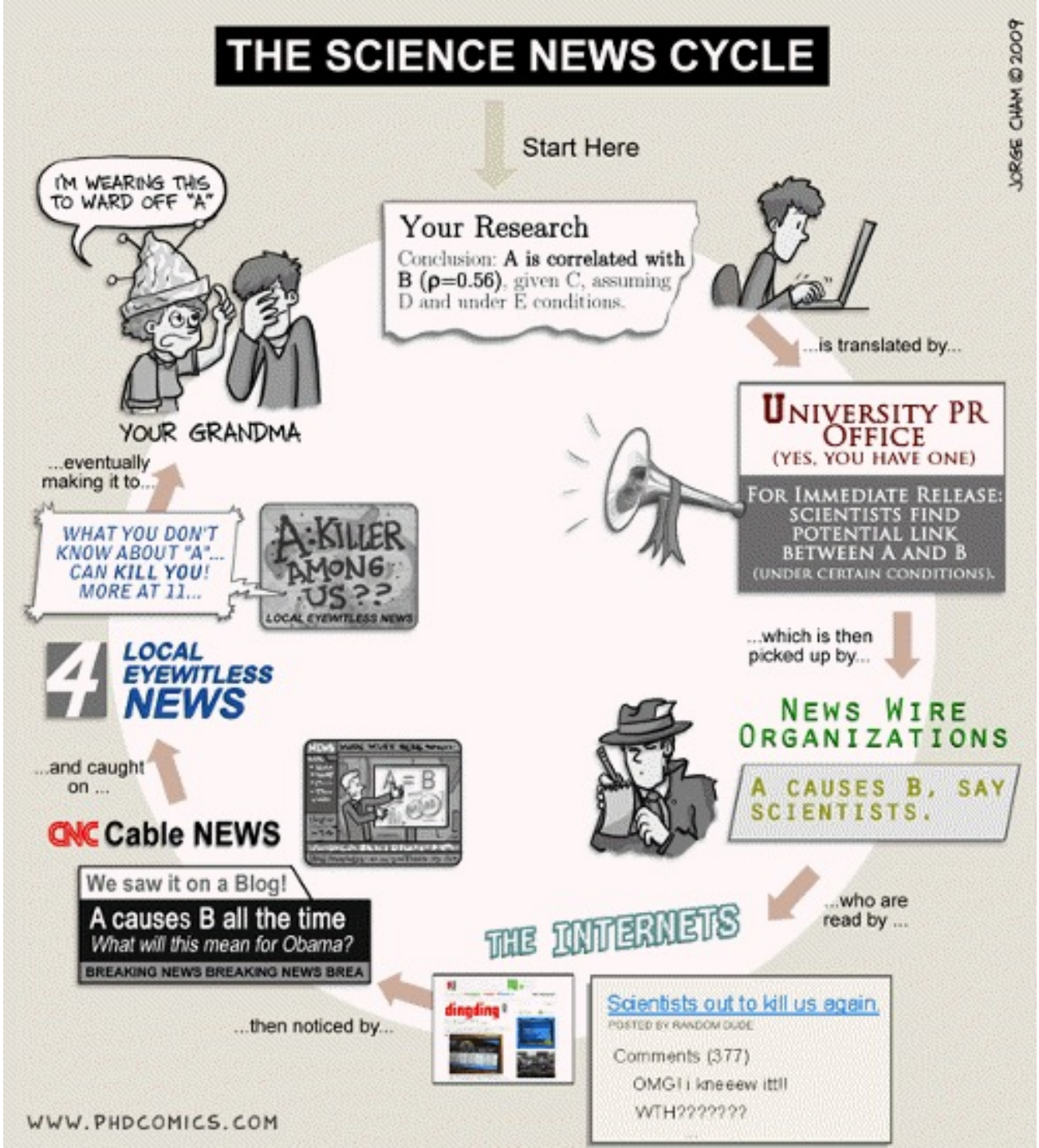
A causal relationship is when changing the value of a treatment variable influences the value outcome variable

- E.g., consuming chocolate ***leads to*** a reduction in heart disease



There's a growing body of evidence suggesting that compounds found in cocoa beans, called polyphenols, may help protect against heart disease.

Philippe Huguen/AFP/Getty Images



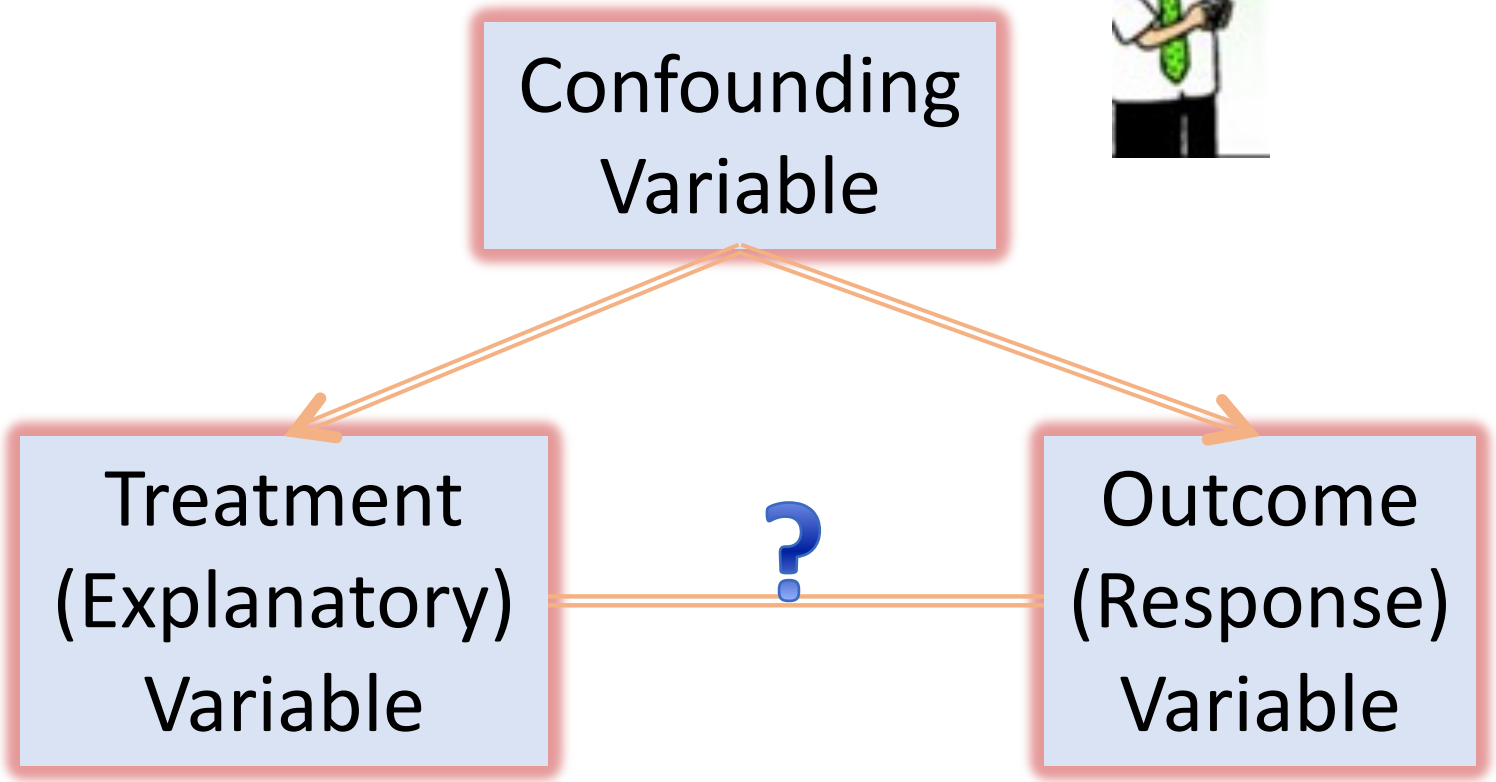
Association does not ≠ causation!

Confounding

A **confounding variable** (also known as a **lurking variable**) is a third variable that is associated with both the treatment (explanatory) variable and the outcome (response) variable

A confounding variable can offer a plausible explanation for an association between the other two variables of interest

Confounding



Observational and experimental studies

An **observational study** is a study in which the researcher does not actively control the value of any treatment variable but simply observes the values as they naturally exist

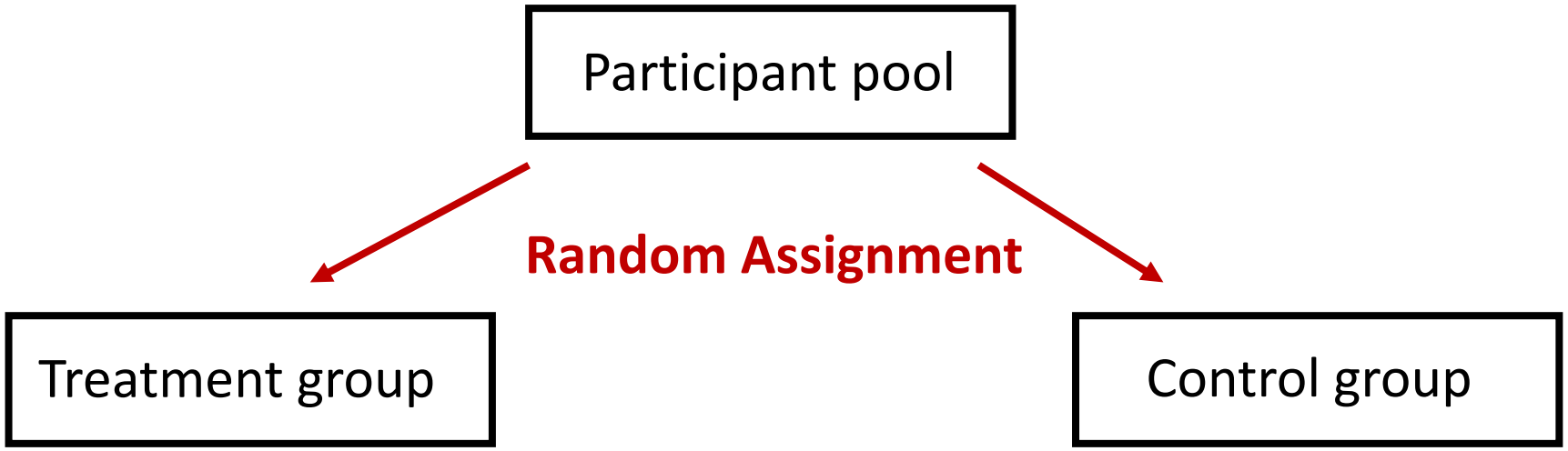
An **experiment** is a study in which the researcher actively controls one or more of the treatment variables

- Randomly assigns treatments to cases
- Allows one to get at questions of **causation**!

Randomized Controlled Experiment

Take a group of participant and ***randomly assign***:

- Half to a *treatment group* where they get chocolate
- Half in a *control group* where they get a fake chocolate (placebo)
- See if there is more improvement in the treatment group compared to the control group



Observational and experimental studies

Experimental science (and data) grew in the 20th century, and dominates the sciences

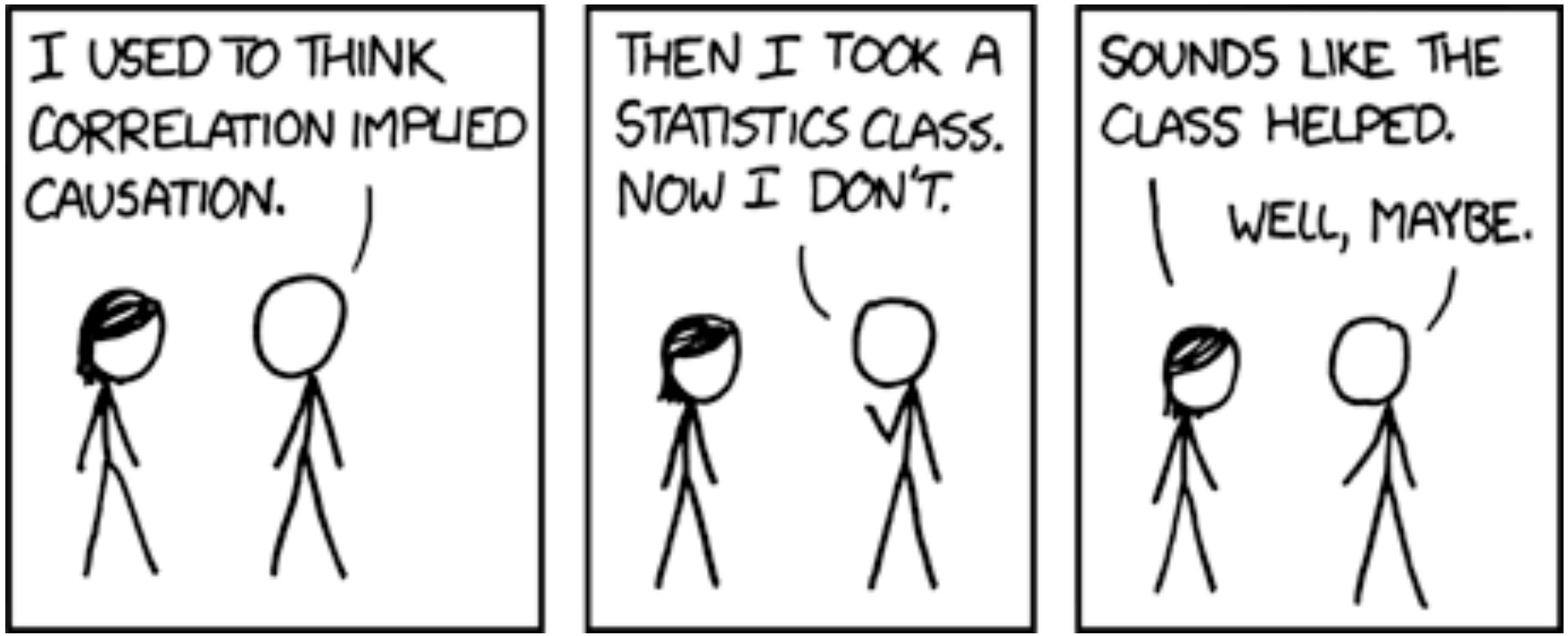
Other fields is not possible or ethical to run experiments

- E.g., Economics
  - although there are "natural" experiments

Data Science analyses often focus on observational data

- Be aware of the limitations in drawing causal conclusions from data!

Questions?


I USED TO THINK CORRELATION IMPLIED CAUSATION.
THEN I TOOK A STATISTICS CLASS. NOW I DON'T.
SOUNDS LIKE THE CLASS HELPED.
WELL, MAYBE.

Programming in Python

Understanding the language fundamentals is important

Learn through practice, not only by reading or watching but by doing

- Like learning to ride a bike

Today you can follow along with the class 2 Jupyter notebook which we will download now!

Let's start up Python!

Did everyone get Anaconda and the *ydata123_2024a* environment installed?

If you weren't able to, you can follow the material in today's class using:

- YCRC Jupyter notebook server
- Google colabs

Downloading the class code

If you have the *ydata123_2024a* environment working, you can get the class code using:

- import YData
- YData.download.download_class_code(2)

If you are using colabs please run:

```
!pip install https://github.com/emeyers/YData_package/tarball/master
 from google.colab import drive
drive.mount('/content/drive')
```

Expressions

Expressions

Expressions describe how a computer should combine pieces of data

- They are evaluated to by the computer and return a value
- E.g., mathematical expressions
  - Multiplication: `3 * 4`
  - Exponentiation: `3**4`

Operation	Operation	Example	**Value**
Addition	+	2 + 3	5
Subtraction	-	2 – 3	-1
Multiplication	*	2*3	6
Division	/	7/3	2.667
Remainder	%	7 % 3	1
Exponentiation	**	2**.05	1.414

Syntax

The *Syntax* of a language is its set of grammar rules for how expressions can be written

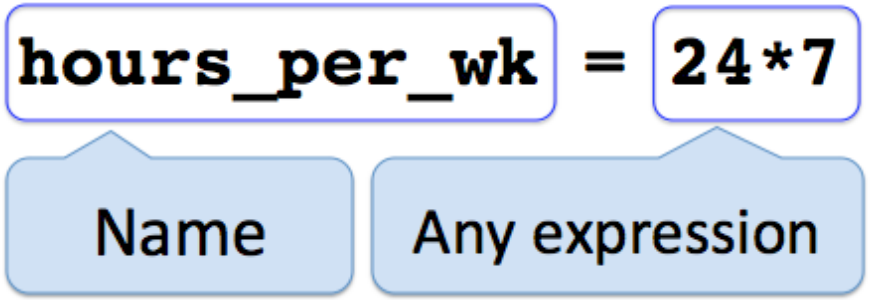
- *SyntaxError* indicates that an expression structure doesn't match any of the rules of the language.
- E.g., failed attempt at exponentiation: `3 * * 4`

```
  File "<ipython-input-2-012ea60b41dd>", line 1
    3 * * 4
        ^
SyntaxError: invalid syntax
```

Let's explore this in Jupyter!

Names

Assignment statements



Names store the values (from an expression)

- i.e., they are like variables in algebra

Names are assigned values using the = symbol

- E.g., my_number = 7

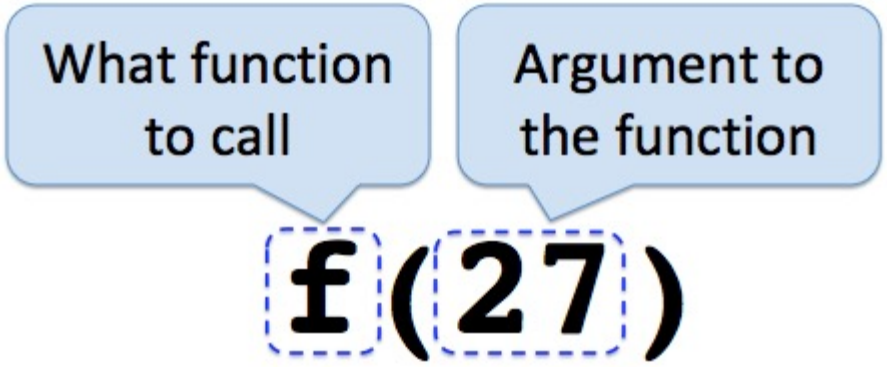
Let's explore this in Jupyter!

Call Expressions

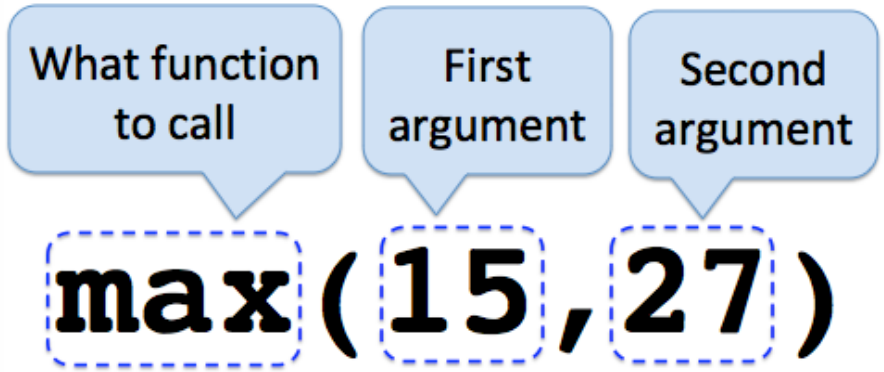
Anatomy of a Call Expression

Call expressions are expressions that call functions

- Functions take in one or more values (arguments) and (usually) return another value



Example: taking the maximum value



Let's explore this in Jupyter!

Numerical data

Arithmetic operations

Operation	Operation	Example	**Value**
Addition	+	2 + 3	5
Subtraction	-	2 – 3	-1
Multiplication	*	2*3	6
Division	/	7/3	2.667
Remainder	%	7 % 3	1
Exponentiation	**	2**.05	1.414

We can store the output of evaluating expression in names

- my_result = 10 * 2

Numbers in Python: Ints and Floats

Python has two real number types

- **int**: an integer of any size
- **float**: a number with an optional decimal part

An int never has a decimal point - a float always does

- 3 # int of float?
- 2.7 # int of float?

A float might be printed using scientific notation

Notes on Floats

Three limitations of float values:

- They have limited size (but the limit is huge)
- They have limited precision of 15 - 16 decimal places
- After arithmetic, the final few decimal places can be wrong

Let's explore this in Jupyter!

Arithmetic Question

What numbers are these expressions equal to?

A. 3 * 10 ** 10	A. 30000000000
B. 10 * 3 ** 10	B. 590490
C. (10 * 3) ** 10	C. 590490000000000
D. 10 / 3 / 10	D. 0.3333333333333337
E. 10 / (3 / 10)	E.33.333333333333336

Best to err on the side of using parentheses!

Strings

Text and Strings

A string value is a snippet of text of any length

- 'a'
- 'word'
- "there can be 2 sentences. Here's the second!"

Strings consisting of numbers can be converted to numbers

- int('12')
- float('1.2')

Any value can be converted to a string

- str(5)

Let's explore this in Jupyter!

Discussion Questions

Assume you have run the following statements

- x = 3
- y = '4'
- z = '5.6'

What's the source of the error in each example?

- A. x + y
- B. x + int(y + z)
- C. str(x) + int(y)
- D. str(x, y) + z

Types

Every value has a type

We've seen several types so far:

- int: 2
- Built-in function: abs()
- float: 2.2
- str: 'Red fish, blue fish'

The type function can tell you the type of a value

- type(2)
- type('Red fish')

An expression's type is based on its value, not how it looks

- x = 2
- type(x)

Let's explore this in Jupyter!

Conversions

Strings that contain numbers can be converted to numbers

- int('12')
- float('1.2')
- float('one point two') # Not a good idea!

Any numeric value can be converted to a string

- str(5)

Numbers can be converted to other numeric types

- float(1)
- int(1.2) # DANGER: loses information!

Lists

Lists

Lists are ways to store multiple items

We can create lists using square brackets []

- my_list = [2, 3, 4]

We can also access list items using square brackets []

- my_list[2]

Lists can contain elements of different types

- my_list2 = [5, 6, 'seven']

Let's explore this in Jupyter!

Dictionaries

Dictionaries

Dictionaries allow you to look up ***values*** based on a ***key***

- i.e., you supply a “key” and the dictionary returns the stored value

We can create dictionaries using the syntax:

- my_dict = { 'key1': 5, ‘key2’: 20}

We can retrieve dictionary values by supplying a key using square brackets []

- my_dict['key2’]

Let's explore this in Jupyter!