YData: Introduction to Data Science

Class 02: Introduction to Python

Overview

Very quick continuation of the history of data science

Quick Discussion of the reading from “Everybody Lies”

Intro to Python

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

- If there is time
  - Lists

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

Before we get started, please log into the YCRC Jupyter notebook server

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

Can everyone log in?

Announcements

Please fill out two surveys

- 1. Background survey
- 2. Practice session and study group survey

If you have not done so already, fill these out by 11pm tonight!

Practice sessions for this week are:

- Thursday 5-6, and 6-7
- Friday 3-4, and 4-5
- Subject to change in future week (fill out survey #2)

Announcement: Homework 1

Homework 1 has been posted!

```
import YData
YData.download.download_homework(1)
```

It is due on Gradescope on Sunday September 8th at 11pm

- **Be sure to mark each question on Gradescope!**

The history of Data Science

(a very incomplete list)

Data

Ishango bone

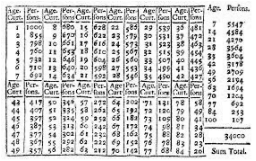
(20,000 BCE)

Cuneiform tablets

(4,000 BCE)

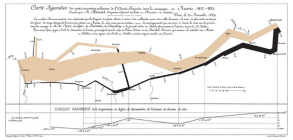
Quipus in South America

(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

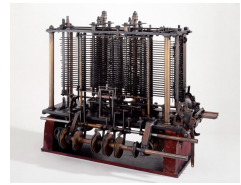
(2400 BCE)

Antikythera mechanism

(100 BCE)

Analytical Engine

(1800's)



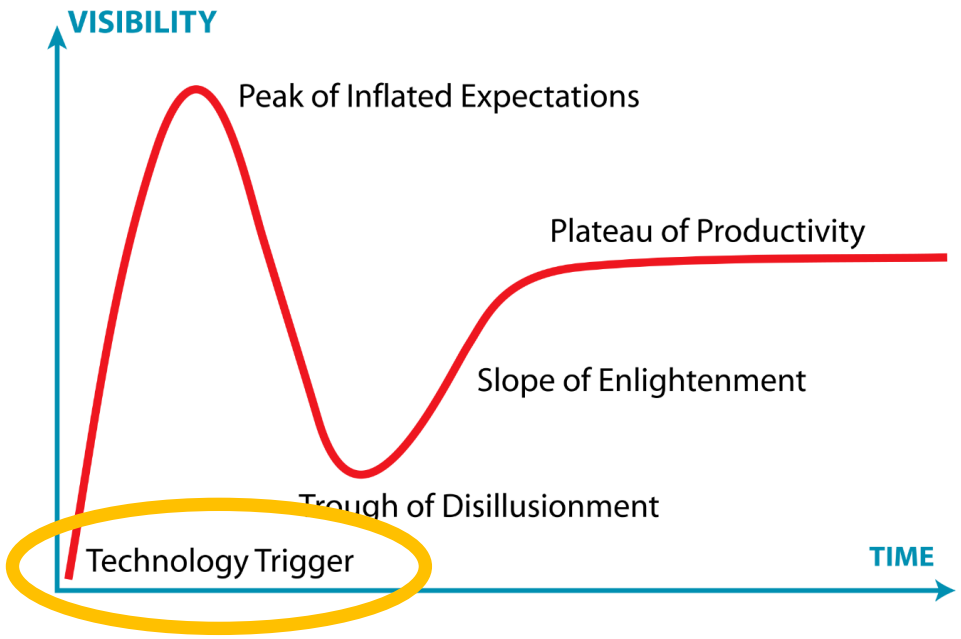
Hollerith Tabulating Machine

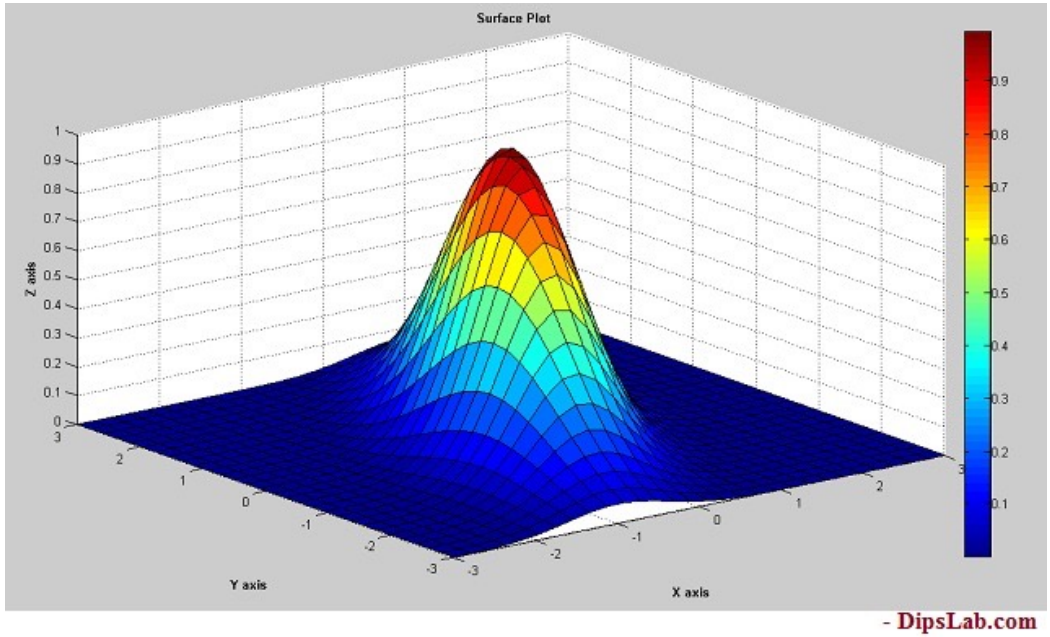
(1890)

Mainframes, PCs, Internet, etc.

(1950-present)

Brief history of Data Science: Technology Trigger



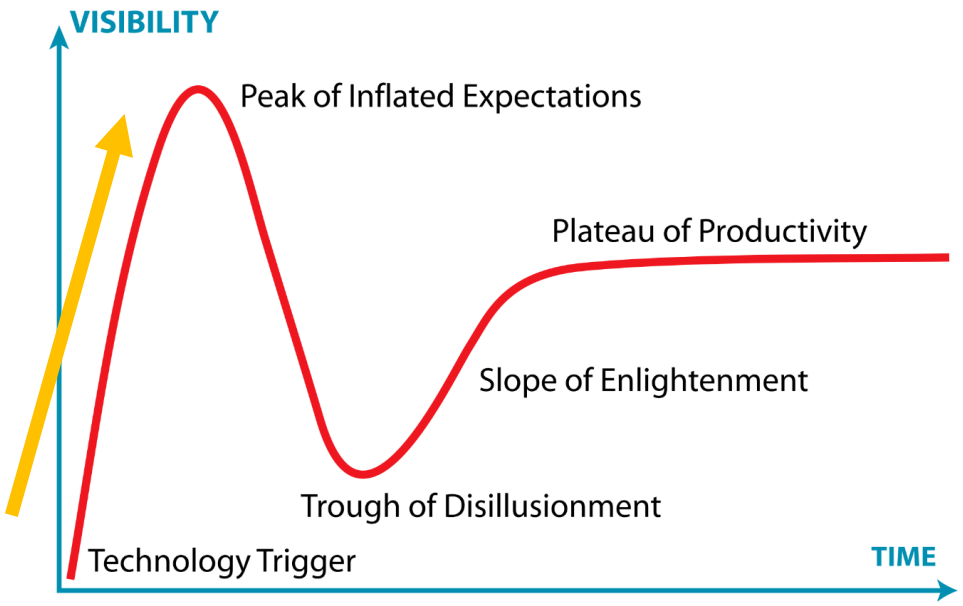


Early 2000's rise of the internet, personal computers and data analysis programming languages changes how data can be analyzed

- MATLAB
- Python: matplotlib 2003, numpy 2005, scikit-learn 2007, pandas 2009

From Downey 2024

Brief history of Data Science



2009

Data Science rises with data science competitions, blog posts, and industry jobs

- Data Scientists viewed as “unicorns” because they had to know both statistics and how to program

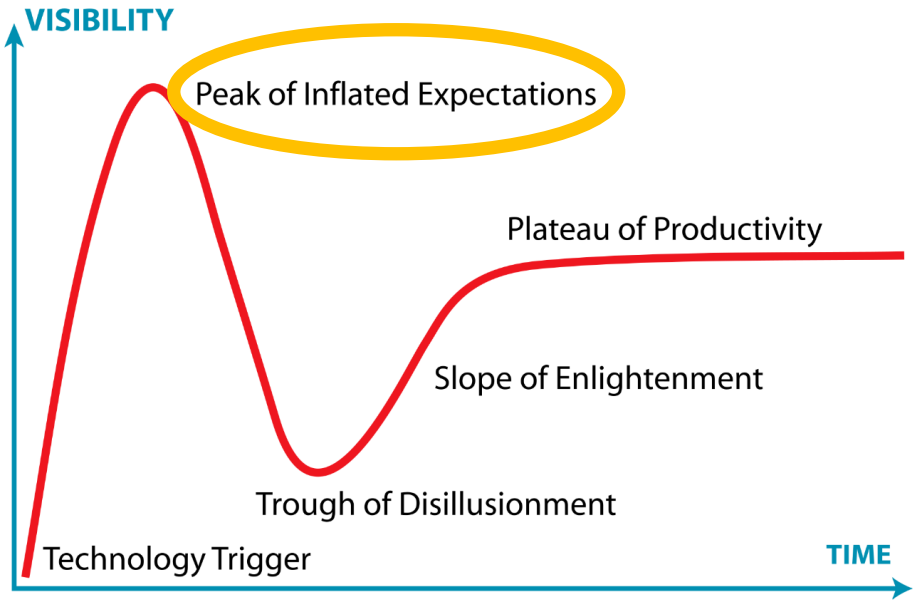
2010

kaggle

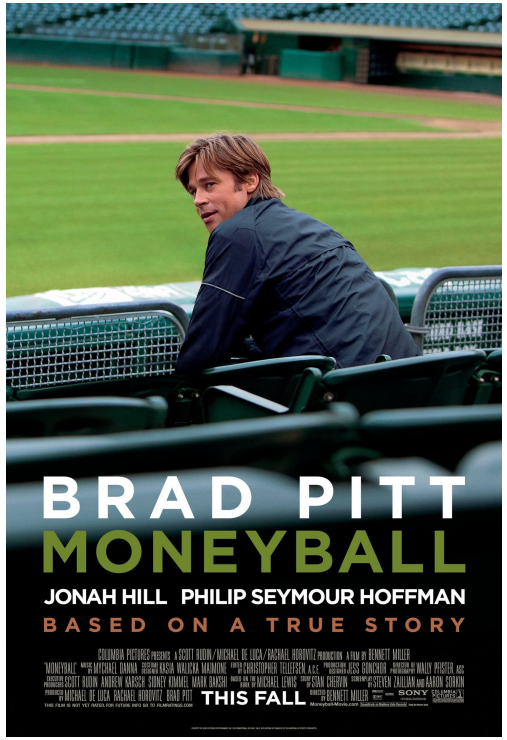
Blog: 2009-2010

okcupid

Brief history of Data Science

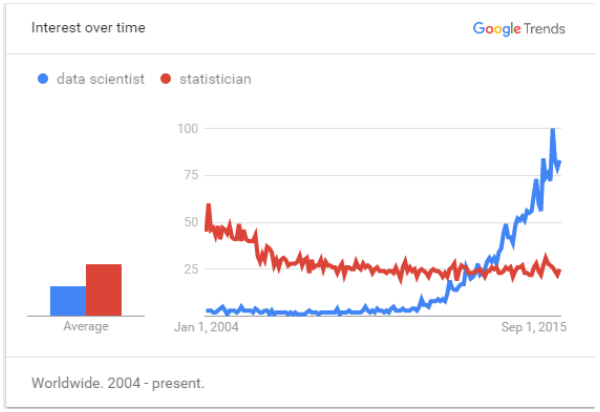


2011



2012

Data Science hits "peak of inflated expectations" around 2012-14



2012

Harvard Business Review

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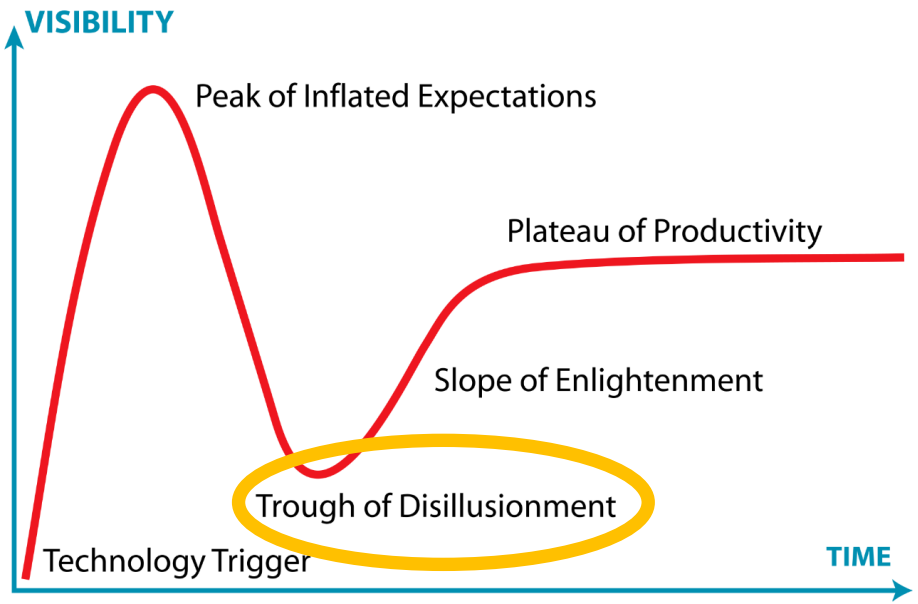
Data Scientist: The Sexiest Job of the 21st Century

Meet the people who can coax treasure out of messy, unstructured data. by Thomas H. Davenport and DJ Patil

From the Magazine (October 2012)

Brief history of Data Science: Technology Trigger

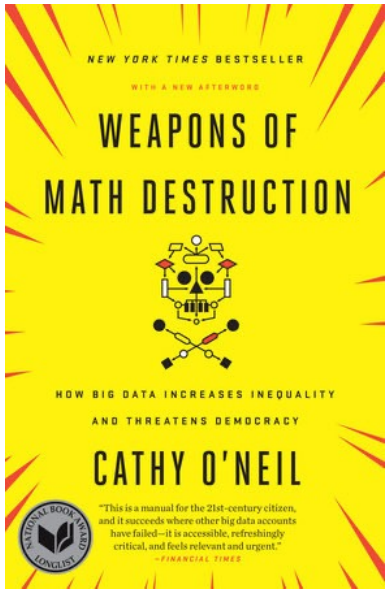


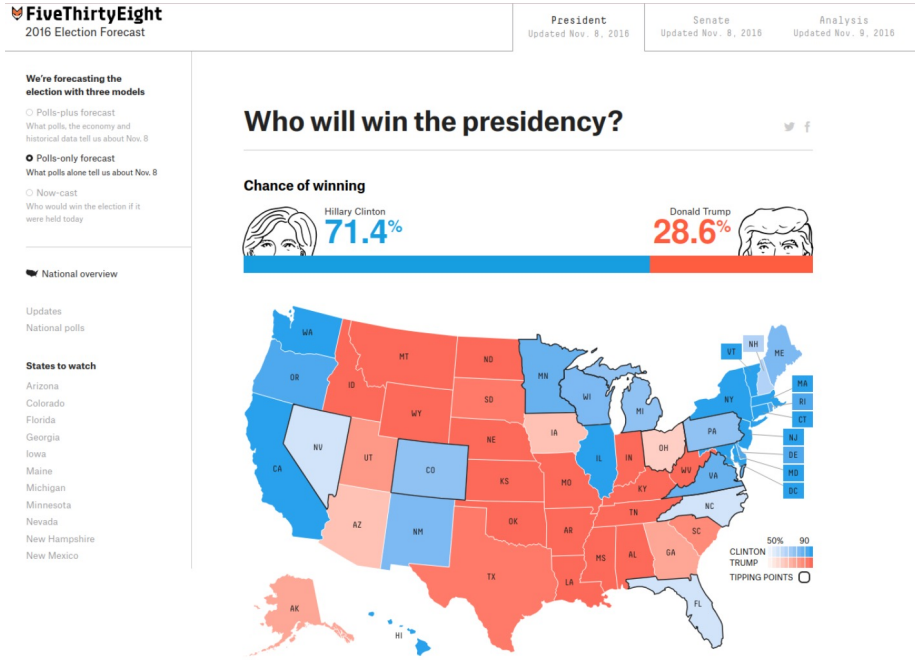
PROPUBLICA

Machine Bias

There's software used across the country to predict future criminals. And it's biased against blacks.

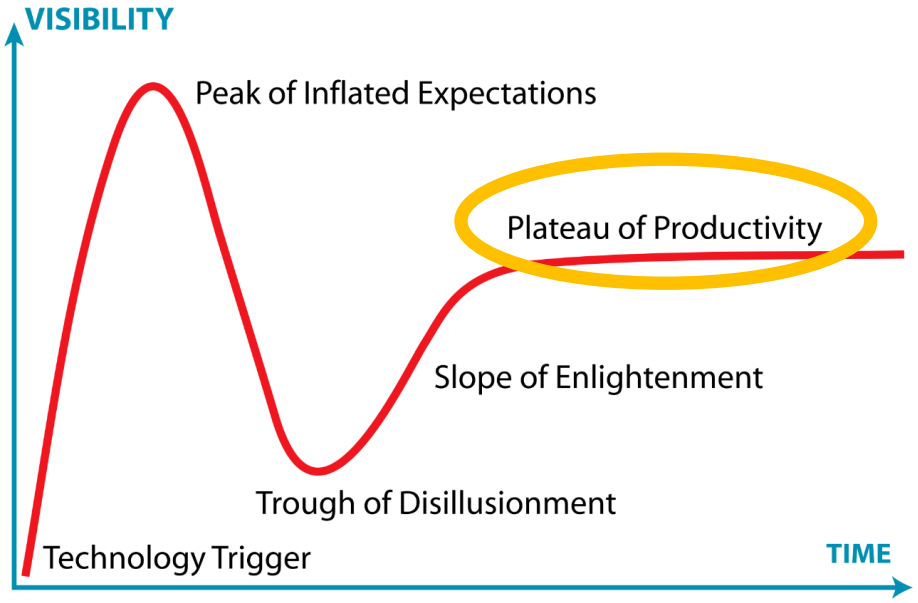
by Julia Angwin, Jeff Larson, Surya Mattu and Lauren Kirchner, ProPublica
May 23, 2016





Negative consequences of predictive models were highlighted circa 2016

Brief history of Data Science: now



Yale S&DS

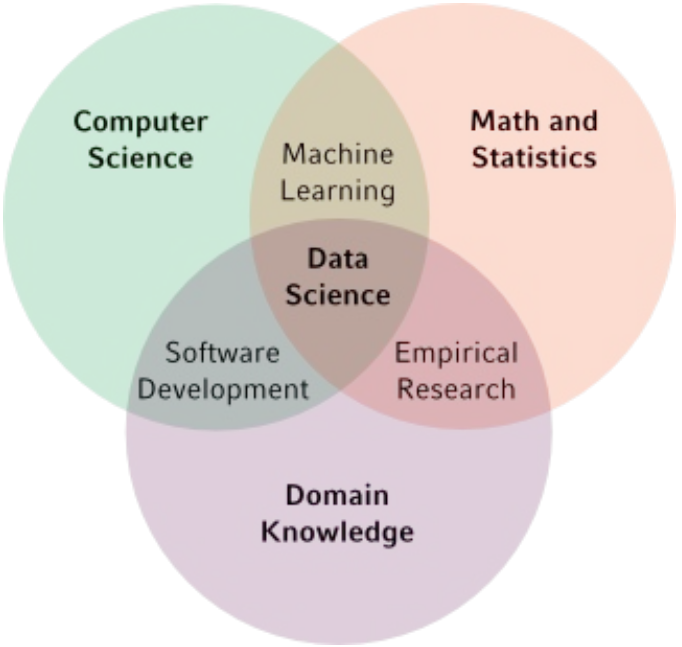
Data Scientists roles in many industries

- E.g., Data journalism (NYTimes TheUpshot)

Many universities have Data Science programs

- In March 2017 Yale renames the Department of Statistics to be the Department of Statistics and Data Science

What is Data Science?



Data Science is a broadening of data analyses:

- Beyond what traditional statistical mathematical/inferential analyses
- To using more computation

Classical statistical analysis

Descriptives

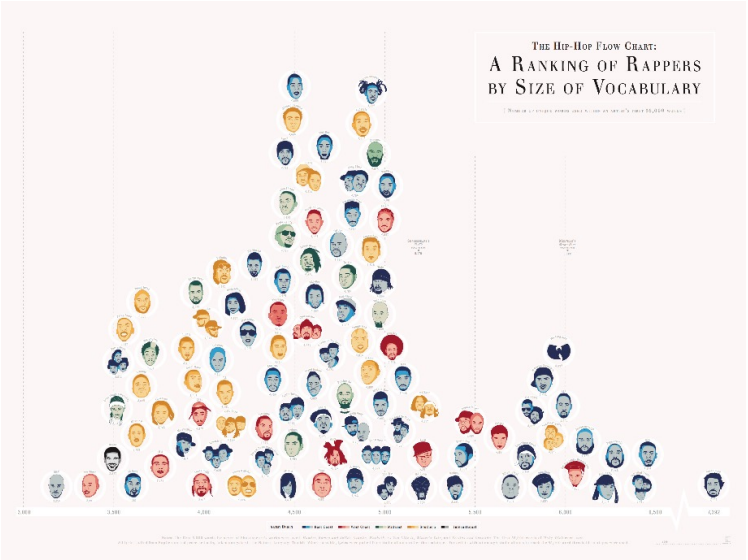
Bronchial reactivity

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Sulfur dioxide	5	18.840	9.6919	4.3344	6.806	30.874	5.1	30.1
Nitrous dioxide	6	6.617	3.9448	1.6105	2.477	10.757	2.2	11.9
Oxygen	4	4.975	3.4092	1.7046	-.450	10.400	2.1	9.3
Total	15	10.253	8.6514	2.2338	5.462	15.044	2.1	30.1

ANOVA

Bronchial reactivity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	559.450	2	279.725	6.873	.010
Within Groups	488.408	12	40.701		
Total	1047.857	14			



Examples:

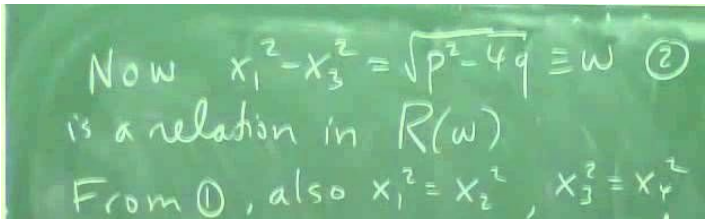
- NYC city bikes
- Wind map visualization

New ways to choose the best methods

Statistics focuses on mathematical models (probability distributions) to analyze data

- Best methods are the ones that have mathematical guarantees (proofs)

The proof is in the math



Data Science empirically evaluates data analysis methods

- Best methods are the one that gives the most insight in practice

The proof is in the pudding

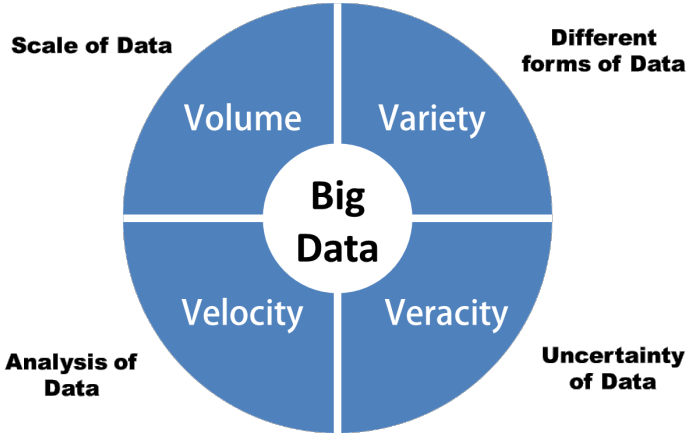
Big Data

New insights:

- Lots of new data from Internet, sensors etc., can be mined to transform our understanding in a range of fields
  - E.g., health, cosmology, social sciences, etc.

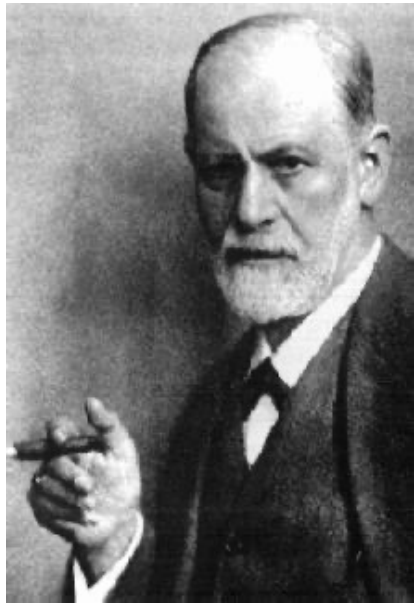
New analysis and approaches:

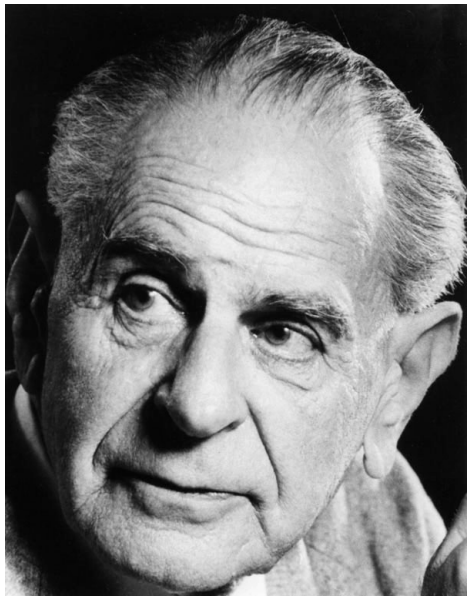
- Hypothesis test pick up on very small (meaningless) effects with very large samples
- Data manipulation and programming are needed to extract insights
- Also, new standards for choosing the best data analysis methods



[Data Science vs. Statistician video]

Thoughts on the reading from Everybody Lies?





Much of Freud's theory dealt with the subconscious

- E.g., Freudian slips

Karl Popper claimed that Freud's theories were unscientific because they couldn't be falsified

- i.e., can come up with any 'just so' story to explain a behavior

New data science analyses might make it possible to actually test Freud's theories

Introduction to Python

Please log into YCRC Jupyter notebook server…

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

If you can’t log in, please try to look at the computer of someone sitting next to you

Programming languages for Data Science

The two most popular languages for Data Science are:

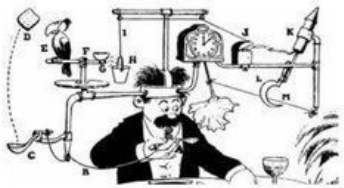
General purpose programming language

- Can do a lot more than data analysis
- Code is easy to read
- Easy to write larger software packages
- Good machine learning package (scikitlearn)

Focused on data analysis

- Better for creating pdf reports
- Easy to create interactive apps
- RStudio created a great IDE and support

AS SEEN BY USERS OF …

	STATA	R	SAS	Python	SPSS
STATA					
R					
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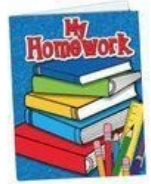
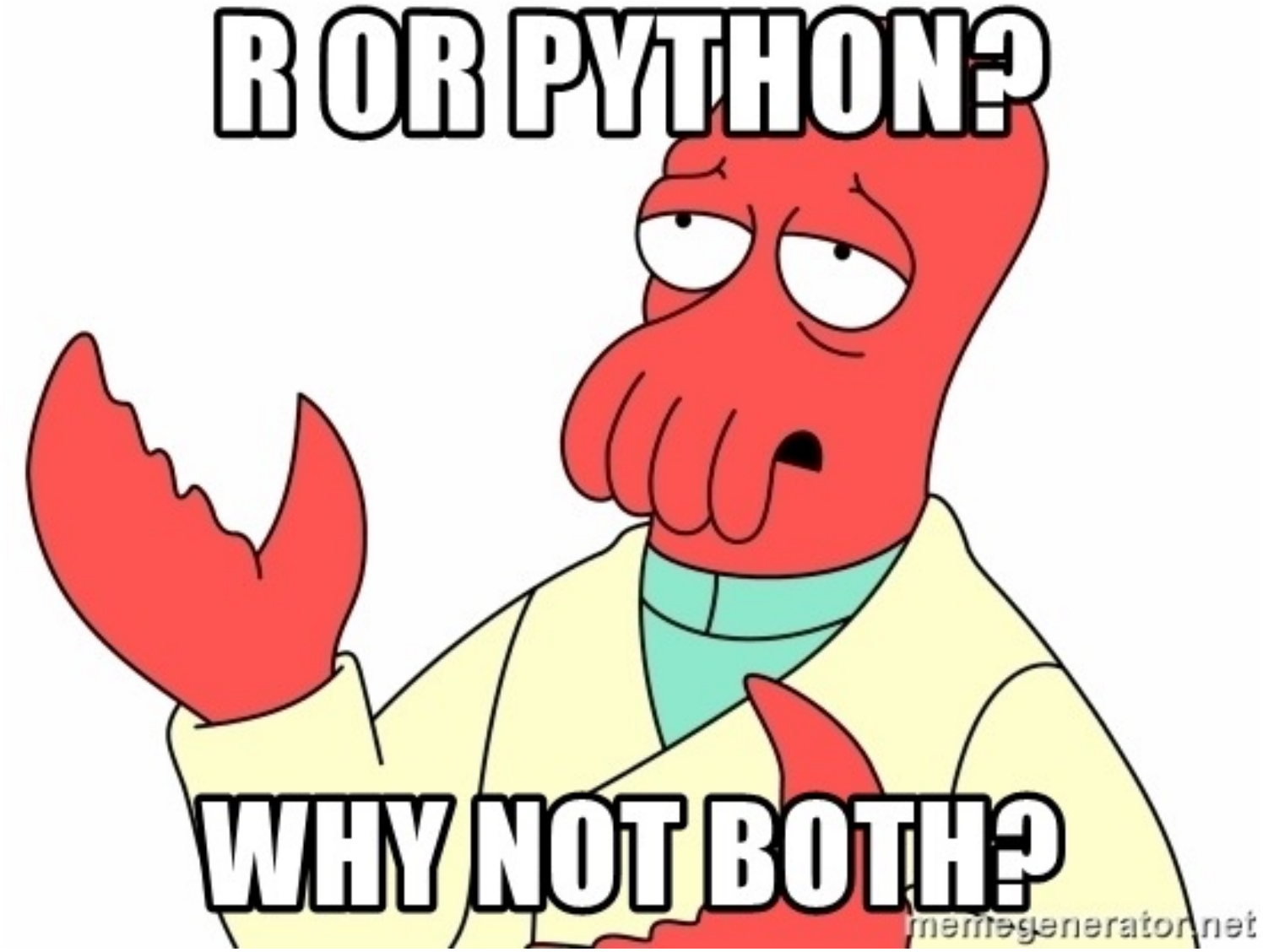
SPSS					


R OR PYTHON?
WHY NOT BOTH?
memegenerator.net

Terminology: scripts, modules, and packages

A **script** is a piece of code that is run to accomplish a specific task

- E.g., one could write and run a script to download a set of files

A **module** is a piece of code that reused by different scripts and programs

- Modules are ***imported*** by other programs/scripts to add commonly used functionality.
- E.g., import matplotlib.pyplot as plt

A **package** (library) contains several related modules

Packages are an essential building block in programming. Without packages, you would waste a lot of time writing code that's already been written

Jupyter notebooks

Jupyter notebooks allow one to create an analysis document that contains text, analysis code, and plotted results

Because one can see all the code used to generate results, it allows one to create reproduce analyses

[5]:
```
import matplotlib.pyplot as plt
plt.style.use('classic')
%matplotlib inline
import numpy as np
import pandas as pd
import seaborn as sns
sns.set()
```

[6]:
```
rng = np.random.RandomState(0)
x = np.linspace(0, 10, 500)
y = np.cumsum(rng.randn(500, 6), 0)
```

Next step

Now, create a graph.

[7]:
```
plt.plot(x, y)
plt.legend('ABCDEF', ncol=2, loc='upper left');
```

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

If you need more practice, be sure to attend the Shivam's practice sessions!

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

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

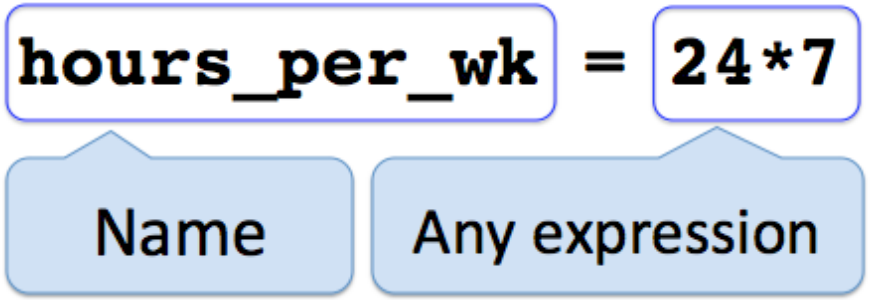
- *SyntaxError* indicates that an expression structure doesn't match any of the rules of the language.
- E.g., failed attempt at exponentiation: `3 * * 4`

```
  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

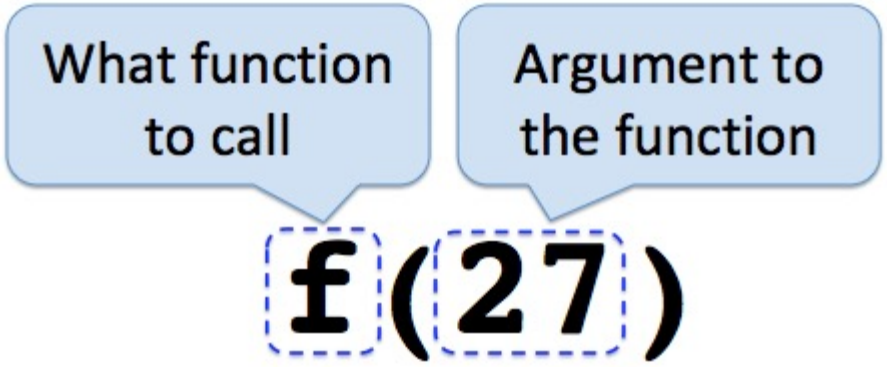
Let's explore this in Jupyter!

Call Expressions

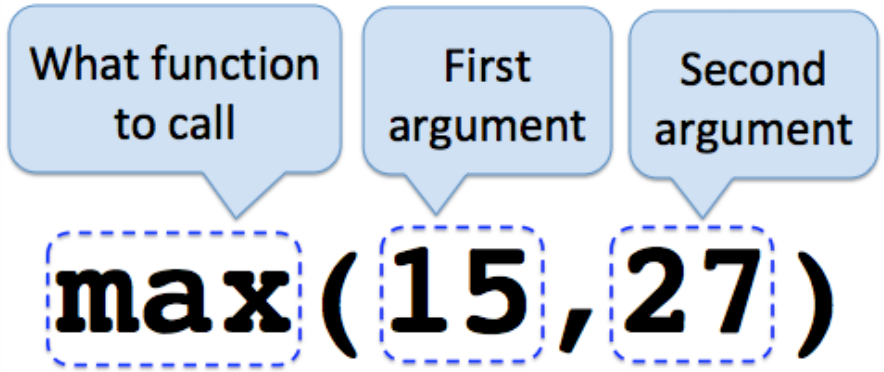
Anatomy of a Call Expression

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 basic 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!

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!

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

- my_text = 2
- type(my_text)

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!

Next class: Text manipulation!

Homework 1 has been posted

```
import YData
YData.download.download_homework(1)
```

It is due on Gradescope on Sunday September 8th at 11pm

- **Be sure to mark each question on Gradescope!**