ENDURE
NIH Blueprint for Neuroscience Research

Python for Neuroscientists

Before we get started, please add your home institution and pronouns to your name on Zoom!

Objectives for this first session

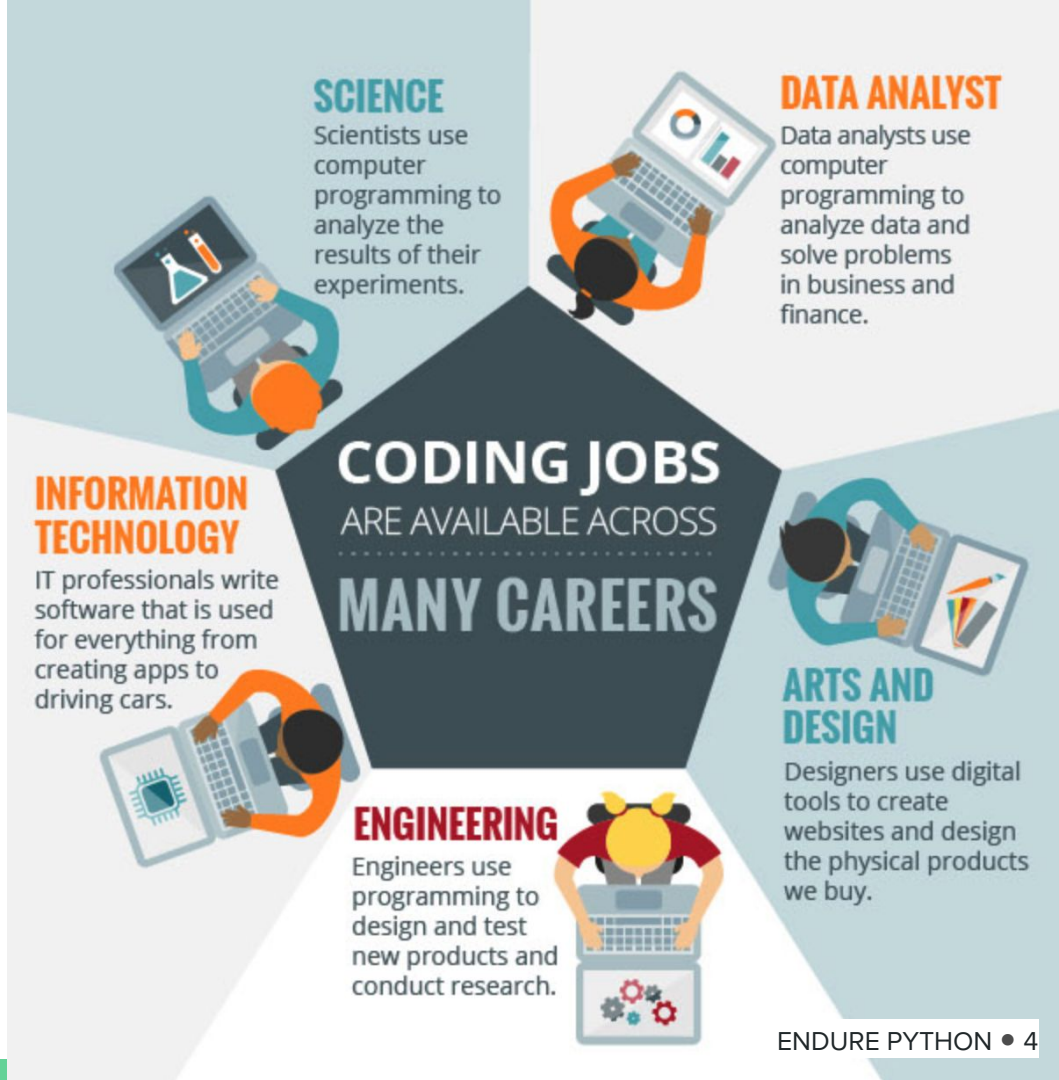
- Introduce the teaching staff, students, and class
- Motivate learning how to code as a neuroscience researcher
- Discuss workshop logistics, expectations, & tools

What does coding have to do with *neuroscience*? Why *you, right now*?

Why should I learn how to code?

- Coding is useful for:
  - Data acquisition (controlling hardware, image acquisition, etc)
  - Data analysis & visualization
  - Computational modeling
- Beyond research, there are more and more jobs for software engineers, and they pay well

(see report by Burning Glass: https://www.burning-glass.com/research-project/coding-skills/)

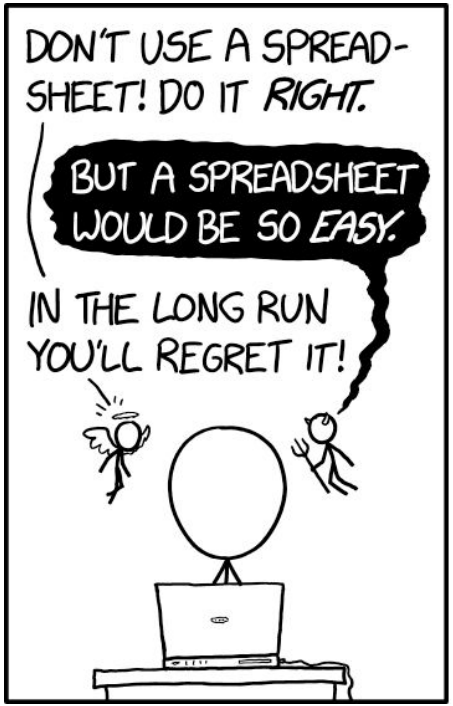


Excel can only handle datasets with **~1 million rows, and ~16,000 columns** — many datasets in biology are much larger than this!

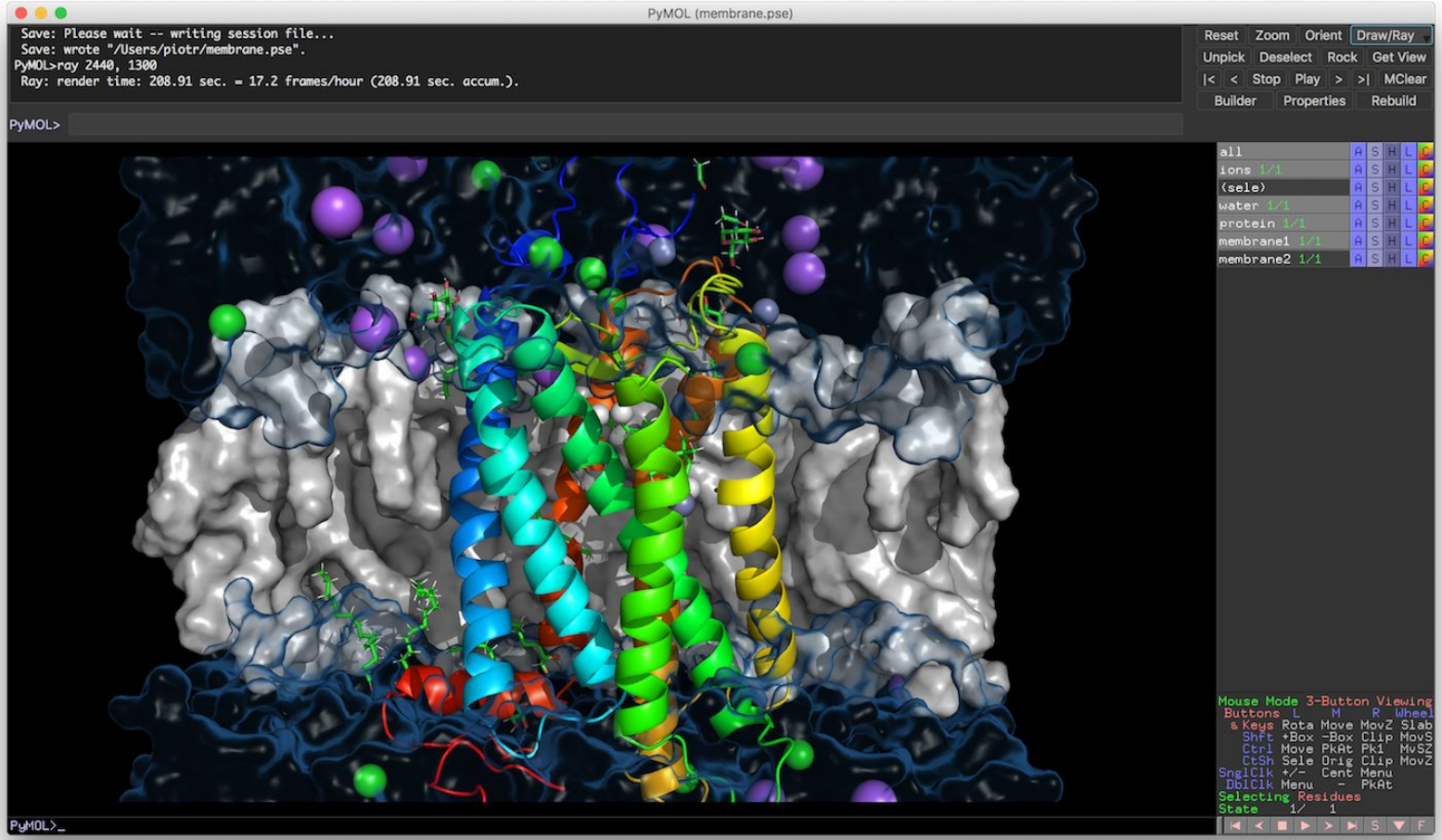
You can automate analyses in Excel, but this is quite limited.

There are also specialized biological data analysis software programs, but often these are limited in how much they can be customized.

Code is *infinitely* customizable.



https://xkcd.com/2180/


PyMOL (membrane.pse)
Save: Please wait -- writing session file...
Save: wrote "/Users/piotr/membrane.pse".
PyMOL>ray 2440, 1300
Ray: render time: 208.91 sec. = 17.2 frames/hour (208.91 sec. accum.).
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protein 1/1
membrane1 1/1
membrane2 1/1
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pymol.org

pymol.org/2/

PyMOL by Schrödinger

DOWNLOAD SCREENSHOTS PRODUCTS SUPPORT CONTACT

Open-Source Philosophy

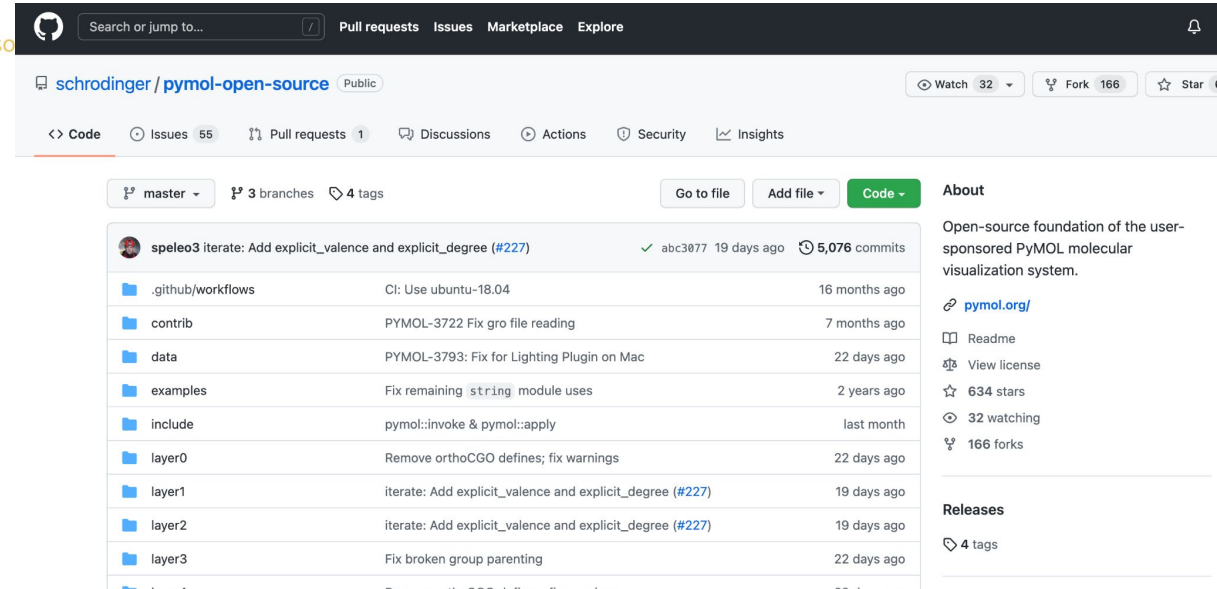
PyMOL is a commercial product, but we make most of its source code freely available under a permissive license. The open source project is maintained by Schrödinger and ultimately funded by everyone who purchases a PyMOL license.

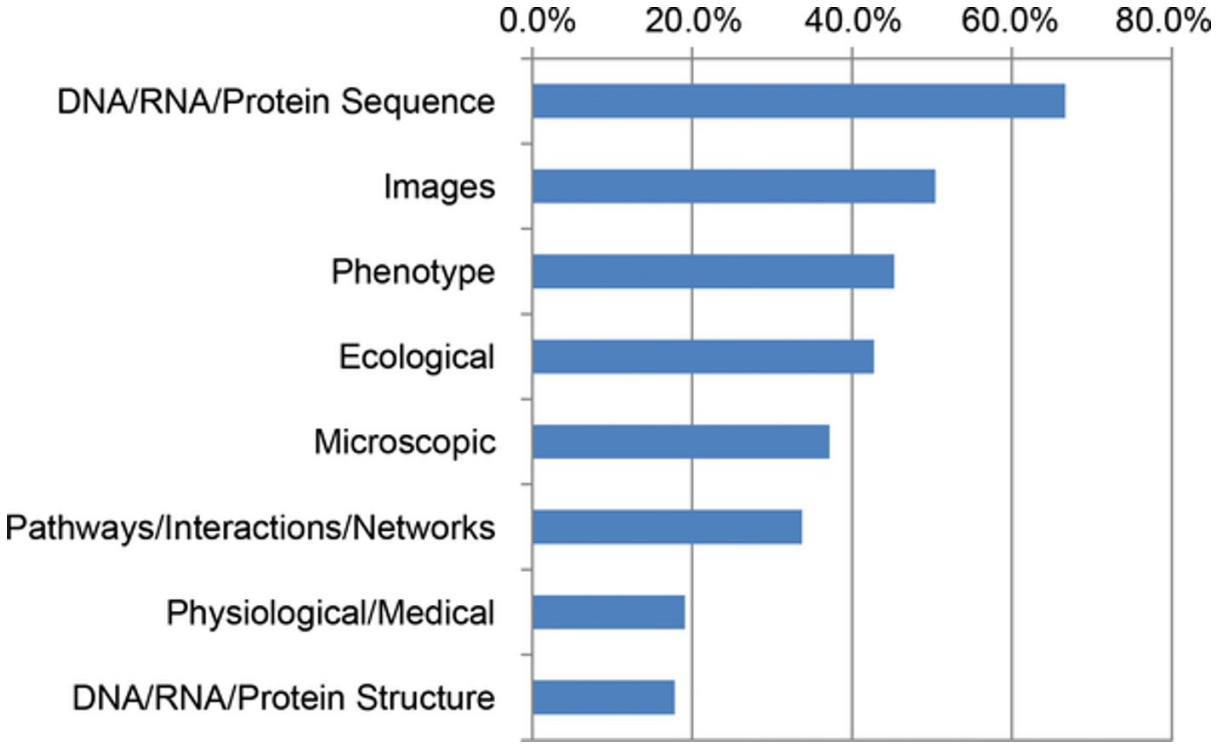
Open source enables open science.
This was the vision of the original PyMOL author Warren L. DeLano.

Visit the Open-Source Project

Become a sponso

AND many software packages for biologists can be modified… if you know how to code!





Major data types used by National Science Foundation (NSF) Biological Sciences Directorate (BIO) principal investigators (PIs).

Barone L, Williams J, Micklos D (2017) Unmet needs for analyzing biological big data: A survey of 704 NSF principal investigators. PLOS Computational Biology https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1005755

Neuroscience has more data than it knows what to do with right now.

And we have the computing power to make some sense of it!

First step: let's drop our ideas of what it means to be a ***coder***.

Programming, like learning a language, *takes time*.

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Your language brain matters more for learning programming than your math brain

New research contradicts long held assumptions about coding

Amy Nippert
Neuroscience
University of Minnesota

May 12, 2020 2 peer comments

Christina Morillo on Wikimedia Commons.

https://massivesci.com/articles/programming-math-language-python-women-in-science/, summarizes this article: https://www.nature.com/articles/s41598-020-60661-8

Previous studies have shown that math and logic problems seem to rely mainly on the multiple demand regions in the left hemisphere, while tasks that involve spatial navigation activate the right hemisphere more than the left. The MIT team found that reading computer code appears to activate both the left and right sides of the multiple demand network, and ScratchJr activated the right side slightly more than the left. This finding goes against the hypothesis that math and coding rely on the same brain mechanisms.

https://news.mit.edu/2020/brain-reading-computer-code-1215
about this study: https://elifesciences.org/articles/58906

29A @StuxnetStudios · 14h

New programming student:

"I'm not very good at this. When I type out the code, I have to fix lots of errors. And I have to look up how to do most of it."

Instructor:

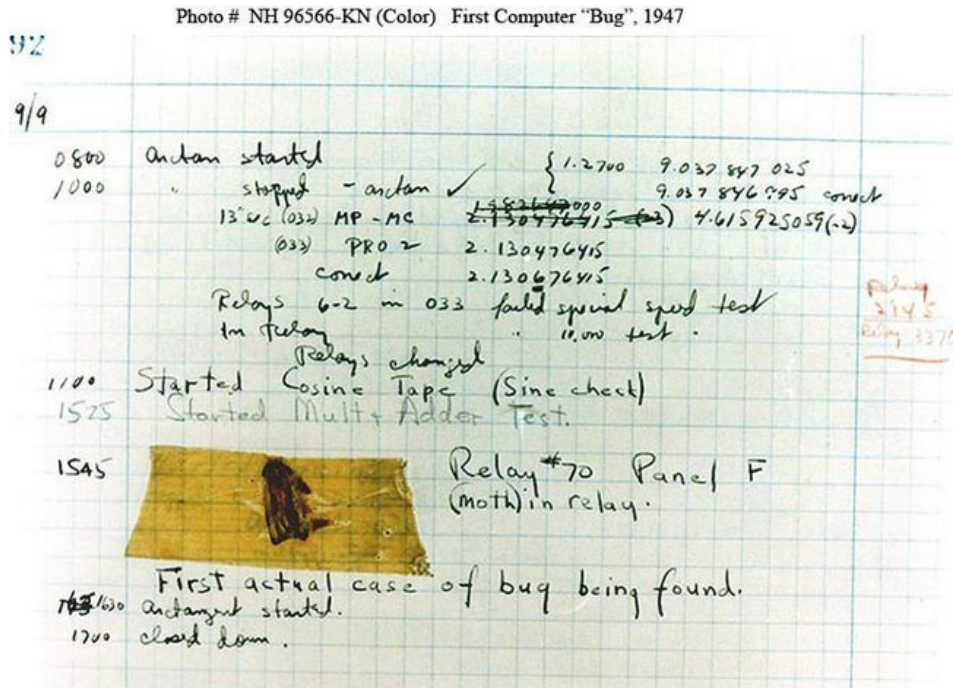
"You're doing it right."

29 275 1.4K

Historical sidenote: why is it called a **bug**?

In 1947, computer scientist & legend **Grace Hopper** found a *literal bug* in their computer, causing it to produce many errors.

Interview with Grace Hopper: https://www.youtube.com/watch?v=QA33wW5LaNY



https://www.nationalgeographic.org/thisday/sep9/worlds-first-computer-bug/

What is programming, anyway?

- Programming is the way humans communicate with computers
  - It's a language!
- The instructions we give the computer are taken **literally** and **sequentially**.

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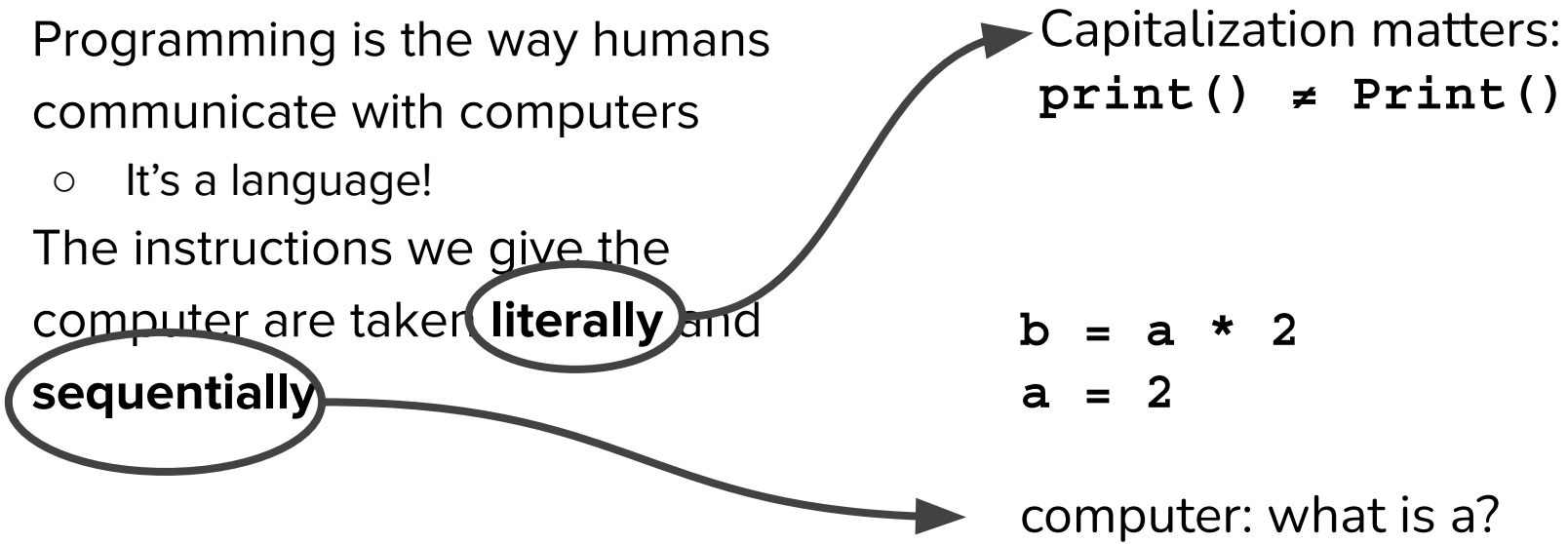


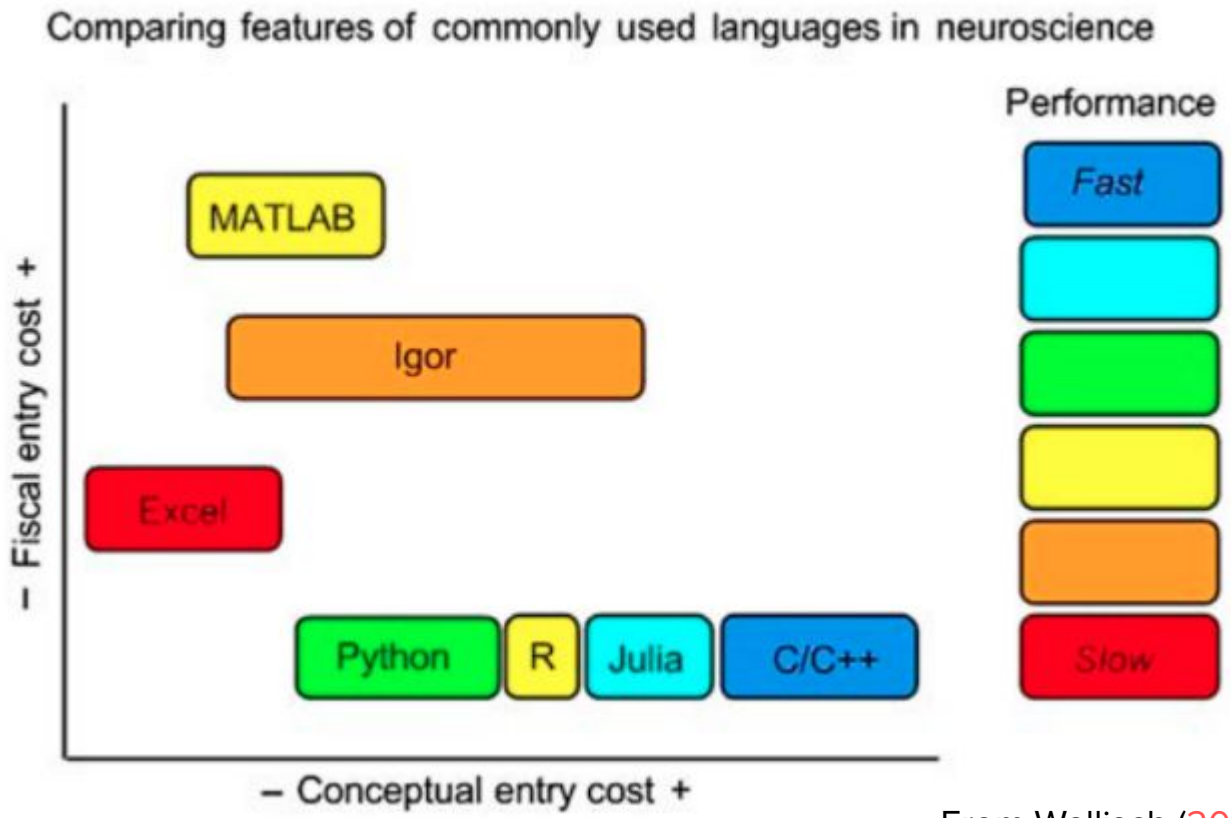
Capitalization matters:
`print() ≠ Print()`

```
b = a * 2
a = 2
```

computer: what is a?

Considerations for choosing a programming language

- Fiscal & conceptual entry
- Usage in particular field or profession



From Wallisch (2017)

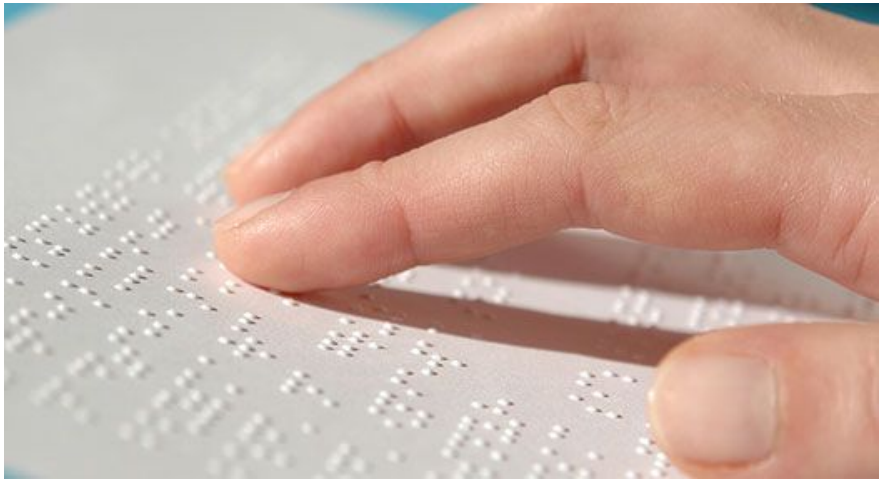
All coding languages eventually need to talk to the computer in binary:

`01001000 01100101 01101100 01101100 01101111 00100001`

(hello)

Learn How To Write Your Name In Binary Code

There are many types of binary code, beyond computers



Braille
https://www.afb.org/blindness-and-low-vision/braille/what-braille

A ●−	J ●−−−	S ●●●
B −●●●	K −●−	T −
C −●−●	L ●−●●	U ●●−
D −●●	M −−	V ●●●−
E ●	N −●	W ●−−
F ●●−●	O −−−	X −●●−
G −−●	P ●−−●	Y −●−−
H ●●●●	Q −−●−	Z −−●●
I ●●	R ●−●	

Morse code
https://www.discoveryworld.org/about/blog/discover_at_home/morse-code/

In this workshop, we'll use Python

- Programming language, development led by Python Software Foundation (www.python.org)
- Uses concise structure & wording similar to human language
- An **interpreted** language — it doesn't speak *directly* to the computer
- Can be used for many purposes, from web programming, to creating games, to analyzing & visualizing data
  - File extension: '.py'
- We'll interact wth Python in **Jupyter/Colab Notebooks**
  - File extension '.ipynb'

python™

Workshop Objectives

- ❏ Write and edit Python code, particularly in Jupyter/Colab Notebooks
- ❏ Manipulate and create different data structures in Python
- ❏ Import different types of data files into Python
- ❏ Visualize *and describe* simple datasets in Python

Take Home Assignments

The take home tasks are an extra chance for you to test your understanding.

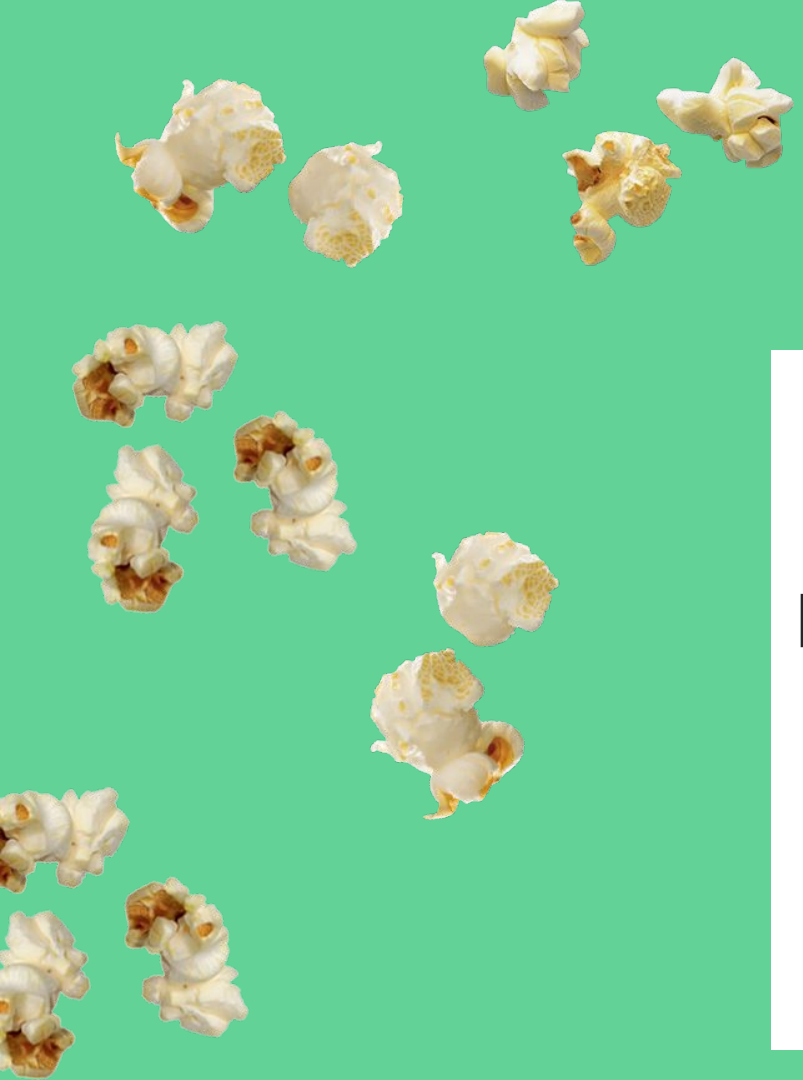
Tasks for both days are in “ENDURE_TakeHomeAssignment”

We’ll discuss the first one tomorrow
— it would be beneficial for you to give it a shot!

Community guidelines

- Be kind and respectful of each other's ideas and experiences — acknowledge that we're all coming in with slightly different experience levels
- Lean into and honor your discomfort and frustration — these feelings are the first step towards growth
- *Ask questions* when you have them — *especially* in breakout rooms. Use the "Raise your hand" function.
- Be present. As you're willing, please have your camera on!
- Not *all* knowledge is contained here. Learning continues after the workshop.

Time (PST)	Time (EST)	Description	Instructor
10-10:30 am	1-1:30 pm	Welcome 01 - Introduction to Course & Tools	Ashley *Associate Teaching Professor, UCSD & Co-Director of STARTneuro*
10:30-11 am	1:30-2 pm	02 - Variables, Expression, and Syntax	Claire *Associate Researcher, Mt. Sinai*
11 am-12 pm	2-3 pm	03 - Conditionals	Luis *PhD Candidate, Boston University, NYU ENDURE Alum*
12 -12:30 pm	3-3:30 pm	Break	
12:30-1:15 pm	3:30-4:15 pm	04 - Data Structures	Karla *PhD student, UCSD*
1:15-2 pm	4:15-5 pm	05 - Functions	Michael *Postdoctoral Fellow, Northwestern University*



Let's discuss in breakout rooms

In the breakout room, please introduce yourself & tell everyone what kind of research you're doing *or hope to do*.

Let’s code!

http://github.com/STARTneuro/ENDURE2022

How To Use These Materials

The easiest way to use these materials is to open them in Colab, using the link below!