

PSY 4219 / 6219
**Scientific Computing for Psychological
and Brain Sciences**

Mon/Wed 2:30-3:35pm
Kissam Center C214

Thomas Palmeri
507 Wilson Hall

thomas.j.palmeri@vanderbilt.edu

Office Hours: Mon 11am-12pm
(or by appointment)

Grader

Jason Chow

jason.k.chow@vanderbilt.edu

Help Session:

Mondays 3:50-5:00

this room (or WH 113)

except for next week, which will be Wed after class

Office Hours:

by appointment (on Zoom or in person)

Brightspace

🏠 PSY 4219-01 Sci Computing Psy and Brain (2022F)



Thomas Palmeri



Content Activities & Assessments ▾ Classlist Grades Course Admin Help ▾

Announcements ▾

Instructor and Teaching Assistant Contact Information



Thomas Palmeri posted on Aug 7, 2022 5:11 PM • 🔄 Edited

Instructor

Thomas Palmeri (Professor)

Department of Psychology

507 Wilson Hall

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thomas.j.palmeri@vanderbilt.edu

office hours: Mon 11-12pm or by appointment

Teaching Assistant

Jason Chow (Graduate Student)

Department of Psychology

517 Wilson Hall

jason.k.chow@vanderbilt.edu

help session (group office hours): Mon 3:50-5:00pm, KC C216 or WH 113

other office hours: by appointment

Calendar ▾

Monday, August 22, 2022



Upcoming events ▾

There are no events to display.

[Create an event.](#)

Brightspace Support Site ▾

Course and Teaching Evaluations ▾

Course Goals

- for students to develop proficiency designing, coding, and debugging computer programs to control experiments, perform data analyses, and simulate neural or psychological mechanisms in Python

programming methods

how to debug programs

computational linear algebra

scientific computing methods

image processing

optimization

algorithms and data structures

best practices

graphing and visualization

data science methods

signal processing

simulation

- some prior programming experience required
- no prior knowledge of Python required
- recommend some psychology or neuroscience

Course Goals

the first several weeks will cover Python basics
at a fairly brisk pace - this will be review for some
(if you have had a ton of experience with Python, scientific
computing, data science, image and signal processing,
talk with me about whether this is the right course for you)

programming methods

how to debug programs

computational linear algebra

scientific computing methods

image processing

optimization

algorithms and data structures

best practices

graphing and visualization

data science methods

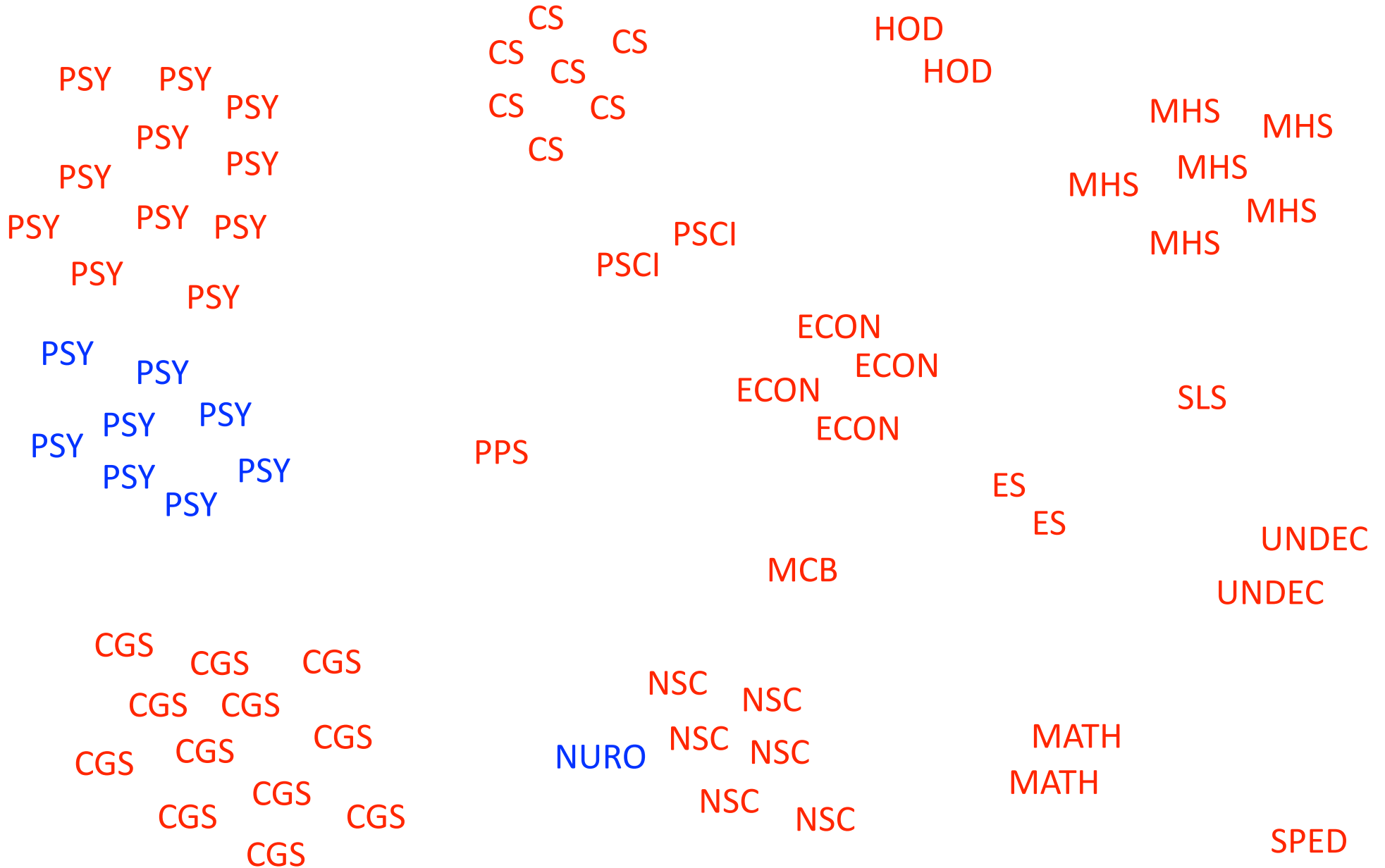
signal processing

simulation

- some prior programming experience required
- no prior knowledge of Python required
- recommend some psychology or neuroscience
concepts and techniques are relevant to those in other disciplines

grad
undergrad

distribution of majors in this course



Best Practice

- Throughout the course I will try to emphasize “best practices” for programming specifically and also for any use of computers (data collection, data storage, computation, analyses, modeling) in science generally.

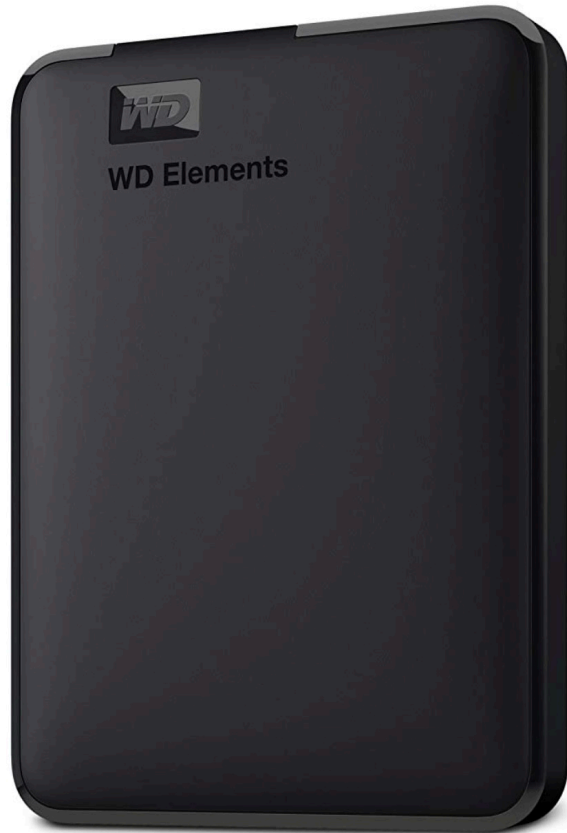
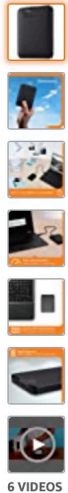
Best Practice

- Throughout the course I will try to emphasize “best practices” for programming specifically and also for any use of computers (data collection, data storage, computation, analyses, modeling) in science generally.

Our first **Best Practice**

- Back up your computer every day.
- Ideally have two backups in two different places.
- Use external hard drives and/or servers.
- If in a lab, talk to your advisor about backing up.

external hard drive



Roll over image to zoom in



WD 2TB Elements Portable External Hard Drive HDD, USB 3.0, Compatible with PC, Mac, PS4 & Xbox - WDBU6Y0020BBK-WESN

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✓prime	✓prime	✓prime	✓prime

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Hard Disk Interface	USB 2.0/3.0
Connectivity Technology	USB
Brand	Western Digital
Hard Disk Form	2.5 Inches
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Secure transaction

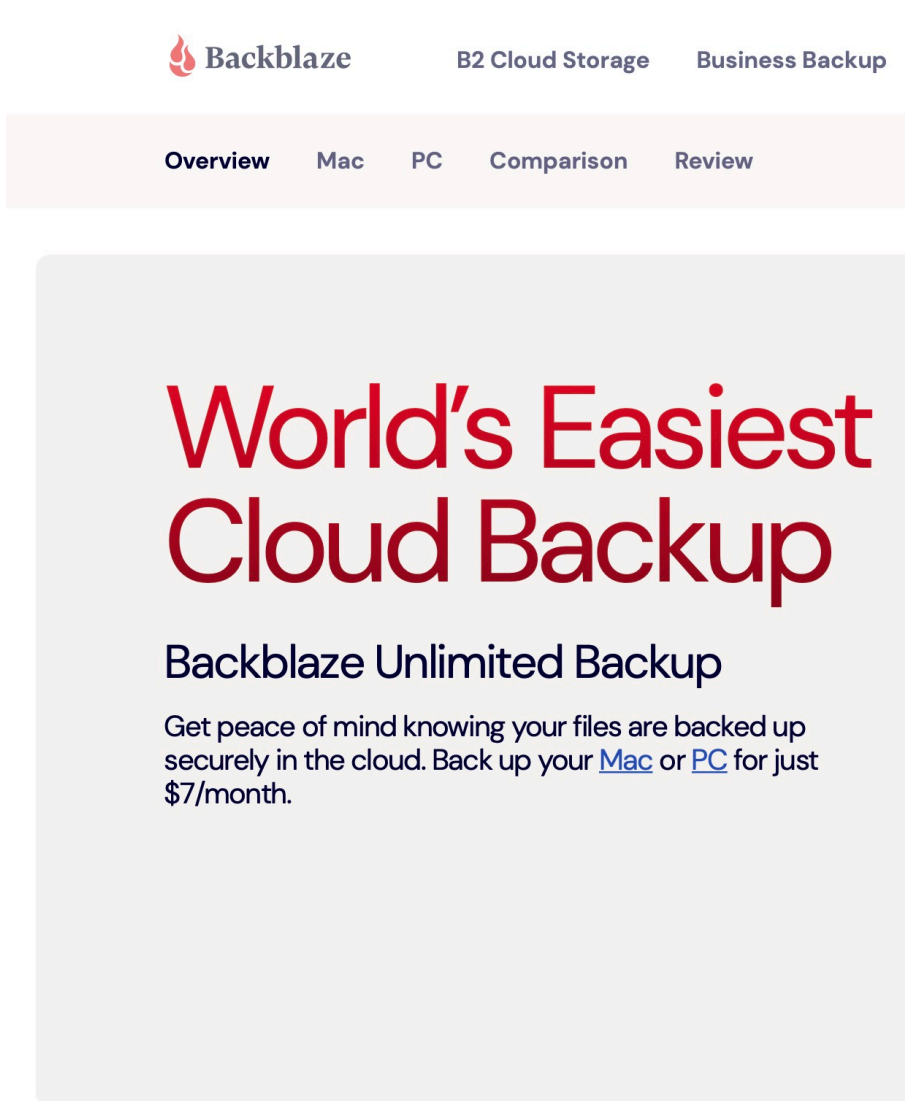
Ships from Amazon.com
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Return policy: Eligible for Return, Refund or Replacement within 30 days of receipt

Add a Protection Plan:

- ☐ 3 year Data Recovery Plan for \$14.99
- ☐ 2-Year Data Recovery Plan for \$12.99
- ☐ Add a gift receipt for easy returns

cloud-based solution



The image shows the top portion of the Backblaze website. At the top, there is a navigation bar with the Backblaze logo (a red flame icon) and the text "Backblaze". To the right of the logo are two links: "B2 Cloud Storage" and "Business Backup". Below this is a secondary navigation bar with links: "Overview", "Mac", "PC", "Comparison", and "Review". The main content area has a large heading "World's Easiest Cloud Backup" in red. Below this is the subheading "Backblaze Unlimited Backup" in dark blue. The text below reads: "Get peace of mind knowing your files are backed up securely in the cloud. Back up your [Mac](#) or [PC](#) for just \$7/month."

Backblaze

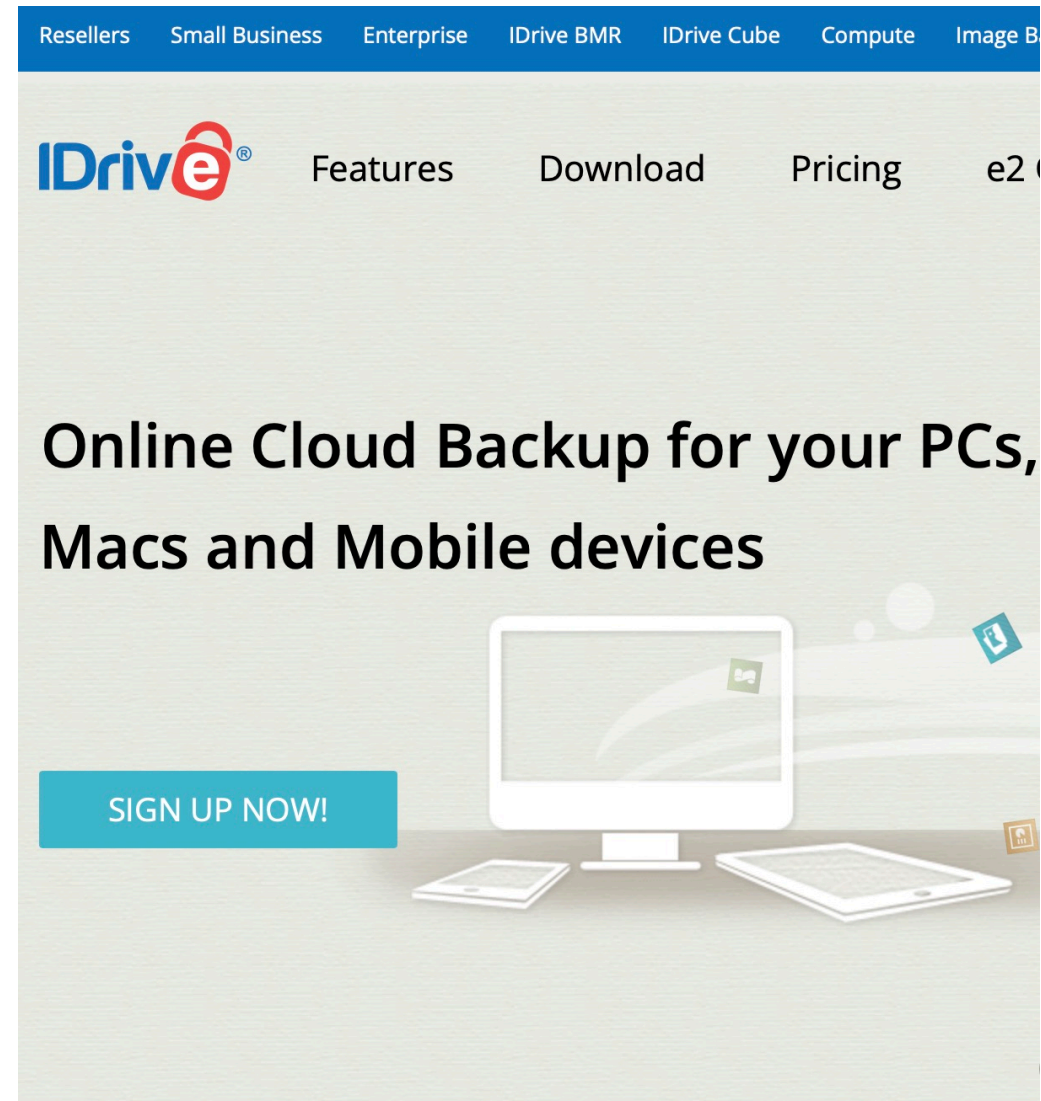
B2 Cloud Storage Business Backup

Overview Mac PC Comparison Review

World's Easiest Cloud Backup

Backblaze Unlimited Backup

Get peace of mind knowing your files are backed up securely in the cloud. Back up your [Mac](#) or [PC](#) for just \$7/month.



The image shows the top portion of the IDrive website. At the top, there is a navigation bar with links: "Resellers", "Small Business", "Enterprise", "IDrive BMR", "IDrive Cube", "Compute", and "Image B". Below this is the IDrive logo (the word "IDrive" in blue with a red padlock icon) and links: "Features", "Download", "Pricing", and "e2". The main content area has a heading "Online Cloud Backup for your PCs, Macs and Mobile devices" in black. Below this is a large blue button with the text "SIGN UP NOW!". At the bottom, there is an illustration of a desktop computer monitor, a smartphone, and a tablet, with some small icons floating around them.

Resellers Small Business Enterprise IDrive BMR IDrive Cube Compute Image B

IDrive® Features Download Pricing e2

Online Cloud Backup for your PCs, Macs and Mobile devices

SIGN UP NOW!

<https://www.nytimes.com/wirecutter/reviews/best-online-backup-service/>

Best Practices

be careful about upgrading your operating system
(obviously, you want to install things like security patches)

apps often do not work right after a major OS upgrade

more generally, specialized applications and programs often break when an OS changes

also, be careful about upgrading Python or its packages - some programs may not work in an upgraded version

Best Practices

be careful about upgrading your operating system

please, never upgrade in the middle of the semester

Best Practices

be careful about upgrading your operating system

in fact, laboratory computers can have operating systems years (if not decades old) that run specialized equipment or perform important analyses (that have not been translated to new platforms)

one of our monkey neurophysiology labs on the ground floor had a computer running Windows XP to control a physiology rig and its instruments

others have had computers running MS DOS

- Hardware
 - chipsets, monitors, CPU vs. GPU
- O/S
 - Mac OS, Windows, Linux
- Programing Languages
 - Python, MATLAB, R, C++, Java, Javascript, Scheme

Why will we focus on Python programming?

What are some differences between programming languages?

- Your statistics course requires R.
- Another requires SAS.
- Your lab uses Matlab.
- Or E-Prime.
- Or a custom system.
- CS1101 teaches Java.
- CS/DS1100, CS1104, and CS2204 use Python.
- This courses uses Python.

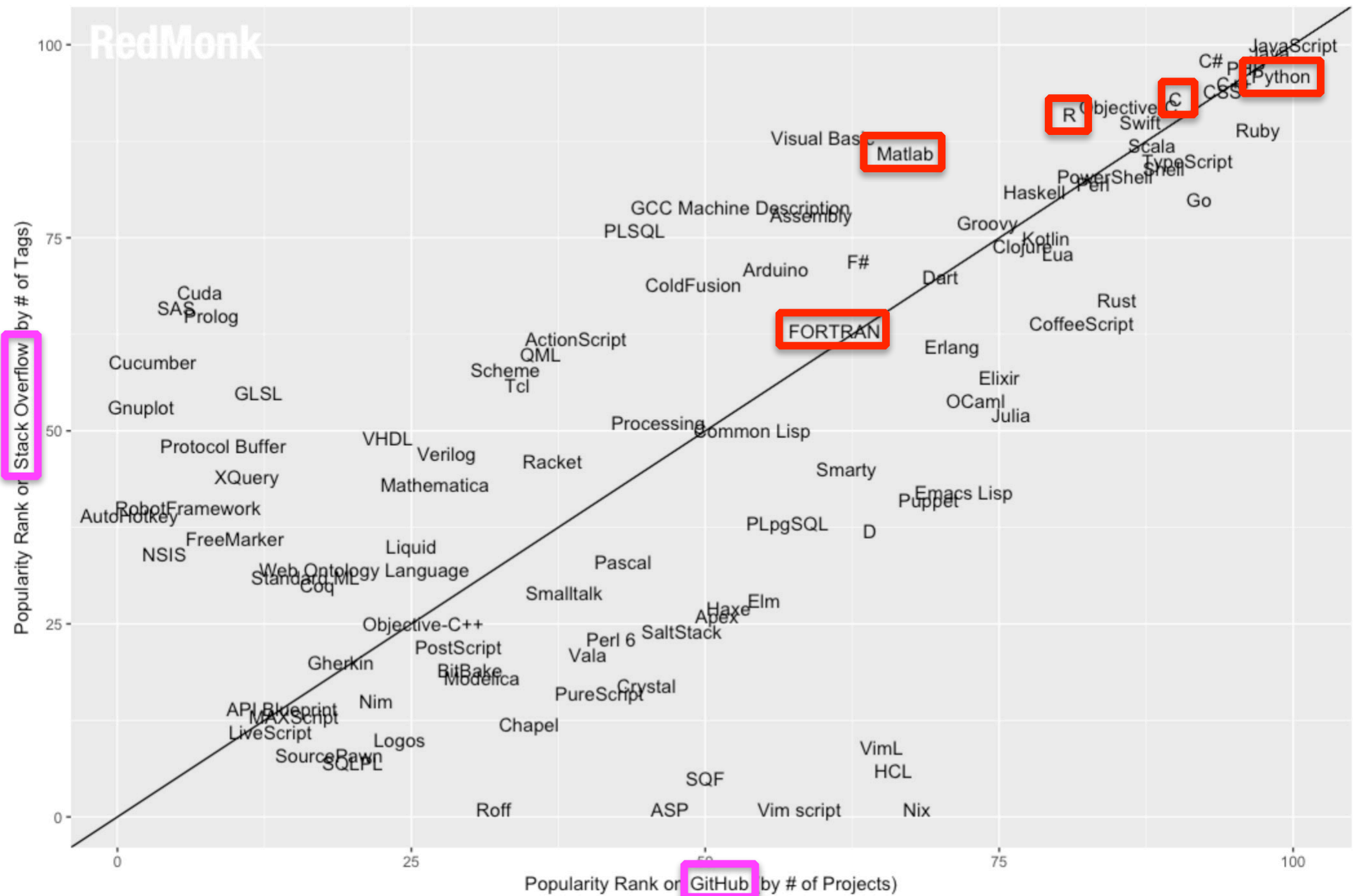
over the course of a career programming, you may change languages several times
I went from Basic & Pascal, to C and Lisp and Fortran, to Matlab, to Python

How do languages differ?

Popularity

- Popularity means lots of code/tools that are shared.
- Popularity means many other users who can help.
 - Python, MATLAB, R
 - most popular languages in psychology and neuroscience
 - Java
 - widely used in industry
 - Javascript
 - runs much of the web
 - C / C++ (the "assembly language" of the 21st century)
 - used for certain critical applications where speed is critical
 - Fortran, Pascal, LISP, BASIC
 - widespread usage in the 70s and 80s
 - Fortran still used extensively in numeric computing tools

RedMonk Q119 Programming Language Rankings



How do languages differ?

Cost

- Free
 - Python, R, C++, Octave (Matlab clone)
 - IDEs may be commercial products (free for education)
- Expensive
 - Matlab (commercial product)
 - “free” with Vanderbilt site license
 - without site license, \$2000+ per user in year one, \$500-1000 per year per user every year after (10x that much in industry)

How do languages differ?

Programming Environment

- IDE (Integrated Development Environment)
 - write and edit computer programs
 - debug computer programs
- Python, R, C++
 - variety of paid and free solutions, some outstanding
 - some are language-specific (R Studio, PyCharm, Spyder)
 - some work with many languages (Eclipse, VS Code)
- MATLAB
 - outstanding, you get what you pay for

How do languages differ?

Programming

- IDE (Integrated Development Environment)
 - write and edit code
 - debug code
- Python, R, C, C++, Java, etc.
 - variety of packages
 - some are languages
 - some work with libraries
- MATLAB
 - outstanding, you get what you pay for

In The Old Days

- use an editor program to write code
- use a compiler to create object files
- use a linker to connect object files with libraries and create an executable program
- debug using print statements
- debug using a standalone debugger program

How do languages differ?

Programming Environment

- Notebooks
 - Jupyter (Python and R)
 - Google Colab (Python)
 - we will use primarily at the start of class

How do languages differ?

Programming Environment

- Notebooks
 - Jupyter (Julia, Python, and R)
 - Google Colab (Python)
 - we will use primarily at the start of class

How do languages differ?

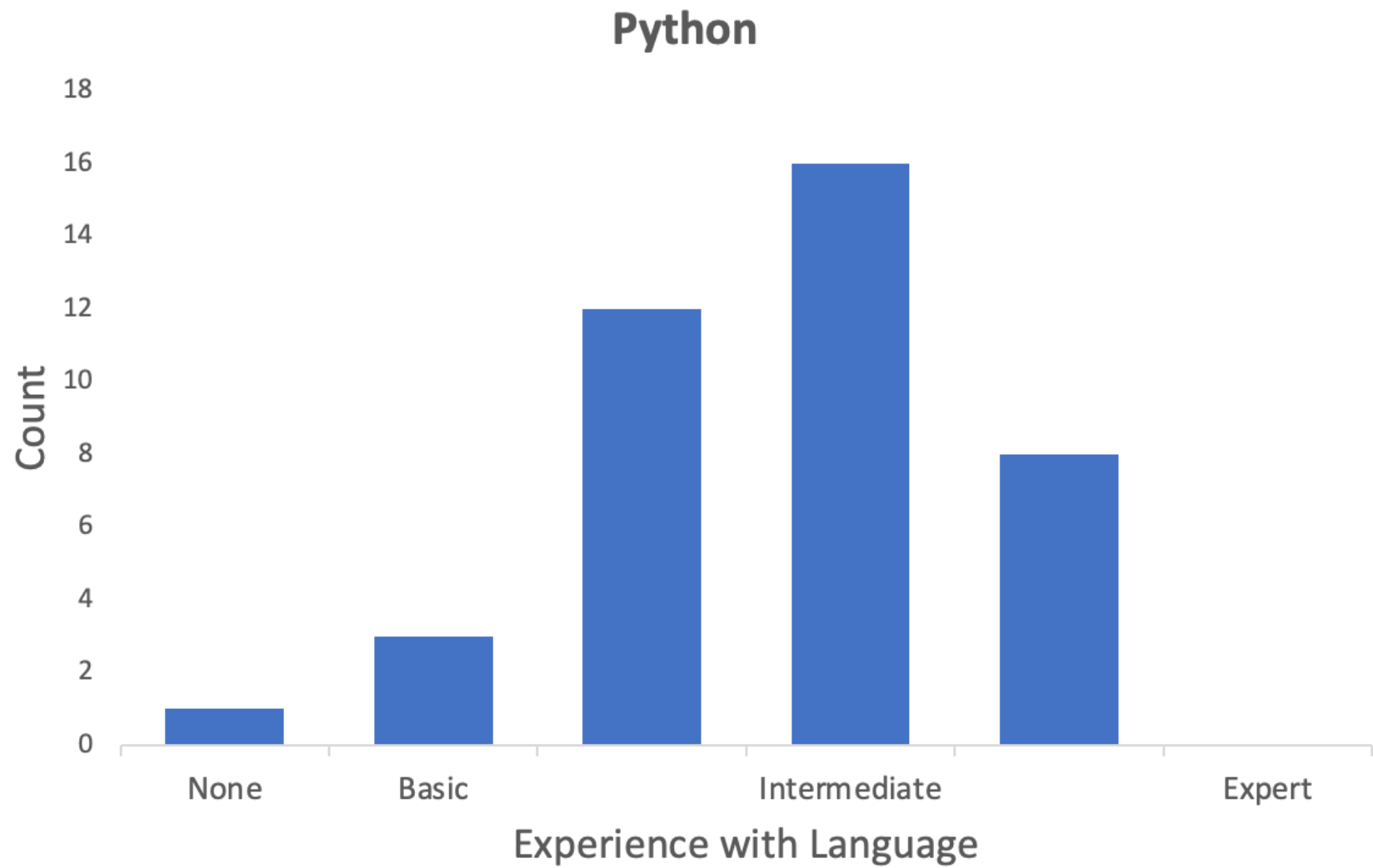
Toolboxes, Libraries, and Extensions

- What functions and tools are available above and beyond the core programming language?
- Python and R
 - 1000s of free routines created, shared, and supported by scientists and statisticians in standard repositories
- Matlab
 - 100+ toolboxes (not free) by Mathworks
 - 1000s of free routines created by users (matlabcentral)
 - free Psychophysics Toolbox

How do languages differ?

Functionality

- What can the language and toolboxes do for you?
- Python
 - complete programming language
 - computer scientists love it
 - mathematics and graphing comparable to Matlab and R
 - object-oriented
 - designed to interface well with other languages
 - widely used in data science and machine learning
 - growing popularity in psychology and neuroscience

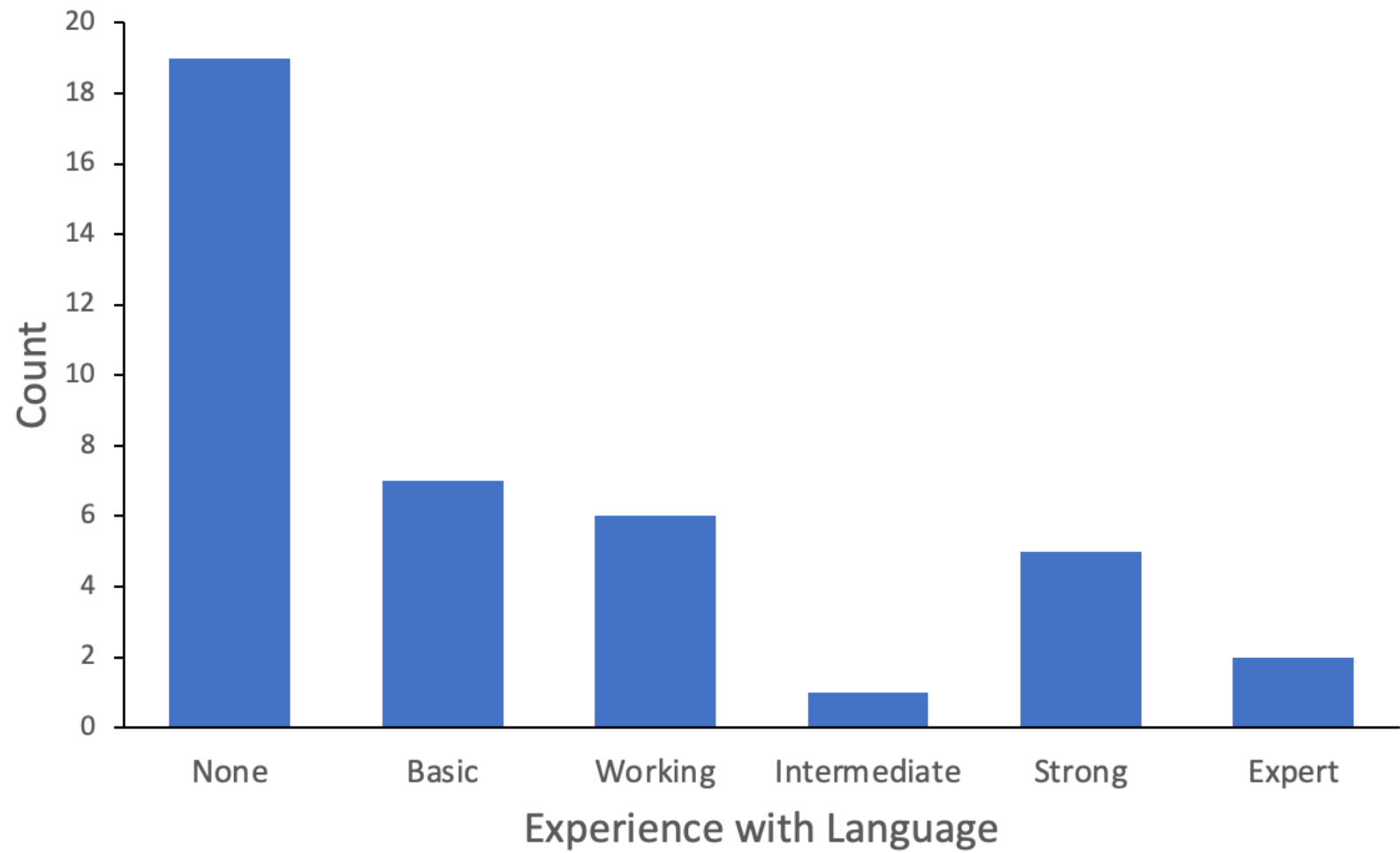


How do languages differ?

Functionality

- What can the language and toolboxes do for you?
- MATLAB
 - designed for numeric operations (Matlab = Matrix Laboratory)
 - outstanding graphing capabilities
 - difficult to implement non-numeric data structures
 - object-oriented capabilities are tacked on
 - lean but quirky syntax
 - many computer scientists hate Matlab
 - widely used in engineering (and psychology and neuroscience)

Matlab

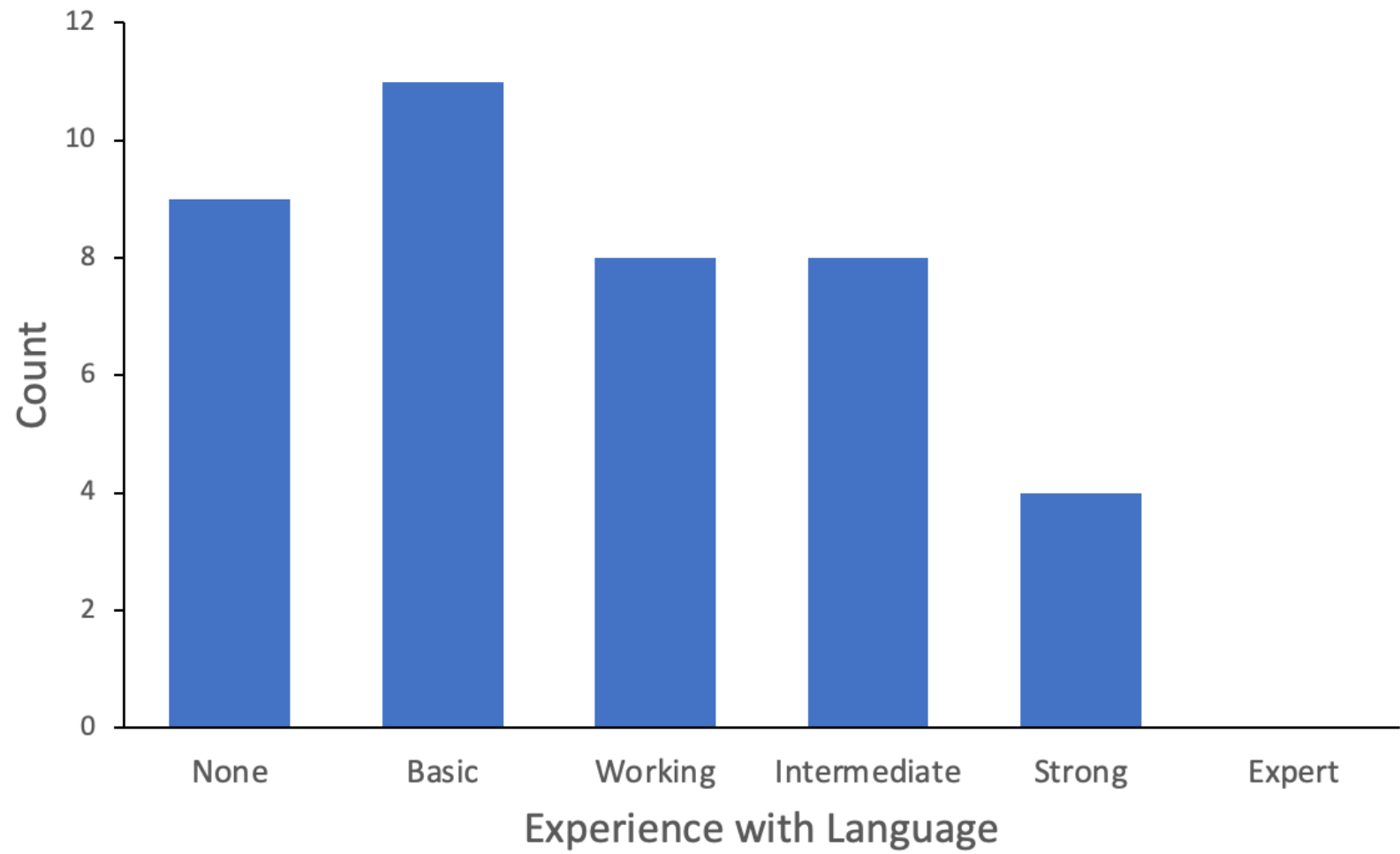


How do languages differ?

Functionality

- What can the language and toolboxes do for you?
- R
 - designed from the ground up for statistical analyses
 - not designed by computer scientists
 - great for analyses and simulation
 - excellent graphing capabilities
 - more general than scripting languages like SAS or SPSS
 - not used as a general purpose programming language
 - widely used in psychology for statistical analyses and computational modeling

R

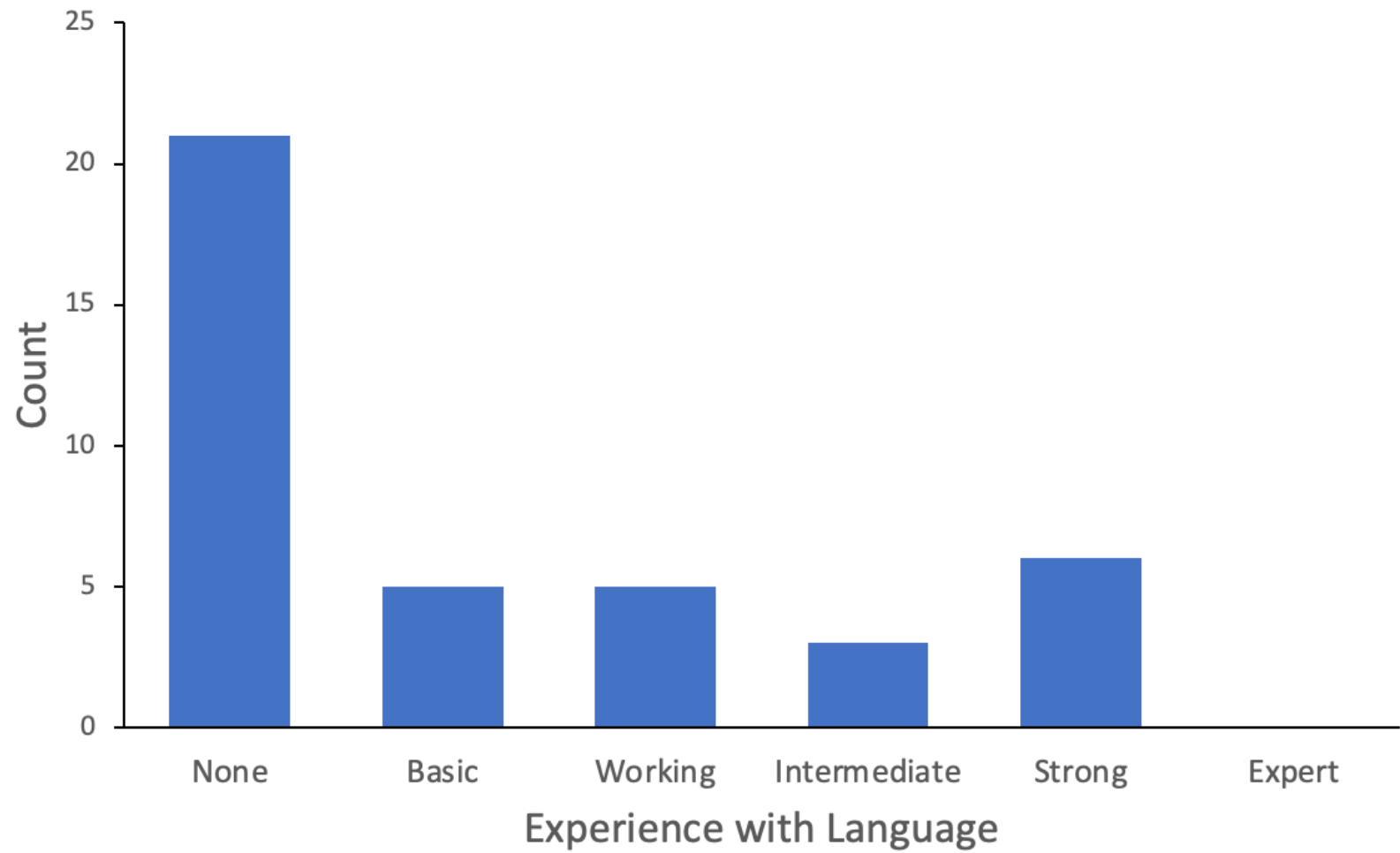


How do languages differ?

Functionality

- What can the language and toolboxes do for you?
- C++
 - full object-oriented language
 - “assembly language” of the 21st century
 - few standard or centralized libraries for science
 - powerful tools for applications development
 - some specialized, powerful libraries
 - Python and Matlab are “written in” C/C++
 - libraries/packages are written in C/C++ or Fortran

C/C++/C#



How do languages differ?

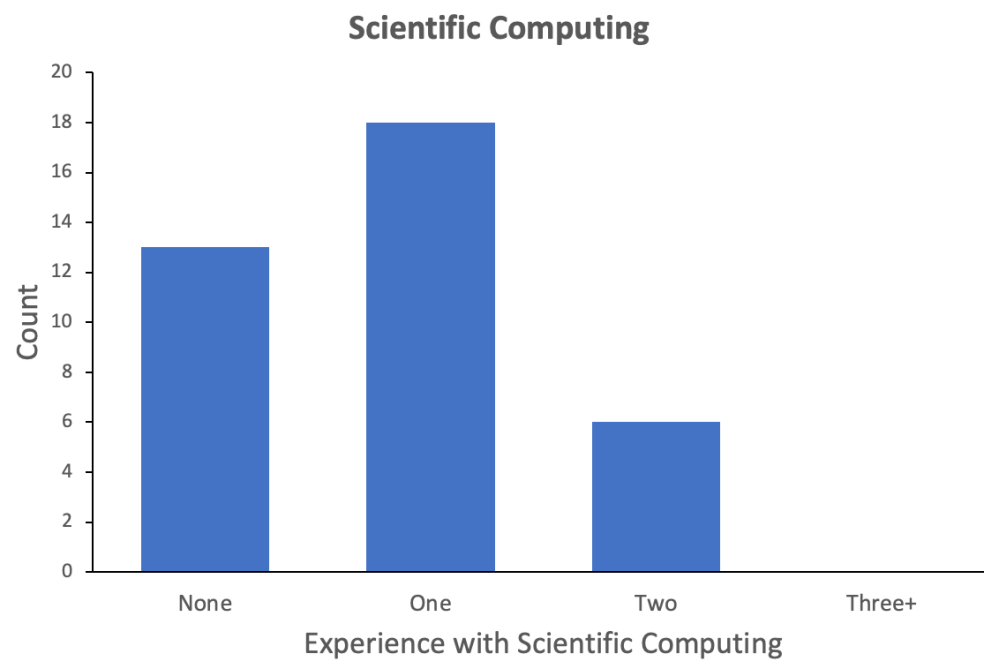
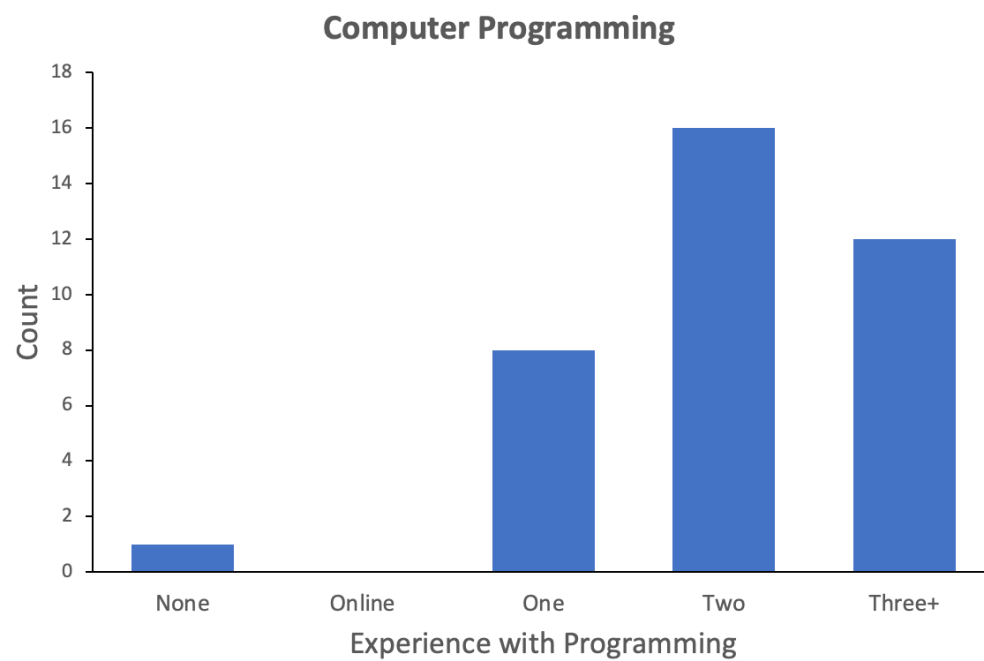
Interpreted vs. Compiled Language

- Matlab, Python, R
 - interpreted language
 - lines of a program are interpreted one at a time, as if you were typing them in by hand (only a bit faster)
 - programs run inside Matlab or Python or R
- C++, Fortran
 - programs compiled and then linked to libraries
 - executable programs (.exe) files (or equivalent)
 - most programs you run are compiled
 - the operating system on your computer is compiled
 - can call compiled C/Fortran from Python (or Matlab)

How do languages differ?

Speed

- Matlab, Python, R
 - slow, because it is interpreted (vectorized can be fast)
 - these languages became popular for real applications only in the past 10 years as computer speeds have increased
 - make gpu/parallel programmer easy(er)
- C/C++, Fortran
 - blazingly fast
 - a C++ program can run 100x faster than Python program
 - core R, Matlab, Python functions are in C/C++ or Fortran
 - doing simulations sometimes requires (some) C/C++ code
 - gpu/parallel programming hard



Course Logistics

Syllabus is on Brightspace

PSY 4219-01 Sci Computing Psy and Brain (2022F)



TP

Thomas Palmeri



Content Activities & Assessments ▾ Classlist Grades Course Admin Help ▾

Search Topics



Syllabus



Bookmarks



Course Schedule

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Wed Aug 24



Mon Aug 29



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Wed Aug 31



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Mon Sep 5



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Syllabus ▾

Print

Settings

Add a welcome message, overview, or description...

Drag a file here to update the attachment



1

of 4



Automatic Zoom ▾



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Scientific Computing for Psychological and Brain Sciences
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Kissam Center C216
Fall 2022

Instructor

Thomas Palmeri
Department of Psychology
507 Wilson Hall
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<http://catlab.psy.vanderbilt.edu>

Office Hours

Mon 11-12pm or by appointment

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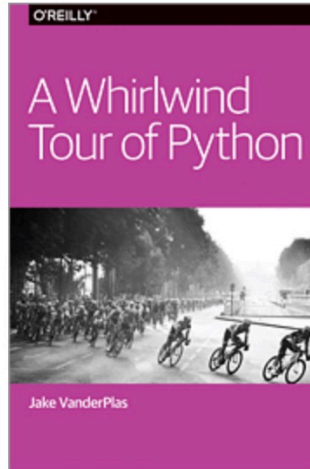
- **Palmeri** (507 Wilson Hall)
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- **Chow** (517 Wilson Hall)
Mondays 3:50-5:00,* this room (or WH 113)
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** the first one will be next Wednesday (August 31)*

Optional Textbooks

- *A Whirlwind Tour of Python* by Jake VanderPlas
<https://jakevdp.github.io/WhirlwindTourOfPython/>
- *Python Data Science Handbook*, also by Jake VanderPlas
<https://jakevdp.github.io/PythonDataScienceHandbook/>
- *Introduction to Computation and Programming in Python*, by John V. Guttag
- plus other readings / web sites on Brightspace

Versions on Google CoLab we'll talk about later



<https://colab.research.google.com/github/jakevdp/WhirlwindTourOfPython/blob/master/Index.ipynb>



<https://colab.research.google.com/github/jakevdp/PythonDataScienceHandbook/blob/master/notebooks/Index.ipynb>

Course Requirements

- **Weekly Homework Assignments**
 - assignment will vary in the number of points
 - turn in assignments on Brightspace
 - multiple files (when necessary) should be ZIPed together
 - Jason will read and run your code
 - the code should work, it must be commented, it must be general, it must use good programming style
 - I encourage students to help each other out (esp on Piazza), but you need to do the assignments on your own
 - come to Jason's help sessions, ask questions
 - come to our offices

Course Requirements

- for graduate students
 - being a mezzanine course (undergrad and grad) I am required from time-to-time to have some additional work (questions on assignments) for graduate students (required by the college and graduate school)
 - undergrads will be able to complete these questions for some extra credit

Laptops in Class

- following along with code (I upload before class)
- download pdf of slides and bringing them to class
(note that slides uploaded before class may differ a bit from notes uploaded after class)
- please avoid non-class-related activities

Piazza

- piazza.com/vanderbilt/fall2022/psy42196219

facilitate discussions about assignments, Python coding, Jupyter notebooks, PyCharm, and Python setup - can learn from each other

The screenshot shows the Piazza web interface for the course PSY 4219/6219. The top navigation bar includes links for LIVE Q&A, Drafts, and various course topics like welcome, setup, jupyter, pycharm, and homework assignments (hw1-hw14). The main content area is titled "Class at a Glance" and provides a summary of the class's status. It indicates that there are no unread posts, no unanswered questions, and no unanswered followups. The license status is "pending instructor license (6 days left)". The total number of posts is 6, and the total number of contributions is 6. There are 0 instructors' responses and 0 students' responses. The average response time is n/a. The student enrollment is 1 out of 50 (estimated). The interface also includes a "Share Your Class" section with instructions on how to share the class link.

PIAZZA PSY 4219/6219 Q & A Resources Statistics Manage Class Buy a License Switch to contribution model Thomas Palmeri

LIVE Q&A Drafts welcome setup jupyter pycharm hw1 hw2 hw3 hw4 hw5 hw6 hw7 hw8 hw9 hw10 hw11 hw12 hw13 hw14 git/github miscellaneous

Unread Updated Unresolved Following

New Post Search or add a post...

Show Actions

PINNED

Private Search for Teammates! 8/7/22

WEEK 8/7 - 8/13

Instr Welcome to Piazza for PSY4... 8/7/22
We use Piazza to facilitate discussions about assignments, Python coding, Jupyter notebooks, PyCharm, PsychoPy, and Pyth

Private Introduce Piazza to your stu... 8/7/22

Private Get familiar with Piazza 8/7/22

Private Tips & Tricks for a successf... 8/7/22

Welcome to Piazza! 8/7/22
Piazza is a Q&A platform designed to get you great answers from classmates and instructors fast. We've put together thi

Class at a Glance Updated 20 seconds ago. Reload Go to Live Q&A

no unread posts
no unanswered questions
no unanswered followups

license status pending instructor license (6 days left)
6 total posts
6 total contributions
0 instructors' responses
0 students' responses
n/a avg. response time

Student Enrollment 1 enrolled out of 50 (estimated) Edit

Download us in the app store: App Store Google play

Share Your Class

Professors appreciate Piazza best when they see how it is being used.
Allow colleagues to view your class through a demo link - a restricted, read only version of your class where all students' names are anonymized and all student information hidden.

Piazza

- piazza.com/vanderbilt/fall2022/psy42196219

you can share code snippets with specific questions, but please do not share a full swath of code (especially if they are for completing assignments)

you can post privately to me and Jason, but try to post publicly

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Piazza

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from syllabus: We also encourage students to help other students on Piazza – doing so will not only help you learn the material more deeply, but may earn you a bit of extra credit at the end of the semester if you're at the borderline between two final grades.

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Homework 1

- I will try to have most assignments due on a Wednesday, allowing for you to post questions on Piazza over the weekend and see Jason during his help session after class on Monday.
- The first homework assignment will be due Wednesday September 7th by class time (submitting on Brightspace).
- There will be some "checkmark" parts as well as a bit of coding. I will post the full assignment soon, but until then I will give a few pieces in the slides.

Piazza

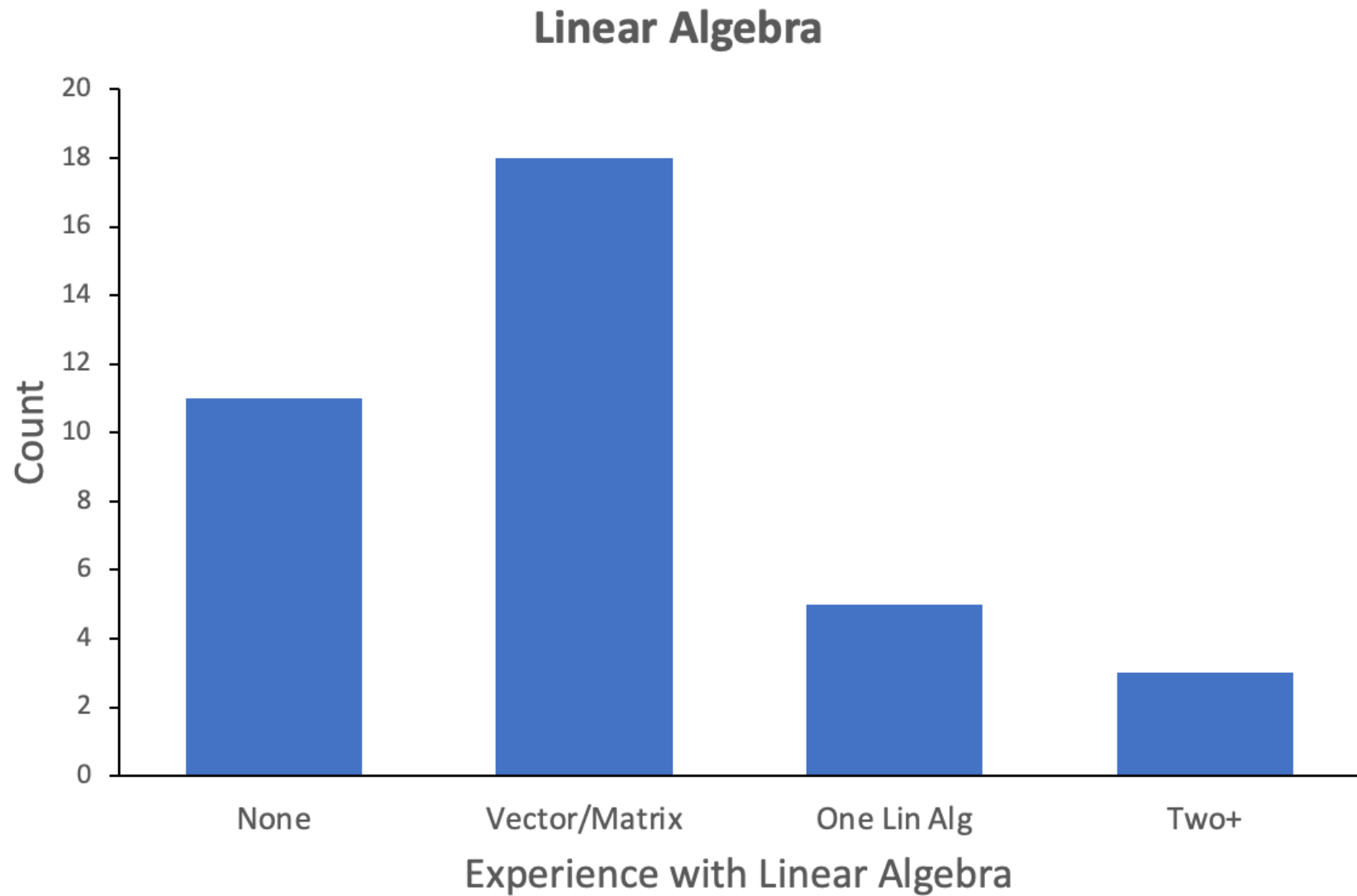
- piazza.com/vanderbilt/fall2022/psy42196219

(part of) HOMEWORK 1:

Create a Post and Respond to a Post on Piazza (under the "welcome" tag) - share something about yourself (your interests and hobbies, or your future plans, or what you hope to learn in the class, or really anything you're willing to share)

I shared a (long) post with a bit about myself - after you create a post for yourself, you can respond to the one I wrote or respond to another post

linear algebra



videos on linear algebra

The Essence of Linear Algebra series ([3blue1brown](#)) linked below is an excellent resource for reviewing (or learning) basic concepts of linear algebra. The most important concepts to review are vectors (Chapter 1-2), linear transformations and matrices (Chapter 3), matrix multiplication (Chapter 4), non-square matrices as transformations between dimensions (Chapter 8), and dot products (Chapter 9).

Please review these over the next few weeks.

https://www.youtube.com/playlist?list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab

statistics background

