دانشکده روانشناسی و علوم تربیتی

پژوهشگاه دانش‌های بنیادی IPM

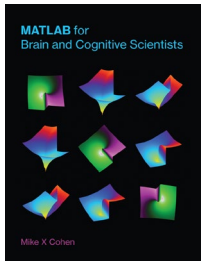
MATLAB for Brain and Cognitive Psychology (Intro)

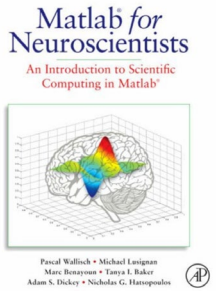
Presented by:
Ehsan Rezayat, Ph.D.
Faculty of Psychology and Education, University of Tehran,
Institute for Research in Fundamental Sciences (IPM), School of Cognitive Sciences,
emails: rezayat@ut.ac.ir, rezayat@ipm.ir, erezayat.er@gmail.com

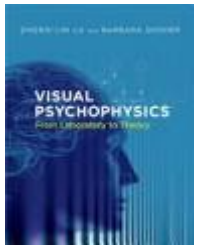
References

- MATLAB Programming

  - Cohen, Mike X. **MATLAB for brain and cognitive scientists**. MIT Press, 2017.
  - Wallisch, Pascal, et al. **MATLAB for neuroscientists: an introduction to scientific computing in MATLAB. Academic** Press, 2014.
  - http://www.jonaskaplan.com/psych599.php
  - Lu, Z. L., & Dosher, B. (2013). **Visual psychophysics: From laboratory to theory**. MIT Press.







رئوس مطالب:

1- معرفی نرم افزار MATLAB
2- جبر خطی و جبر ماتریسی در MATLAB
3- فرمانهای کنترلی فرمانهای کنترلی
4- برنامه نویسی در MATLAB
5- ایجاد محرکهای حسی
6- مقدمات سایکوتولیکس Psychtoolbox
7- نمایش محرکهای حسی بینایی ساده در صفحه نمایش
8- ارائه محرکها بینایی روی صفحه نمایش

9- جمع آوری پاسخ

10- کنترل و محاسبه زمان در آزمایش

11- اجزای یک آزمایش کامل

12- تحلیل نتایج رفتاری

13- انجام دو نمونه تکلیف رفتاری استروپ و بازشناسی هیجانات

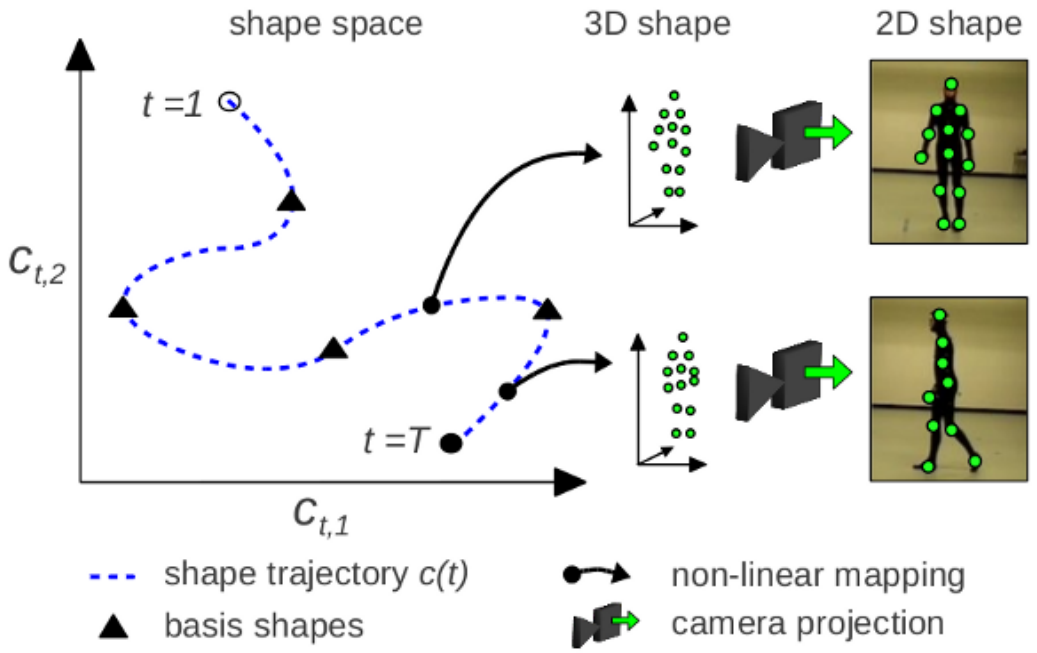
14- مدلسازی اولیه نتایج

15- کاربرد برنامه نویسی MATLAB در تحلیل سیگنالهای مغزی

16- کاربرد برنامه نویسی MATLAB در تحلیل تصاویر مغزی

Cognitive science dataset

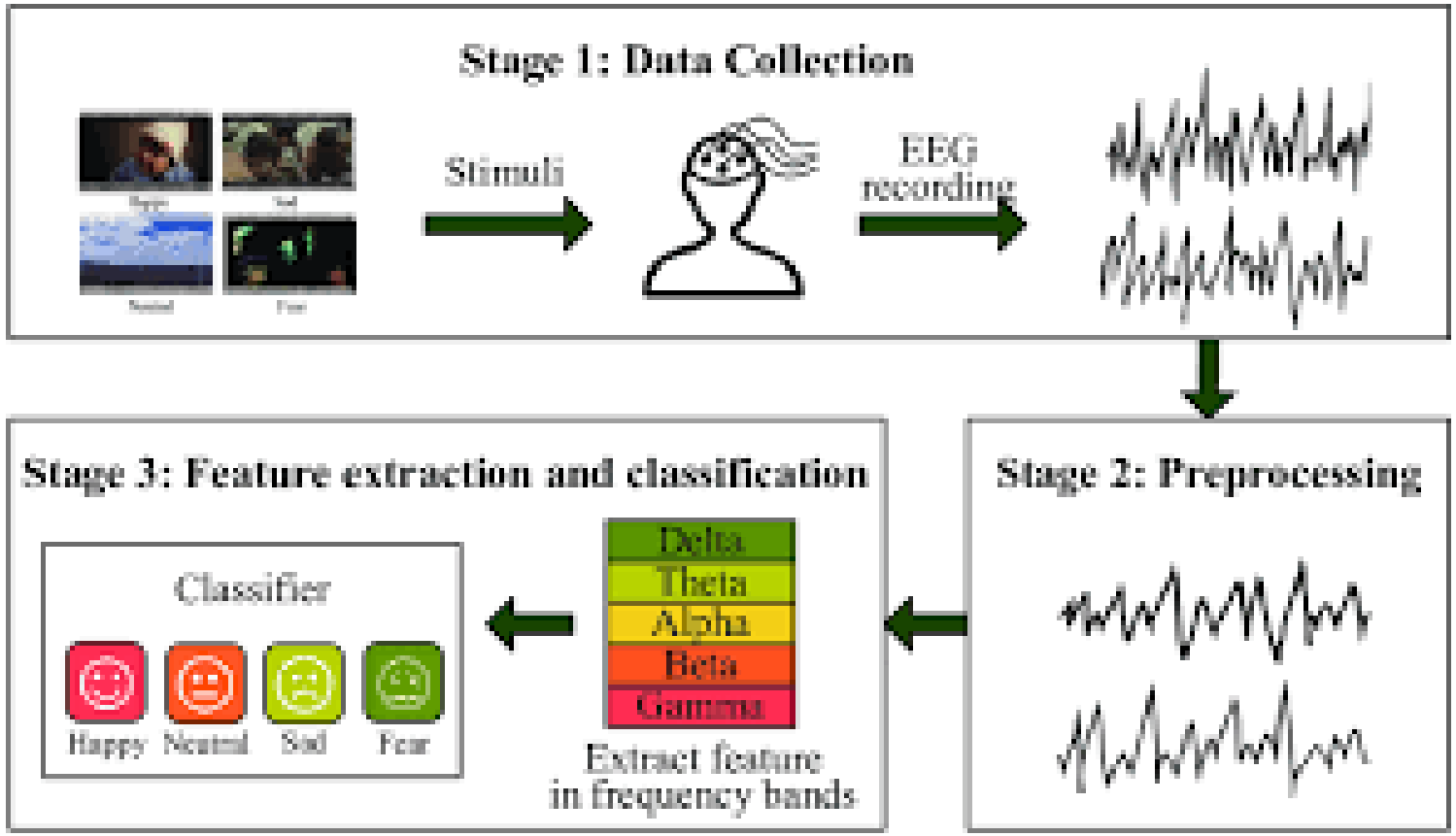
- Behavioral data



https://cbcsl.ece.ohio-state.edu/demos.html

Cognitive science dataset

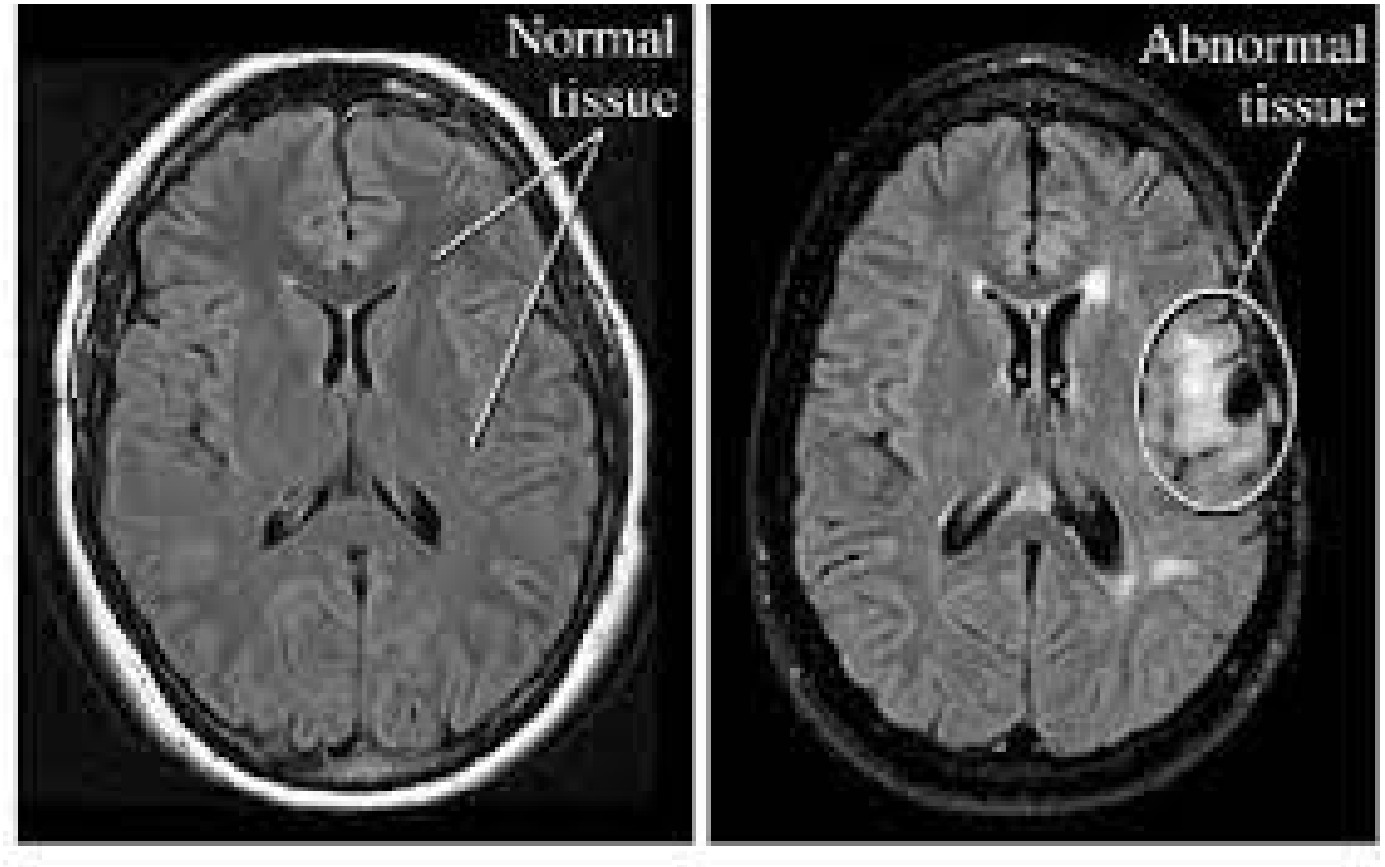
- Behavioral data
- Signal data



https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcTh0CNcGMo_DJYRBWJbJza1yqVZaKjr88xTXg&usqp=CAU

Cognitive science dataset

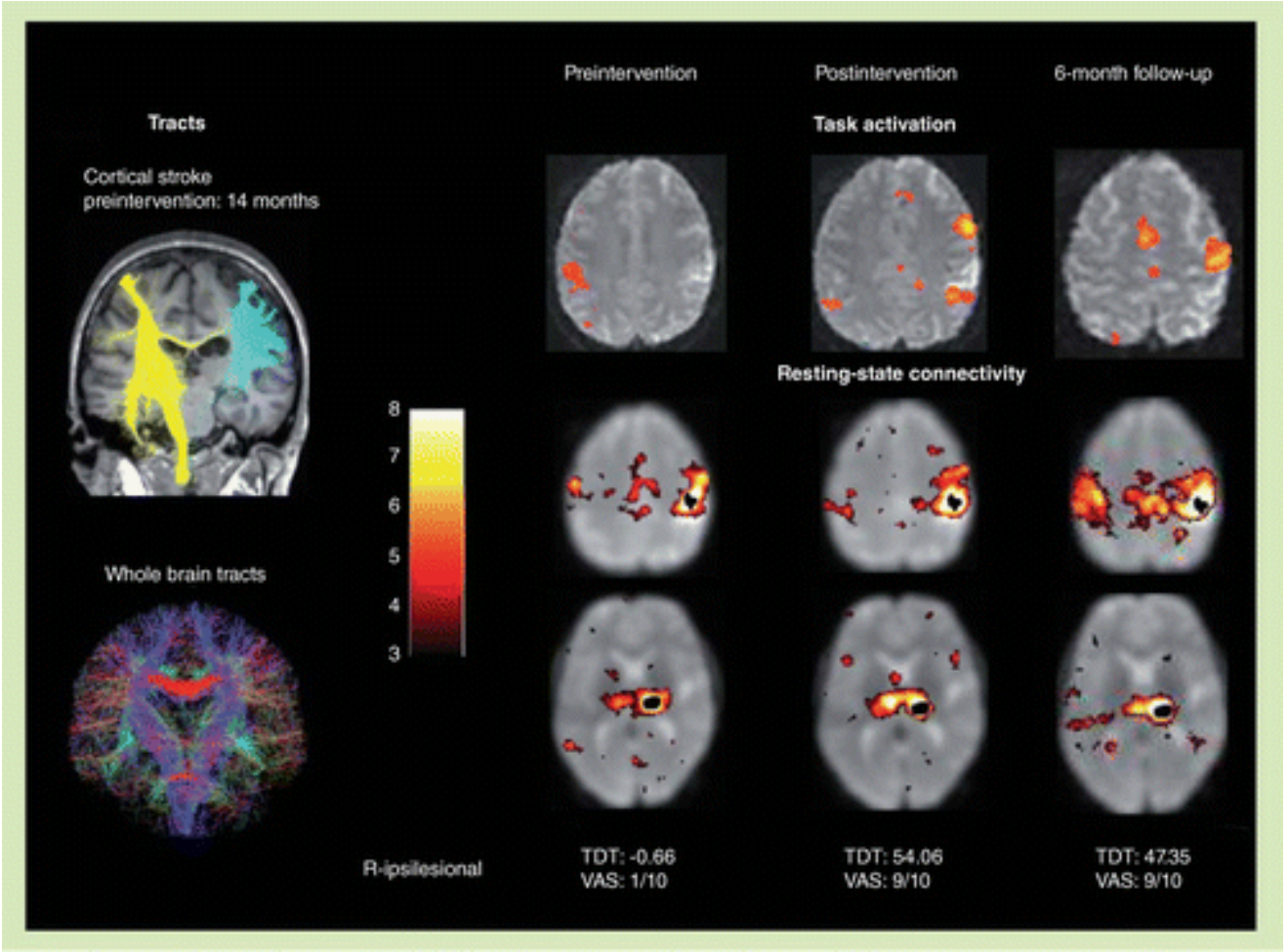
- Behavioral data
- Signal data
- Images



https://www.researchgate.net/figure/Normal-and-abnormal-MRI-image_fig1_303914251

Cognitive science dataset

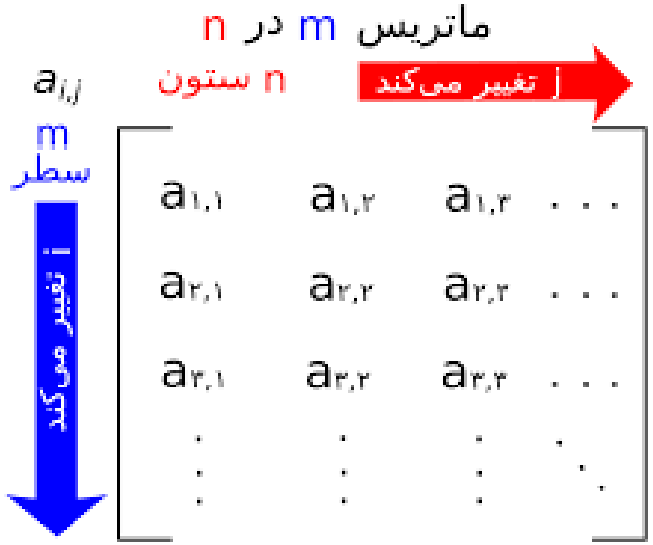
- Behavioral data
- Signal data
- Images
- Video or Functional images

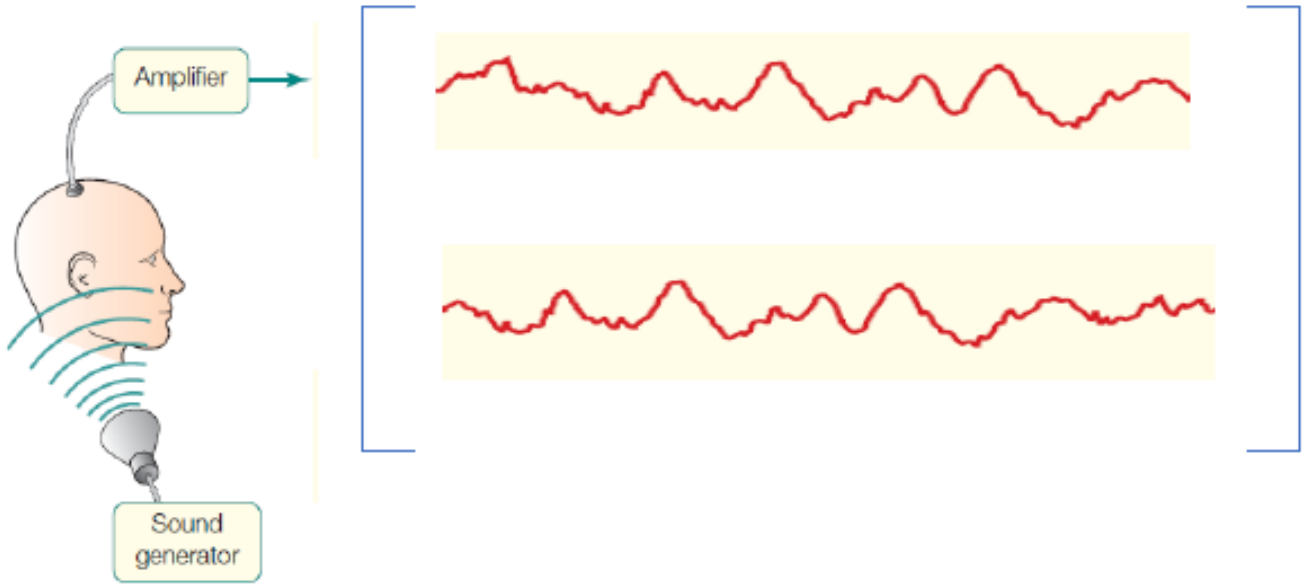


https://www.futuremedicine.com/doi/10.2217/fnl.13.39

Matrix

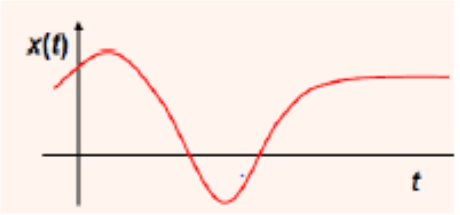
$$A = \begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \end{bmatrix} \qquad \begin{bmatrix} 6 & 4 & 24 \\ 1 & -9 & 8 \end{bmatrix}$$



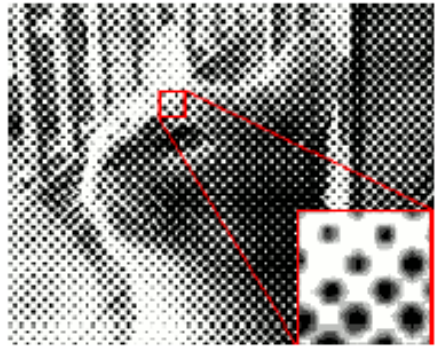


Multidimensional matrix

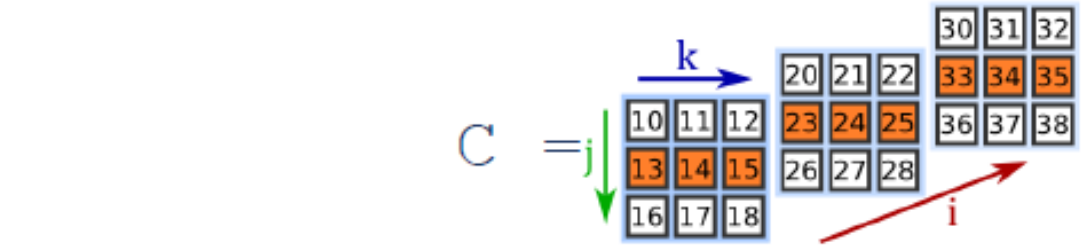
```
A =[2  5  ..  9]
```

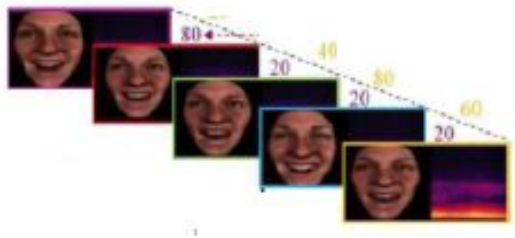



```
B= [ 1  9  ...  6
     3  4  ...  5
     .
     .          ]
```



```
C =
```





One example in Psychology: Psychophysics

Methodology for investigating relationships between sensations in the psychological domain and stimuli in the physical domain

- **Perception**:

The goal (task) of perception is to acquire accurate and reliable (precise) information about the environment.

Reality ≠ Perception

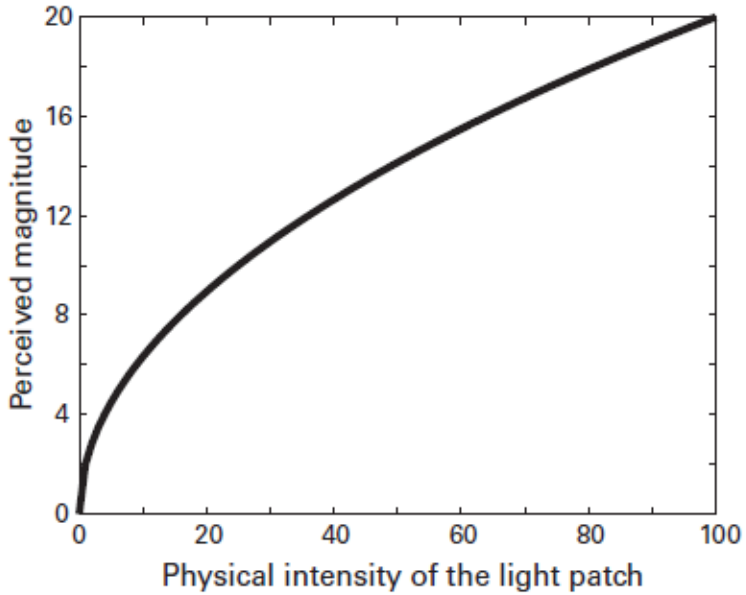
$$\Psi = f(\Phi)$$

Example: Steven ’ s law

- I the physical intensity
- β the power exponent,
- α a scaling factor.

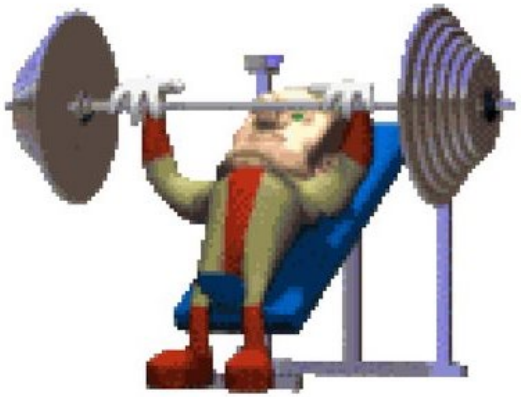
$$g(I) = a\, I^{\beta}$$

ادارک



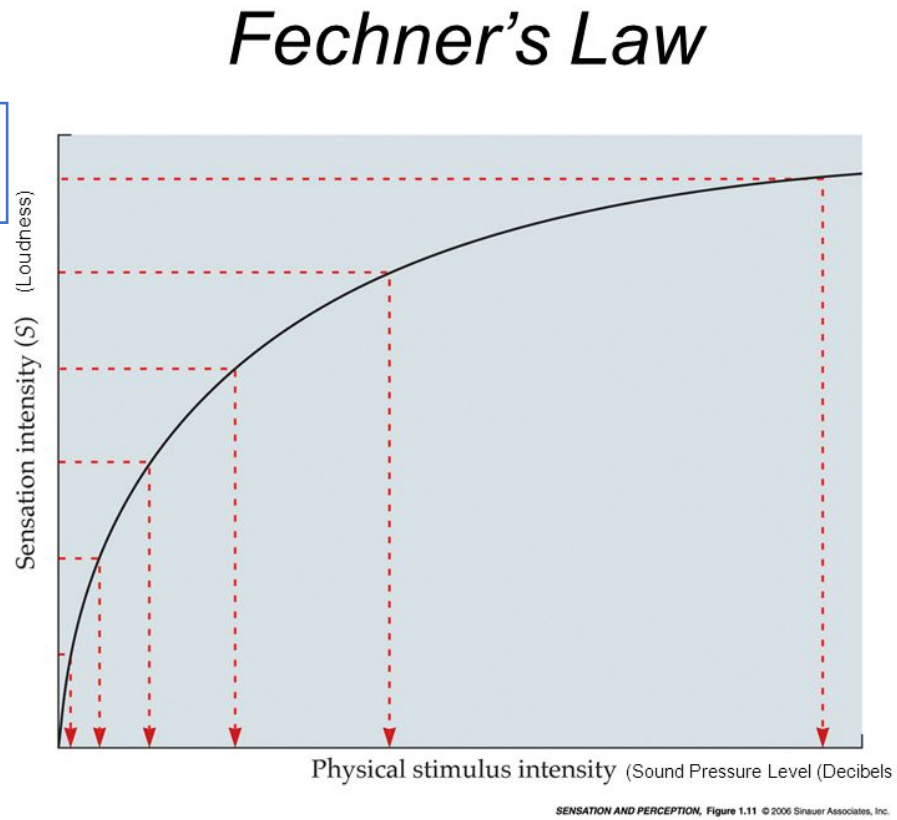
فیزیک

Example: Weber – Fechner law



ادارک

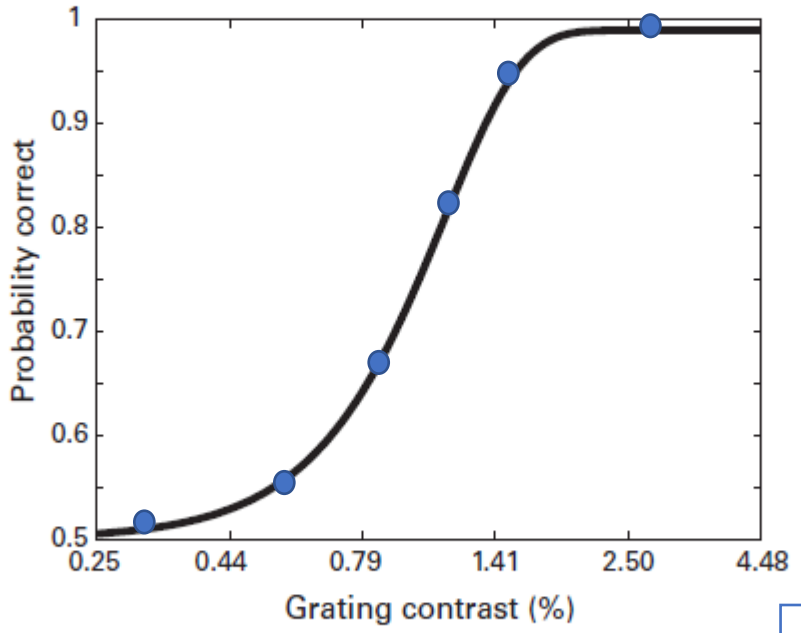
$$S = k\ log\ (I)$$



فیزیک

Example: Psychometric function

ادارک

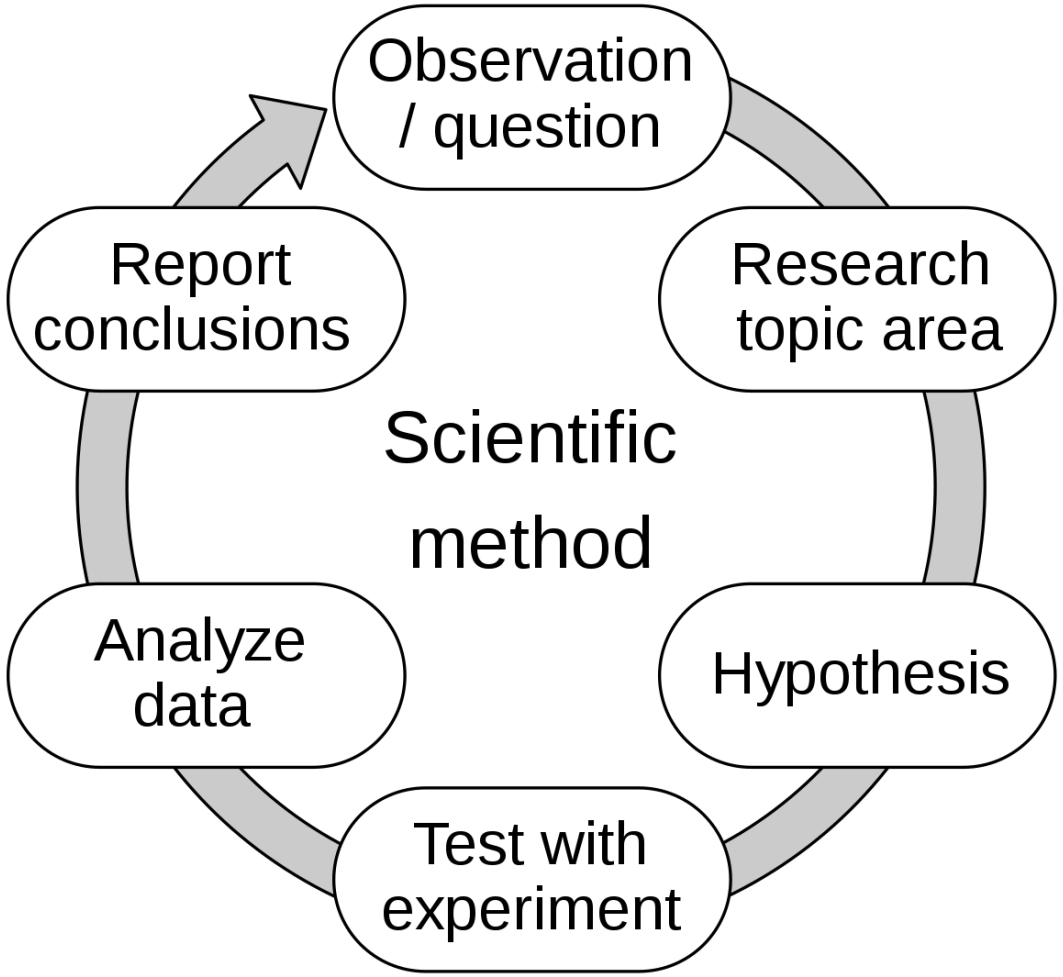


فیزیک

Figure 2.2
Psychometric function for detecting sine-wave gratings of different contrasts.

Becoming a programmer: why?

- Increase your freedom
- Increase your scientific value
- Enjoyment
- Exercise your logical mind



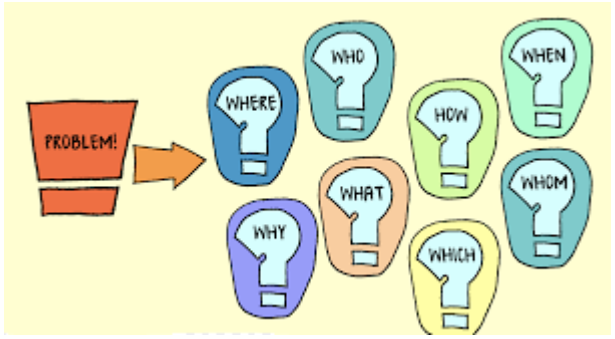
Do I Also Need to Be a Good Programmer?

- The brain is a complex system and analysis for that need to be custom-fit so need to custom tailored codes.

$$t = \frac{m - \mu}{s/\sqrt{n}}$$

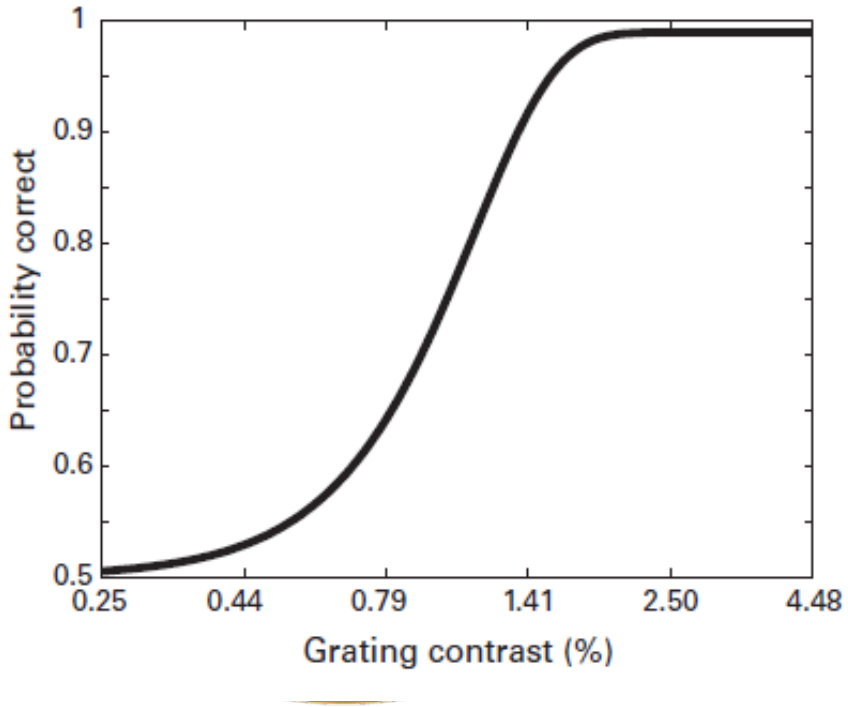
- Programing skills are your tool in research and they might not be a bottleneck

- Programing is problem solving



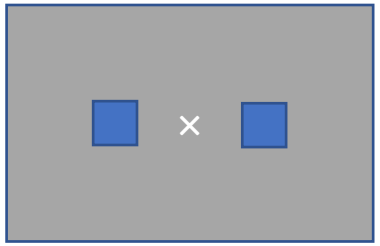
The Three Steps of Programming

- Think
- Write
- Debug



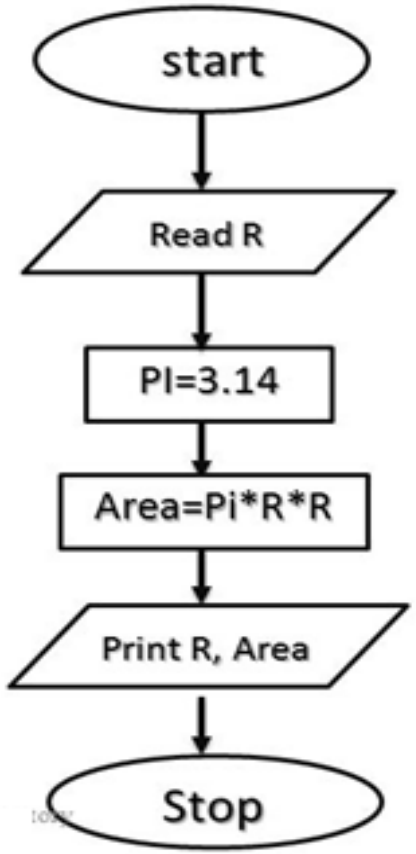
SOA
-50 :2: 50 ms

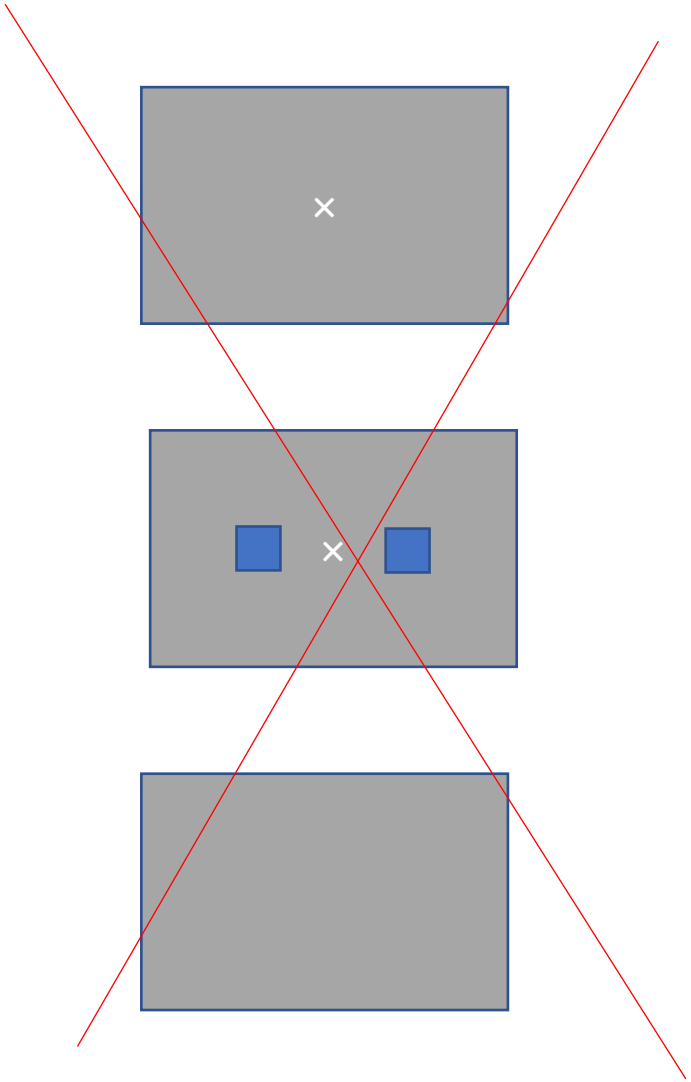
Saccades
Left or Right



Example: algorithm for calculate the area of circle

1. Start
2. Read value of R
3. Set PI equal to 3.14
4. Calculate Area=PI*R*R
5. Print R, Area
6. Stop





- No one is born a programmer.
- The difference between a good programmer and a bad programmer is that a good programmer spends years learning from his or her mistakes, and a bad programmer thinks that good programmers never make mistakes.”

The process of programming

- Programming is not a linear process
- Lots of trial and error
- Problem solving, detective work, deductive reasoning
- Debugging may take longer than initial writing.

Enjoy it!

Learning how to program

- Learn how to learn
- Practice
- Proficiency is not in being able to do everything you need to do, but knowing how to figure out what you need to do when you don’t know

Imposter Syndrome

- **From codeahoy.com: “Do experienced programmers use Google frequently?”**

The resounding answer is YES, experienced (and good) programmers use Google… a lot. In fact, one might argue they use it more than the beginners. Using Google doesn’t make them bad programmers or imply that they cannot code without Google. In fact, truth is quite the opposite: Google is an essential part of their software development toolkit and they know when and how to use it.

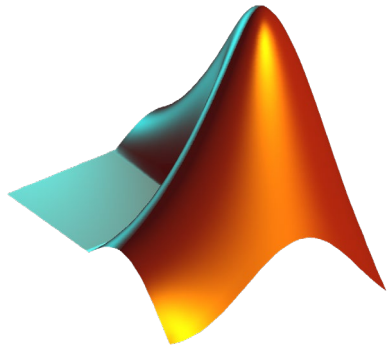
A big reason to use Google is that it is hard to remember all those minor details and nuances especially when you are programming in multiple languages and using dozens of frameworks. As Einstein said:

“Never memorize something that you can look up.” - Albert Einstein

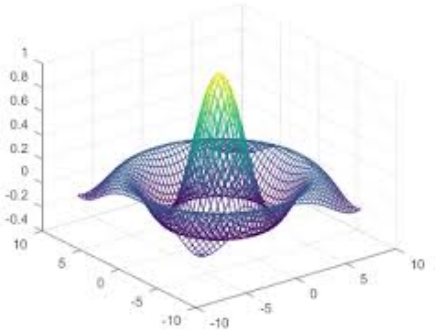
Aside from that, good programmers also know that they cannot be the first one to have encountered a problem. They use Google to research possible solutions, carefully evaluating the results and consciously separating the wheat from the chaff; they don’t blindly follow or copy-paste any solution they come across. Expert programmers are also paranoid, living in self-doubt and questioning their competence. Whenever their spidey senses start tingling, they know they may be going the wrong hole; they rely on Google on validate their logic.

Getting the software and looking around

Why MATLAB?



- Octave
- Python
- Julia
- SPSS
- C/ C++/C#
- HTML

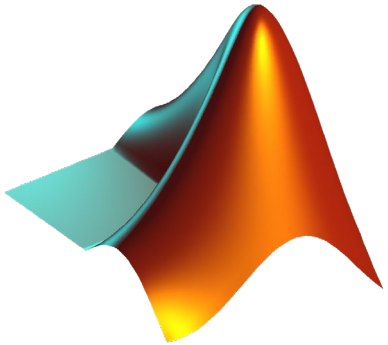


julia

HTML

IBM SPSS

What is Matlab?

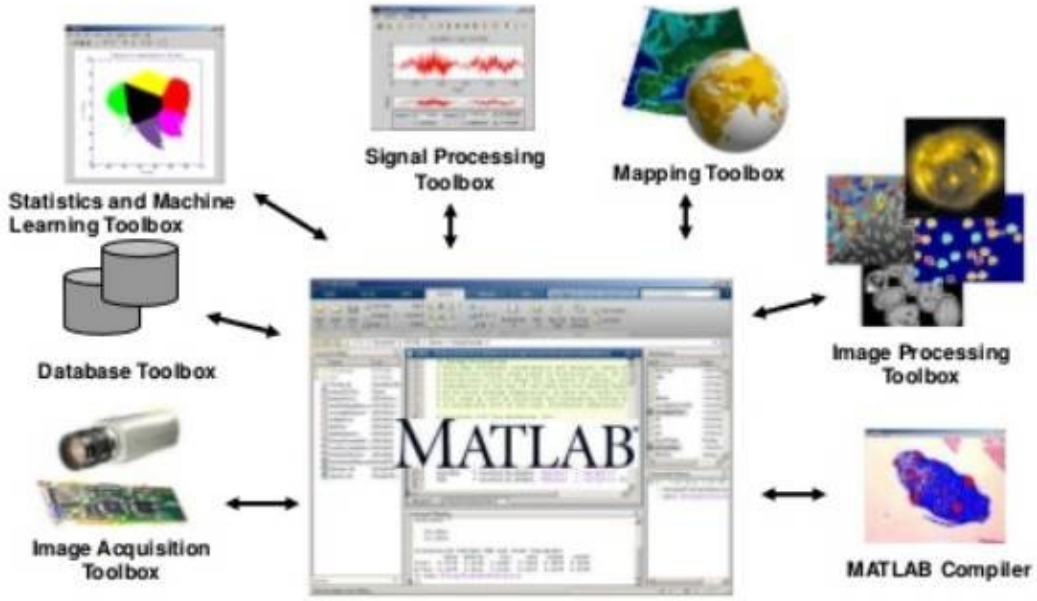


- Matrix Laboratory
- “MATLAB® is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java™.

- You can use MATLAB for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. More than a million engineers and scientists in industry and academia use MATLAB, the language of technical computing.

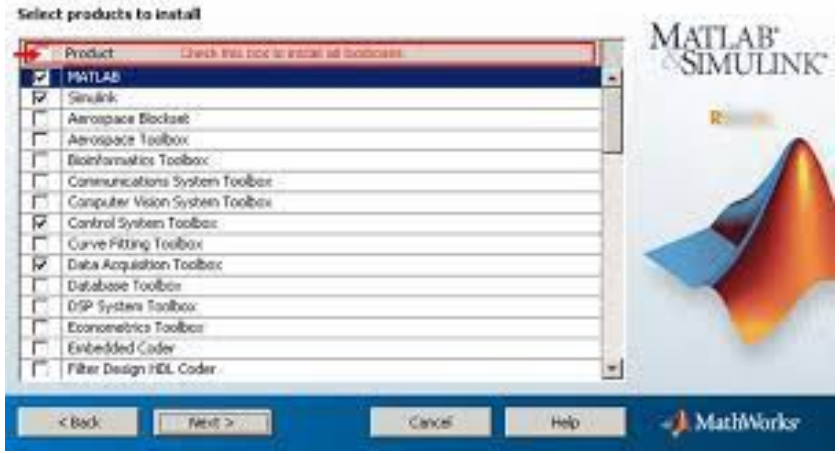
What is Psychtoolbox?

- Psychophysics Toolbox is a set of Matlab functions for behavioral research
- It runs on Mac, Windows, and Linux
- Allows precise control of your screen, audio, collection of responses
- Controls low-level system events using a high-level language (Matlab)
- Freely available
- http://psychtoolbox.org



Getting the software

- Get MATLAB: https://www.mathworks.com/
  - Current Mathworks version: 2022b



- Get Psychtoolbox: http://psychtoolbox.org
- May also need:
  - Gstreamer SDK to play video:
    http://www.gstreamer.com
    (make sure to check all the boxes when you install)

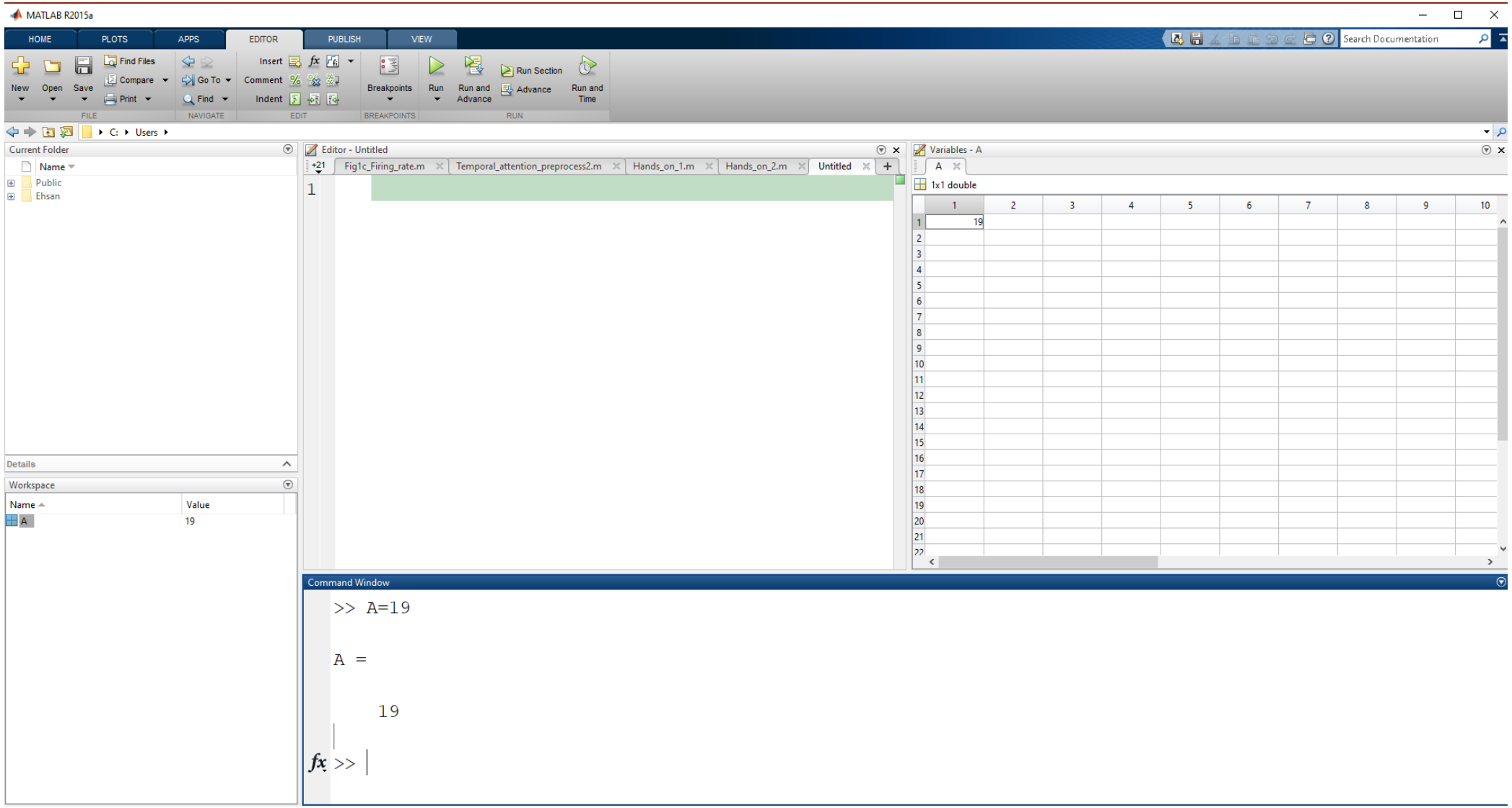
Installing Psychtoolbox

- http://psychtoolbox.org/download/
- Make sure you have all the prerequisites
- Download the “DownloadPsychtoolbox.m” script and run it
- Restart Matlab
- Type

  ```
  PsychtoolboxVersion
  ```

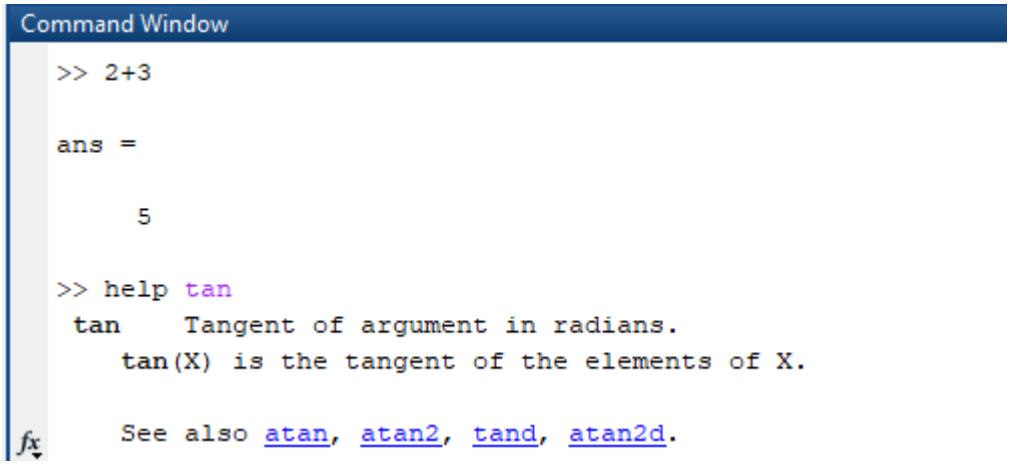
  to check your installation

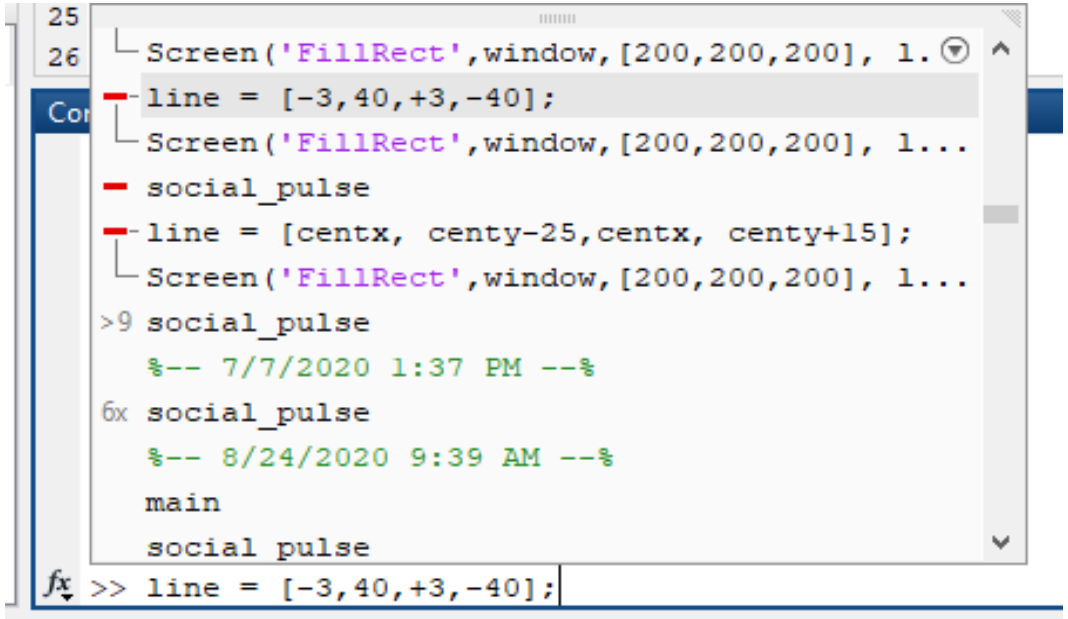
MATLAB Environment



The Command Window and Command History

- Typing in commands
- moving through history
- re-executing commands





The file browser

- Moving around through the folder hierarchy
- Command line tools for navigation

cd	change directory
ls	list directory contents
dir	list directory contents

Variables - filenames

filenames

6x1 struct with 5 fields

Fields	name	date	bytes	isdir	datenum
1	'.'	'24-Jul-2021...	0	1	7.3836e+05
2	'..'	'24-Jul-2021...	0	1	7.3836e+05
3	'.DS_Store'	'22-Jul-2021...	6148	0	7.3836e+05
4	'session1.asv'	'24-Jul-2021...	8716	0	7.3836e+05
5	'session1.m'	'24-Jul-2021...	8855	0	7.3836e+05
6	'supplemen...	'24-Jul-2021...	0	1	7.3836e+05

The workspace and variable editor

- Settings variables:

  x = 3

- Clearing variables:

  clear x

  clear all

Getting help

- help function
- doc function
- pop-up help

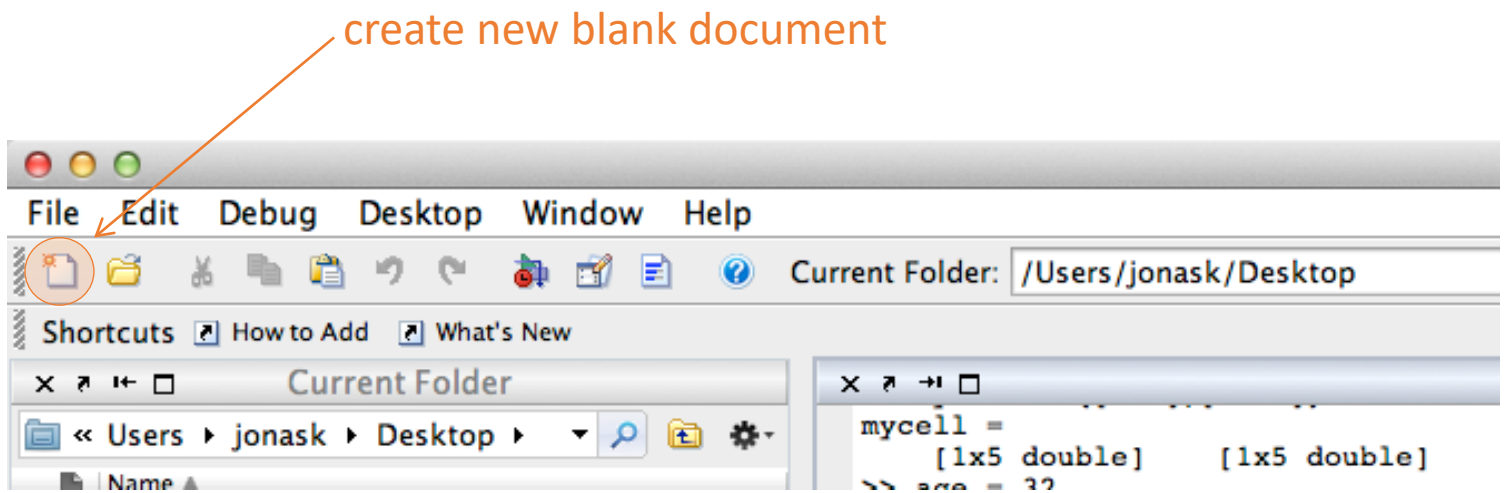
```
>> help sin
sin    Sine of argument in radians.
    sin(X) is the sine of the elements of X.

    See also asin, sind.

    Reference page in Help browser
       doc sin
```

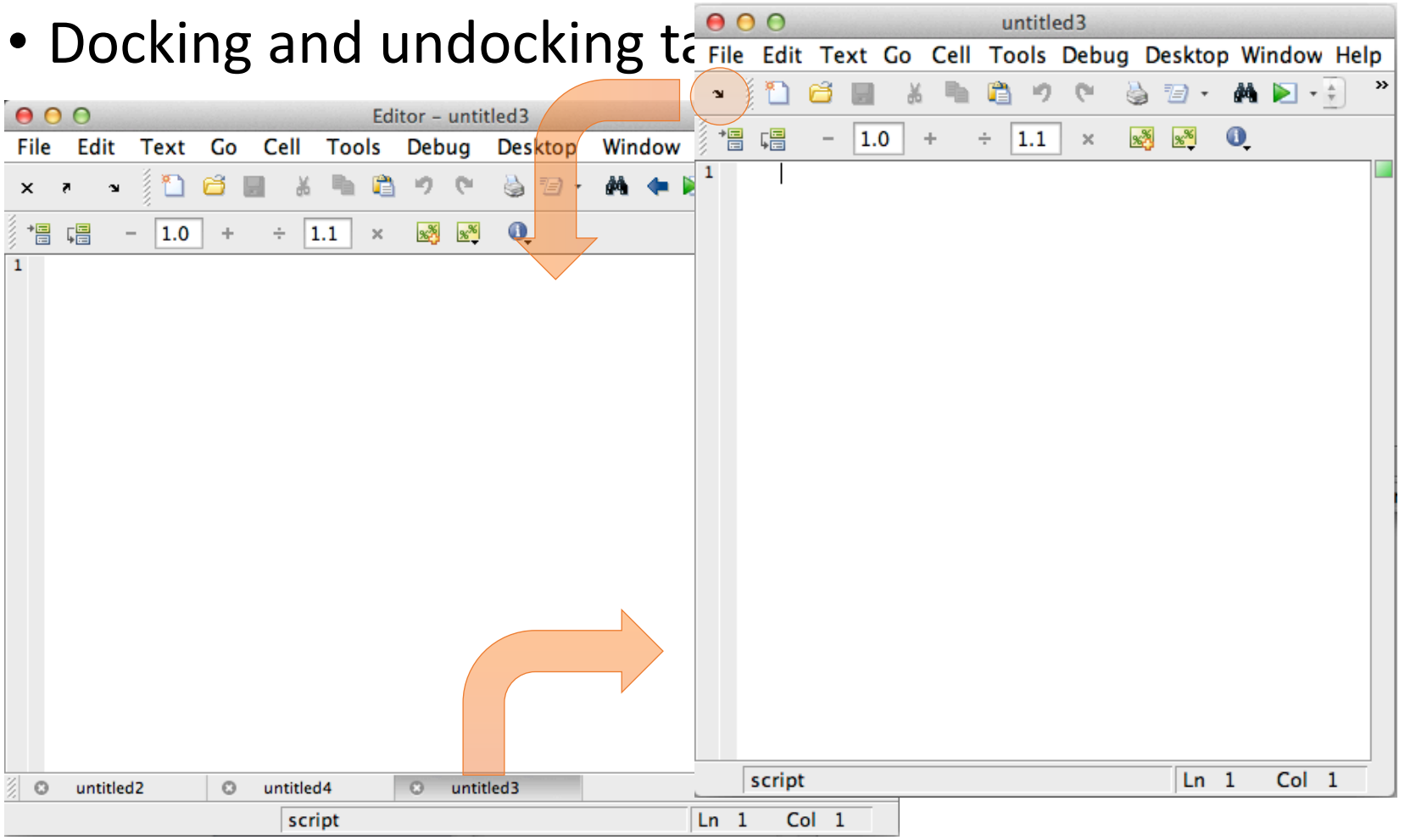
Scripts

- Anything you type into the workspace can also be run from a script
- ".m" files are just saved lists of matlab commands



Editor options

- Docking and undocking ta



Assignment session #1

- Not for first session
- Install MATLAB on your computer