METHODS 3: MULTILEVEL STATISTICAL MODELLING AND MACHINE LEARNING

COURSE OVERVIEW (SECOND HALF)

W6: Machine Learning Intro

Moving the goal away from explanations towards prediction and getting Python running

W7: Linear Regression Revisited (machine learning)

How to constrain our models to make them more predictive

W8: Logistic regression (machine learning)

Categorizing responses based on informed guesses

W9: Dimensionality reduction, Principled Component Analysis (PCA)

What to do with very rich data?

W10: Organizing and preprocessing messy data

How to clean up?

W11: Final evaluation and wrap-up of course

Ask anything

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How to clean up?

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Ask anything

TODAYS PLAN

- Slides with tips on assignment
    - Only some tips, since you should be progressing with assignment
- Work on the assignment

TODAYS PLAN

- Catch-up
- .gitignore
    - (being pro-active, and resolving issues)
- Python Class()
    - (overall and with example)
- 3D arrays
    - (averaging, collapsing/flattening)
- Assignment tips
- Assignment code-review
    - Over the shoulder
    - Pair programming

TODAYS PLAN

Anything that seems redundant?
(can skip it – but in doubt as to what has been explained by Lau)

- Catch-up
- .gitignore
  - (being pro-active, and resolving issues)
- Python Class()
  - (overall and with example)
- 3D arrays
  - (averaging, collapsing/flattening)
- Assignment tips
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CATCH-UP

CATCH-UP

- How are you holding up?
- Any comments on the course for Lau or me?

CATCH-UP

- Long and tough assignment
- Use me as a resource… Ask(!)/Write
    - Also did the assignment, so might as well utilize it
- I’ll be there at the coding-café this Friday also

CATCH-UP

- Feedback from last class:
  - Python classes and basics (.fit concept, etc.)
  - Exercise help (close to coding)
  - Help on Spyder/other IDE's
  - Python workshop?

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  - Python classes and basics (.fit concept, etc.)
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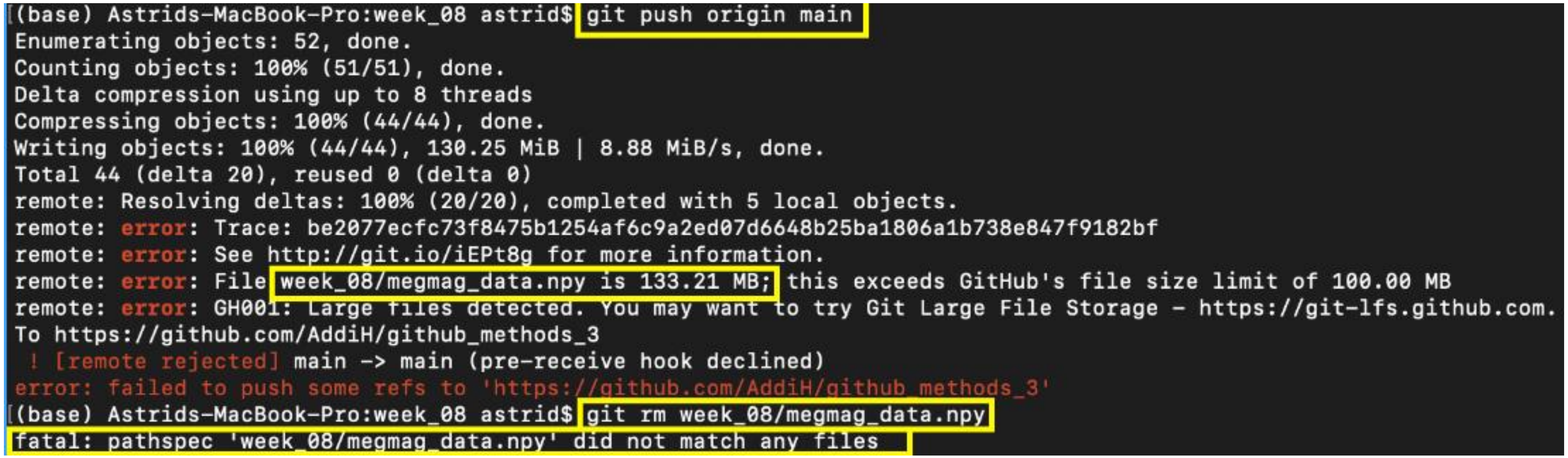
.GITIGNORE

.GITIGNORE



```
[(base) Astrids-MacBook-Pro:week_08 astrid$ git push origin main
Enumerating objects: 52, done.
Counting objects: 100% (51/51), done.
Delta compression using up to 8 threads
Compressing objects: 100% (44/44), done.
Writing objects: 100% (44/44), 130.25 MiB | 8.88 MiB/s, done.
Total 44 (delta 20), reused 0 (delta 0)
remote: Resolving deltas: 100% (20/20), completed with 5 local objects.
remote: error: Trace: be2077ecfc73f8475b1254af6c9a2ed07d6648b25ba1806a1b738e847f9182bf
remote: error: See http://git.io/iEPt8g for more information.
remote: error: File week_08/megmag_data.npy is 133.21 MB; this exceeds GitHub's file size limit of 100.00 MB
remote: error: GH001: Large files detected. You may want to try Git Large File Storage - https://git-lfs.github.com.
To https://github.com/AddiH/github_methods_3
 ! [remote rejected] main -> main (pre-receive hook declined)
error: failed to push some refs to 'https://github.com/AddiH/github_methods_3'
[(base) Astrids-MacBook-Pro:week_08 astrid$ git rm week_08/megmag_data.npy
fatal: pathspec 'week_08/megmag_data.npy' did not match any files
```

.GITIGNORE

- Live examples
  - Resolving issues
    - git reset –-soft HEAD~1 *(Deletes last commit)*
    - git restore --staged <file> *(untracks file)*
  - Being proactive
    - Create .gitignore (use python troubleshooting pdf)
    - git add .gitignore

.GITIGNORE

- Rather quick live example… But only if interested?
    - Note to self: remember to zoom in bash

PYTHON CLASSES

PYTHON CLASSES

Try to figure out how the classes work

- Only large difference between R and Python a numpy array is just a class
  - *(apart from other types of objects, dict, lists, tuples, etc.)*

PYTHON CLASSES

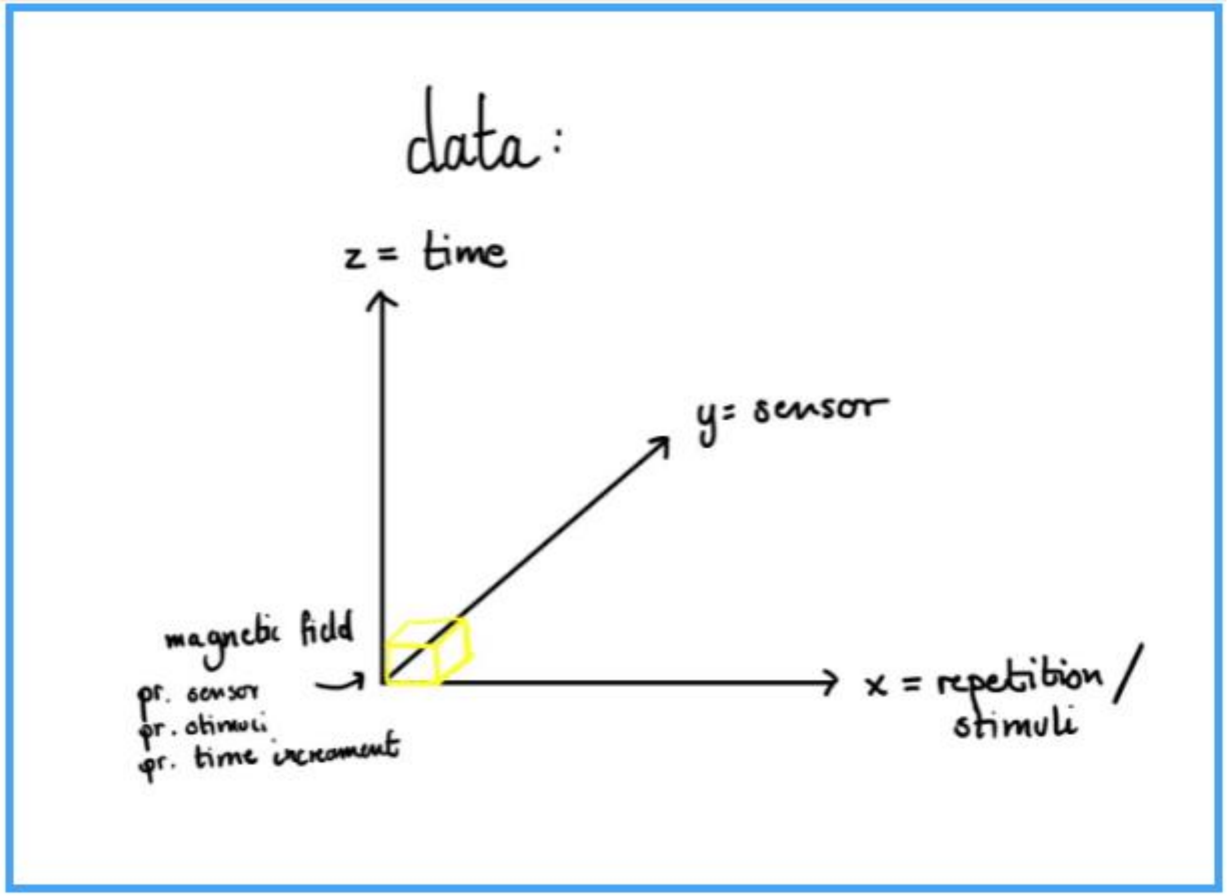
- Going through an example of a Class()
- Won't necessarily give full understanding but …
    - Blogposts
    - Youtube
    - **Trying it out yourself (feel free to use my script also)**

PYTHON CLASSES

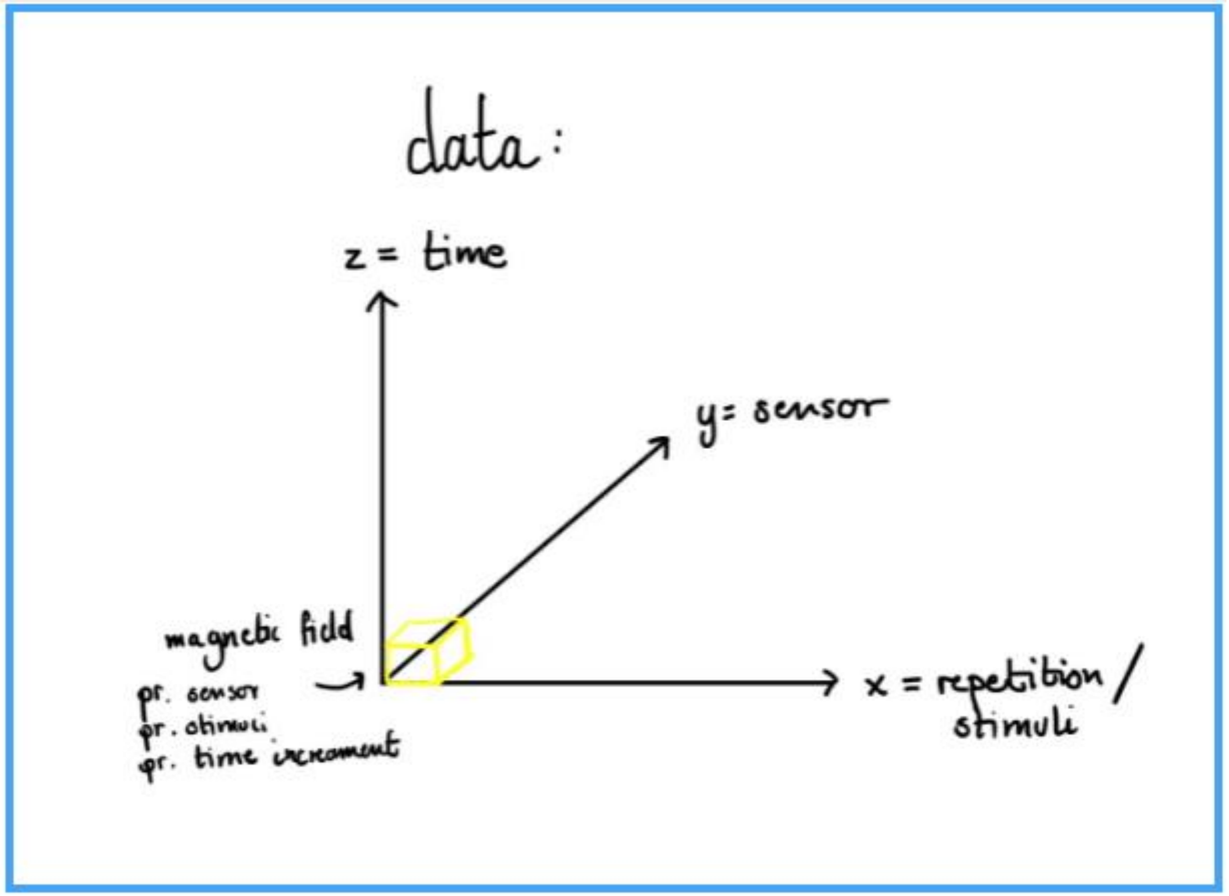
- Live example

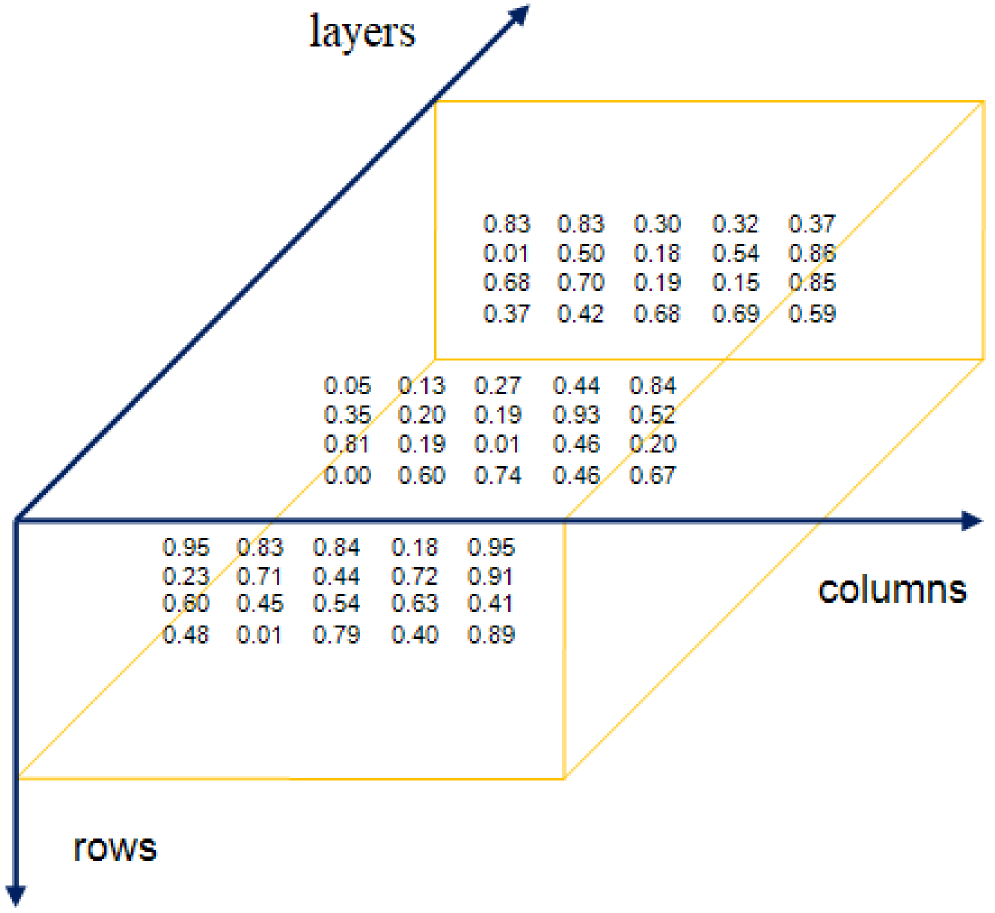
ARRAYS AND MEANS

ARRAYS


data:
z = time
y = sensor
x = repetition / stimuli
magnetic field
pr. sensor
pr. stimuli
pr. time increment

ARRAYS





0.83 0.83 0.30 0.32 0.37
0.01 0.50 0.18 0.54 0.86
0.68 0.70 0.19 0.15 0.85
0.37 0.42 0.68 0.69 0.59

0.05 0.13 0.27 0.44 0.84
0.35 0.20 0.19 0.93 0.52
0.81 0.19 0.01 0.46 0.20
0.00 0.60 0.74 0.46 0.67

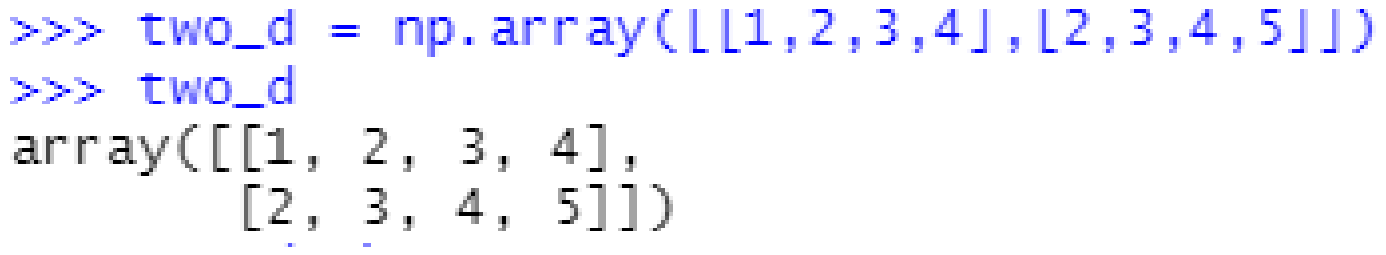
0.95 0.83 0.84 0.18 0.95
0.23 0.71 0.44 0.72 0.91
0.60 0.45 0.54 0.63 0.41
0.48 0.01 0.79 0.40 0.89

A 3-D array, with size **4×5×3**, may be described as a "block array" containing three **4×5** matrices (one per page), or also four **5×3** matrices

ARRAYS

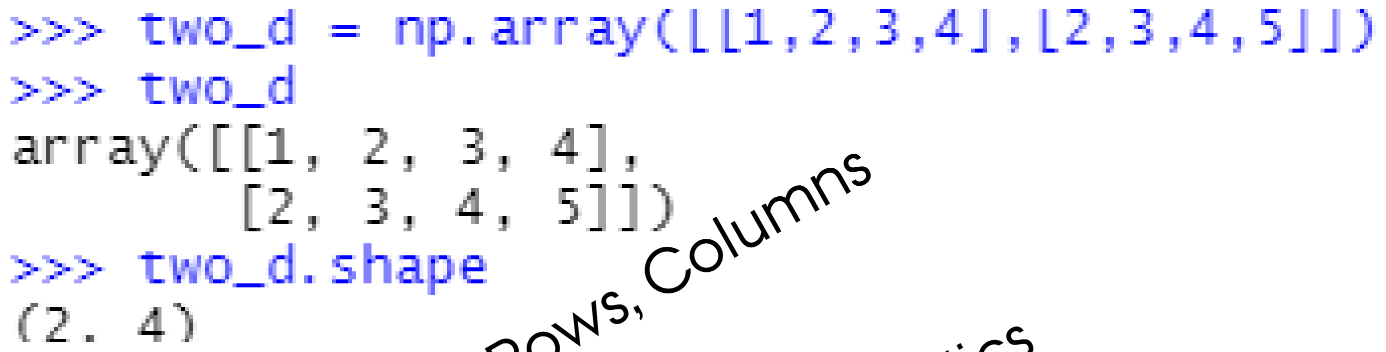
- How do they behave?

ARRAYS



```
>>> two_d = np.array([[1,2,3,4],[2,3,4,5]])
>>> two_d
array([[1, 2, 3, 4],
       [2, 3, 4, 5]])
```

ARRAYS



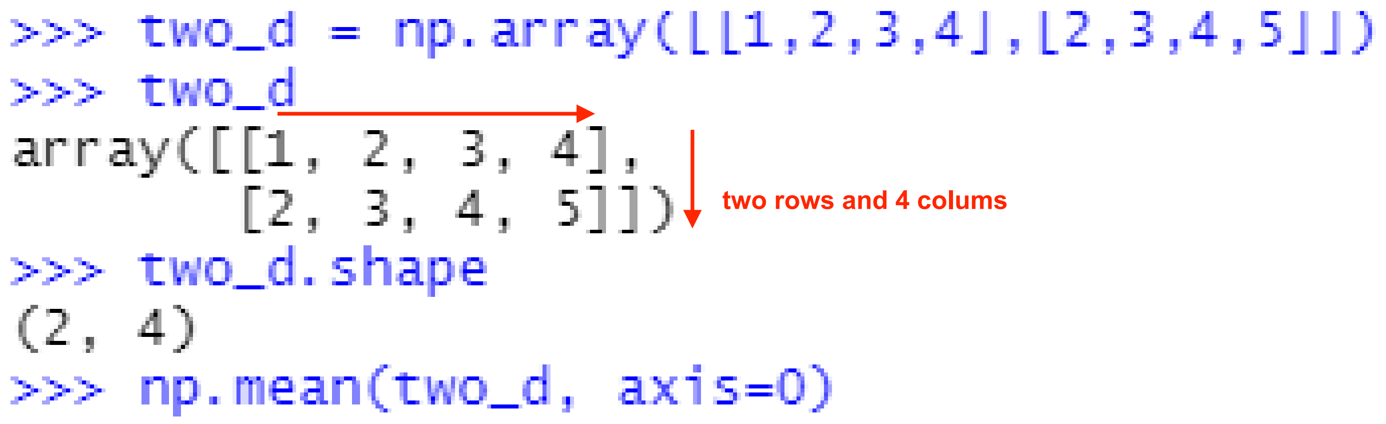
```
>>> two_d = np.array([[1,2,3,4],[2,3,4,5]])
>>> two_d
array([[1, 2, 3, 4],
       [2, 3, 4, 5]])
>>> two_d.shape
(2. 4)
```

Rows, Columns

=

Roman Catholics

ARRAYS



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array([[1, 2, 3, 4],
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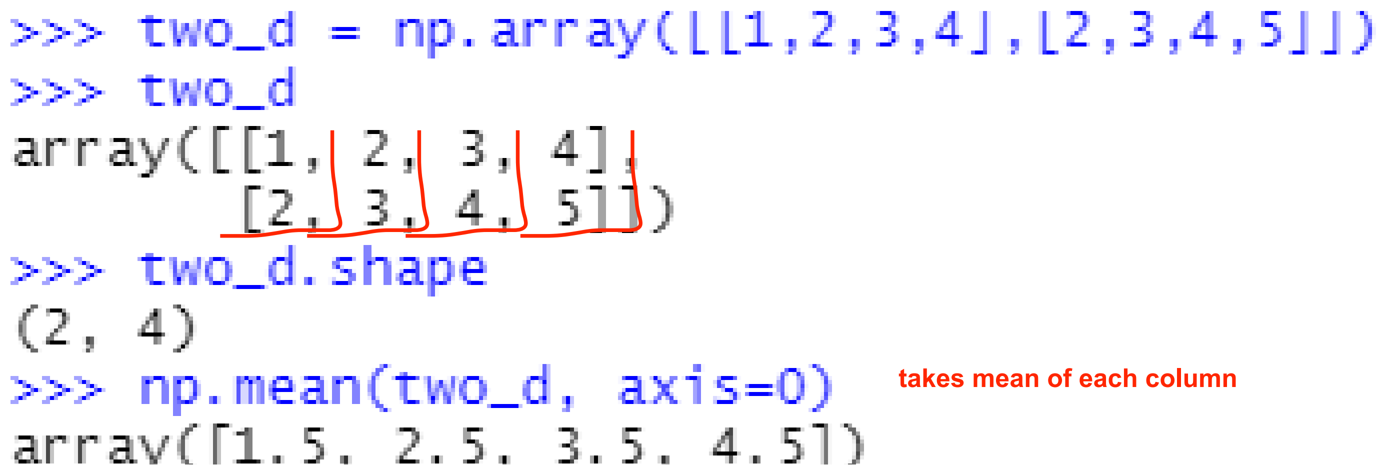
>>> two_d.shape
(2, 4)
>>> np.mean(two_d, axis=0)
```

ARRAYS



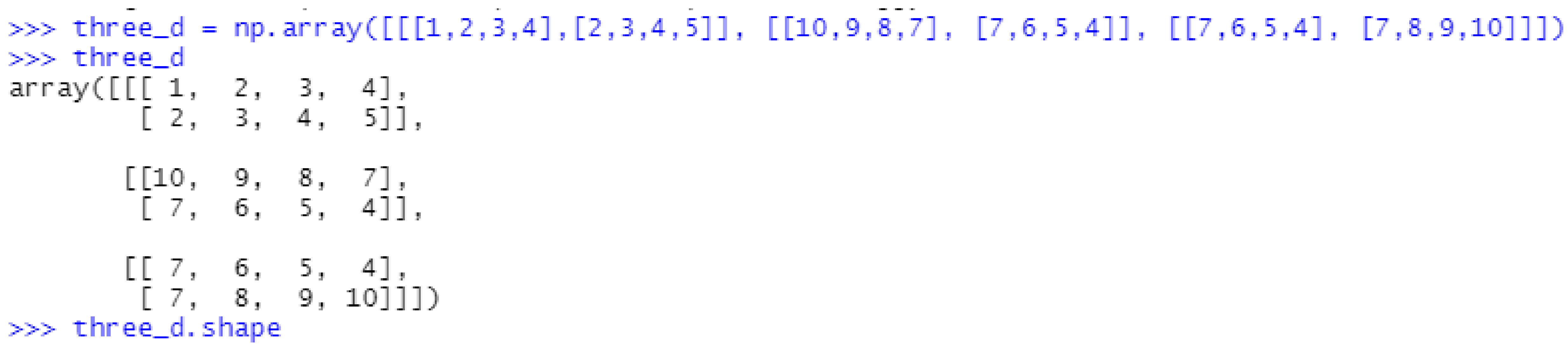
```
>>> two_d = np.array([[1,2,3,4],[2,3,4,5]])
>>> two_d
array([[1, 2, 3, 4],
       [2, 3, 4, 5]])
>>> two_d.shape
(2, 4)
>>> np.mean(two_d, axis=0)
array([1.5, 2.5, 3.5, 4.5])
```

takes mean of each column

~~Mean of each column?~~

Takes mean so that axis 0 is collapsed

ARRAYS

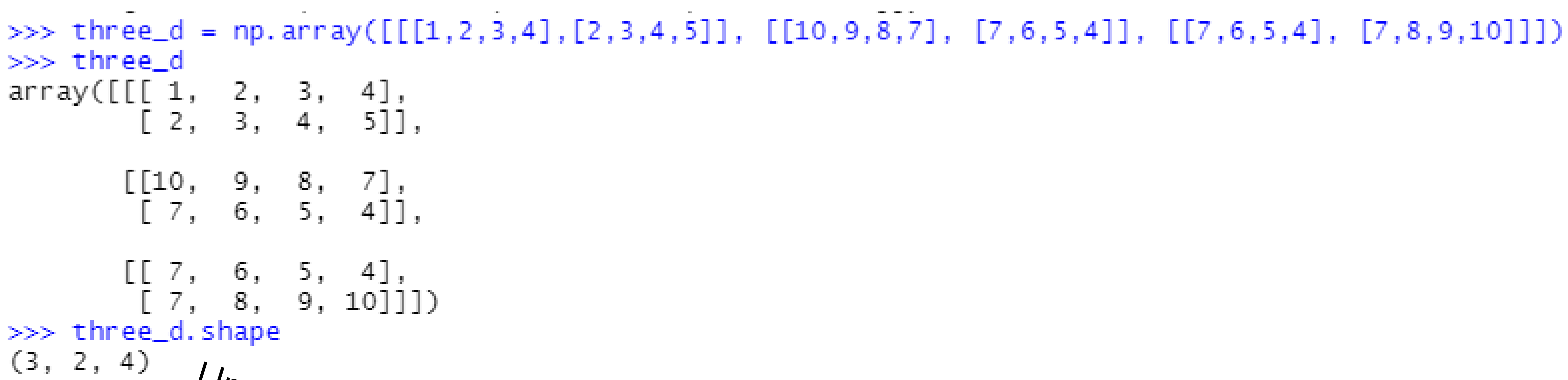


```
>>> three_d = np.array([[[1,2,3,4],[2,3,4,5]], [[10,9,8,7], [7,6,5,4]], [[7,6,5,4], [7,8,9,10]]])
>>> three_d
array([[[ 1,  2,  3,  4],
        [ 2,  3,  4,  5]],

       [[10,  9,  8,  7],
        [ 7,  6,  5,  4]],

       [[ 7,  6,  5,  4],
        [ 7,  8,  9, 10]]])
>>> three_d.shape
```

ARRAYS



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>>> three_d = np.array([[[1,2,3,4],[2,3,4,5]], [[10,9,8,7], [7,6,5,4]], [[7,6,5,4], [7,8,9,10]]])
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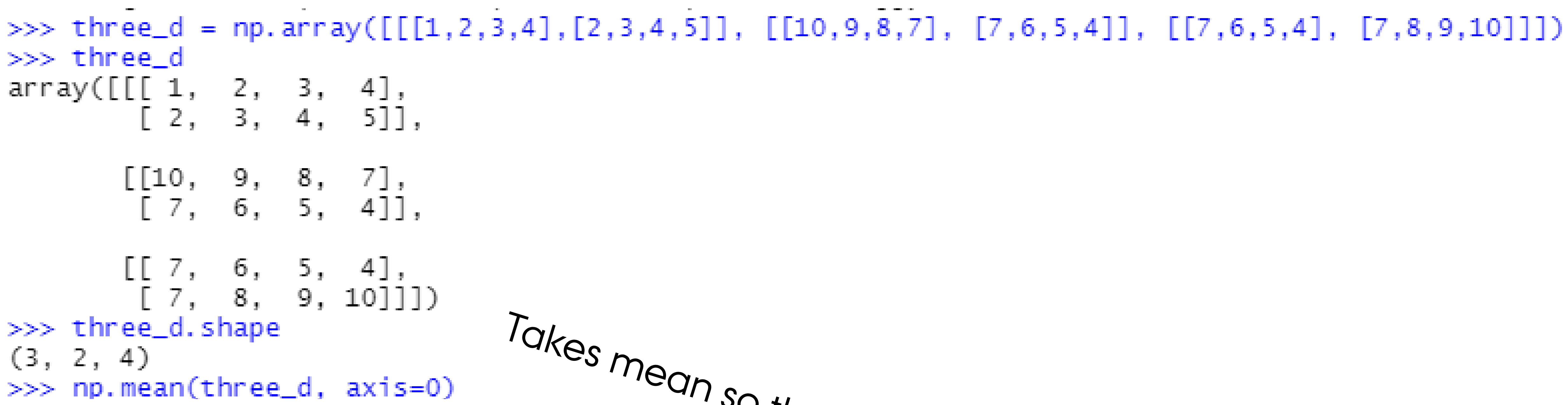
array([[[ 1,  2,  3,  4],
        [ 2,  3,  4,  5]],

       [[10,  9,  8,  7],
        [ 7,  6,  5,  4]],

       [[ 7,  6,  5,  4],
        [ 7,  8,  9, 10]]])
>>> three_d.shape
(3, 2, 4)
```

Unexpected?

ARRAYS



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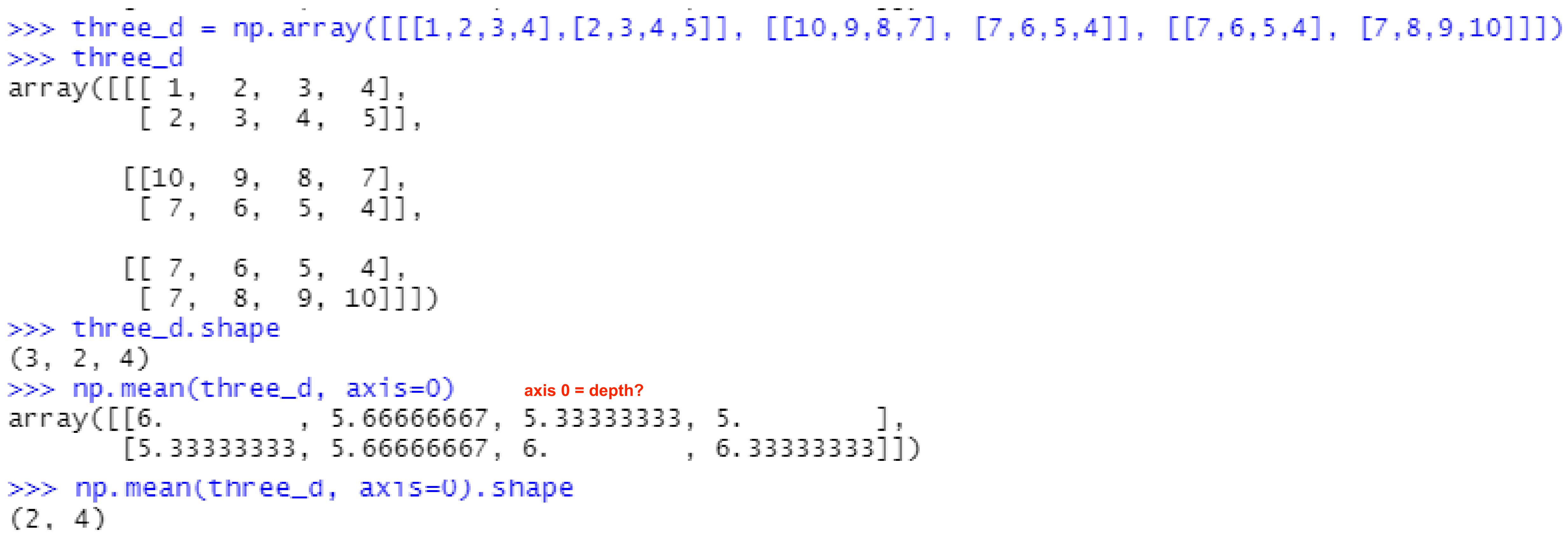
>>> three_d.shape
(3, 2, 4)
>>> np.mean(three_d, axis=0)
```

Takes mean so that axis 0 is collapsed

????

ARRAYS



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>>> three_d.shape
(3, 2, 4)
>>> np.mean(three_d, axis=0)
```

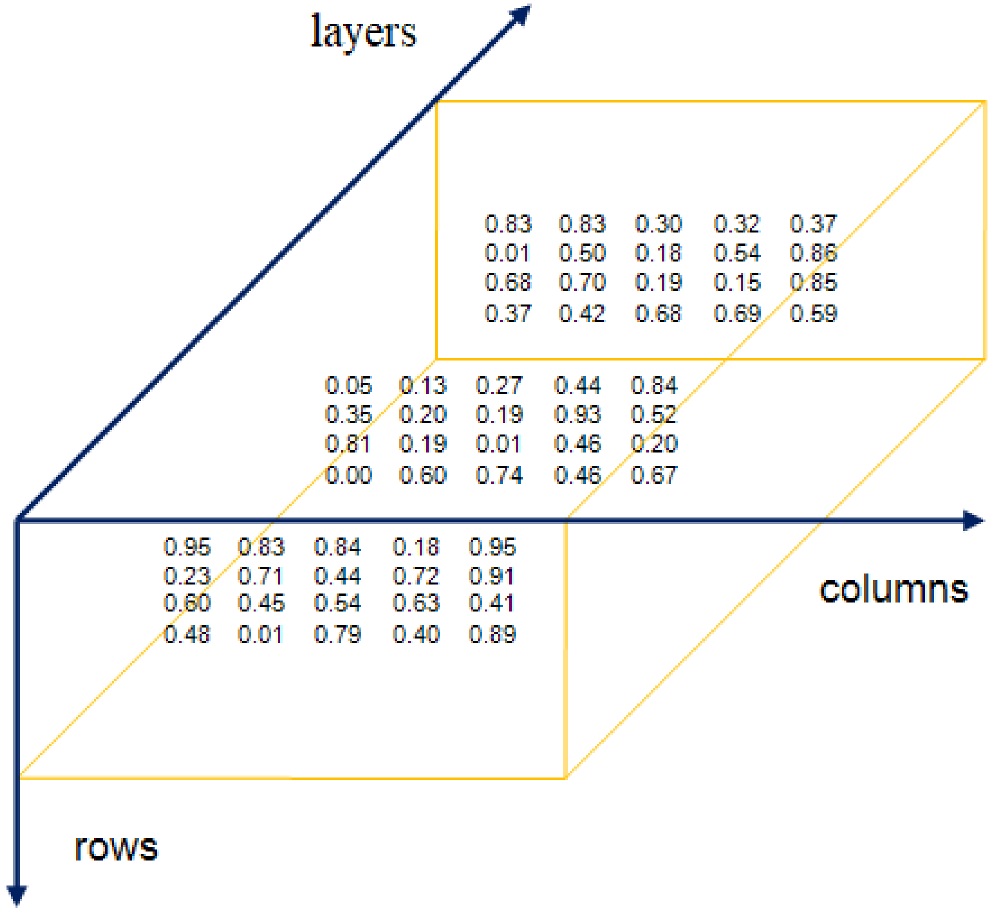
axis 0 = depth?

```
array([[6.        , 5.66666667, 5.33333333, 5.        ],
       [5.33333333, 5.66666667, 6.        , 6.33333333]])
>>> np.mean(three_d, axis=0).shape
(2, 4)
```

ARRAYS

```
>>> np.mean(three_d, axis=0)
```

- What will happen here?
- What are the new dimensions?



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0.01	0.50	0.18	0.54	0.86
0.68	0.70	0.19	0.15	0.85
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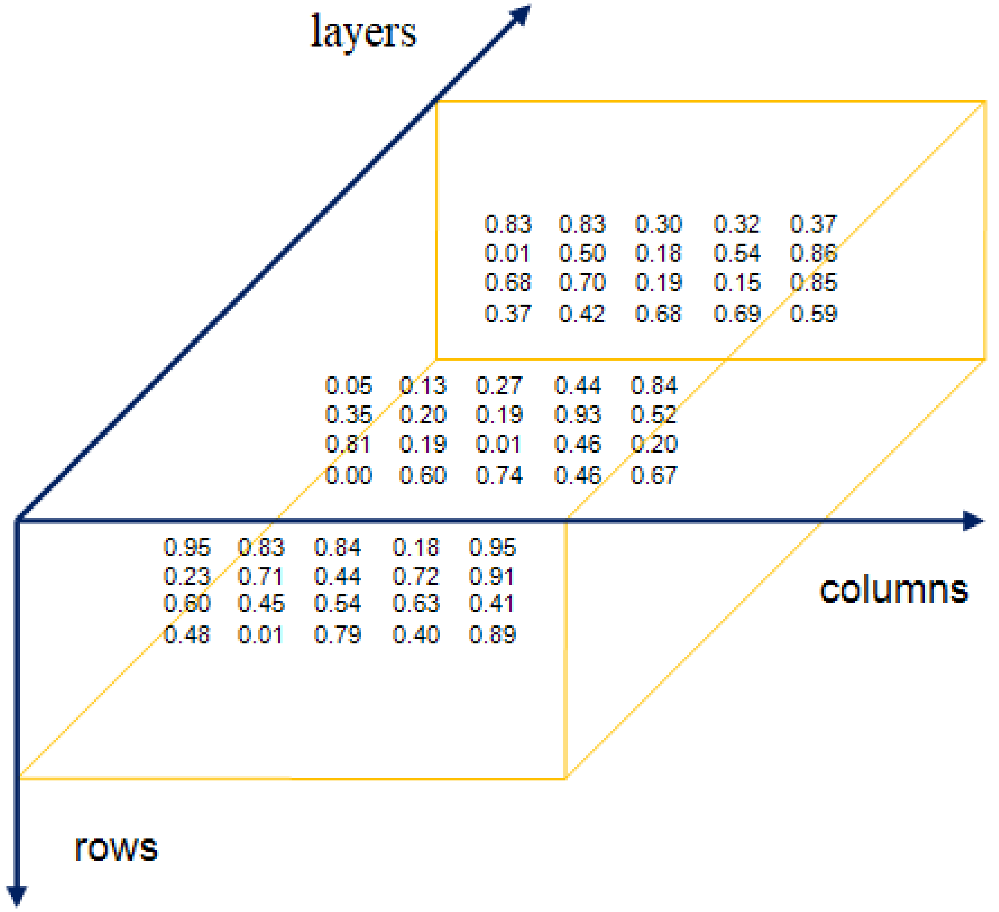
ARRAYS

```
>>> np.mean(three_d, axis=0)
```

- What will happen here?
- What are the new dimensions?
  - *We won't have the dimension[0]*

    -> we won't have depth/layers
  - *New shape = (4,5)*



$$\begin{array}{ccccc} 0.83 & 0.83 & 0.30 & 0.32 & 0.37 \\ 0.01 & 0.50 & 0.18 & 0.54 & 0.86 \\ 0.68 & 0.70 & 0.19 & 0.15 & 0.85 \\ 0.37 & 0.42 & 0.68 & 0.69 & 0.59 \end{array}$$

$$\begin{array}{ccccc} 0.05 & 0.13 & 0.27 & 0.44 & 0.84 \\ 0.35 & 0.20 & 0.19 & 0.93 & 0.52 \\ 0.81 & 0.19 & 0.01 & 0.46 & 0.20 \\ 0.00 & 0.60 & 0.74 & 0.46 & 0.67 \end{array}$$

$$\begin{array}{ccccc} 0.95 & 0.83 & 0.84 & 0.18 & 0.95 \\ 0.23 & 0.71 & 0.44 & 0.72 & 0.91 \\ 0.60 & 0.45 & 0.54 & 0.63 & 0.41 \\ 0.48 & 0.01 & 0.79 & 0.40 & 0.89 \end{array}$$

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ARRAYS AND FLATTENING

ARRAYS

- Collapsing/flattening arrays using np.reshape()

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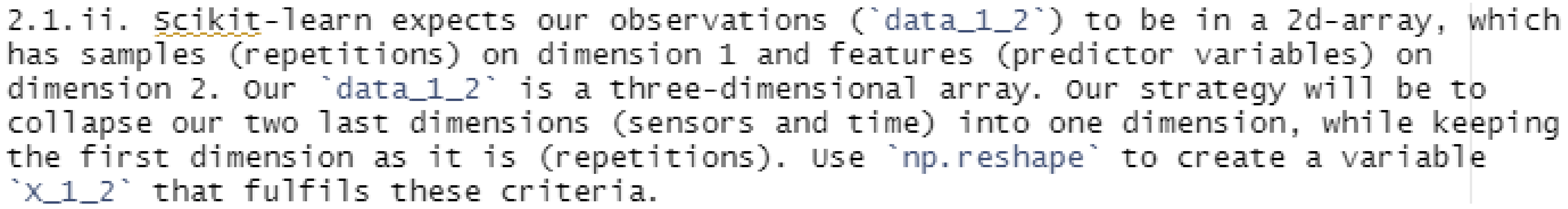
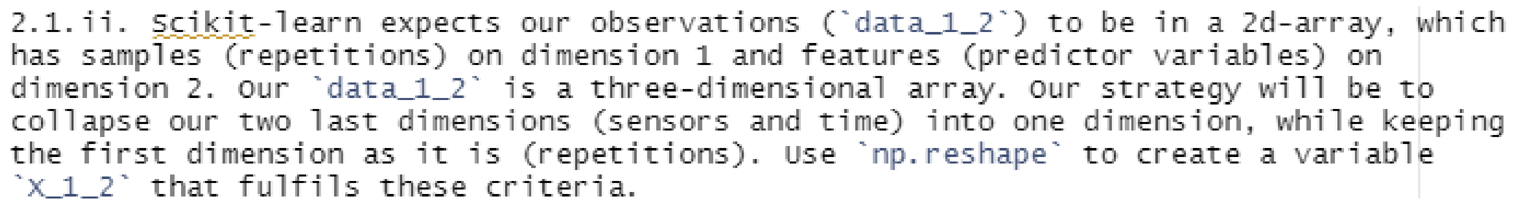

2.1.ii. Scikit-learn expects our observations (`data_1_2`) to be in a 2d-array, which has samples (repetitions) on dimension 1 and features (predictor variables) on dimension 2. Our `data_1_2` is a three-dimensional array. Our strategy will be to collapse our two last dimensions (sensors and time) into one dimension, while keeping the first dimension as it is (repetitions). Use `np.reshape` to create a variable `X_1_2` that fulfils these criteria.

ARRAYS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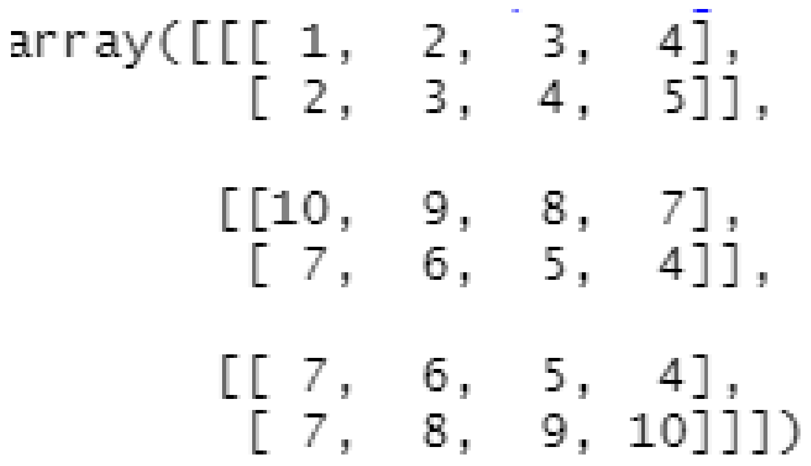
- We want to go from this:


```
array([[[ 1,   2,   3,   4],
        [ 2,   3,   4,   5]],

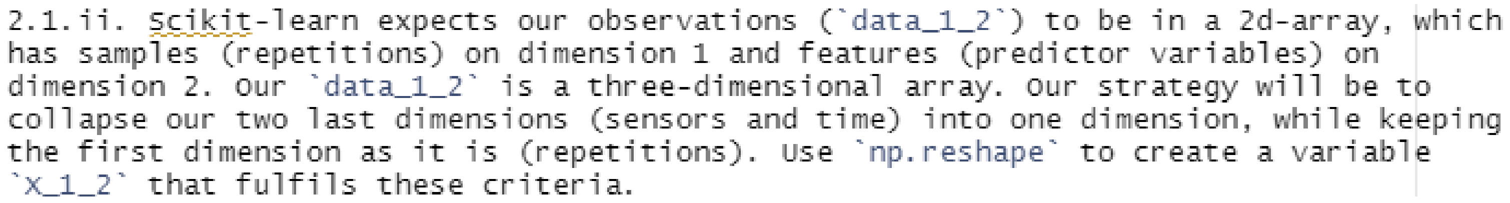
       [[10,   9,   8,   7],
        [ 7,   6,   5,   4]],

       [[ 7,   6,   5,   4],
        [ 7,   8,   9,  10]]])
```

Trials   Sensors   Timepoints

- Of shape: `(3, 2, 4)` 3D

ARRAYS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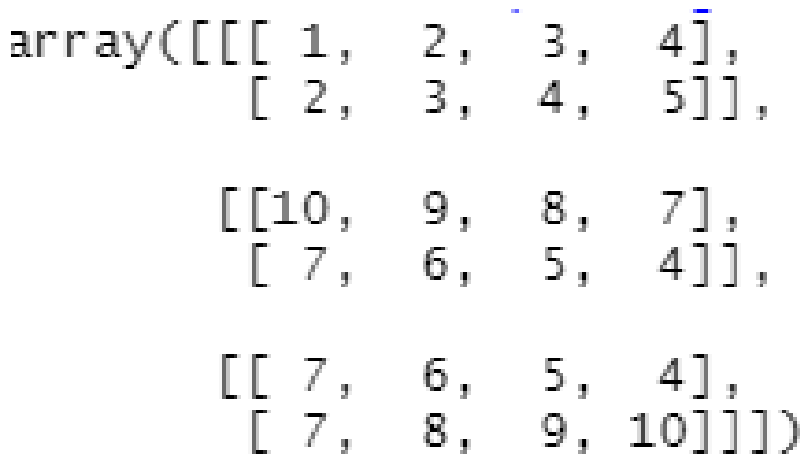
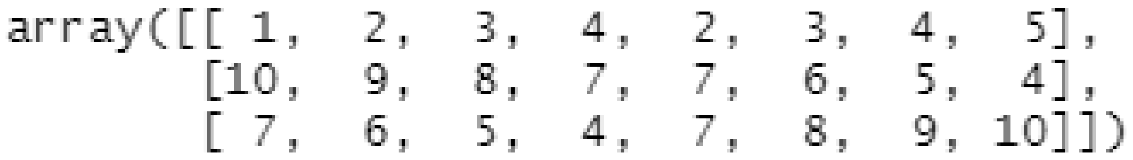

```
array([[[ 1,  2,  3,  4],
        [ 2,  3,  4,  5]],

       [[10,  9,  8,  7],
        [ 7,  6,  5,  4]],

       [[ 7,  6,  5,  4],
        [ 7,  8,  9, 10]]])
```

- To this:

2D


```
array([[ 1,  2,  3,  4,  2,  3,  4,  5],
       [10,  9,  8,  7,  7,  6,  5,  4],
       [ 7,  6,  5,  4,  7,  8,  9, 10]])
```

Trials Sensors Timepoints

- Of shape: (3, 2, 4)

Trials Sensors and timepoints concatenated

- Of shape: (3, 8)

2.1.ii. Scikit-learn expects our observations (`data_1_2`) to be in a 2d-array, which has samples (repetitions) on dimension 1 and features (predictor variables) on dimension 2. Our `data_1_2` is a three-dimensional array. Our strategy will be to collapse our two last dimensions (sensors and time) into one dimension, while keeping the first dimension as it is (repetitions). Use `np.reshape` to create a variable `x_1_2` that fulfils these criteria.

ARRAYS

- We want to go from this:

```
array([[[ 1,  2,  3,  4],
        [ 2,  3,  4,  5]],

       [[10,  9,  8,  7],
        [ 7,  6,  5,  4]],

       [[ 7,  6,  5,  4],
        [ 7,  8,  9, 10]]])
```

- To this:

[s1t1, s1t2 … s2t4]

trial1
trial2
trial3

```
array([[ 1,  2,  3,  4,  2,  3,  4,  5],
       [10,  9,  8,  7,  7,  6,  5,  4],
       [ 7,  6,  5,  4,  7,  8,  9, 10]])
```

Trials Sensors Timepoints

- Of shape: (3, 2, 4)

depth Row Column

hvis ddet var 4D = e.g (3,2,4,2)
Når man reshaper det reshape(3,-1)
- så colapser man into 2D og får (3, 16) = altså 2*4*2

Trials Sensors and timepoints concatenated

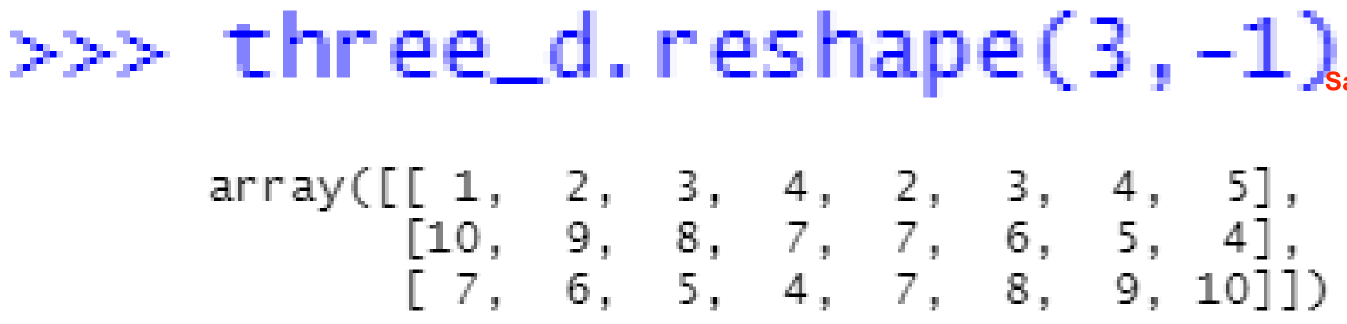
- Of shape: (3, 8)

vitterligt bare 2*4

ARRAYS

3= length of 1's dimension

-1 = all the other data



```
>>> three_d.reshape(3,-1)

        array([[ 1,  2,  3,  4,  2,  3,  4,  5],
               [10,  9,  8,  7,  7,  6,  5,  4],
               [ 7,  6,  5,  4,  7,  8,  9, 10]])
```

Så vi colapser alt andet end sammen ved siden af 3; og så bliver det 2D

hvis ddet var 4D = e.g (3,2,4,2)
Når man reshaper det reshape(3,-1)
- så colapser man into 2D og får (3, 16) = altså 2*4*2

https://numpy.org/doc/stable/reference/generated/numpy.reshape.html

CODE EXAMPLES

CODE EXAMPLES

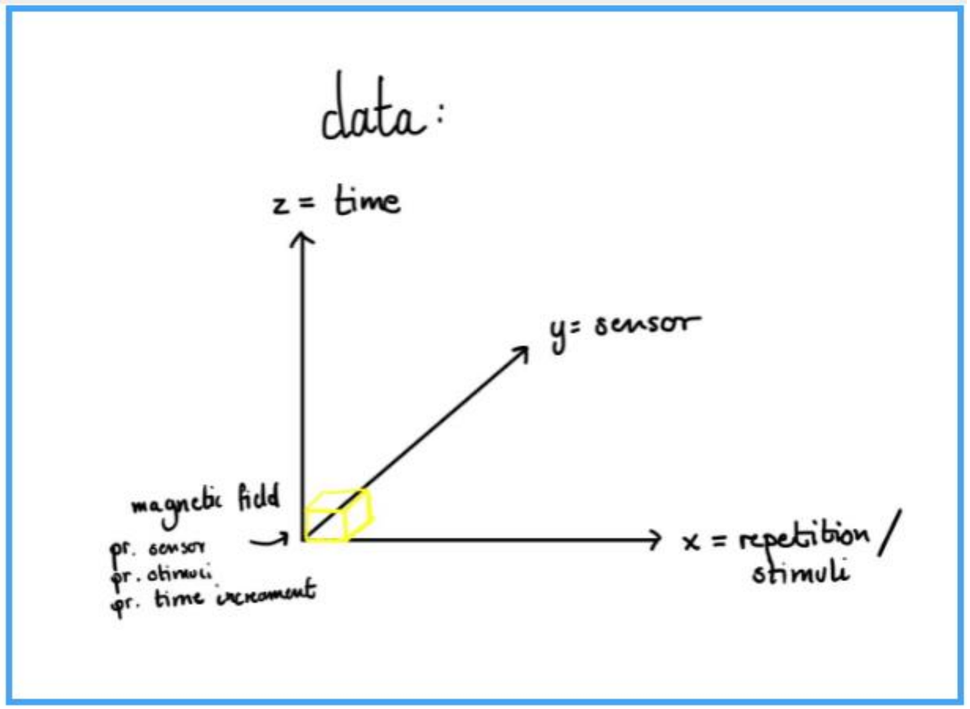
- Can be found on GitHub
  - week_09/support_files/code_for_slides.Rmd
  - week_09/support_files/NumPy.pdf
  - week_09/recapitulation_support_vector_machine.pdf

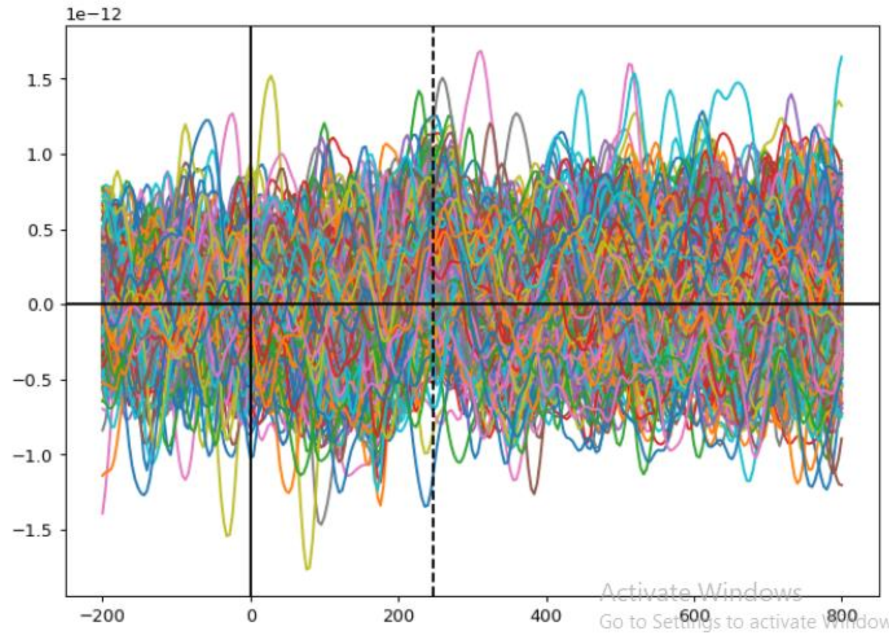
ASSIGNMENT TIPS

ASSIGNMENT TIP

- Conceptual understanding:
  - Have you had neuroscience (and know about epochs/ERP’s/evoked signals)?

ASSIGNMENT TIPS





Plot:

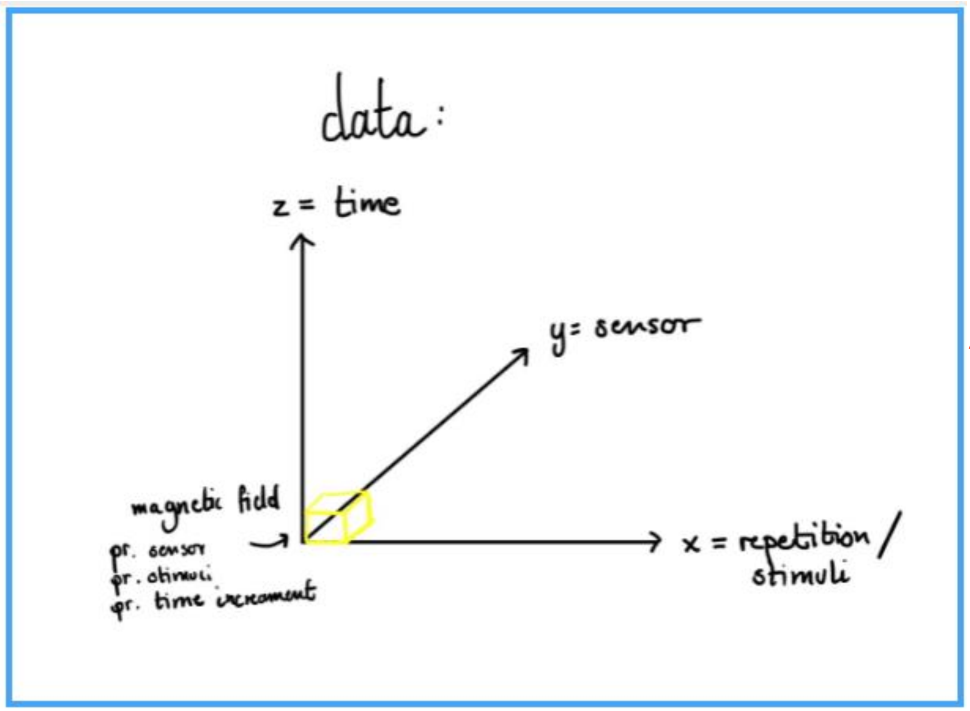
Tesla over time,

for 1 sensor.

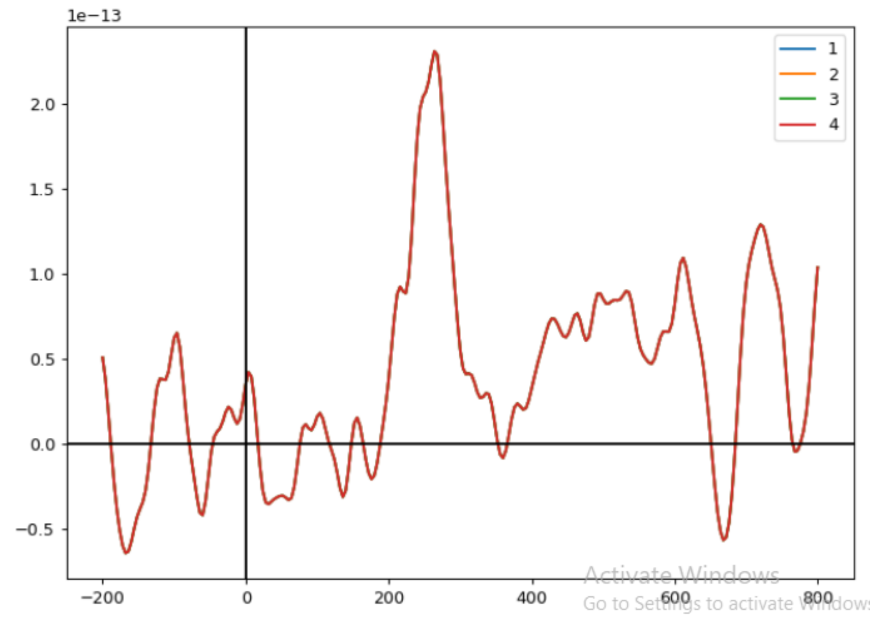
Lines represent

trials

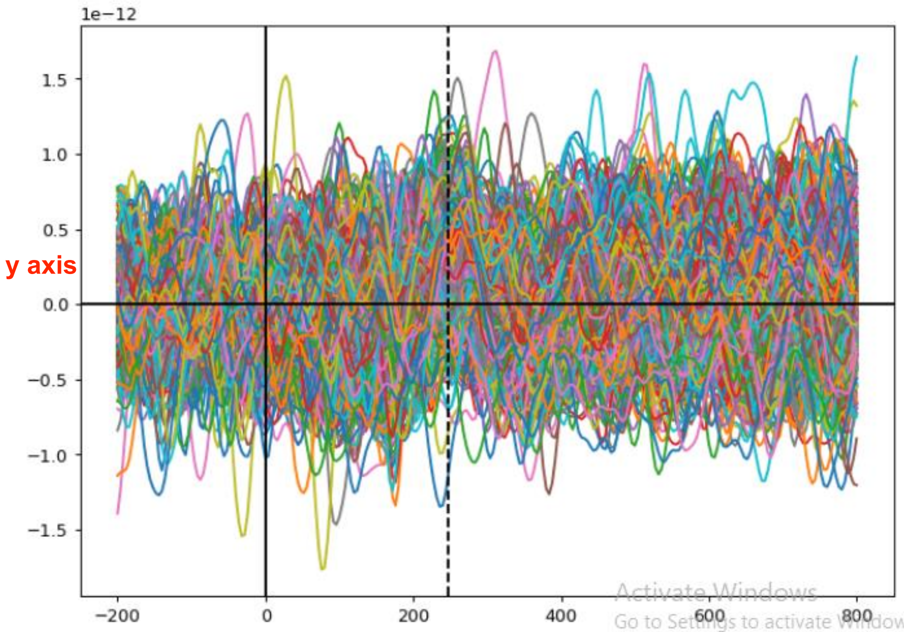
ASSIGNMENT TIPS



Amplitude on y axis



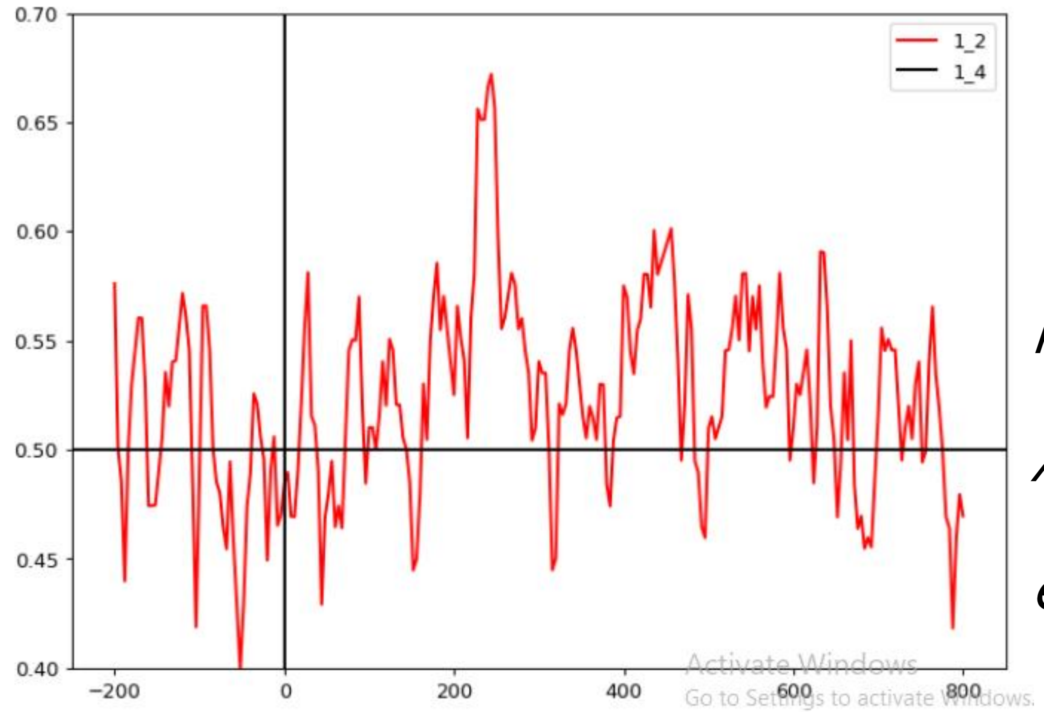
Tesla over time, for 1 sensor. Lines is averaged across trials



Tesla over time, for 1 sensor. Lines represent trials

ASSIGNMENT TIPS

- Conceptual understanding of assignment (as I understand it, at least):
  - Can we train a classifier to predict the PAS rating?



Plot:

Accuracies for 251 models (one for each time point)

ASSIGNMENT TIPS

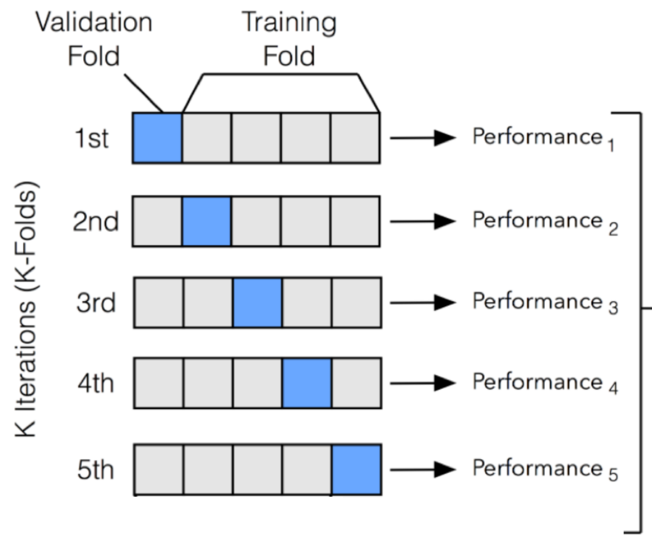
- How to do cross-validation using sklearn? (2.2.ii)
  - cross_val_score()

ASSIGNMENT TIPS

- How to do cross-validation using sklearn? (2.2.ii)
  - cross_val_score()
  - cross_val_score(LinearRegression(), X, y, StratifiedKFold(n_folds=_)
  - This function takes a classifier (class object), data, and a way to split dataset.

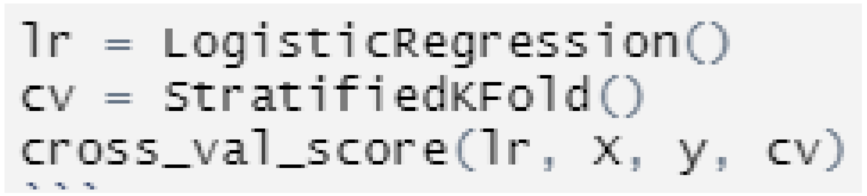
ASSIGNMENT TIPS

- How to do cross-validation using sklearn? (2.2.ii)
  - cross_val_score()
  - cross_val_score(LinearRegression(), X, y, StratifiedKFold(n_folds=_)
  - This function takes a classifier (class object), data, and a way to split dataset.
  - The function them performs k-fold cv:
  - Output:
    - List of validation performances (one for each fold)



ASSIGNMENT TIPS

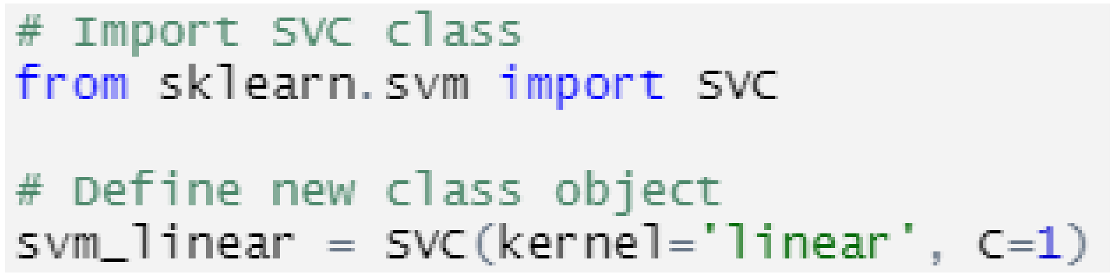
- How to do cross-validation using sklearn? (2.2.ii)



```
lr = LogisticRegression()
cv = StratifiedKFold()
cross_val_score(lr, X, y, cv)
```

ASSIGNMENT TIPS

- Exercise 3:
  - Support vector machines (SVMs)



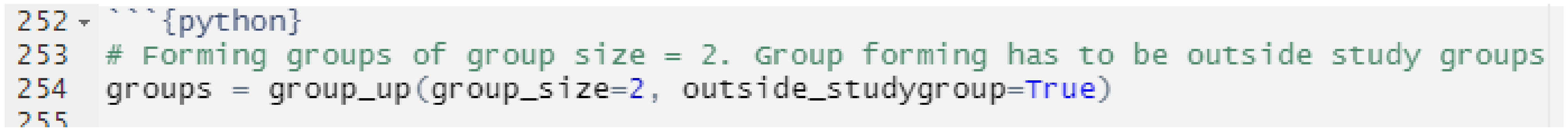
```
# Import SVC class
from sklearn.svm import SVC

# Define new class object
svm_linear = SVC(kernel='linear', C=1)
```

Radial is called "rbf"

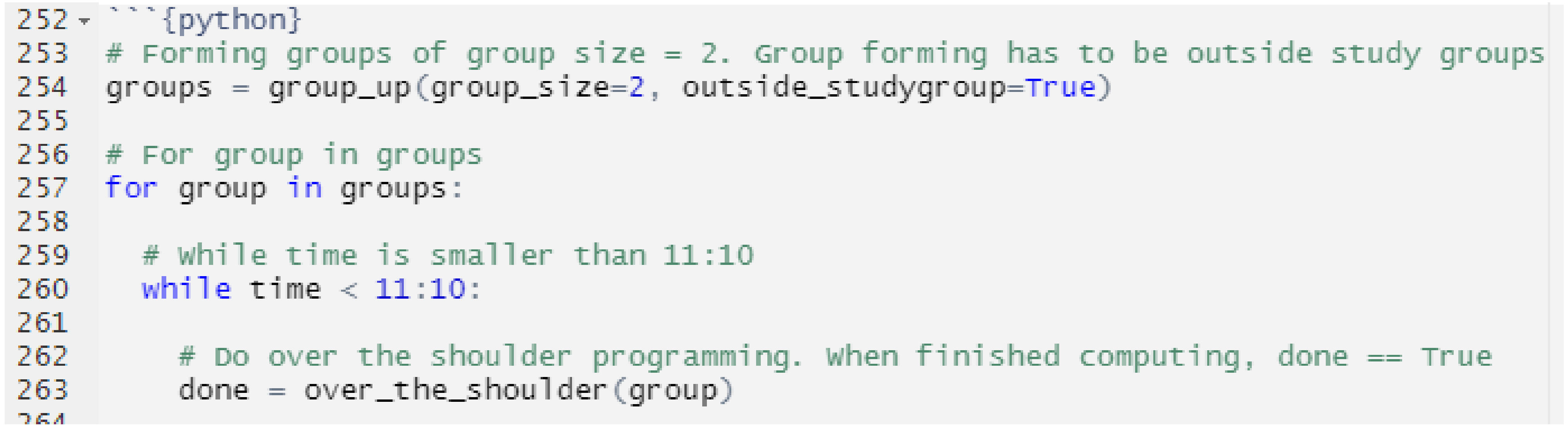
ASSIGNMENT (PEER REVIEW)

ASSIGNMENT (PEER REVIEW)



~~~
```{python}
# Forming groups of group size = 2. Group forming has to be outside study groups
groups = group_up(group_size=2, outside_studygroup=True)
~~~

ASSIGNMENT (PEER REVIEW)



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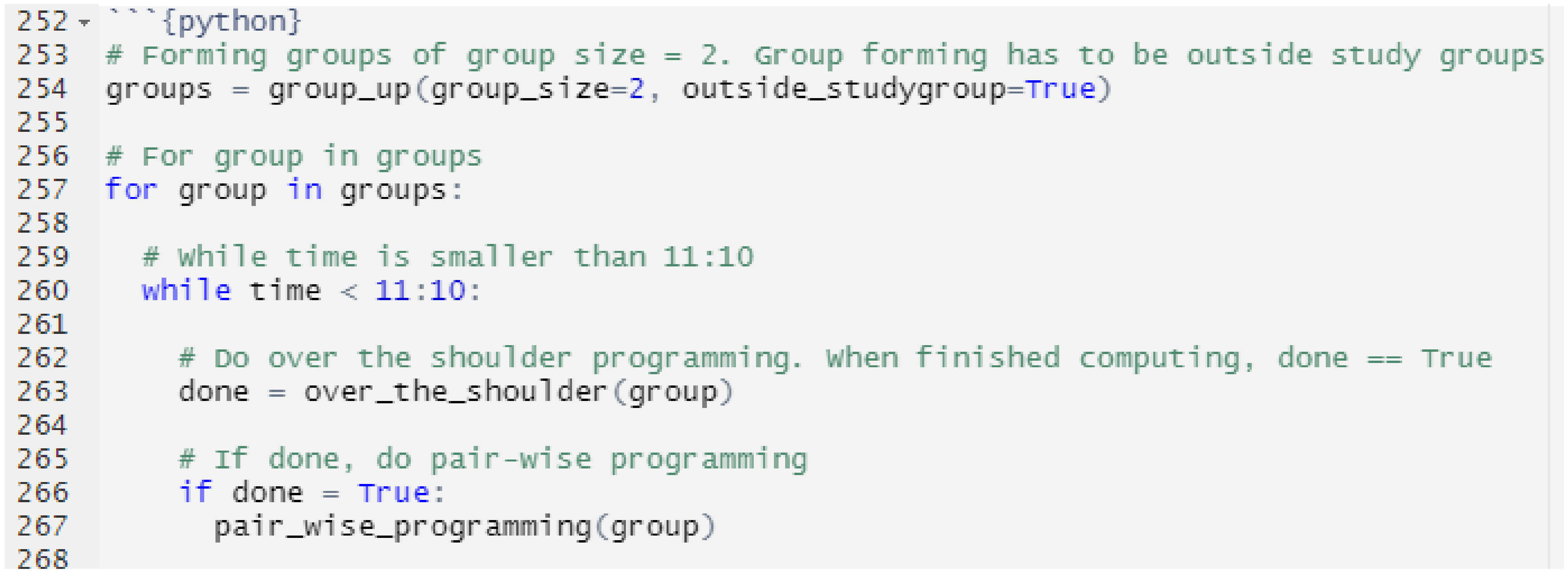
groups = group_up(group_size=2, outside_studygroup=True)

# For group in groups
for group in groups:

  # While time is smaller than 11:10
  while time < 11:10:

    # Do over the shoulder programming. When finished computing, done == True
    done = over_the_shoulder(group)
~~~

ASSIGNMENT (PEER REVIEW)



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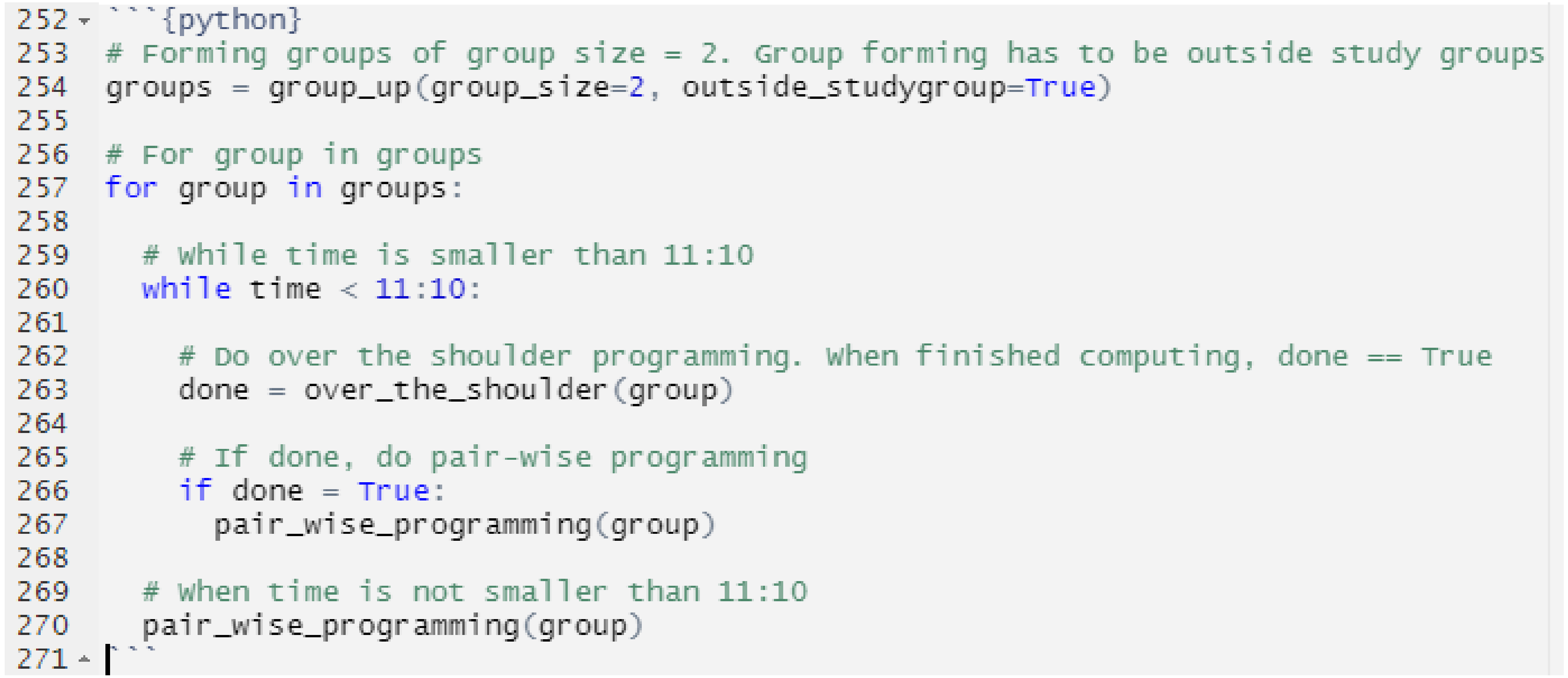
      pair_wise_programming(group)

~~~

ASSIGNMENT (PEER REVIEW)



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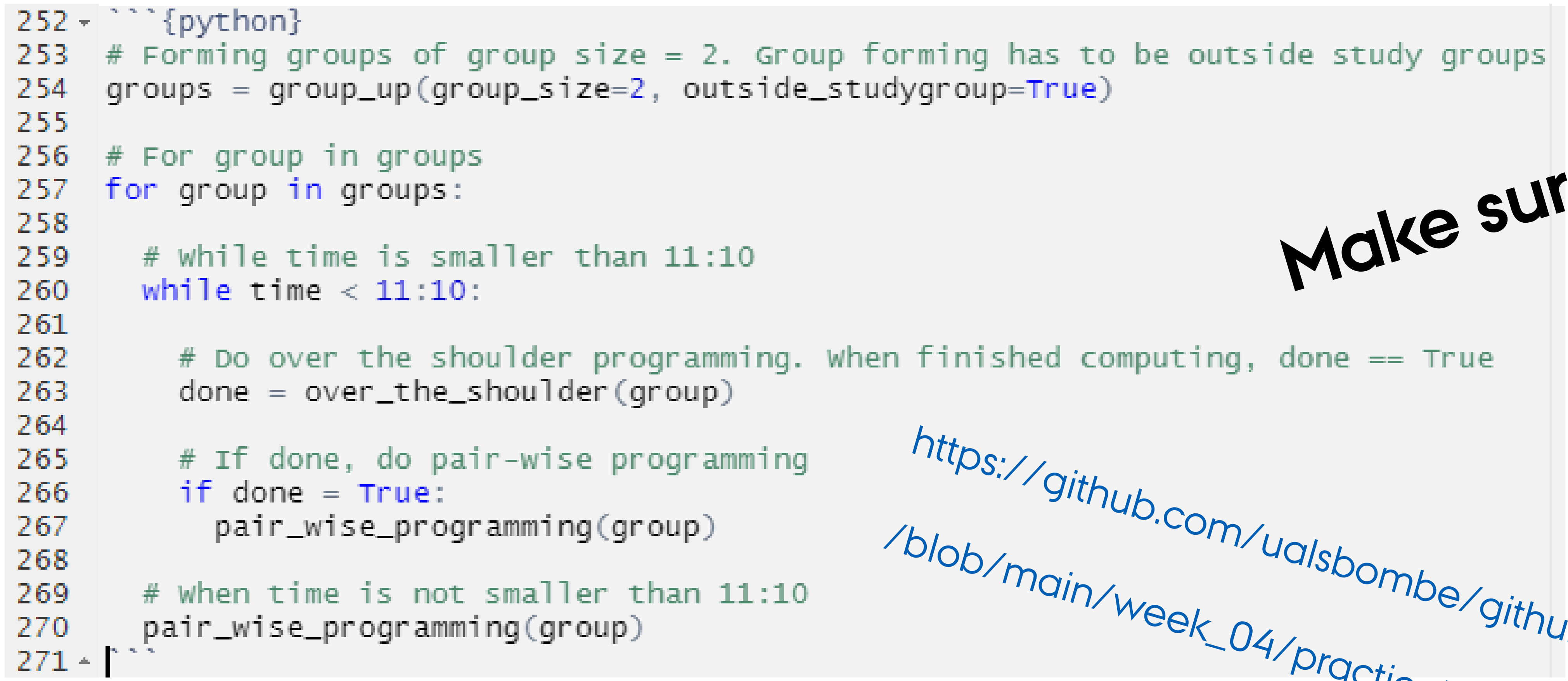
  # When time is not smaller than 11:10
  pair_wise_programming(group)
```
~~~

ASSIGNMENT (PEER REVIEW)



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Make sure to ask!

https://github.com/ualsbombe/github_methods_3/blob/main/week_04/practical_exercise_4.pdf

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