心理與神經資訊學
(Psychoinformatics & Neuroinformatics)

課號: Psy5261

識別碼: 227U9340

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時間: 五234

黃從仁

本週就要繳作業了喔！

More on “import”

- **正規法:**

import random ⇦幫助大家了解函數來源
random.random()

- **取暱稱:**

import random as rnd
rnd.random()

試import this
試import antigravity

- **懶人法:**

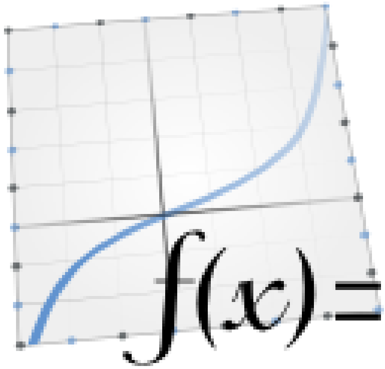
from random import *
random() ⇦別的模組可能有一樣名稱的函數

基本資料分析

(NumPy & Pandas)

自建函數

Try: **(注意縮排用來告訴Python從屬關係)**



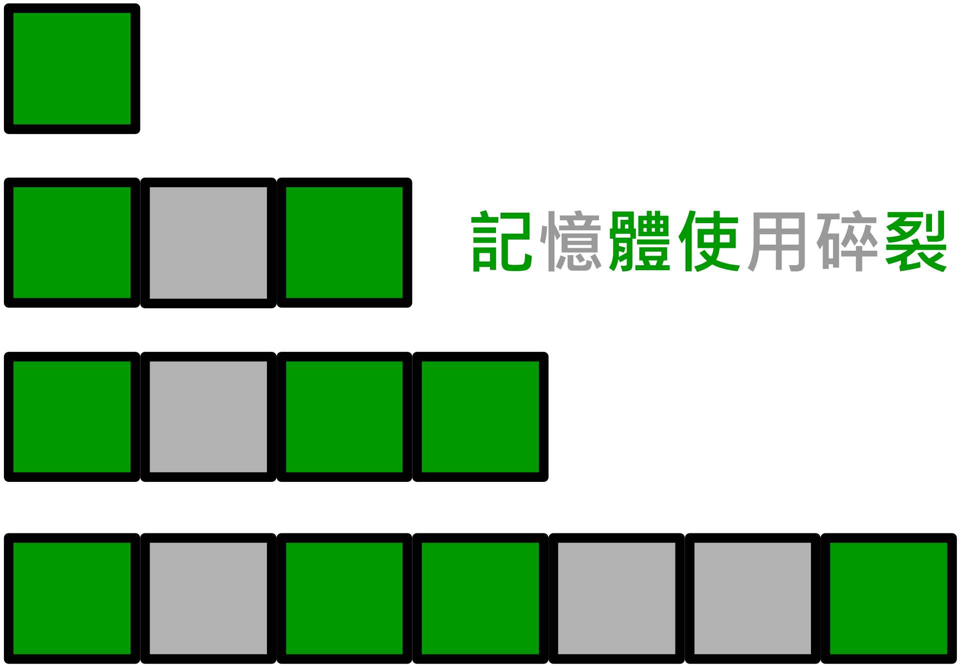
```
import math
def adjust_score(old):
  new=math.sqrt(old)*10
  return new

a=adjust_score(0)
b=adjust_score(60)
print(a,b)
```

處理多個數據的需求

```
print(adjust_score(range(0,101,10)))
 TypeError: a float is required
```

解法1a:利用迴圈

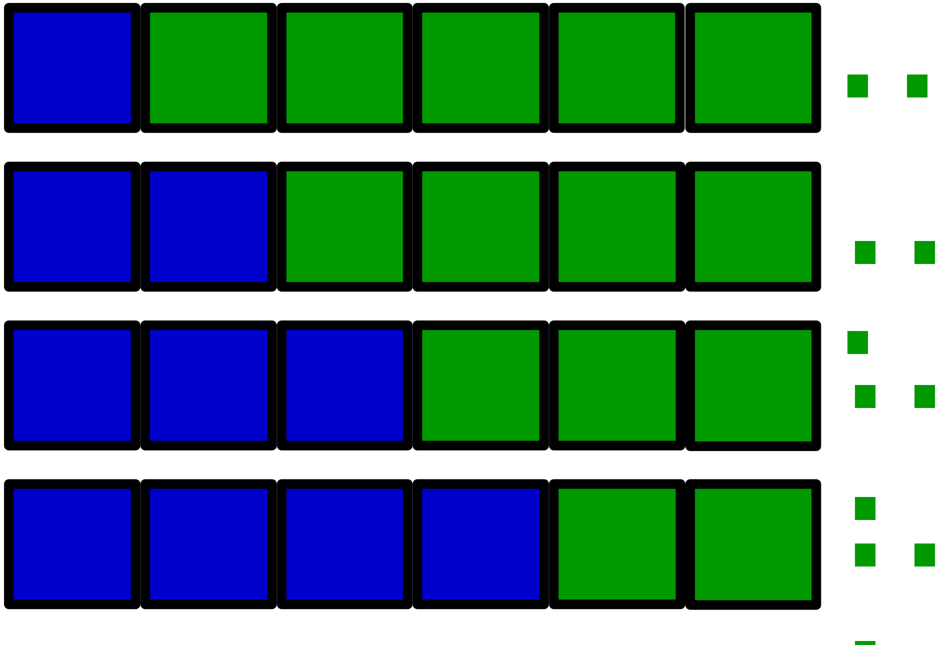
```
scores=[]
for i in range(0,101,10):
 scores.append(adjust_score(i))
 #scores=scores+[adjust_score(i)]
print(scores)
```



記憶體使用碎裂

解法1b:利用迴圈

```
old=range(0,101,10)
N=len(old)
scores=[0.]*N
for i in range(N):
 scores[i]=adjust_score(i)
print(scores)
```



序列計算vs.平行計算

調 調 調 調 調 調 調 調 調 調

0 10 20 30 40 50 60 70 80 90 100

(只有1條生產線)

調 調 調 調 調 調 調 調 調 調 調

0 10 20 30 40 50 60 70 80 90 100

(共有11條生產線)

解法2:利用內建函數map

```
import math
def adjust_score(old):
 new=math.sqrt(old)*10
 return new
```

套上去

```
print(list(map(adjust_score,range(0,101,10))))
```

multiprocessing的map才是真的平行計算
以後講Big Data的時候會再看到類似觀念

資料科學家真實案例

某臺大畢業生去Facebook應徵時

請解釋何謂

MapReduce?

.... (默然)

解法3: 利用NumPy (1行!)

```
import numpy as np
(np.arange(0,101,10)**0.5)*10 #但仍是單核計算
```

NumPy的arange和內建的range有何不同?

```
a=range(0,101,10)
b=np.arange(0,101,10)
a+1
b+1
a+a
b+b
a*3
b*3
```

⇐ **向量加法(c,d)+(e,f)=(c+e,d+f)**
因此element-wise的平行運算又稱
向量化(vectorization)

另一個例子:亂數

若要產生100個亂數

用random.random做100次:

```
import random
r=[]
for i in range(100):
   r.append(random.random())
```

用numpy.random.rand做1次:

```
import numpy as np
r=np.random.rand(100)
```

List vs. NumPy Array (1/2)

List很自由，可以亂塞資料

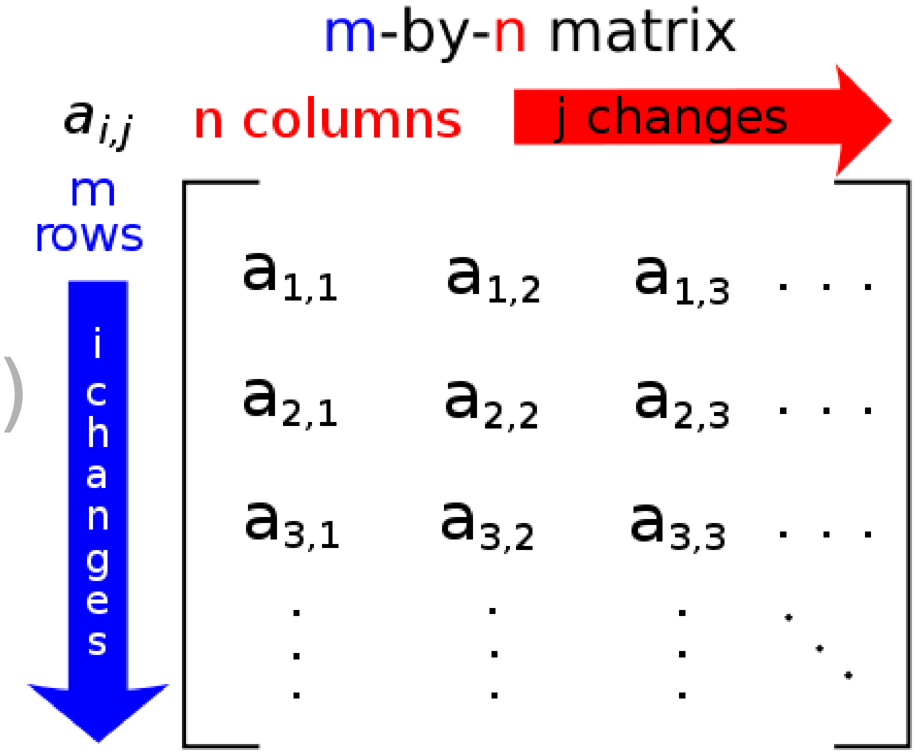
```
a=[[5566,'never dies'],5,[[['R',range(3)],'doll'],6]]
a[0] #[5566, 'never dies']
a[1] #5
a[0][0] #5566
a[2][0][0][1] #range(0,3)
```

Tip:想成樹狀結構就不會昏頭了

List vs. NumPy Array (2/2)

通常Array內所有元素皆為數字以方便計算
結構上較List方正(2維平面, 3維方塊, etc.)

```
a=np.array([range(3),np.random.rand(3)])
a.dtype #dtype('float64')
a.T # transpose:矩陣轉置
a[0][2] #2.0
a[0,2] #2.0
a[0,:] #array([ 0.,  1.,  2.])
a[0,1:3] #array([ 1.,  2.])
np.mean(a)
np.mean(a,0)
np.mean(a,1)
```


m-by-n matrix
$a_{i,j}$
n columns
j changes
m rows
i changes
$a_{1,1}$ $a_{1,2}$ $a_{1,3}$ . . .
$a_{2,1}$ $a_{2,2}$ $a_{2,3}$ . . .
$a_{3,1}$ $a_{3,2}$ $a_{3,3}$ . . .

實驗設計

Randomized design:

```
import numpy as np
trials=np.random.randint(0,3,15)
```

Counterbalanced design:

```
import numpy as np
trials=np.array(list(range(3))*5) #3條件各5次
trials=np.random.permutation(trials)

for t in trials:
  print(t)
  if t==0:
    print("I got you!")
```

資料分析(1/2)

實驗條件	正確與否	反應時間
1	1	-1 (timed out)
0	1	0.444112
1	0	-1 (timed out)
1	0	2.597051
2	1	1.927228
...	...	...

```
import numpy as np
data=np.loadtxt('exp_subj0.txt') # 匯入資料
valid=(data[:,2]>0) #尋找RT>0的valid trials
data=data[valid,:] #平均正確率 & 平均反應時間
print(np.mean(data[:,1]),np.mean(data[:,2]))
```

資料分析(2/2)

資料應該要分組別分析

```
Ngroups=np.unique(data[:,0]).size #3
groups=[0]*Ngroups #[0, 0, 0]
for i in range(Ngroups):
  selector=(data[:,0]==i) #判斷組別為0, 1, or 2
  groups[i]=data[selector,:] #用List來存Array!
print(groups[0]) #印出第0組來看看
```

Python For Data Science *Cheat Sheet*

NumPy Basics

Learn Python for Data Science Interactively at www.DataCamp.com

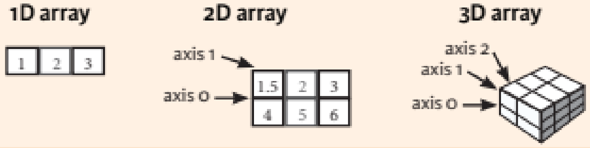
NumPy

The **NumPy** library is the core library for scientific computing in Python. It provides a high-performance multidimensional array object, and tools for working with these arrays.

Use the following import convention:

```
>>> import numpy as np
```

NumPy Arrays


1D array · 2D array · 3D array

Creating Arrays

```
>>> a = np.array([1,2,3])
>>> b = np.array([(1.5,2,3), (4,5,6)], dtype = float)
>>> c = np.array([[(1.5,2,3), (4,5,6)], [(3,2,1), (4,5,6)]],
                  dtype = float)
```

Initial Placeholders

`>>> np.zeros((3,4))`	Create an array of zeros
`>>> np.ones((2,3,4),dtype=np.int16)`	Create an array of ones
`>>> d = np.arange(10,25,5)`	Create an array of evenly spaced values (step value)
`>>> np.linspace(0,2,9)`	Create an array of evenly spaced values (number of samples)
`>>> e = np.full((2,2),7)`	Create a constant array
`>>> f = np.eye(2)`	Create a 2X2 identity matrix
`>>> np.random.random((2,2))`	Create an array with random values
`>>> np.empty((3,2))`	Create an empty array

I/O

Saving & Loading On Disk

```
>>> np.save('my_array', a)
>>> np.savez('array.npz', a, b)
>>> np.load('my_array.npy')
```

Saving & Loading Text Files

```
>>> np.loadtxt("myfile.txt")
>>> np.genfromtxt("my_file.csv", delimiter=',')
>>> np.savetxt("myarray.txt", a, delimiter=" ")
```

Data Types

`>>> np.int64`	Signed 64-bit integer types
`>>> np.float32`	Standard double-precision floating point
`>>> np.complex`	Complex numbers represented by 128 floats
`>>> np.bool`	Boolean type storing `TRUE` and `FALSE` values
`>>> np.object`	Python object type
`>>> np.string_`	Fixed-length string type
`>>> np.unicode_`	Fixed-length unicode type

Inspecting Your Array

`>>> a.shape`	Array dimensions
`>>> len(a)`	Length of array
`>>> b.ndim`	Number of array dimensions
`>>> e.size`	Number of array elements
`>>> b.dtype`	Data type of array elements
`>>> b.dtype.name`	Name of data type
`>>> b.astype(int)`	Convert an array to a different type

Asking For Help

```
>>> np.info(np.ndarray.dtype)
```

Array Mathematics

Arithmetic Operations

`>>> g = a - b`
`array([[-0.5,  0. ,  0. ],`
`       [-3. , -3. , -3. ]])`
	Subtraction

`>>> np.subtract(a,b)`	Subtraction

`>>> b + a`
`array([[ 2.5,  4. ,  6. ],`
`       [ 5. ,  7. ,  9. ]])`
	Addition

`>>> np.add(b,a)`	Addition

`>>> a / b`
`array([[ 0.66666667,  1.        ,  1.        ],`
`       [ 0.25      ,  0.4       ,  0.5       ]])`
	Division

`>>> np.divide(a,b)`	Division

`>>> a * b`
`array([[  1.5,   4. ,   9. ],`
`       [  4. ,  10. ,  18. ]])`
	Multiplication

`>>> np.multiply(a,b)`	Multiplication
`>>> np.exp(b)`	Exponentiation
`>>> np.sqrt(b)`	Square root
`>>> np.sin(a)`	Print sines of an array
`>>> np.cos(b)`	Element-wise cosine
`>>> np.log(a)`	Element-wise natural logarithm

`>>> e.dot(f)`
`array([[ 7.,  7.],`
`       [ 7.,  7.]])`
	Dot product

Comparison

`>>> a == b`
`array([[False,  True,  True],`
`       [False, False, False]], dtype=bool)`
	Element-wise comparison

`>>> a < 2`
`array([True, False, False], dtype=bool)`
	Element-wise comparison

`>>> np.array_equal(a, b)`	Array-wise comparison

Aggregate Functions

`>>> a.sum()`	Array-wise sum
`>>> a.min()`	Array-wise minimum value
`>>> b.max(axis=0)`	Maximum value of an array row
`>>> b.cumsum(axis=1)`	Cumulative sum of the elements
`>>> a.mean()`	Mean
`>>> b.median()`	Median
`>>> a.corrcoef()`	Correlation coefficient
`>>> np.std(b)`	Standard deviation

Copying Arrays

`>>> h = a.view()`	Create a view of the array with the same data
`>>> np.copy(a)`	Create a copy of the array
`>>> h = a.copy()`	Create a deep copy of the array

Sorting Arrays

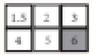
`>>> a.sort()`	Sort an array
`>>> c.sort(axis=0)`	Sort the elements of an array's axis

Subsetting, Slicing, Indexing

Also see Lists

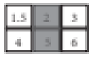
Subsetting

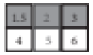
`>>> a[2]`
`3`
		Select the element at the 2nd index

`>>> b[1,2]`
`6.0`
		Select the element at row 1 column 2 (equivalent to `b[1][2]`)

Slicing

`>>> a[0:2]`
`array([1, 2])`
		Select items at index 0 and 1

`>>> b[0:2,1]`
`array([ 2.,  5.])`
		Select items at rows 0 and 1 in column 1

`>>> b[:1]`
`array([[1.5, 2., 3.]])`
		Select all items at row 0 (equivalent to `b[0:1, :]`)

`>>> c[1,...]`
`array([[[ 3.,  2.,  1.],`
`        [ 4.,  5.,  6.]]])`
		Same as `[1,:,:]`

`>>> a[ : :-1]`
`array([3, 2, 1])`
		Reversed array `a`

Boolean Indexing

`>>> a[a<2]`
`array([1])`
		Select elements from `a` less than 2

Fancy Indexing

`>>> b[[1, 0, 1, 0],[0, 1, 2, 0]]`
`array([ 4. , 2. , 6. , 1.5])`
	Select elements `(1,0)`,`(0,1)`,`(1,2)` and `(0,0)`

`>>> b[[1, 0, 1, 0]][:,[0,1,2,0]]`
`array([[ 4. ,5. , 6. , 4. ],`
`       [ 1.5, 2. , 3. , 1.5],`
`       [ 4. , 5. , 6. , 4. ],`
`       [ 1.5, 2. , 3. , 1.5]])`
	Select a subset of the matrix's rows and columns

Array Manipulation

Transposing Array

`>>> i = np.transpose(b)`	Permute array dimensions
`>>> i.T`	Permute array dimensions

Changing Array Shape

`>>> b.ravel()`	Flatten the array
`>>> g.reshape(3,-2)`	Reshape, but don't change data

Adding/Removing Elements

`>>> h.resize((2,6))`	Return a new array with shape (2,6)
`>>> np.append(h,g)`	Append items to an array
`>>> np.insert(a, 1, 5)`	Insert items in an array
`>>> np.delete(a,[1])`	Delete items from an array

Combining Arrays

`>>> np.concatenate((a,d),axis=0)`
`array([ 1,  2,  3, 10, 15, 20])`
	Concatenate arrays

`>>> np.vstack((a,b))`
`array([[ 1. ,  2. ,  3. ],`
`       [ 1.5,  2. ,  3. ],`
`       [ 4. ,  5. ,  6. ]])`
	Stack arrays vertically (row-wise)

`>>> np.r_[e,f]`	Stack arrays vertically (row-wise)

`>>> np.hstack((e,f))`
`array([[ 7.,  7.,  1.,  0.],`
`       [ 7.,  7.,  0.,  1.]])`
	Stack arrays horizontally (column-wise)

`>>> np.column_stack((a,d))`
`array([[ 1, 10],`
`       [ 2, 15],`
`       [ 3, 20]])`
	Create stacked column-wise arrays

`>>> np.c_[a,d]`	Create stacked column-wise arrays

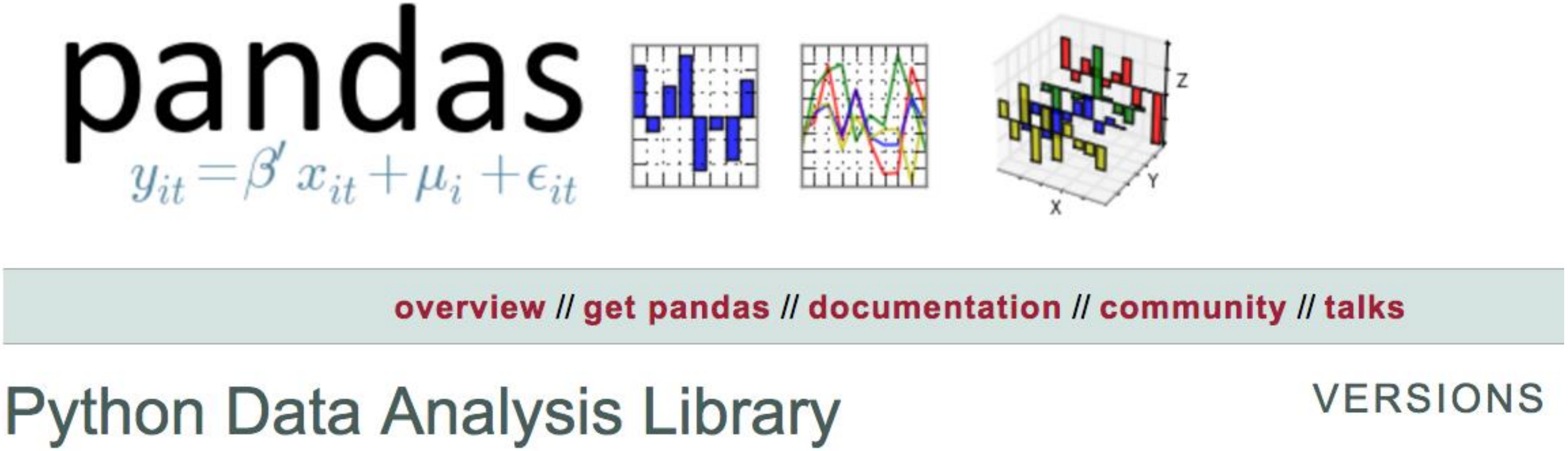
Splitting Arrays

`>>> np.hsplit(a,3)`
`[array([1]),array([2]),array([3])]`
	Split the array horizontally at the 3rd index

`>>> np.vsplit(c,2)`
`[array([[[ 1.5,  2. ,  1. ],`
`        [ 4. ,  5. ,  6. ]]]),`
` array([[[ 3.,  2.,  3.],`
`        [ 4.,  5.,  6.]]])]`
	Split the array vertically at the 2nd index

模仿R的Pandas

DataFrame便於整理/分析混合型資料&時間序列



pandas

$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

overview // get pandas // documentation // community // talks

Python Data Analysis Library

VERSIONS

有必看的小抄和大抄

```
import pandas as pd
df=pd.read_table('exp_subj0.txt',sep=' ')
df.describe() # ~ R's summary
```

Data Wrangling with pandas Cheat Sheet http://pandas.pydata.org

Syntax – Creating DataFrames

	a	b	c
1	4	7	10
2	5	8	11
3	6	9	12

```
df = pd.DataFrame(
          {"a" : [4 ,5, 6],
           "b" : [7, 8, 9],
           "c" : [10, 11, 12]},
        index = [1, 2, 3])
```

Specify values for each column.

```
df = pd.DataFrame(
     [[4, 7, 10],
      [5, 8, 11],
      [6, 9, 12]],
     index=[1, 2, 3],
     columns=['a', 'b', 'c'])
```

Specify values for each row.

		a	b	c
n	v			
d	1	4	7	10
	2	5	8	11
e	2	6	9	12

```
df = pd.DataFrame(
          {"a" : [4 ,5, 6],
           "b" : [7, 8, 9],
           "c" : [10, 11, 12]},
index = pd.MultiIndex.from_tuples(
          [('d',1),('d',2),('e',2)],
             names=['n','v'])))
```

Create DataFrame with a MultiIndex

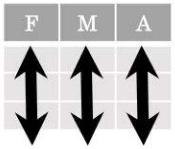
Method Chaining

Most pandas methods return a DataFrame so that another pandas method can be applied to the result. This improves readability of code.

```
df = (pd.melt(df)
        .rename(columns={
                'variable' : 'var',
                'value' : 'val'})
        .query('val >= 200')
     )
```

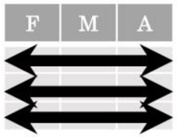
Tidy Data – A foundation for wrangling in pandas

In a tidy data set:



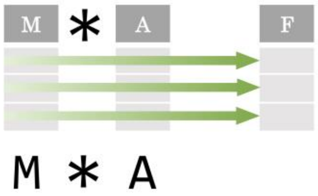
Each **variable** is saved in its own **column**

&

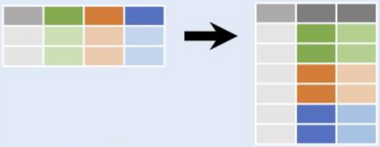


Each **observation** is saved in its own **row**

Tidy data complements pandas's **vectorized operations**. pandas will automatically preserve observations as you manipulate variables. No other format works as intuitively with pandas.

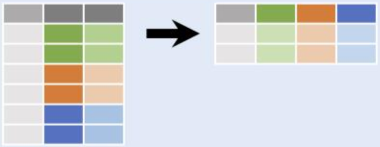


Reshaping Data – Change the layout of a data set



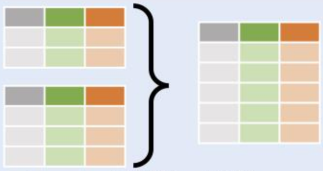
```
pd.melt(df)
```

Gather columns into rows.



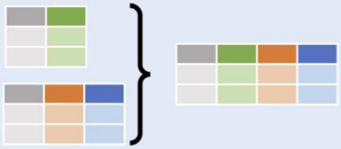
```
df.pivot(columns='var', values='val')
```

Spread rows into columns.



```
pd.concat([df1,df2])
```

Append rows of DataFrames



```
pd.concat([df1,df2], axis=1)
```

Append columns of DataFrames

```
df.sort_values('mpg')
```

Order rows by values of a column (low to high).

```
df.sort_values('mpg',ascending=False)
```

Order rows by values of a column (high to low).

```
df.rename(columns = {'y':'year'})
```

Rename the columns of a DataFrame

```
df.sort_index()
```

Sort the index of a DataFrame

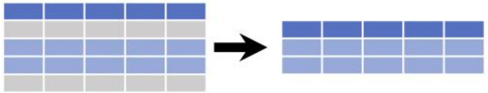
```
df.reset_index()
```

Reset index of DataFrame to row numbers, moving index to columns.

```
df.drop(columns=['Length','Height'])
```

Drop columns from DataFrame

Subset Observations (Rows)



```
df[df.Length > 7]
```

Extract rows that meet logical criteria.

```
df.drop_duplicates()
```

Remove duplicate rows (only considers columns).

```
df.head(n)
```

Select first n rows.

```
df.tail(n)
```

Select last n rows.

```
df.sample(frac=0.5)
```

Randomly select fraction of rows.

```
df.sample(n=10)
```

Randomly select n rows.

```
df.iloc[10:20]
```

Select rows by position.

```
df.nlargest(n, 'value')
```

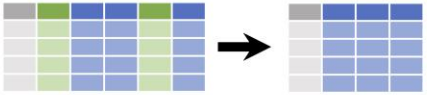
Select and order top n entries.

```
df.nsmallest(n, 'value')
```

Select and order bottom n entries.

Logic in Python (and pandas)			
<	Less than	!=	Not equal to
>	Greater than	df.column.isin(*values*)	Group membership
==	Equals	pd.isnull(*obj*)	Is NaN
<=	Less than or equals	pd.notnull(*obj*)	Is not NaN
>=	Greater than or equals	&,|,~,^,df.any(),df.all()	Logical and, or, not, xor, any, all

Subset Variables (Columns)



```
df[['width','length','species']]
```

Select multiple columns with specific names.

```
df['width']  or  df.width
```

Select single column with specific name.

```
df.filter(regex='regex')
```

Select columns whose name matches regular expression *regex*.

regex (Regular Expressions) Examples	
'\.'	Matches strings containing a period '.'
'Length$'	Matches strings ending with word 'Length'
'^Sepal'	Matches strings beginning with the word 'Sepal'
'^x[1-5]$'	Matches strings beginning with 'x' and ending with 1,2,3,4,5
''^(?!Species$).*'	Matches strings except the string 'Species'

```
df.loc[:,'x2':'x4']
```

Select all columns between x2 and x4 (inclusive).

```
df.iloc[:,[1,2,5]]
```

Select columns in positions 1, 2 and 5 (first column is 0).

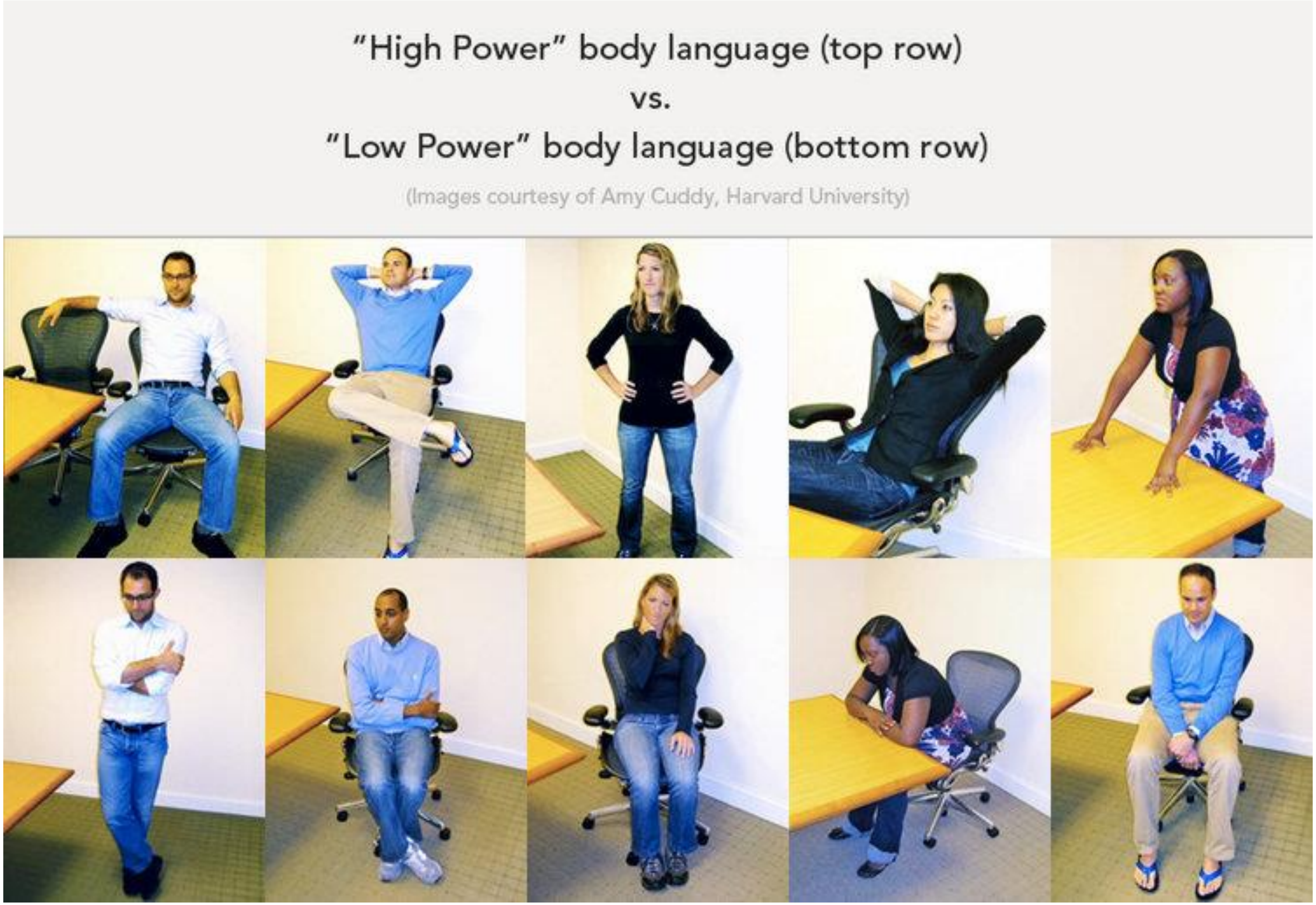
```
df.loc[df['a'] > 10, ['a','c']]
```

Select rows meeting logical condition, and only the specific columns .

http://pandas.pydata.org/ This cheat sheet inspired by Rstudio Data Wrangling Cheatsheet (https://www.rstudio.com/wp-content/uploads/2015/02/data-wrangling-cheatsheet.pdf) Written by Irv Lustig, Princeton Consultants

本週作業

用pandas分析power poses實驗資料



"High Power" body language (top row)

vs.

"Low Power" body language (bottom row)

(Images courtesy of Amy Cuddy, Harvard University)

Game Over