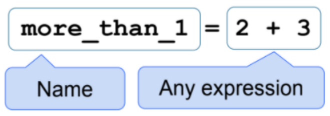
Statements



- Statements don't have a value; they perform an action.
- An assignment statement changes the meaning of the name to the left of the = symbol.
- The name is bound to the value of the right hand side

Comparisons

- < and > mean what you expect (less than, greater than)
- <= means "less than or equal; likewise for >=
- == means "equal to"; != means "not equal to"
- Comparing strings compares their alphabetical order

Arrays: sequences of the same type that can be manipulated

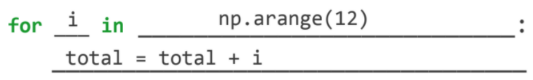
- Arithmetic and comparisons are applied to each element individually
  - ❍ `make_array(1, 2, 3) > 2 # array([False, False, True])`
- Elementwise operations can be done on arrays of the same size
  - ❍ `make_array(1, 2)* make_array(2, 3) # array([2, 6])`

Defining a Function

```
def function(arg1, arg2, ...):
    # Body can contain any code
```

Note: Many functions `return` a value

for Statements



```
for i in np.arange(12):
    total = total + i
```

- The body is executed **for** every item in a sequence
- The body of the statement can have multiple lines
- The body should do something: assign, sample, etc

Conditional Statements

```
if <if_expression>:
    <if_body>
elif <elif_expression_0>:
    <elif_body_0>
elif <elif_expression_1>:
    <elif_body_1>
...
else:
    <else_body>
```

Simulating a Statistic

- Define a function to simulate one value of the statistic
- Create an empty collection array
- For each repetition of the process:
  - ❍ Call the function to simulate one value
  - ❍ Append this value to the collection array
- At the end, all simulated values will be in the collection array

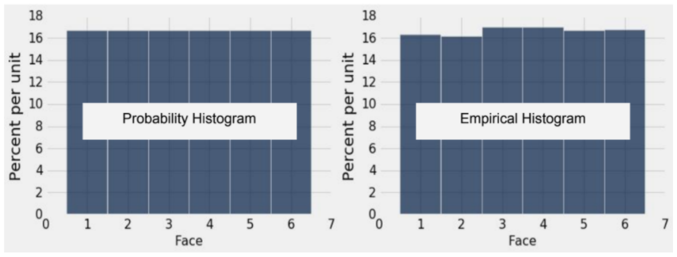
Total Variation Distance between two categorical distributions

- For each category, find the difference between the proportions in the two distributions
- Take the absolute value of the differences
- Sum all the absolute values, then divide by 2

A **histogram** has three defining properties:

- Bins are contiguous (though some may be empty) and drawn to scale.
- The area of each bar is the percent of entries in the bin.
- The total area of the histogram is 100%.

- The histogram on the left displays the theoretical probabilities of the number of spots on one roll of a fair die.
- The histogram on the right represents the empirical (or observed) distribution of the numbers of spots on many rolls of a fair die.
- Example of the *Law of Averages*: The more we roll, the more the histogram on the right is likely to resemble the one on the left.



Finding Probabilities

Complement Rule:
P(event happens) = 1 – P(event does not happen)

Multiplication Rule:
P(two events both happen) = P(first event happens) * P(second event happens given that the first event happened)

Addition Rule: If an event can happen in only one of two ways, then:
P(event happens) = P(happens in the first way) + P(happens in the second way)

p-values

- The *observed significance level* (or *p-value*) of a test is the chance, calculated under the null hypothesis, that the test statistic is equal to the one observed in the sample or more in the direction of the alternative.
- The result of a test of hypotheses is called *statistically significant* if the p-value is less than 5%; *highly statistically significant* if the p-value is less than 1%.

Table Functions and Methods

In the examples in the left column, np refers to the NumPy module, as usual. Everything else is a function, a method, an example of an argument to a function or method, or an example of an object we might call the method on. For example, tbl refers to a table, array refers to an array, and num refers to a number. array.item(0) is an example call for the method item, and in that example, array is the name previously given to some array.

Name	**Description**	**Input**	**Output**
Table()	Create an empty table, usually to extend with data (Ch 6)	None	An empty **Table**
Table().read_table(filename)	Create a table from a data file (Ch 6)	**string**: the name of the file	**Table** with the contents of the data file

tbl.with_columns(name, values)
tbl.with_columns(n1, v1, n2, v2,...)
	A table with an additional or replaced column or columns. name is a string for the name of a column, values is an array (Ch 6)	1. **string**: the name of the new column;
		2. **array**: the values in that column
			Table: a copy of the original Table with the new columns added

tbl.column(column_name_or_index)	The values of a column (an array) (Ch 6)	**string** or **int**: the column name or index	**array**: the values in that column
tbl.num_rows	Compute the number of rows in a table (Ch 6)	None	**int**: the number of rows in the table
tbl.num_columns	Compute the number of columns in a table (Ch 6)	None	**int**: the number of columns in the table
tbl.labels	Lists the column labels in a table (Ch 6)	None	**array**: the names of each column (as strings) in the table
tbl.select(col1, col2, ...)	Create a copy of a table with only some of the columns. Each column is the column name or index. (Ch 6)	**string** *or* **int**: column name(s) or index(es)	**Table** with the selected columns
tbl.drop(col1, col2, ...)	Create a copy of a table without some of the columns. Each column is the column name or index. (Ch 6)	**string** *or* **int**: column name(s) or index(es)	**Table** without the selected columns
tbl.relabeled(old_label, new_label)	Creates a new table, changing the column name specified by the old label to the new label, and leaves the original table unchanged. (Ch 6)	1. **string**: the old column name 2. **string**: the new column name	**Table**: a new Table
tbl.show(n)	Display n rows of a table. If no argument is specified, defaults to displaying the entire table. (Ch 6.1)	(Optional) **int**: number of rows you want to display	None: displays a table with n rows
tbl.sort(column_name_or_index)	Create a copy of a table sorted by the values in a column. Defaults to ascending order unless descending = True is included. (Ch 6.1)	1. **string** *or* **int**: column index or name 2. (Optional) descending=True	**Table**: a copy of the original with the column sorted
tbl.where(column, predicate)	Create a copy of a table with only the rows that match some *predicate*. See Table.where predicates below. (Ch 6.2)	1. **string** *or* **int**: column name or index 2. are.(...) predicate	**Table**: a copy of the original table with only the rows that match the predicate
tbl.take(row_indices)	A table with only the rows at the given indices. row_indices is either an array of indices or an integer corresponding to one index. (Ch 6.2)	**array** of ints: the indices of the rows to be included in the Table OR **int**: the index of the row to be included	**Table**: a copy of the original table with only the rows at the given indices

tbl.exclude(row_indices)	A table without the rows at the given indices. row_indices is either an array of indices or an integer corresponding to one index.	**array** of ints: the indices of the rows to be excluded from the Table OR **int**: the index of the row to be excluded	**Table**: a copy of the original table without the rows at the given indices
tbl.scatter(x_column, y_column)	Draws a scatter plot consisting of one point for each row of the table. Note that x_column and y_column must be strings specifying column names. Include optional argument fit_line=True if you want to draw a line of best fit for each set of points. (Ch 7)	1. **string**: name of the column on the x-axis 2. **string**: name of the column on the y-axis 3. (Optional) fit_line=True	None: draws a scatter plot

tbl.plot(x_column, y_column)
tbl.plot(x_column)
	Draw a line graph consisting of one point for each row of the table. If you only specify one column, it will plot the rest of the columns on the y-axis as different colored lines. (Ch 7)	1. **string**: name of the column on the x-axis
		2. **string**: name of the column on the y-axis
			None: draws a line graph

tbl.barh(categories)
tbl.barh(categories, values)
	Displays a bar chart with bars for each category in a column, with height proportional to the corresponding frequency. values argument unnecessary if table has only a column of categories and a column of values. (Ch 7.1)	1. **string**: name of the column with categories
		2. (Optional) **string**: the name of the column with values for corresponding categories
			None: draws a bar chart

tbl.hist(column, unit, bins, group)	Generates a histogram of the numerical values in a column. unit and bins are optional arguments, used to label the axes and group the values into intervals (bins), respectively. Bins have the form [a, b), where a is included in the bin and b is not. (Ch 7.2)	1. **string**: name of the column with categories 2. (Optional) **string**: units of x-axis 3. (Optional) **array** of ints/floats denoting bin boundaries 4. (Optional) **string**: name of categorical column to draw separate overlaid histograms for	None: draws a histogram

tbl.bin(column_name_or_index)
tbl.bin(column_name_or_index, bins)
	Groups values into intervals, known as bins. Results in a two-column table that contains the number of rows in each bin. The first column lists the left endpoints of the bins, except in the last row. If the bins argument isn't used, default is to produce 10 equally wide bins between the min and max values of the data. (Ch 7.2)	1. **string** *or* **int**: column name(s) or index(es)
		2. (Optional) **array** of ints/floats denoting bin boundaries or an **int** of the number of bins you want
			Table: a new tables

tbl.apply(function)
tbl.apply(function, col1, col2, ...)
	Returns an array of values resulting from applying a function to each item in a column. (Ch 8.1)	1. **function**: function to apply to column
		2. (Optional) **string**: name of the column to apply function to (if you have multiple columns, the respective column's values will be passed as the corresponding argument to the function), and if there is no argument, your function will be applied to every row object in tbl
			array: contains an element for each value in the original column after applying the function to it

tbl.group(column_or_columns, func)	Group rows by unique values or combinations of values in a column(s). Multiple columns must be entered in array or list form. Other values aggregated by count (default) or optional argument func. (Ch 8.2)	1. **string** or **array of strings**: column(s) on which to group 2. (Optional) **function**: function to aggregate values in cells (defaults to count)	**Table**: a new Table

tbl.pivot(col1, col2, values, collect)
tbl.pivot(col1, col2)
	A pivot table where each unique value in col1 has its own column and each unique value in col2 has its own row. Count or aggregate values from a third column, collect with some function. Default values and collect return counts in cells. (Ch 8.3)	1. **string**: name of column whose unique values will make up columns of pivot table
		2. **string**: name of column whose unique values will make up rows of pivot table
		3. (Optional) **string**: name of column that describes the values of cell
		4. (Optional) **function**: how the values are collected, e.g. sum or np.mean
			Table: a new Table

tblA.join(colA, tblB, colB)
tblA.join(colA, tblB)
	Generate a table with the columns of tblA and tblB, containing rows for all values of a column that appear in both tables. Default colB is colA. colA and colB must be strings specifying column names. (Ch 8.4)	1. **string**: name of a column in tblA with values to join on
		2. **Table**: other Table
		3. (Optional) **string**: if column names are different between Tables, the name of the shared column in tblB
			Table: a new Table

tbl.sample(n)
tbl.sample(n, with_replacement)
	A new table where n rows are randomly sampled from the original table; by default, n=tbl.num_rows. Default is with replacement. For sampling without replacement, use argument with_replacement=False. For a non-uniform sample, provide a third argument weights=distribution where distribution is an array or list containing the probability of each row. (Ch 10)	1. **int**: sample size
		2. (Optional) with_replacement=False
			Table: a new Table with n rows

tbl.row(row_index)	Accesses the row of a table by taking the index of the row as its argument. Note that rows are in general not arrays, as their elements can be of different types. However, you can use .item to access a particular element of a row using row.item(label). (Ch 17.3)	**int**: row index	**Row object** with the values of the row and labels of the corresponding columns
tbl.rows	Can use to access all of the rows of a table.	None	**Rows object** made up of all rows as individual row objects

String Methods

Name	**Description**
str.split(separator)	Splits the string (str) into a list based on the separator that is passed in
str.join(array)	Combines each element of array into one string, with str being in-between each element
str.replace(old_string, new_string)	Replaces each occurrence of old_string in str with the value of new_string (Ch 4.2.1)

Array Functions and Methods

Name	**Chapter**	**Description**
max(array)	3.3	Returns the maximum value of an array
min(array)	3.3	Returns the minimum value of an array
sum(array)	3.3	Returns the sum of the values in an array
abs(num), np.abs(array)	3.3	Takes the absolute value of a number or each number in an array

round(num), np.round(array)
round(num, decimals), np.round(array, decimals)
	3.3	Rounds a number or an array of numbers to the nearest integer. If decimals (integer) is included, rounds to that many digits. If decimals is negative, remove that many digits of precision.

len(array), len(string)	3.3	Returns the length (number of elements) of an array. If a string (str) is passed in instead, returns the number of characters in the string.
make_array(val1, val2, ...)	5	Makes a numpy array with the values passed in

np.average(array)
np.mean(array)
	5.1	Returns the mean value of an array

np.std(array)	14.2	Returns the standard deviation of an array
np.diff(array)	5.1	Returns a new array of size len(arr)-1 with elements equal to the difference between adjacent elements; val_2 - val_1, val_3 - val_2, etc.
np.sqrt(array)	5.1	Returns an array with the square root of each element

np.arange(start, stop, step)
np.arange(start, stop)
np.arange(stop)
	5.2	An array of numbers starting with start, going up in increments of step, and going up to but excluding stop. When start and/or step are left out, default values are used in their place. Default step is 1; default start is 0.

array.item(index)	5.3	Returns the i-th item in an array (remember Python indices start at 0!)

np.random.choice(array, n)
np.random.choice(array)
	9	Picks one (by default) or some number (n) of items from array at random with replacement.

np.count_nonzero(array)	9	Returns the number of non-zero (or True) elements in an array.
np.append(array, item)	9.2	Returns a copy of the input array with item appended to the end.
percentile(percentile, array)	13.1	Returns the corresponding percentile of an array.

Table Filtering Predicates

Any of these predicates can be negated by adding not_ in front of them, e.g. are.not_equal_to(Z) or are.not_containing(S).

Predicate	Description
are.equal_to(Z)	Equal to Z
are.not_equal_to(Z)	Not equal to Z
are.above(x)	Greater than x
are.above_or_equal_to(x)	Greater than or equal to x
are.below(x)	Less than x
are.below_or_equal_to(x)	Less than or equal to x
are.between(x, y)	Greater than or equal to x and less than y
are.between_or_equal_to(x, y)	Greater than or equal to x, and less than or equal to y
are.strictly_between(x, y)	Greater than x and less than y
are.contained_in(A)	Is a substring of A (if A is a string) or an element of A (if A is a list/array)
are.containing(S)	Contains the string S

Miscellaneous Functions

These are functions in the datascience library that are used in the course that don't fall into any of the categories above. You can also read more about all functions in the datascience library on the datascience documentation.

Name	Description	Intput	Output
sample_proportions(sample_size, model_proportions)	sample_size should be an integer, model_proportions an array of probabilities that sum up to 1. The function samples sample_size objects from the distribution specified by model_proportions. It returns an array with the same size as model_proportions. Each item in the array corresponds to the proportion of times it was sampled out of the sample_size times. (Ch 11.1)	1. **int**: sample size 2. **array**: an array of proportions that should sum to 1	**array**: each item corresponds to the proportion of times that corresponding item was sampled from model_proportions in sample_size draws, should sum to 1
minimize(function)	Returns an array of values such that if each value in the array was passed into function as arguments, it would minimize the output value of function. (Ch 15.4)	**function**: name of a function that will be minimized	**array**: An array in which each element corresponds to an argument that minimizes the output of the function. Values in the array are listed based on the order they are passed into the function; the first element in the array is also going to be the first value passed into the function.