Analyzing and Visualizing Experiments

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1 Analyzing and Visualizing Experiments

Standard tools for analyzing and visualizing data:

- matplotlib: Python module for generating high-quality graphs
- pyplot: wrapper for MATLAB-style plotting (nicer for interactive use)
- pylab: combines numpy and pyplot into one namespace as a kind of MATLAB replacement
- Alternatives:
- Pandas - highly recommended
- Chaco
- Mayavi (3D)
- PyQtGraph (which we will use later in the course)
- plot.ly
- Google Chart API

Example: You have conducted an experiment with four different input techniques comparing the *task completion time* for a certain task. Each task was repeated 11 times. Task completion times (in seconds) were stored in the files technique1.txt, technique2.txt, technique3.txt, and technique4.txt.

```
In [7]: cat technique1.txt # built-in command
```

```
4.26
5.68
7.24
4.82
6.95
8.81
8.04
8.33
10.84
7.58
9.96
```

1.1 Reading in data from log files

```
In [8]: t = []
        for i in range(1,5):
```

```
        t.append(list(map(float, open("technique"+str(i)+".txt").readlines())))
    t1,t2,t3,t4 = t
```

In [9]:
```
t1
```

Out[9]: [4.26, 5.68, 7.24, 4.82, 6.95, 8.81, 8.04, 8.33, 10.84, 7.58, 9.96]

In [10]:
```
ID = range(len(t1)) # just a little helper range for plotting
```

In [11]:
```
%matplotlib inline
from pylab import *
rcParams['figure.figsize'] = (16,9)
```

In [12]:
```
mean(t1), std(t1)
```

Out[12]: (7.5009090909090901, 1.9370242151086692)

In [13]:
```
mean(t2), std(t2)
```

Out[13]: (7.5009090909090901, 1.9371086914896203)

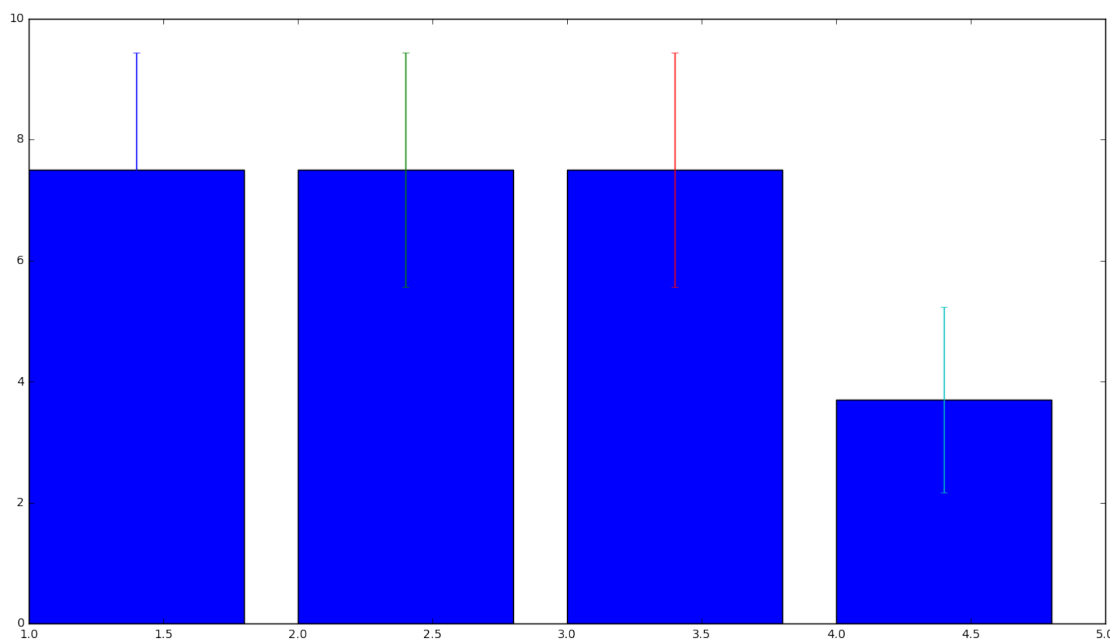
In [14]:
```
mean(t3), std(t3)
```

Out[14]: (7.5, 1.9359329439927313)

In [15]:
```
mean(t4), std(t4)
```

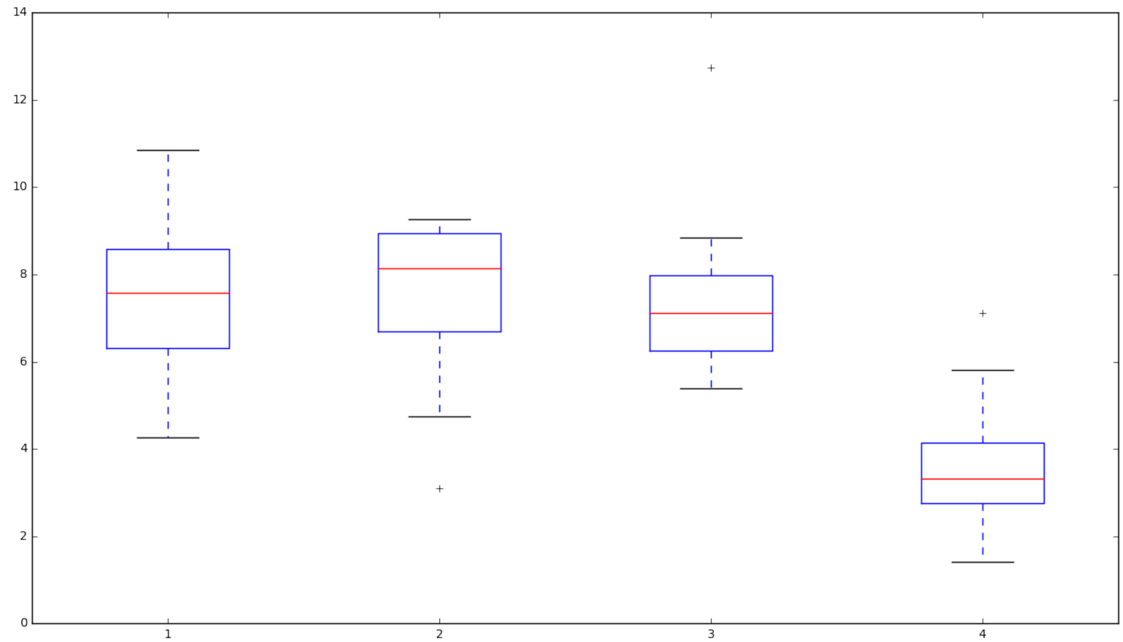
Out[15]: (3.7045454545454546, 1.5305219765364879)

In [16]:
```
bar(1, mean(t1), yerr=std(t1));
bar(2, mean(t2), yerr=std(t2));
bar(3, mean(t3), yerr=std(t3));
bar(4, mean(t4), yerr=std(t4));
```



dataset modified from: https://en.wikipedia.org/wiki/Anscombe's_quartet
Bar graphs only display very little information about a sample. Use box plots instead:

```
In [17]: boxplot([t1, t2, t3, t4]);
```



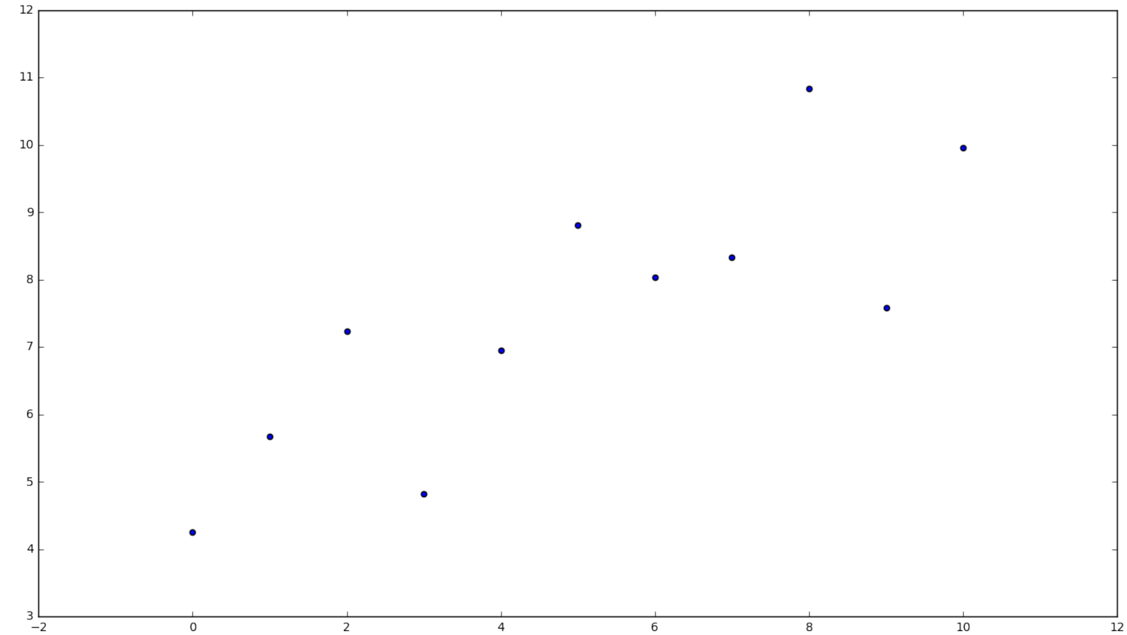
Box plots:

- Red line indicates *median*.
- Box indicates the second and third quartiles (divided by the median) of the data. These are also called lower/upper quartile.
- Whiskers may indicate various ranges. With matplotlib, whiskers are placed 1.5 IQR above/below the upper/lower quartile
- + indicates an outlier, i.e. a value that is outside the range defined by the whiskers. Defining outliers in this way is less arbitrary than deciding which values are outliers ad-hoc.

1.1.1 Scatter plots for exploring your data:

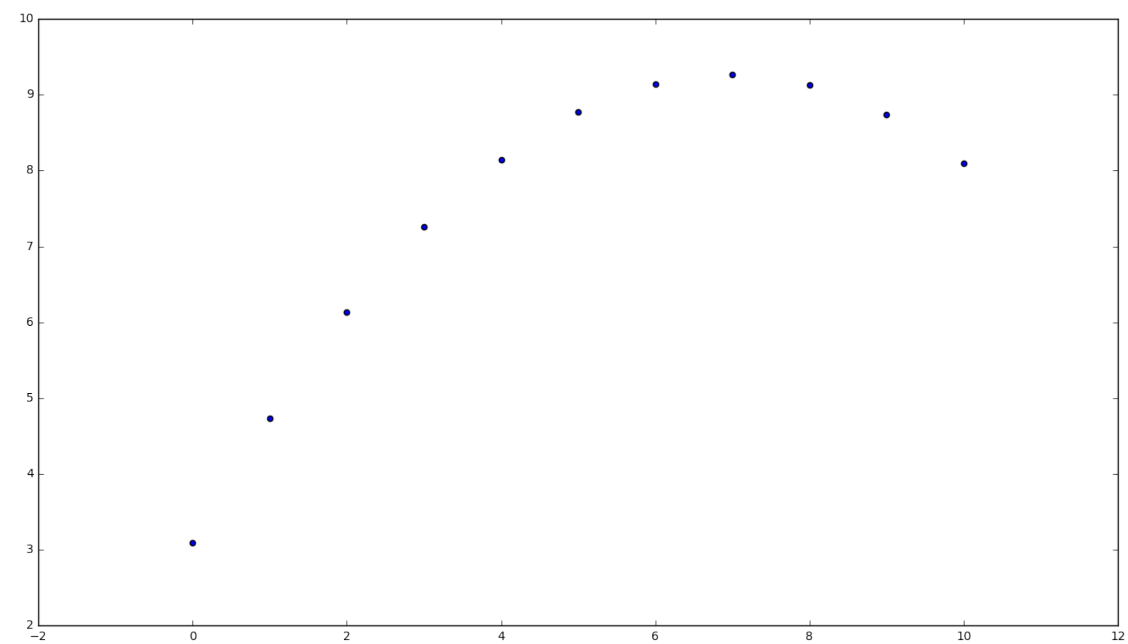
```
In [18]: scatter(ID, t1)

Out[18]: <matplotlib.collections.PathCollection at 0x7f2145c24b00>
```



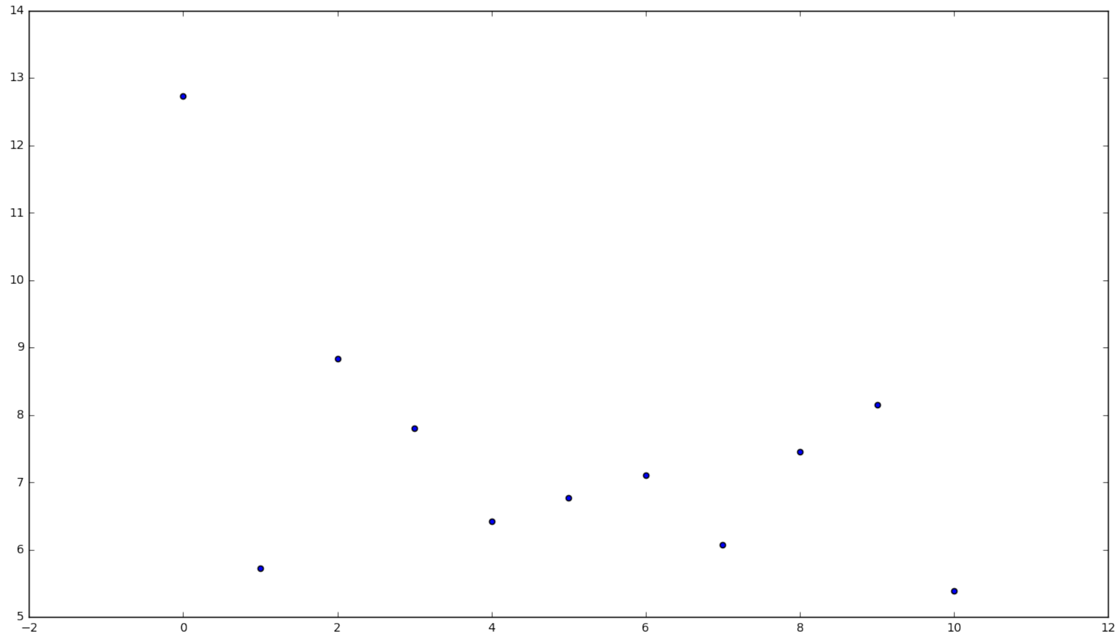

```
In [19]: scatter(ID,t2)
```

```
Out[19]: <matplotlib.collections.PathCollection at 0x7f2145b8a908>
```



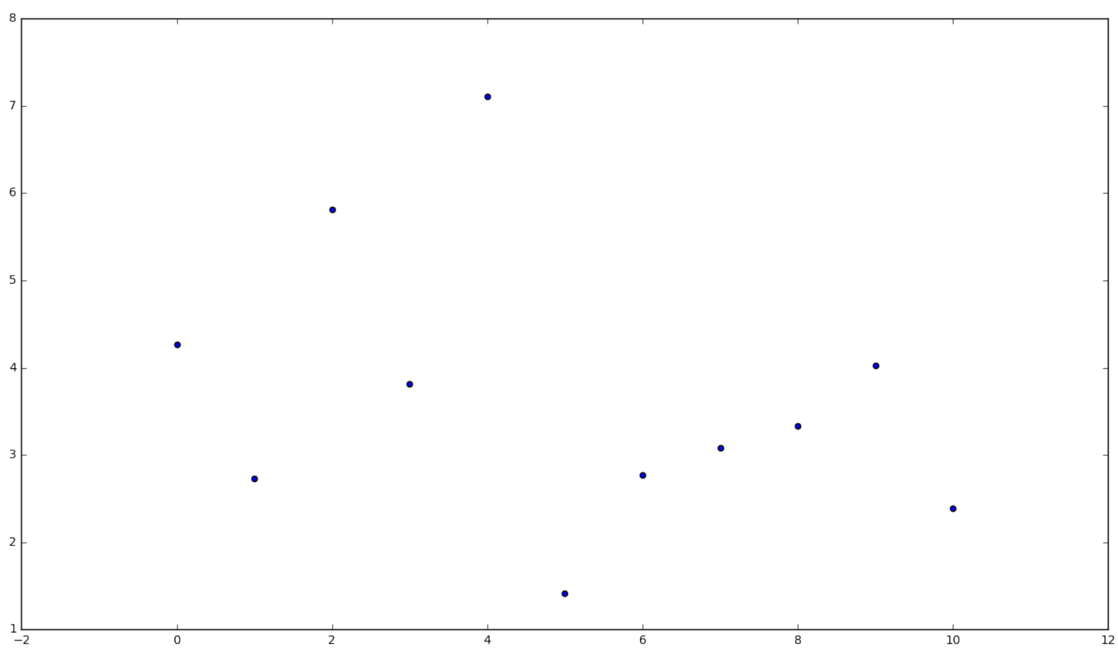

```
In [20]: scatter(ID,t3)
```

```
Out[20]: <matplotlib.collections.PathCollection at 0x7f2145af15c0>
```




```
In [21]: scatter(ID,t4)
```

```
Out[21]: <matplotlib.collections.PathCollection at 0x7f2145adbf98>
```



1.2 Inferential Statistics: t-test and linear regression

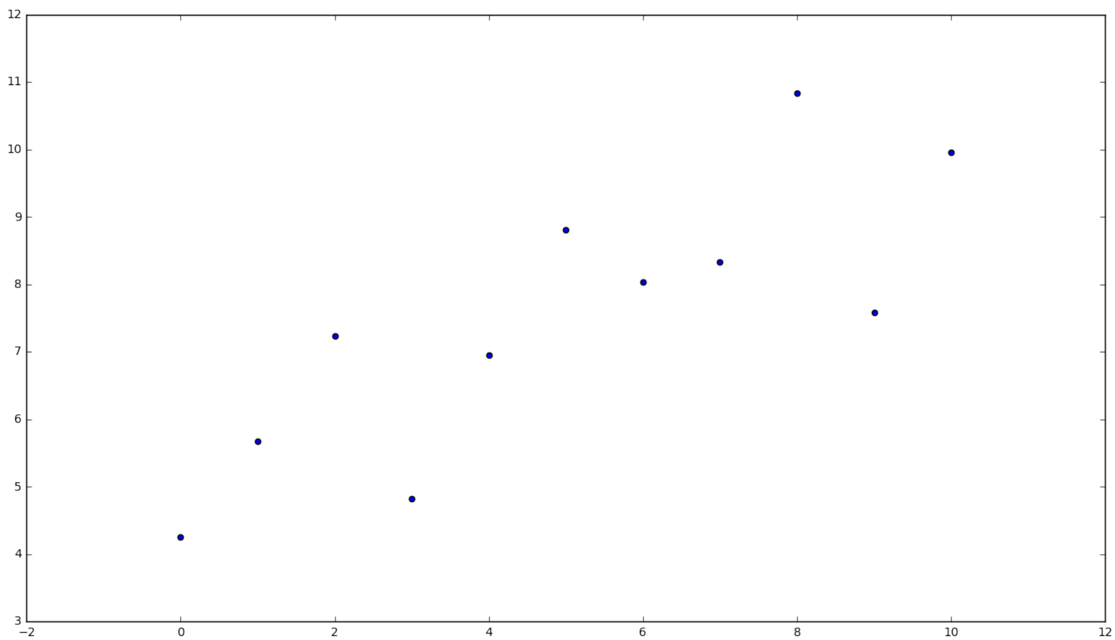
```
In [22]: from scipy.stats import ttest_ind, ttest_rel, ttest_1samp
```

```
In [23]: t_statistic, p_value = ttest_ind(t3, t4)
         print("p-value: %2.30f" %(p_value))
```

```
p-value: 0.000094141940205694229788085936
```

```
In [24]: scatter(ID, t1)
```

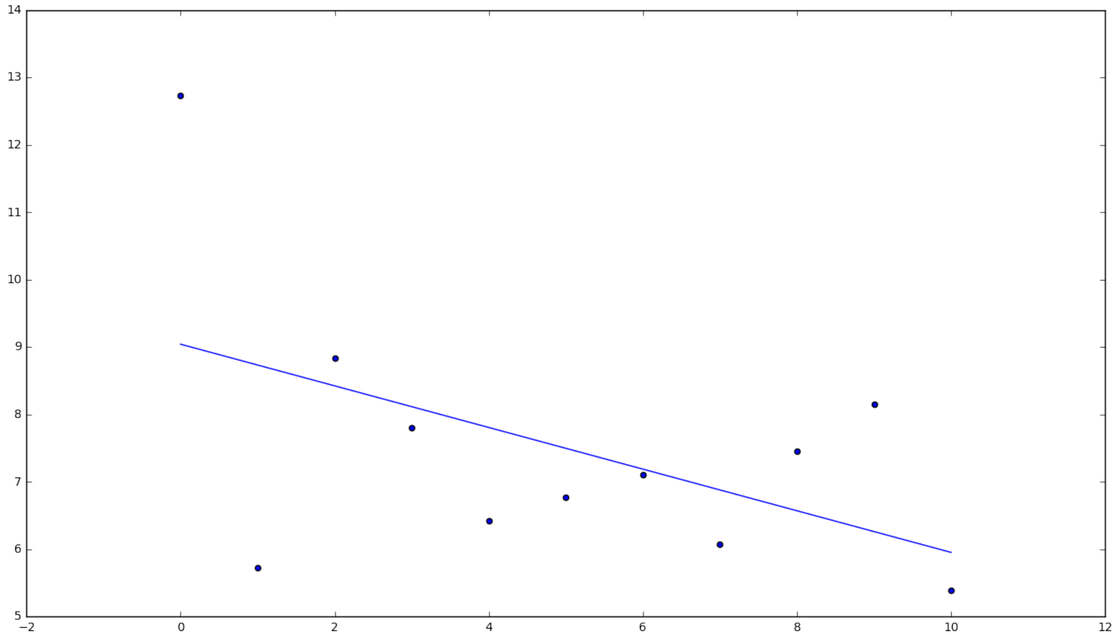
```
Out[24]: <matplotlib.collections.PathCollection at 0x7f214575f3c8>
```




```
In [25]: b, a = polyfit(ID, t3, 1)
         print("y = %f * x + %f" % (b,a))
```

```
y = -0.308909 * x + 9.044545
```

```
In [26]: yr = polyval([b,a],ID)
         plot(ID, yr);
         scatter(ID, t3);
```

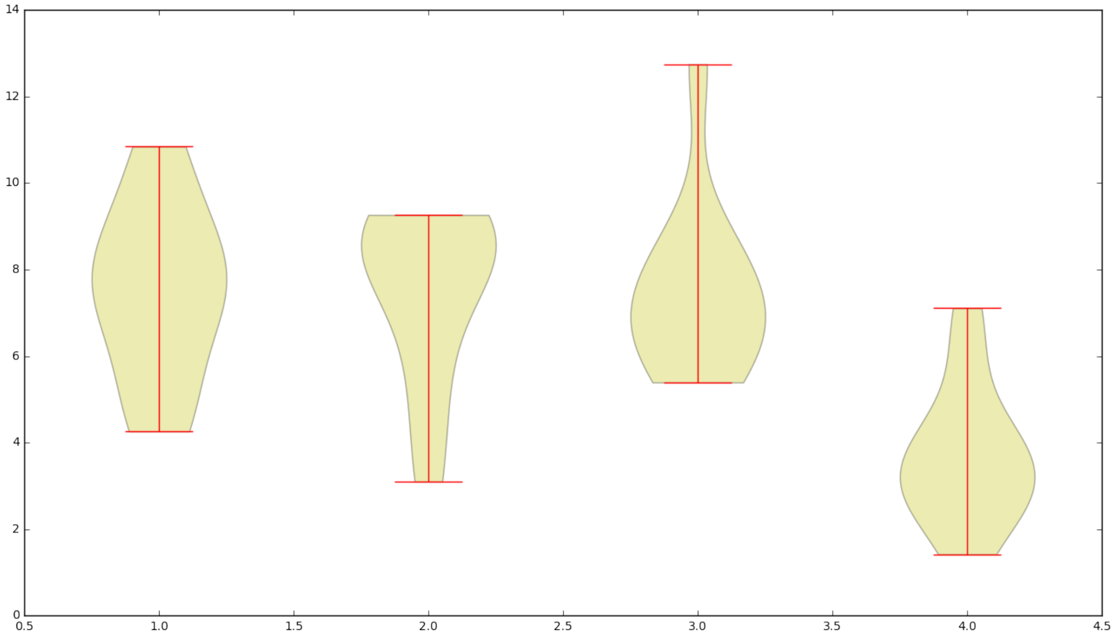



```
In [27]: a = [80, 120, 200]  * 10
         b = [100, 200, 400] * 10
         _, p_value = ttest_ind(a, b)
         print("p-value: %2.8f" %(p_value))
```

```
p-value: 0.00017643
```

1.3 Bonus: Violin plots combine histograms and box plots

```
In [28]: violinplot(t);
```



1.4 Bonus: reading in data from a CSV file

```
In [29]: !head test2.csv # execute shell command by prepending "!"

timestamp (ISO); user_id; trial; left_or_right_hand; stimulus_or_choice; movement_t
2014-04-23T01:31:36;1;0;l;s;2348
2014-04-23T01:31:37;1;1;l;c;729
2014-04-23T01:31:38;1;2;r;s;602
2014-04-23T01:31:39;1;3;r;c;306
2014-04-23T01:31:40;1;4;l;s;801
2014-04-23T01:31:40;1;5;l;c;608
2014-04-23T01:31:41;1;6;r;s;386
2014-04-23T01:31:42;1;7;r;c;489
2014-04-23T01:31:42;1;8;l;s;529


In [30]: data = genfromtxt("test2.csv", dtype=None, delimiter=";", names=True)

In [31]: data.dtype # see which data types were detected for each column ("S19" inc

Out[31]: dtype([('timestamp_ISO', 'S19'), ('user_id', '<i8'), ('trial', '<i8'), ('l

In [32]: # access all values in a column
         data['movement_time_ms']

Out[32]: array([2348,  729,  602,  306,  801,  608,  386,  489,  529,  802,  666,
                 513,  385,  617,  490,  729,  520,  633, 1155,  305,  776,  962,
```

```
                  890,   625,   408,   329,   521,   571, 1041,   638,   481,   825,   489,
                  513,   546,   688,   633, 1102,   425,   537,   730, 1055, 1226,   562,
                  393,   634,   849,   550,   441,   786,   610,   526,   662,   505, 1401,
                  650,   627,   586,   440,   651,   905,   515,   749,   647])
```

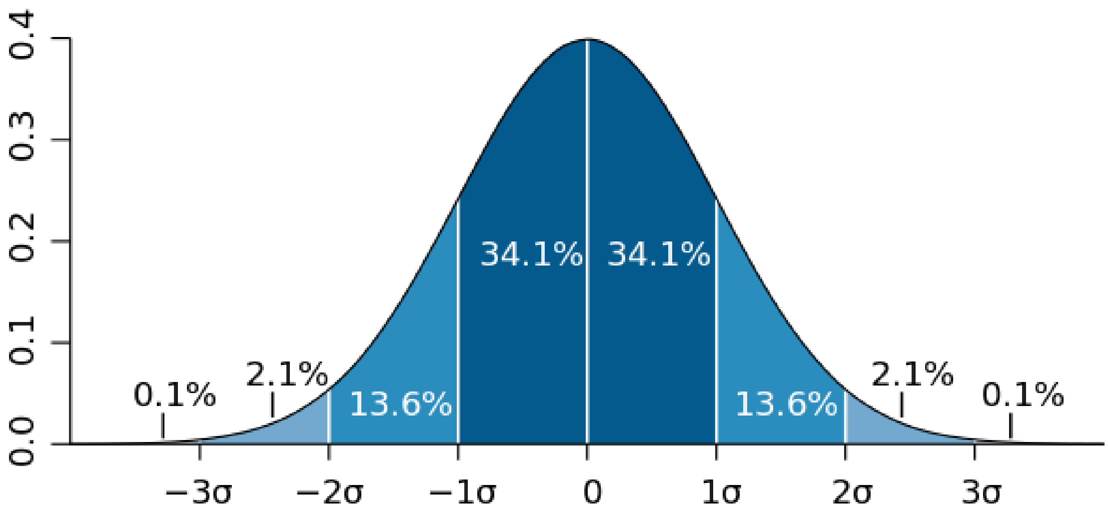
```
In [33]: # access individual record:
         data[1]
```

```
Out[33]: (b'2014-04-23T01:31:37', 1, 1, b'l', b'c', 729)
```

1.5 Bonus: displaying external images

```
In [34]: from IPython.display import Image
         Image("https://upload.wikimedia.org/wikipedia/commons/thumb/8/8c/Standard_
```

```
Out[34]:
```




```
In [ ]:
```