Hypothesis Testing

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χ^2 Example

Random sample of 500 U.S. adults: political affiliation and opinion on a tax reform. Dependent at a 5% level of significance?

Observed

	Favor	Indifferent	Oppose
Dem	138	83	64
Rep	64	67	84

Expected

	Favor	Indifferent	Oppose
Dem			
Rep			

χ^2 Example

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	Favor	Indifferent	Oppose
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Rep	64	67	84

Expected

	Favor	Indifferent	Oppose
Dem	115.14		
Rep			

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	Favor	Indifferent	Oppose
Dem	138	83	64
Rep	64	67	84

Expected

	Favor	Indifferent	Oppose
Dem	115.14	85.50	
Rep			

χ^2 Example

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Observed

	Favor	Indifferent	Oppose
Dem	138	83	64
Rep	64	67	84

Expected

	Favor	Indifferent	Oppose
Dem	115.14	85.50	84.36
Rep			

χ^2 Example

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Observed

	Favor	Indifferent	Oppose
Dem	138	83	64
Rep	64	67	84

Expected

	Favor	Indifferent	Oppose
Dem	115.14	85.50	84.36
Rep	86.86		

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Rep	64	67	84

Expected

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Dem	115.14	85.50	84.36
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	Favor	Indifferent	Oppose
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Dem	115.14	85.50	84.36
Rep	86.86	64.50	63.64

$$4.539 + 0.073 + 4.914 + 6.016 + 0.097 + 6.514 = 22.152 \tag{1}$$

Running test: df, *p*-Value

- Degrees of Freedom?

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```
>>> from scipy.stats.distributions import chi2
>>> 1 - chi2.cdf(22.15, 2)
1.5494894118783797e-05
>>> from scipy.stats import chisquare
>>> chisquare([138, 83, 64, 64, 67, 84],
...            [115.14, 85.5, 84.36, 86.86, 64.5, 63.64],
...            3)
Power_divergenceResult(statistic=22.152468645918482,
                                 pvalue=1.5475780213
```

US vs. Japanese Mileage

Read in Data

```
>>> import pandas as pd
>>> mpg = pd.read_csv("jp-us-mpg.dat", delim_whitespace=Tr
>>> mpg.head()
   US  Japan
0  18   24.0
1  15   27.0
2  18   27.0
3  16   25.0
4  17   31.0
```

Is the average car in the US as efficient as the average car in Japan?

Two-Tailed Two-Sample t-test

- Compute means

Two-Tailed Two-Sample *t*-test

- Compute means

```
>>> from numpy import mean
>>> mean(mpg["Japan"].dropna())
30.481012658227847
>>> mean(mpg["US"].dropna())
20.14457831325301
```

- Compute sample variances

Two-Tailed Two-Sample *t*-test

- Compute means

```
>>> from numpy import mean
>>> mean(mpg["Japan"].dropna())
30.481012658227847
>>> mean(mpg["US"].dropna())
20.1445783132530l
```

- Compute sample variances

```
>>> from numpy import var
>>> us = mpg["US"].dropna()
>>> jp = mpg["Japan"].dropna()
>>> jp_var = var(jp) * len(jp) / float(len(jp) - 1)
>>> us_var = var(us) * len(us) / float(len(us) - 1)
```

Degrees of Freedom

$$\nu = \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{\left(\frac{s_1^2}{N_1}\right)^2}{N_1 - 1} + \frac{\left(\frac{s_2^2}{N_2}\right)^2}{N_2 - 1}} \tag{2}$$

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$$\nu = \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{\left(\frac{s_1^2}{N_1}\right)^2}{N_1 - 1} + \frac{\left(\frac{s_2^2}{N_2}\right)^2}{N_2 - 1}} \tag{2}$$

$\nu = 136.8750$

t-Statistic

$$T = \frac{(\overline{x}_1 - \overline{x}_2)}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \tag{3}$$

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$T = 12.94$

p-value

p-value

```
>>> 2*(1.0 - t.cdf(abs(12.946), 136.8750))
0.0
```