A Way of Implementing Statistical Methods for Ordinal Data to Researchers

Elisabeth Svensson,Journal of Mathematics and System Science 2 (2012) 8-12

The frequency distribution of ordinal data from certain population with size n on a five-point scale, the ordered categories being

$$A < B < C < D < E$$

degrees scaled from very satisfied, A, to very un-satisfied, E, 5scales. Let X be pre-category data, Y be post-category data

某個單位, 工作人員對工作環境的滿意度從極好到極差, 分為五個等級, 為了提高工作人員對環境的滿意度, 公司決定重新裝修辦公室, 並且回收了 243 調查紀錄, 其中 X 代表裝修前員工的評價, Y 代表裝修後員工的評價. 裝修的代價, 是否提高了員工對環境的滿意度？

Other Applications

檢驗受訓前後的認知是否有明顯的差別? 手術前後, 吃藥前後, 病人的不舒服感是否有效改善?

Relative Position, RP

with value within (-1,1), estimates the difference between the probabilities of the marginal distribution Y being shifted toward higher categories than X and the opposite, $\mathbf{P}(X < Y) – \mathbf{P}(Y < X)$. A positive value of **RP**, indicates that the data set Y has systematically toward higher categories than X has, and negative toward lower categories:

$$RP = \frac{1}{n^2} \sum_i y_i C(X)_{i-1} - \frac{1}{n^2} \sum_i x_i C(Y)_{i-1}$$

where $C(X), C(Y)$: Accumated Frequencies of X, Y respectively. In brief, RP is a sign of a homogeneous group change which could reflect the efficacy of certain plan for the group and reflects the what future trends become.

Relative rank variance, RV,

is defined by the sum squares of aug-rank differences:

$$RV = \frac{6}{n^3} \sum_i \sum_j \left(\bar{R}_{ij}^{(X)} - \bar{R}_{ij}^{(Y)} \right)^2 x_{ij}$$

where n is the total sample size and:

$$\begin{aligned} \bar{R}_{ij}^{(X)} &= \sum_k^{i-1} \sum_j x_{kj} + \sum_{\nu=1}^{j-1} x_{i\nu} + \frac{1}{2}\left(1 + x_{ij}\right) \\ \bar{R}_{ij}^{(Y)} &= \sum_k^{j-1} \sum_i x_{ik} + \sum_{\nu=1}^{i-1} x_{\nu j} + \frac{1}{2}\left(1 + x_{ij}\right) \end{aligned}$$

RV indicates sign of individual heterogeneity in changes, or individual variation in changes.

The percentage un-satisfication, **PA**, is 0:

$$\frac{f_{EE} + f_{DD}}{\text{total}} = 0$$

In [1]:

```
import numpy as np
from scipy.stats import t,norm
from ipy_table import make_table,apply_theme,set_cell_style,set_column_
%precision 4
```

Out[1]: '%.4f'

In [4]:

```
from IPython.display import HTML
HTML('''<script>
code_show=true;
function code_toggle() {
 if (code_show){
 $('div.input').hide();
 } else {
 $('div.input').show();
 }
 code_show = !code_show
}
$( document ).ready(code_toggle);
</script>
To toggle on/off the raw Python code, click <a href="javascript:code_t
[<code style="background-color:brown;color:yellow;"> here </code>]</a>
```

Out[4]: To toggle on/off the raw Python code, click [`here`].

Jackknife Resampling

`Like Harry Potter looking for sword of gryffindor in Gringotts.`

Suppose that $\phi(X)$ be the estimator from X, here RP and RV included. The ^{i,j} th pseudovalue of $\phi(X)$ is the same estimator from the submatrix of X, by deleting i column and j row of X, and denoted as $\phi_{i,j}(X)$.

In [9]:

```
S=np.array([
       [' Y\X ','1','...','i','...','m'],
       ['1','X11','...','X1i','...','X1m'],
       ['⁞','','','','',''],
       ['j','Xj1','...','Xji','...','Xjm'],
       ['⁞','','','','',''],
       ['m','Xm1','...','Xmi','...','Xmm']
])
make_table(S)
apply_theme('basic_both')
set_cell_style(0,0, thick_border='left,top')
#set_cell_style(0, 0, color='lightblack')
set_column_style(0, color='lightgray')
set_column_style(3, color='gray')
set_row_style(3, color='gray')
#for i in range(1,n+1):
#    set_cell_style(i,n+1-i, thick_border='all',color="lightbrown")

set_cell_style(0, 0, color='orange')
```

Out[9]:

 Y\X	1	...	i	...	m
1	X11	...	X1i	...	X1m
⁞					
j	Xj1	...	Xji	...	Xjm
⁞					
m	Xm1	...	Xmi	...	Xmm

One can then obtain confidence intervals and carry out statistical tests using the Central Limit The- orem. Specifically, let

$$\bar{\phi}(X) = \frac{\sum_{i,j} \phi_{i,j}(X)}{n}, V(\bar{\phi}(X)) = \frac{\sum_{i,j}(\phi_{i,j}(X) - \bar{\phi}(X))^2}{n-1}$$

be the mean and sample variance of the pseudovalues. The **Jackknife** $(1-\alpha)\%$ **confidence interval** for $\phi(X)$ is:

$$\left(\bar{\phi}(\mathbf{X}) + \mathbf{z}_{\alpha/2}\sqrt{\frac{\mathbf{V}(\bar{\phi}(\mathbf{X}))}{\mathbf{n}}}, \bar{\phi}(\mathbf{X}) + \mathbf{z}_{1-\alpha/2}\sqrt{\frac{\mathbf{V}(\bar{\phi}(\mathbf{X}))}{\mathbf{n}}}\right)$$

where Z represents the standard normal random variable, and z_α is the percent point at α for Z, i.e.

$$\mathbf{Pr(Z < z_\alpha) = \alpha}$$

In [10]:

```
tabledata=np.array([[0,15,0,8,0],[0,0,16,62,10],[0,0,20,43,0],
                    [0,5,0,0,45],[0,0,3,16,0]])
```

Sub-Matrix Slicing of Numpy array

The following slices the numpy ndarray by deleting `(i)`-row and `(j)`-column:
`np.delete(np.delete(tabledata,j-1,1),i-1,0)`

In [11]:
```
# displat the ordinal data
make_table(tabledata)
```

Out[11]:

0	15	0	8	0
0	0	16	62	10
0	0	20	43	0
0	5	0	0	45
0	0	3	16	0

In [12]:
```
def ordinalData(tabledata, category=['A','B','C','D','E']):
    n=len(tabledata)
    Span_data=np.array([])
    for k in range(n+1):
      if k==0:
         column_ex= np.append(np.array(['Y\X']),category)
         column_ex= np.append(column_ex,'Total')
         #column_ex= np.append(np.array([' \ ']),category)
         Span_data=np.append(Span_data,column_ex)
      else:
         Sdata=np.array([category[-k]])
         total=  np.sum(tabledata[-k])
         Sdata=np.append(Sdata,tabledata[-k])
         Sdata=np.append(Sdata,total)
         Span_data=np.append(Span_data,Sdata)
    # sum for each pre-Category data
    Span_data= np.append(Span_data,'Total')
    Span_data= np.append(Span_data,np.sum(tabledata,axis=0))
    Span_data= np.append(Span_data,np.sum(tabledata))
    Span_data=Span_data.reshape([n+2,n+2])

    return Span_data
```

In [13]:
```
Sdata=ordinalData(tabledata)
n=len(tabledata)
make_table(Sdata)

apply_theme('basic_both')
set_cell_style(0,0, thick_border='left,top')
#set_cell_style(0, 0, color='lightblack')
set_column_style(0, color='lightgray')
for i in range(1,n+1):
    set_cell_style(i,n+1-i, thick_border='all',color="lightbrown")

set_cell_style(0, 0, color='orange')
```

Out[13]:

Y\X	A	B	C	D	E	Total
E	0	0	3	16	0	19
D	0	5	0	0	45	50
C	0	0	20	43	0	63
B	0	0	16	62	10	88
A	0	15	0	8	0	23
Total	0	20	39	129	55	243

In [22]:
```
def senssonRP(tabledata):
    AvgX=np.sum(tabledata,axis=0)
    AvgX=AvgX/sum(AvgX)
    AvgY=np.sum(tabledata,axis=1)
    AvgY=AvgY/sum(AvgY)
    CX=np.zeros(len(AvgX))
    for i in range(len(AvgX)-1):
        CX[len(AvgX)-i-1]=sum(AvgX[:len(AvgX)-i-1])
    CY=np.zeros(len(AvgY))
    for i in range(len(AvgY)-1):
        CY[len(AvgY)-i-1]=sum(AvgY[:len(AvgY)-i-1])
    RP=sum(AvgY*CX-AvgX*CY)

    return RP
```

In [23]:
```
def senssonRV(tabledata):

    n=len(tabledata[0])
    RX=np.zeros([n,n])
    for i in range(n):
        for j in range(n):
            RX[i][j]=np.sum(tabledata[:i][:n])+sum(tabledata[i][:j])+(
    RY0=np.zeros([n,n])
    tabledata1=tabledata.transpose()
    for i in range(n):
        for j in range(n):
            RY0[i][j]=np.sum(tabledata1[:i][:n])+sum(tabledata1[i][:j]
    RY=RY0.transpose()
    RV=np.sum((RX-RY)*(RX-RY)*tabledata)/np.sum(tabledata)**3*6
    return RV
```

In [24]:

```
def RPJackknife(tabledata):
    n=len(tabledata)
    tt=np.array([])
    for i in range(n):
        for j in range(n):
            tt=np.append(tt,senssonRP(np.delete(np.delete(tabledata,j,
    return tt.reshape([n,n])
```

In [25]:

```
def RVJackknife(tabledata):
    n=len(tabledata)
    tt=np.array([])
    for i in range(n):
        for j in range(n):
            tt=np.append(tt,senssonRV(np.delete(np.delete(tabledata,j,
    return tt.reshape([n,n])
```

In [27]:

```
def SvenssonRPCIs(tabledata,p=0.95):
    RP=senssonRP(tabledata)
    RPJ=RPJackknife(tabledata)
    pp=norm.ppf((1+p)/2, loc=0)
    a=RP-pp*RPJ.std()/np.sqrt(len(tabledata[0])**2)
    b=RP+pp*RPJ.std()/np.sqrt(len(tabledata[0])**2)
    if int(p*100) == float(p*100):
       decimals = 0
    else:
       decimals = 1 # Assumes 2 decimal places for money

    print('{0:.{1}f}'.format(p*100, decimals),"% confidence interval o
    print(" CIs:  (%.3f,%.3f)" %(a,b))
    print(O+'\n--[---------- ○ ----------]--'+W)
    print(" %.3f     %0.3f     %.3f " %(a,RP,b))
    if (RP<0):
        result="Toward the Lower A"
    else:
        result="Toward the Upper E"
    print("\nConclusion: %s" %result)
```

In [167]:

```
#Reference  the bottom

W  = '\033[0m'  # white (normal)
R  = '\033[31m' # red
G  = '\033[32m' # green
O  = '\033[1;33m' # orange
B  = '\033[34m' # blue
P  = '\033[35m' # purple

T =  '\033[1;33;47m' #Title
```

In [45]:
```
def SvenssonRVCIs(tabledata,p=0.95):
    RV=senssonRV(tabledata)
    RVJ=RVJackknife(tabledata)
    pp=norm.ppf((1+p)/2, loc=0)
    a=RV-pp*RVJ.std()/np.sqrt(len(tabledata[0])**2)
    b=RV+pp*RVJ.std()/np.sqrt(len(tabledata[0])**2)
    if int(p*100) == float(p*100):
       decimals = 0
    else:
       decimals = 1 # Assumes 2 decimal places for money

    print(T+' {0:.{1}f}'.format(p*100, decimals),"% confidence interva
    print(" CIs:  (%.3f,%.3f)" %(a,b))
    print(B+'\n--[----------- ○ -----------]--'+W)
    print(" %.3f       %0.3f       %.3f " %(a,RV,b))
    if (RV<0.2):
        result="Individual Variation is small"
    elif (RV<0.6):
        result="Individual Variation has to be concerned"
    else:
        result="Individual Variation is ver large"
    print("\nConclusion: %s" %result)
```

Estimated RP and 95%/97.5% Confidence Intervals

In [40]:
```
SvenssonRPCIs(tabledata)
```

```
95 % confidence interval of RP,  -0.538 :
 CIs:  (-0.609,-0.467)

--[----------- ○ -----------]--
 -0.609     -0.538     -0.467

Conclusion: Toward the Lower A
```

In [39]:
```
SvenssonRPCIs(tabledata,p=0.975)
```

```
97.5 % confidence interval of RP,  -0.538 :
 CIs:  (-0.620,-0.456)

--[----------- ○ -----------]--
 -0.620     -0.538     -0.456

Conclusion: Toward the Lower A
```

Estimated RV and 95% Confidence Intervals

In [168]:
```
SvenssonRVCIs(tabledata)
```

```
 95 % confidence interval of RV,  0.221 :
 CIs:  (0.194,0.248)

--[---------- ○ ----------]--
 0.194       0.221       0.248

Conclusion: Individual Variation has to be concerned
```

In [ ]:
```

```

Conclusion

1. The negavtive RP and 95% confidence interval of RP, which not including 0, confirm that re-design the office workplace actually make the satisfication more progress.
2. Though the RV is too small not to neglect the individual variations, we have to respect to each person's feeling.

Note

Original reference about ordinal data always suggests make statistical inferences by Central Limit Theorem; however, t-criterion is much suitable here.

Appendix: HTML Layout in color

The escape codes are entered right into the print statement.

```
print("\033[1;32;40m Bright Green  \n")
```

The above ANSI escape code will set the text colour to bright green. The format is;

- \033[Escape code, this is always the same
- 1 = Style, 1 for normal.
- 32 = Text colour, 32 for bright green.
- 40m = Background colour, 40 is for black.

TEXT COLOR	CODE	TEXT STYLE	CODE	BACKGROUND COLOR	CODE
Black	30	No effect	0	Black	40
Red	31	Bold	1	Red	41
Green	32	Underline	2	Green	42
Yellow	33	Negative1	3	Yellow	43
Blue	34	Negative2	5	Blue	44

Purple	35	Purple	45
Cyan	36	Cyan	46
White	37	White	47

In [33]:

```
print("\033[0;37;40m Normal text\n")
print("\033[2;37;40m Underlined text\033[0;37;40m \n")
print("\033[1;37;40m Bright Colour\033[0;37;40m \n")
print("\033[3;37;40m Negative Colour\033[0;37;40m \n")
print("\033[5;37;40m Negative Colour\033[0;37;40m\n")

print("\033[1;37;40m \033[2;37:40m TextColour BlackBackground
print("\033[1;30;40m Dark Gray      \033[0m 1;30;40m            \033[0
print("\033[1;31;40m Bright Red     \033[0m 1;31;40m            \033[0
print("\033[1;32;40m Bright Green   \033[0m 1;32;40m            \033[0
print("\033[1;33;40m Yellow         \033[0m 1;33;40m            \033[0
print("\033[1;34;40m Bright Blue    \033[0m 1;34;40m            \033[0
print("\033[1;35;40m Bright Magenta \033[0m 1;35;40m            \033[0
print("\033[1;36;40m Bright Cyan    \033[0m 1;36;40m            \033[0
print("\033[1;37;40m White          \033[0m 1;37;40m            \033[0
```

```
 Normal text

 Underlined text

 Bright Colour

 Negative Colour

 Negative Colour

  TextColour BlackBackground          TextColour GreyBackground
WhiteText ColouredBackground

 Dark Gray        1;30;40m            Black        0;30;47m
Black        0;37;41m
 Bright Red       1;31;40m            Red          0;31;47m
Black        0;37;42m
 Bright Green     1;32;40m            Green        0;32;47m
Black        0;37;43m
 Yellow           1;33;40m            Brown        0;33;47m
Black        0;37;44m
 Bright Blue      1;34;40m            Blue         0;34;47m
Black        0;37;45m
 Bright Magenta   1;35;40m            Magenta      0;35;47m
Black        0;37;46m
 Bright Cyan      1;36;40m            Cyan         0;36;47m
Black        0;37;47m
 White            1;37;40m            Light Grey   0;37;40m
Black        0;37;48m
```

χ^2 Analysis

the same Properties

$$\chi^2 = \sum \frac{(f_0 - f_e)^2}{f_e} \sim \chi^2_{(m-1)\times(n-1)}$$

Correlation Analysis

Correlation

$$\rho = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Fisher Statistics

$$t_{n-2} = |r|\sqrt{\frac{n-2}{1-r^2}}$$

ANOVA

$H_0 : \mu_1 = \mu_2 = \cdots = \mu_n$

$$SSE = \sum_{j=1}^{s}\sum_{i=1}^{n_j}(x_{ij} - \bar{x}_{\cdot j})^2 \sim \chi^2_{ns-s}$$

$$SSA = \sum_{j=1}^{s}\sum_{i=1}^{n_j}(\bar{x}_{\cdot j} - \bar{x})^2 \sim \chi^2_{n-s}$$

$$SST = SSE + SSA \sim \chi^2_{ns-1}$$

Statistic

$$F_{(s-1)\times(n-s)} = \frac{SSA/(s-1)}{SSE/(n-s)}$$

χ^2 Test

The numbers of absent data of certain person were recorded as follows. Are there the same during same year? 某人的出缺席資料如下, 每一年的情況是否相同?

```
Month                3   4  5  6
absent num(2015)    21  18 15  5
absent num(2016)    21  18 15 11
```

1. 2015: $\chi^2 = 9.814 > \chi^2_{0.05}(3) = 7.815$, reject H_0, data are different in 2015.
2. 2016: $\chi^2 = 3.369 < \chi^2_{0.05}(3) = 7.815$, do not reject H_0, data is the same in 2016.

In [ ]:

```

```

In [3]:

```
import scipy.stats as stats
import numpy as np
import pandas as pd
```

In [3]:
```
abs2015 = pd.DataFrame(["March"]*21 + ["April"]*18 +\
                        ["May"]*15 + ["June"]*5)


abs2016 = pd.DataFrame(["March"]*21 + ["April"]*18 +\
                        ["May"]*15 + ["June"]*11)

abs2015_table = pd.crosstab(index=abs2015[0], columns="count")

print( "2015")
print(abs2015_table)
```

```
2015
col_0  count
0
April     18
June       5
March     21
May       15
```

In [6]:
```
def chisqrare(data,alpha=0.05):
    data_table = pd.crosstab(index=data[0], columns="count")
    fo = data_table
    fe = fo.mean()  # Get expected counts
    chi_squared_stat = (((fo-fe)**2)/fe).sum()
    df=len(fo)-1 # degree of freedoms
    crit = stats.chi2.ppf(q = 0.95,df=df) # Find the critical value fo
    p_val = 1 - stats.chi2.cdf(x=chi_squared_stat,df=df)  # p-value= P
    stat_str="The χ2 statistic is "
    df_str=" with degree of freedoms "
    p_str="the p-value is "
    cri_str=", critical value χ2 is "
    if (p_val>alpha):
       test_str="Test: do not reject H0 ";
    else:
       test_str="Test: reject H0 ";
    print(stat_str,chi_squared_stat[0],df_str,df,"\n",p_str,p_val[0],c
```

In [22]:
```
def chisqrare_v2(data,alpha=0.05):
    data_table = pd.crosstab(index=data[0], columns="count")
    fo = data_table
    fe = fo.mean()  # Get expected counts
    chi_squared_stat = (((fo-fe)**2)/fe).sum()
    df=len(fo)-1 # degree of freedoms
    crit = stats.chi2.ppf(q = 0.95,df=df) # Find the critical value fo
    p_val = 1 - stats.chi2.cdf(x=chi_squared_stat,df=df)  # p-value= P
    stat_str="The χ2 statistic is "
    df_str=" with degree of freedoms "
    p_str=", the p-value is "
    cri_str=", critical value χ2 is "
    print(stat_str,chi_squared_stat[0],df_str,df,p_str,p_val[0],)

    if (p_val>alpha):
       test_str="Test: do not reject H0 ";
       print("                        χ2")
       print("|---------x-------)ᶜ-------> oo")
       print("         %.3f   %.3f" %(chi_squared_stat[0],crit) )
       print(test_str)
    else:
       test_str="Test: reject H0 ";
       print("              χ2")
       print("|---------)ᶜ-------x-------> oo")
       print("         %.3f   %.3f" %(crit,chi_squared_stat[0]) )
       print(test_str)
    #print(stat_str,chi_squared_stat[0],df_str,df,"\n",p_str,p_val[0],
```

In [20]:
```
chisqrare_v2(abs2015,alpha=0.05)
```

```
The χ2 statistic is  9.81355932203  with degree of freedoms  3 , the
p-value is  0.0202192807196
             χ2
|---------)ᶜ-------x-------> oo
         7.815   9.814
Test: reject H0
```

In [23]:
```
chisqrare_v2(abs2016,alpha=0.05)
```

```
The χ2 statistic is  3.36923076923  with degree of freedoms  3 , the
p-value is  0.338122659055
                        χ2
|---------x-------)ᶜ-------> oo
         3.369   7.815
Test: do not reject H0
```

χ^2

Whether does the eduacation degree relate to the gendre? 教育程度和性别是否有差别

Gener\ Education Types	A	B	C	D
Male	71	115	140	130
Female	110	141	181	198

Same between Males' and Females'

In [25]:
```
from scipy.stats import chi2_contingency
```

In [29]:
```
def chisquare2_v2(data,alpha=0.05,index="",columns=""):
    if (index!=""):
       df=pd.DataFrame(Edu_data.T,index=index, columns=columns)
    else:
        df=pd.DataFrame(Edu_data.T)
    fo= data
    chi2, p, df, fe =chi2_contingency(fo)
    fo_str="Observed Data: "
    stat_str="The χ2 statistic is "
    df_str=" with degree of freedoms "
    p_str="the p-value is "
    cri_str=", critical value χ2 is "
    crit = stats.chi2.ppf(q = 1-alpha,df=df)
    print(stat_str,chi2,df_str,df,p_str,p)

    if (p>alpha):
       test_str="Test: do not reject H0 ";
       print("                  χ2")
       print("|---------x-------)ᶜ-------> oo")
       print("       %.3f   %.3f" %(chi2,crit) )
       print(test_str)
    else:
       test_str="Test: reject H0 ";
       print("          χ2")
       print("|---------)ᶜ-------x-------> oo")
       print("       %.3f   %.3f" %(crit,2) )
       print(test_str)
```

In [31]:
```
def chisquare2(data,alpha=0.05,index="",columns=""):

    fo= data
    chi2, p, df, fe =chi2_contingency(fo)
    fo_str="Observed Data: "
    stat_str="The χ2 statistic is "
    df_str=" with degree of freedoms "
    p_str="the p-value is "
    cri_str=", critical value χ2 is "
    crit = stats.chi2.ppf(q = 1-alpha,df=df)
    if (p>alpha):
       test_str="Test: do not reject H0 ";
    else:
       test_str="Test: reject H0 ";
    print(stat_str,chi2,df_str,df,"\n",p_str,p,cri_str,crit,"\n",test_s
```

In [27]:
```
Edu_data=np.array([[71,115, 140, 130],[110, 141, 181, 198]])
Edutype=["A","B","C","D"]
gender=["Male","Female"]
```

In [147]:
```
df=pd.DataFrame(Edu_data.T,index=Edutype, columns=gender)
df
```

Out[147]:

	Male	Female
A	71	110
B	115	141
C	140	181
D	130	198

In [150]:
```
chisquare2(Edu_data,index=Edutype, columns=gender)
```

```
The χ2 statistic is  2.56567071395  with degree of freedoms  3
 the p-value is  0.463539723191 , critical value χ2 is  7.8147279032
5
 Test: do not reject H0
```

In [33]:
```
chisquare2_v2(Edu_data,index=Edutype, columns=gender)
```

```
The χ2 statistic is  2.56567071395  with degree of freedoms  3 the p
-value is  0.463539723191
                   χ2
|---------x-------)c-------> oo
       2.566   7.815
Test: do not reject H0
```

Correlation

Does the profit have related to the ad. buget? 每一年的獲得利益程度 是否和廣告支出有關?

```
X  0.20 0.30 0.20 0.40 0.35 0.48 0.30 0.58  0.43 0.60 0.55 0.4
2 0.4 0.58 0.51
Y   20   25   24   30   32   40   28   50    40   70   48   39
42   65   56
```

1. $r = 0.9179$
2. $t = |0.9179|\sqrt{\frac{15-2}{1-0.9179^2}} = 8.3403 > t_{0.025}(13) = 2.1604$ reject $H_0 : r = 0$, i.e. $X. Y$ do have corelated with each other.

In [35]:
```
dataXY=np.array([[0.20,0.30,0.20,0.40,0.35,0.48,0.30,0.58 ,0.43,0.60 ,
                 [20,   25 ,  24  , 30 ,  32 ,  40  , 28 ,  50  ,  40
stats.pearsonr(dataXY[0],dataXY[1] )
```

Out[35]: (0.9179, 0.0000)

In [45]:
```
def fisherR_v2(data,alpha=0.05,two_sided=True):
    r,p=stats.pearsonr(data[0],data[1] )
    df=len(data[0])-2
    cor_str=" correlation is: "
    print(cor_str+"%.3f" %r)

    stat_str="The Fisher t statistic is "
    df_str=" with degree of freedoms "
    p_str="the p-value is "
    if two_sided:
       cri_str=", critical value t (two-tailed) is "
       q=1-alpha/2
    else:
       cri_str=", critical value t (one-tailed) is "
       q=1-alpha
    t_cri = stats.t.ppf(q = q,df=df)
    rt=np.abs(r)*np.sqrt((df)/(1-r**2))
    #t=np.abs(r_cri)*np.sqrt((df)/(1-r_cri**2))
    if (p>alpha and two_sided):
       test_str="Test: do not reject H0: r=0, i.e. X, Y independent ";
       print("                      t(%s,%.3f)" %(df,q))
       print("-oo <---(------x-------)ᶜ-------> oo")
       print("       %.3f   %.3f" %(chi2,crit) )
       print(test_str)
    elif(p>alpha and not two_sided):
       print("")
    elif(p<alpha and not two_sided):
       print("")
    else:
       test_str="Test: reject H0, i.e. X,Y dependent";
       print("                      t(%s,%.3f)" %(df,q))
       print("-oo <---(------x-------)ᶜ-------> oo")
       print("       %.3f   %.3f" %(chi2,crit) )
       print(test_str)

    #print(cor_str,r,"\n",stat_str,rt,df_str,df,"\n",p_str,p,cri_str,t_
```

In [47]:
```
def fisherR(data,alpha=0.05,two_sided=True):
    r,p=stats.pearsonr(data[0],data[1] )
    df=len(data[0])-2
    cor_str=" correlation is: "

    stat_str="The Fisher t statistic is "
    df_str=" with degree of freedoms "
    p_str="the p-value is "
    if two_sided:
       cri_str=", critical value t (two-tailed) is "
       q=1-alpha/2
    else:
       cri_str=", critical value t (one-tailed) is "
       q=1-alpha
    t_cri = stats.t.ppf(q = q,df=df)
    rt=np.abs(r)*np.sqrt((df)/(1-r**2))
    #t=np.abs(r_cri)*np.sqrt((df)/(1-r_cri**2))
    if (p>alpha):
       test_str="Test: do not reject H0: r=0, i.e. X, Y independent ";
    else:
       test_str="Test: reject H0, i.e. X,Y dependent";
    print(stat_str,rt,df_str,df,"\n",p_str,p,cri_str,t_cri,"\n",test_s
```

In [48]:
```
fisherR(dataXY)
```

```
The Fisher t statistic is  8.33951789063  with degree of freedoms  1
3
 the p-value is  1.414544429e-06 , critical value t (two-tailed) is
2.16036865646
 Test: reject H0, i.e. X,Y dependent
```

ANOVA

are there any difference amounf different groups? 群眾之間是否有差別?

```
Type/trial   A  B  C  D
  1          3  8 10  8
  2          7 11  7  8
  3          7  9  3  5
  4          3  7  5  5
  5          8  8 11  2


                            df
SSA(Factor A)  31.350     3   MSA=SSA/3=10.45
SSE(Error)     102.4     16   MSE=SSE/16=6.4
SST(Total)     133.75    19

F_A(3,16)=MSA/MSE=1.6328
```

$F_A(3,16) < F_0.05(3,16) = 3.24$ do not reject $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$

In [209]:

```

```

In [1]:

```
import plotly.plotly as py
import plotly.graph_objs as go
from plotly.tools import FigureFactory as FF
from io import StringIO
%matplotlib inline
```

In [4]:

```
csv_str=StringIO("""A,B,C,D
          3,8,10,8
          7,11,7,8
          7,  9,  3,  5
          3 , 7,  5 , 5
          8 , 8, 11,  2""")
data = pd.read_csv(csv_str)
```

In [5]:

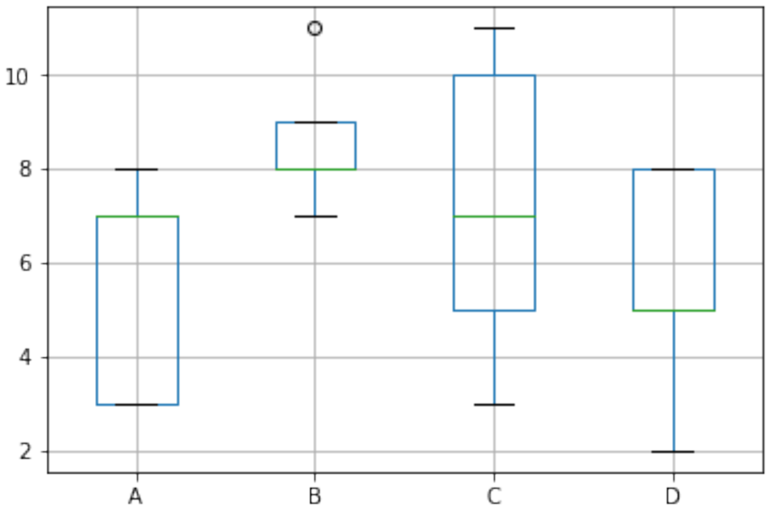
```
data
```

Out[5]:

	A	B	C	D
0	3	8	10	8
1	7	11	7	8
2	7	9	3	5
3	3	7	5	5
4	8	8	11	2

In [7]:

```
data.boxplot(figsize=(12, 8));
```



In [8]:

```
F, p = stats.f_oneway(data['A'], data['B'], data['C'], data['D'])
F,p
```

Out[8]: (1.6328125, 0.22133164752533896)

In [9]:
```
def onewayANOVA(data,alpha=0.05):
    s=data.shape[1]
    n=data.shape[0]*data.shape[1]
    F, p = stats.f_oneway(data['A'], data['B'], data['C'], data['D'])

    stat_str="The one-way ANOVA f statistic is "
    df_str=" with degrees of freedoms "
    p_str="the p-value is "
    cri_str=", critical value f is "
    f_cri = stats.f.ppf(q = 1-alpha,dfn=s-1,dfd=n-s)

    if (p>alpha):
       test_str="Test: do not reject H0: there is no difference among 
    else:
       test_str="Test: reject H0, i.e. there is some difference amoung
    print(stat_str,F,df_str,"(",s-1,",",n-s,")","\n",p_str,p,cri_str,f_
```

In [10]:
```
onewayANOVA(data)
```

```
The one-way ANOVA f statistic is  1.6328125  with degrees of freedom
s  ( 3 , 16 )
 the p-value is  0.221331647525 , critical value f is  3.23887151745
 Test: do not reject H0: there is no difference among groups
```

In [ ]:

In [ ]: