TP1F3B

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1 Introduction to data mining with the tips dataset

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1.1 Data and objective understanding

–The Tips dataset– Food server's tips in restaurants may be influenced by many factors (e.g. the nature and location of the restaurant, the size of the party, the table location and the day of the week. . .). Restaurant managers need to know which factors matter when they assign tables to food servers. Indeed, for the sake of staff morale, they usually want to avoid either the substance or the appearance of unfair treatment of the servers, for whom tips (at least in restaurants in the United States) are a major component of pay. In one restaurant, a food server recorded some data on all customers they served during an interval of two and a half months in early 1990. The restaurant, located in a suburban shopping mall, was part of a national chain and served a varied menu. In observance of local law the restaurant offered seating in a non-smoking section to patrons who requested it. Each record includes a day and time, and thus taken together, they show the server's work schedule. The food server provided a comma-separated-value file tips.csv containing 244 records, described by 7 variables (total bill, tip, sex, smoker, day, time and size).

```
In [1]: # import useful libraries
        import pandas as pd
        import matplotlib.pyplot as plt
        %matplotlib inline
        import seaborn as sns
        import numpy as np
        import scipy as sp
```

1.1.1 Question 1

What do you know from the text above and what information is missing?

1.1.2 Question 2

Do you have some idea about the objectives of the study and the knowledge you could extract from the data? Could you suggest a list of questions of interest?

Here we want to know the influence of total bill, sex, smoker, day, time and size on tip by finding a model that can generalise the data.

Some questions :

```
- What factors can most influence the tip value ?
- Which factors matter when managers assign tables to food servers ?
```

1.1.3 Question 3

Load the dataset and have a look at it using the describe() function. Describe the data (the format of the data, the quantity of data –number of example/ records and variable/fields–). What are the expected values and role of each variable?

```
In [2]: # the code below loads the data for you
        data_tips=pd.read_csv('tips.csv')
        # you can run the below code to see the first five observations
        data_tips.head()
```

```
Out[2]:    total_bill   tip     sex smoker  day    time  size
        0       16.99  1.01  Female     No  Sun  Dinner     2
        1       10.34  1.66    Male     No  Sun  Dinner     3
        2       21.01  3.50    Male     No  Sun  Dinner     3
        3       23.68  3.31    Male     No  Sun  Dinner     2
        4       24.59  3.61  Female     No  Sun  Dinner     4
```

```
In [3]: # this function should return a tuple of 3 values: the class of your datase
        def answer_3():
            # write your code here:
            # the type of the object data_tips
            dataset_type=type(data_tips)
            # the shape of data
            shape=data_tips.shape
            #variables in data
            col_names=data_tips.columns

            return dataset_type,shape,col_names

        answer_3()
```

```
Out[3]: (pandas.core.frame.DataFrame,
         (244, 7),
         Index(['total_bill', 'tip', 'sex', 'smoker', 'day', 'time', 'size'], dtype
```

```
In [4]: # a description for each variable :
        # 'total_bill' : total to pay
        #'tip' : the tip value
        #'sex' : the gender of the customer
        #'smoker' :  customer smokes or not
        #'day' : 4 days ( from thursday to sunday)
        #'time' : either dinner or lunch
        #'size' : the size of the party
```

1.1.4 Question 4

Tip is usually referred to by percentage points, or as a rate. This enables a normalization over the total bill and a comparison of values across other variables. The question is now to create a "tip rate" variable and to add it to the original dataset.

```
In [5]: #This function should return a dataframe including the new variable tip_rat
        def answer_4():
            # write your code here
            data_tips['tip_rate']=data_tips['tip']/data_tips['total_bill']

            return data_tips
        answer_4().head()
```

```
Out[5]:    total_bill   tip     sex smoker  day    time  size  tip_rate
        0       16.99  1.01  Female     No  Sun  Dinner     2  0.059447
        1       10.34  1.66    Male     No  Sun  Dinner     3  0.160542
        2       21.01  3.50    Male     No  Sun  Dinner     3  0.166587
        3       23.68  3.31    Male     No  Sun  Dinner     2  0.139780
        4       24.59  3.61  Female     No  Sun  Dinner     4  0.146808
```

Home work Explore the notion of scale of measurement. Provide a short note with meaningful definitions and examples. Explain why it is important to consider the right scale for each variable. What is the scale for each of the eight variables?

you can visit the link below to explore the notion of scale measurement: http://stattrek.com/statistics/measurement-scales.aspx?Tutorial=AP

1.2 Descriptive statistics and visualisation

1.2.1 Question 5

Explore univariate summaries with the describe() function.

```
In [6]: #This function should return summary about numerical and categorical featu
        # use the output of answer4() for your this question
        def answer_5():
            # write your code here:
            num_des=answer_4().describe()
            cate_des=answer_4().describe(include=['object'])
            return num_des,cate_des
        answer_5()
```

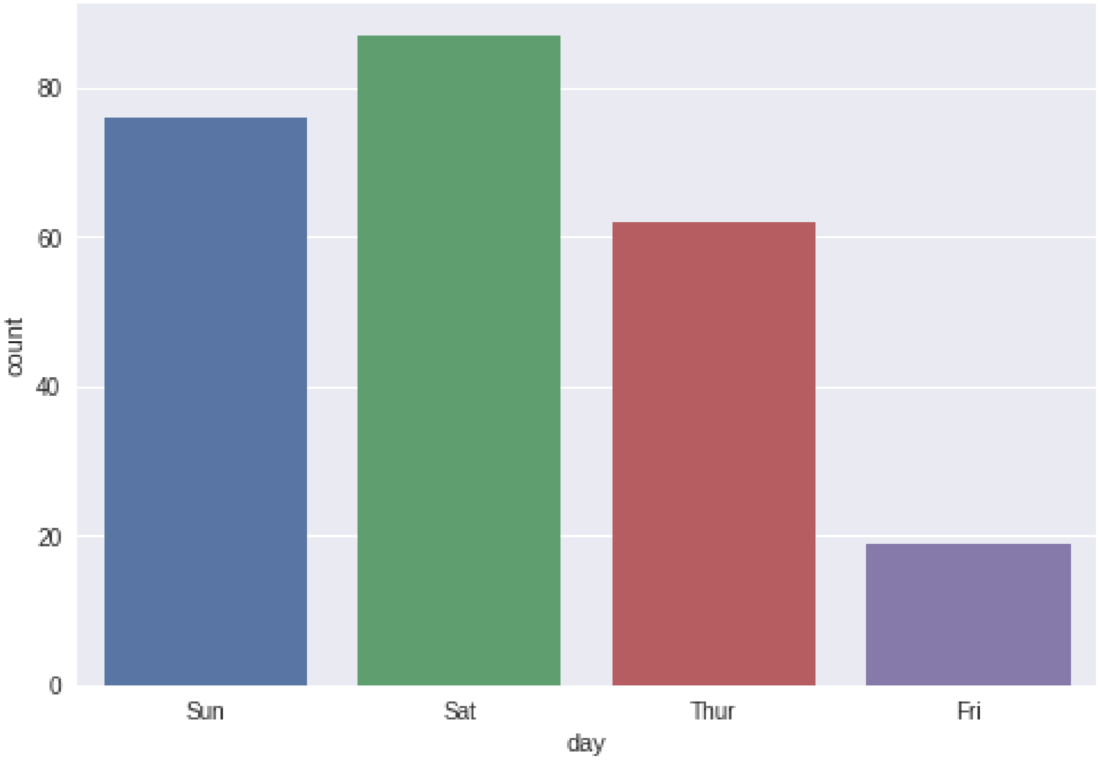
```
Out[6]: (       total_bill         tip        size    tip_rate
         count  244.000000  244.000000  244.000000  244.000000
         mean    19.785943    2.998279    2.569672    0.160803
         std      8.902412    1.383638    0.951100    0.061072
         min      3.070000    1.000000    1.000000    0.035638
         25%     13.347500    2.000000    2.000000    0.129127
         50%     17.795000    2.900000    2.000000    0.154770
         75%      24.127500    3.562500    3.000000    0.191475
         max      50.810000   10.000000    6.000000    0.710345,
                  sex  smoker  day     time
         count      244     244  244      244
         unique       2       2    4        2
         top       Male      No  Sat   Dinner
         freq       157     151   87      176)
```

1.2.2 Question 6

Plot a representation of the days distribution in the dataset and comment.

```
In [7]: # this function should return a plot of the days distribution, give a comme
        def answer_6():
            # write your code here
            return sns.countplot(x='day',data=data_tips)
        answer_6()
```

```
Out[7]: <matplotlib.axes._subplots.AxesSubplot at 0x7fed0493b828>
```



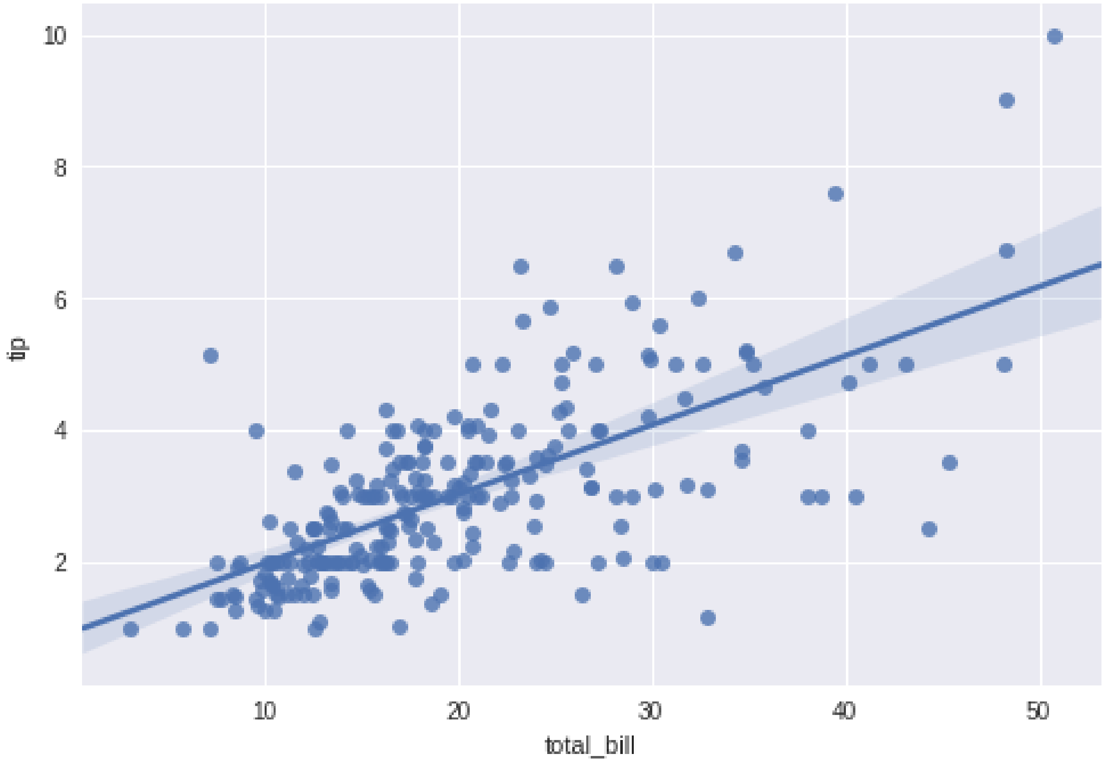
let your comment here:

1.2.3 Question 7

Prepare a plot of the amount of tips against the total bill. What can you see ? Test the correlation between the two variables.

```
In [8]: # this function should return a plot of tips against the total_bill
        def answer_7():
            # write your code here
            ax = sns.regplot(x="total_bill", y="tip", data=data_tips)
            return ax
        answer_7()

Out[8]: <matplotlib.axes._subplots.AxesSubplot at 0x7fed048ff550>
```



We can say that tip correlate strongly with the total_bill. As shown above we can draw a line that can approximate the relationship between them.

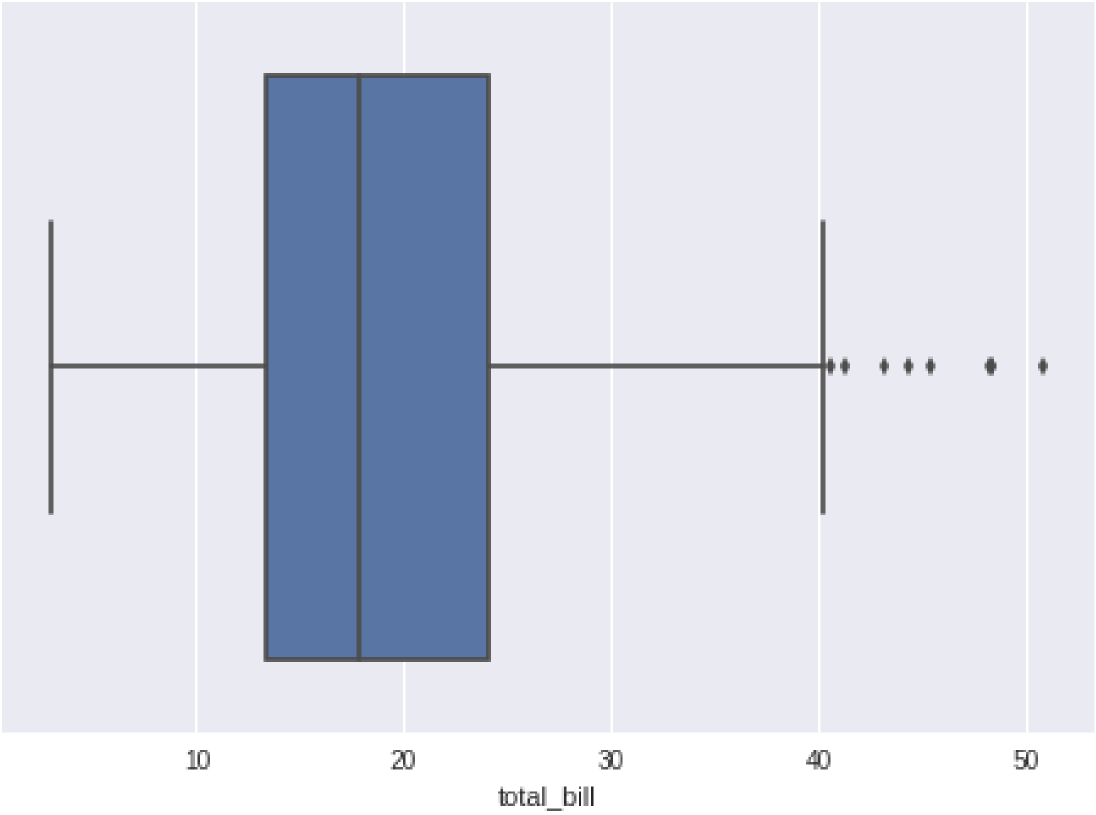
1.2.4 Question 8

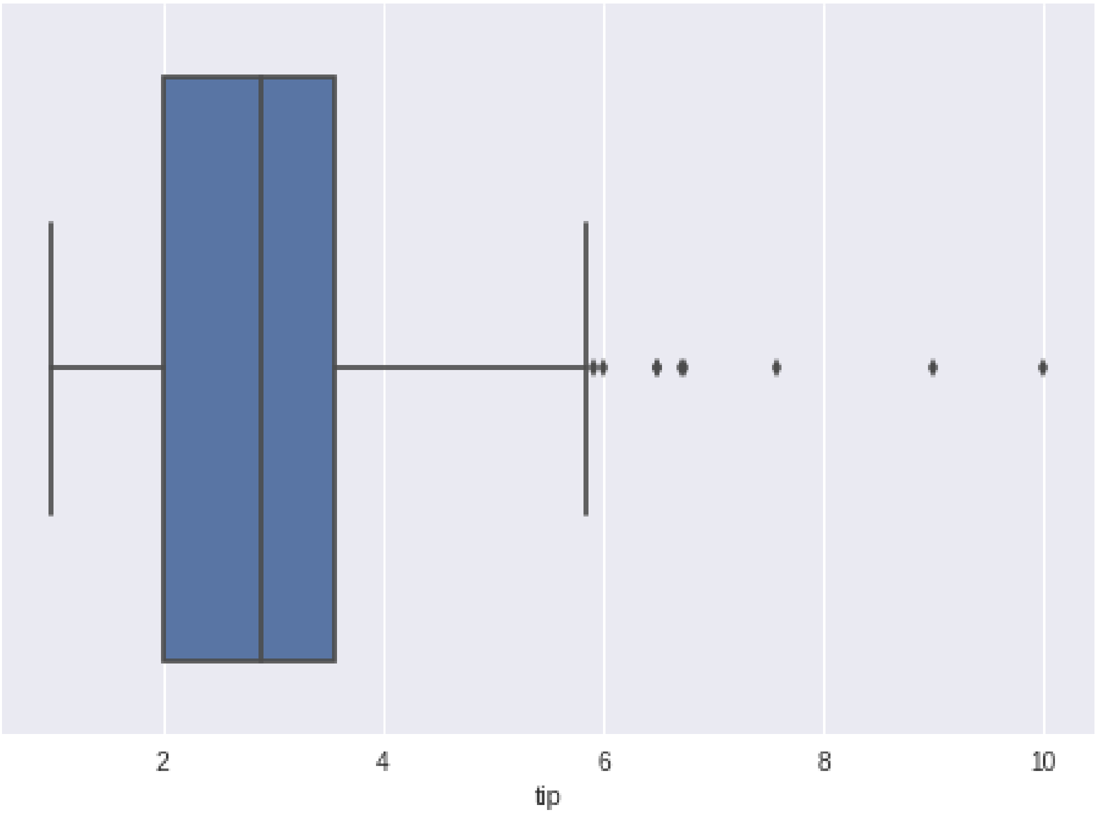
Draw and interpret three boxplots :

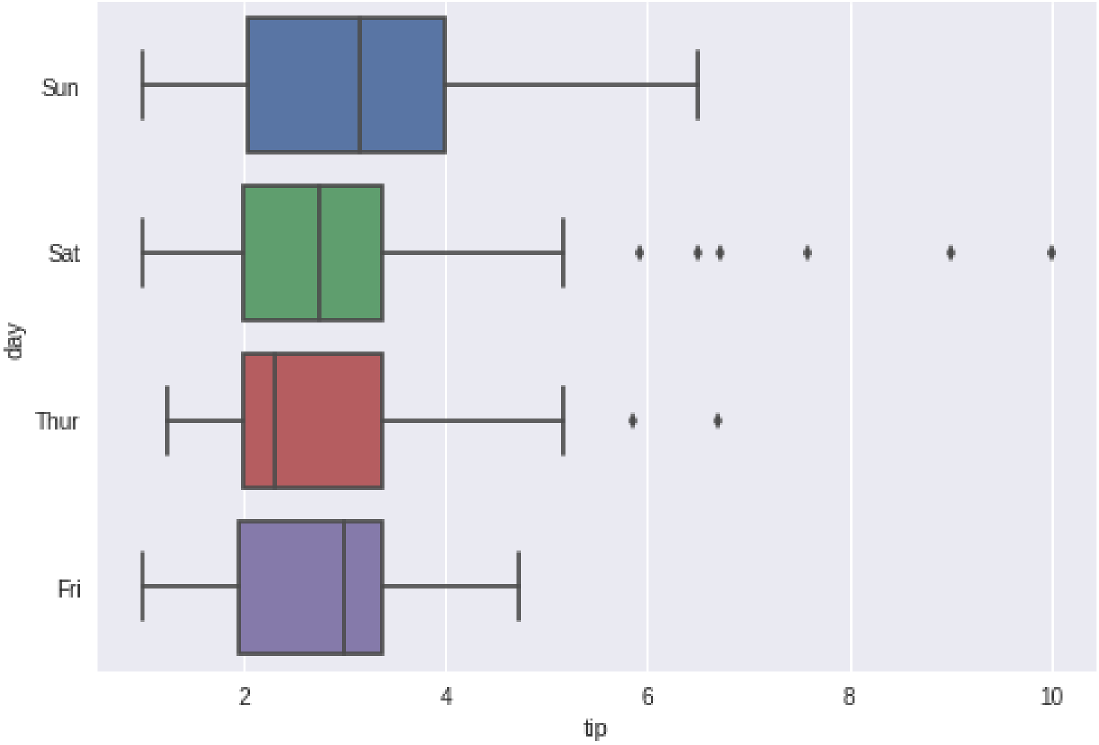
```
1. the distribution of the total bill,
2. the distribution of tips;
3. the distributions of tips vs. days.
```

```
In [9]: def answer_8():
            # write your code here
            plt.figure()
            boxplot_total_bill = sns.boxplot(x= 'total_bill',data=data_tips)
            plt.figure()
            boxplot_tip =sns.boxplot(x= 'tip',data=data_tips)
            plt.figure()
            boxplot_tip_vs_day = sns.boxplot(x= 'tip',y='day',data=data_tips)
            return boxplot_total_bill,boxplot_tip,boxplot_tip_vs_day
        answer_8()
```

```
Out[9]: (<matplotlib.axes._subplots.AxesSubplot at 0x7fed0490f710>,
         <matplotlib.axes._subplots.AxesSubplot at 0x7fecfef6e7f0>,
         <matplotlib.axes._subplots.AxesSubplot at 0x7fecfef47e10>)
```




2
4
6
8
10
tip

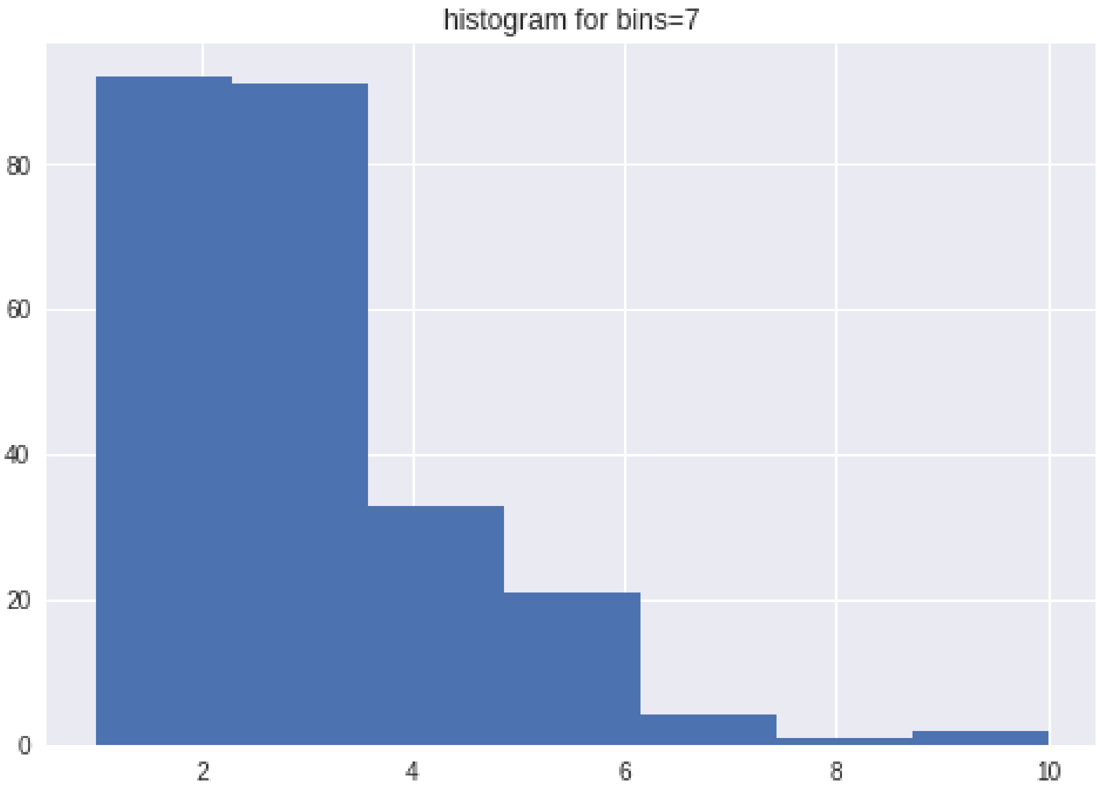

Sun
Sat
Thur
Fri
day
2
4
6
8
10
tip

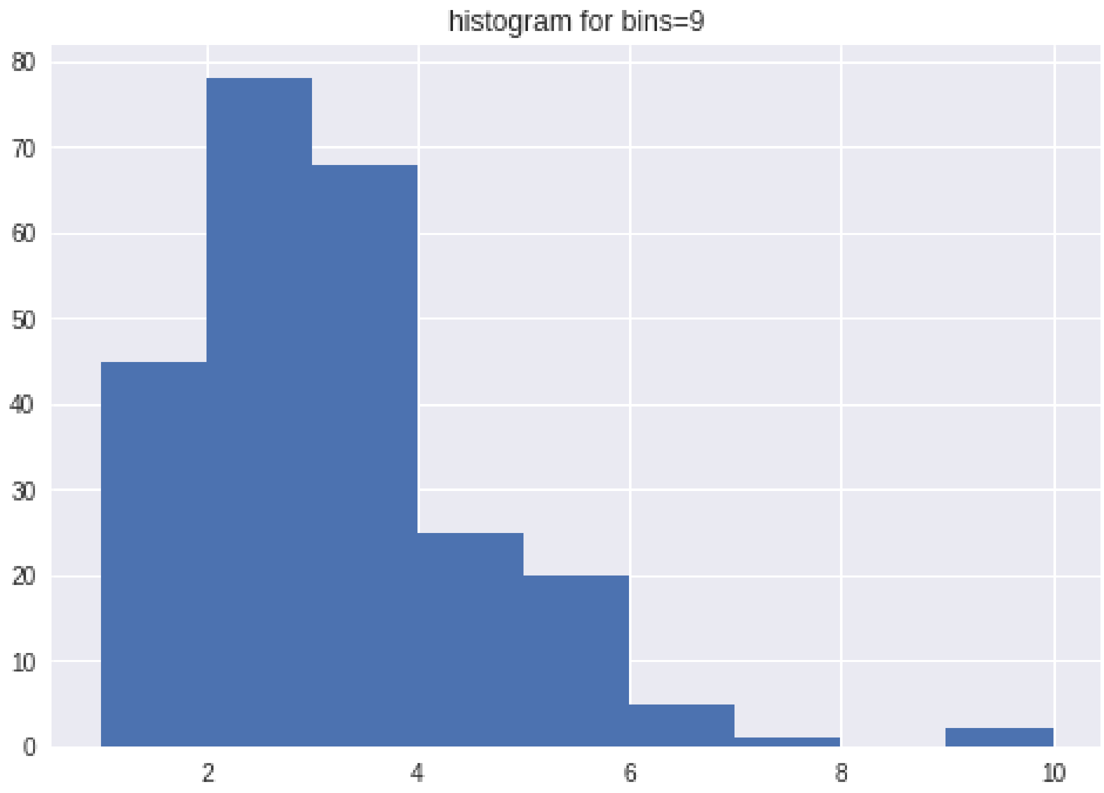
```
In [10]: # to interpret:  firstly, there outliers ( black points in the boxplots)
```

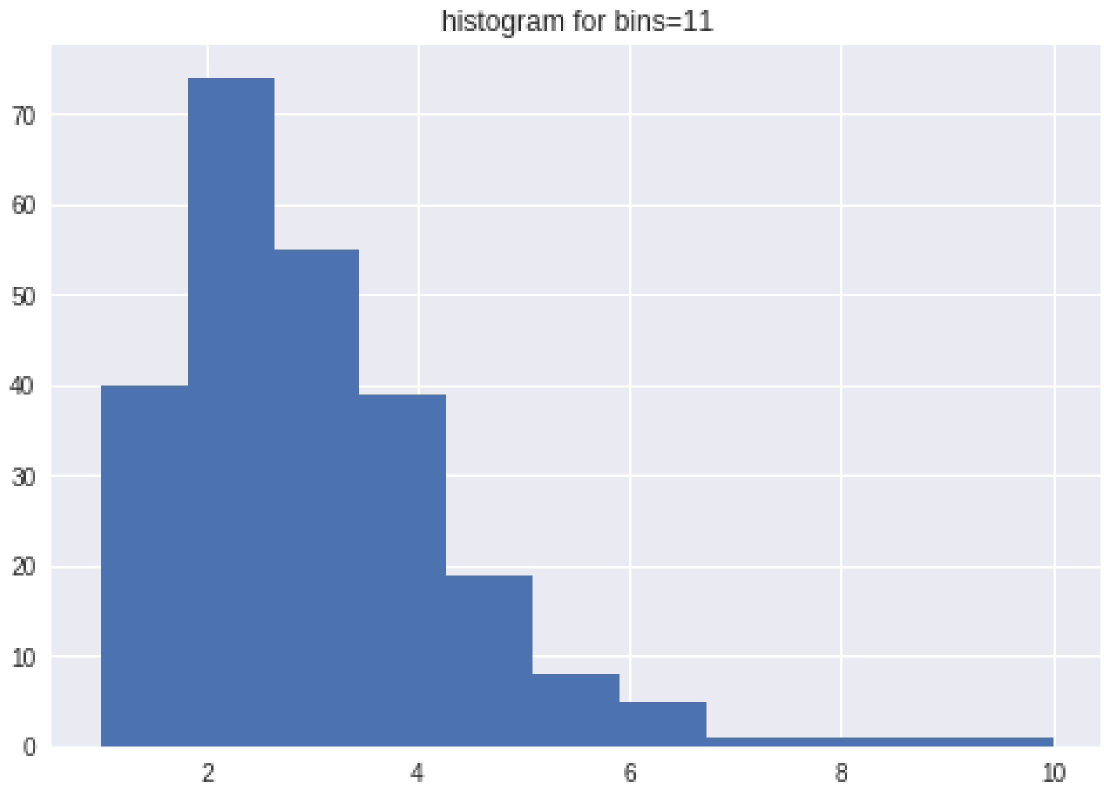
1.2.5 Question 9

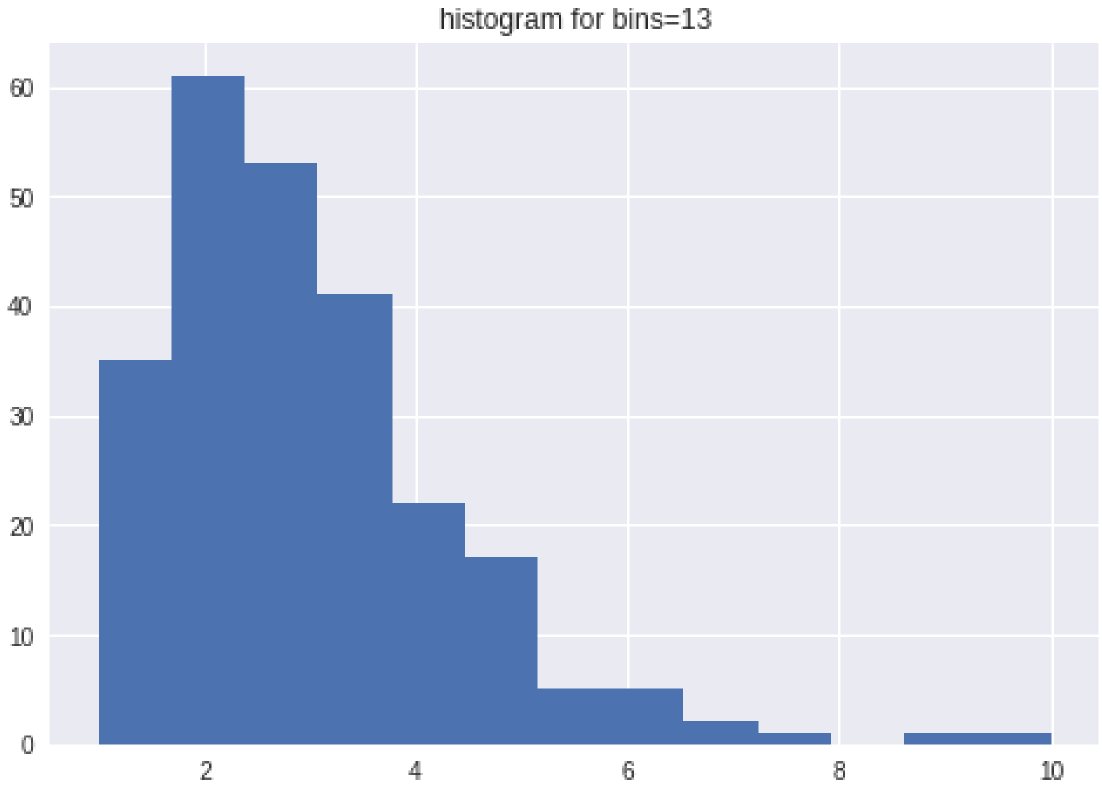
Draw an histogram of tips. What can you say about the shape of the data ? Is this restaurant expensive ? plot 6 histograms with increasing numbers of breaks.

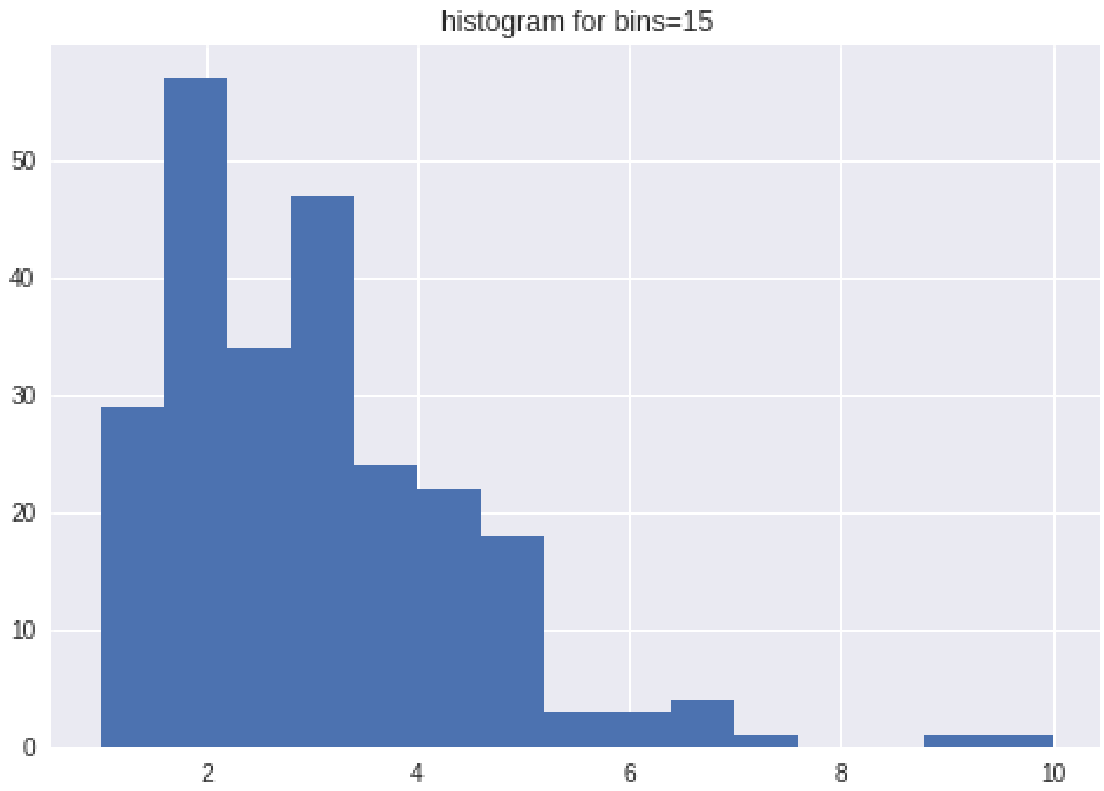
```
In [11]: def answer_9():
             # write your code here
             #plt.subplot(nrows=2,ncols=3)
             for i in range(7,17,2):
                 plt.figure()
                 plt.hist(x='tip',data=data_tips,bins=i)
                 plt.title('histogram for bins='+str(i))
         answer_9()
```




histogram for bins=9
0
10
20
30
40
50
60
70
80
2
4
6
8
10


histogram for bins=11
0
10
20
30
40
50
60
70
2
4
6
8
10


histogram for bins=13
0
10
20
30
40
50
60
2
4
6
8
10



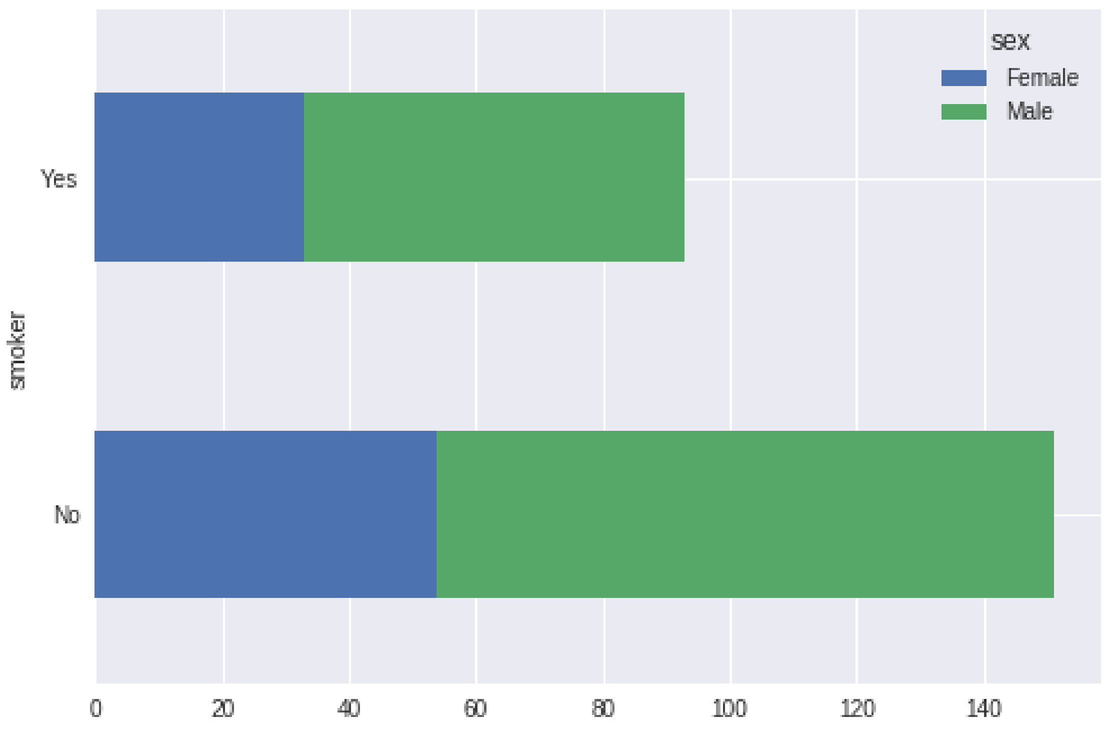
1.2.6 Question 11

Display the counts (proportions) for Gender of the Bill Payer and Smoking Parties. Do the same for time of the day (dinner or lunch) and day of the week

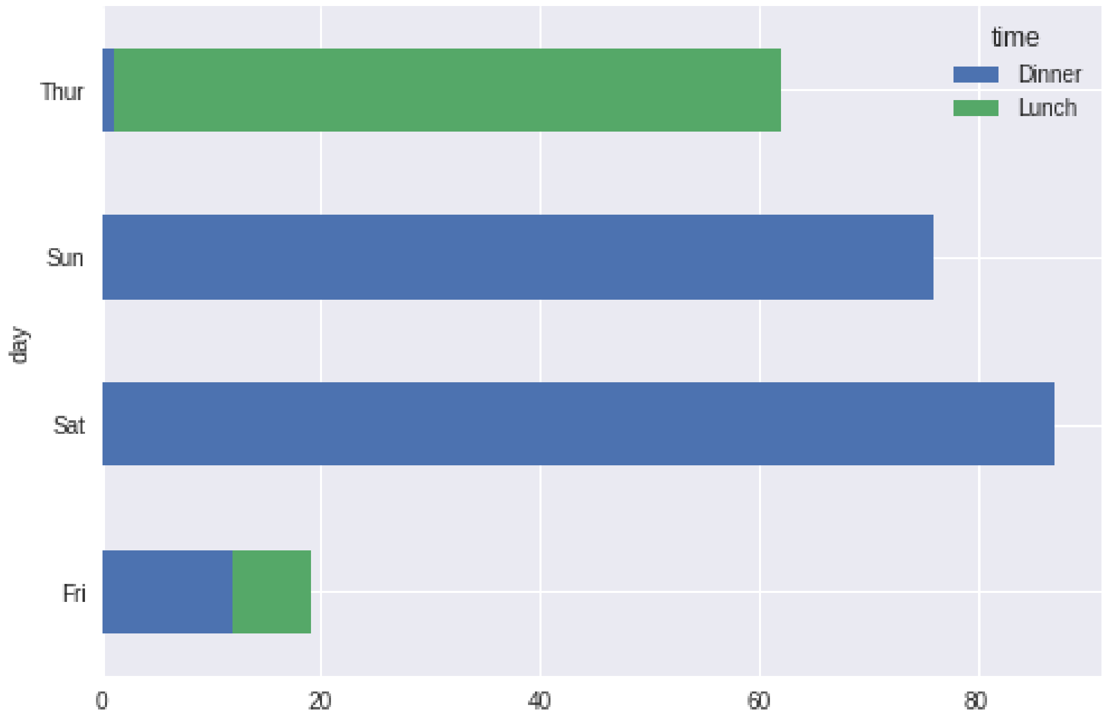
```
In [12]: def answer_11():
             # write your code here
             ax1=pd.crosstab(data_tips.smoker,data_tips.sex).plot.barh(stacked=True
             ax2=pd.crosstab(data_tips.day,data_tips.time).plot.barh(stacked=True)

             return ax1,ax2
         answer_11()
```

```
Out[12]: (<matplotlib.axes._subplots.AxesSubplot at 0x7fecfec64208>,
          <matplotlib.axes._subplots.AxesSubplot at 0x7fecfeb28f98>)
```



sex
Female
Male
smoker
Yes
No
0
20
40
60
80
100
120
140



time
Dinner
Lunch
day
Thur
Sun
Sat
Fri
0
20
40
60
80

1.2.7 Question 12

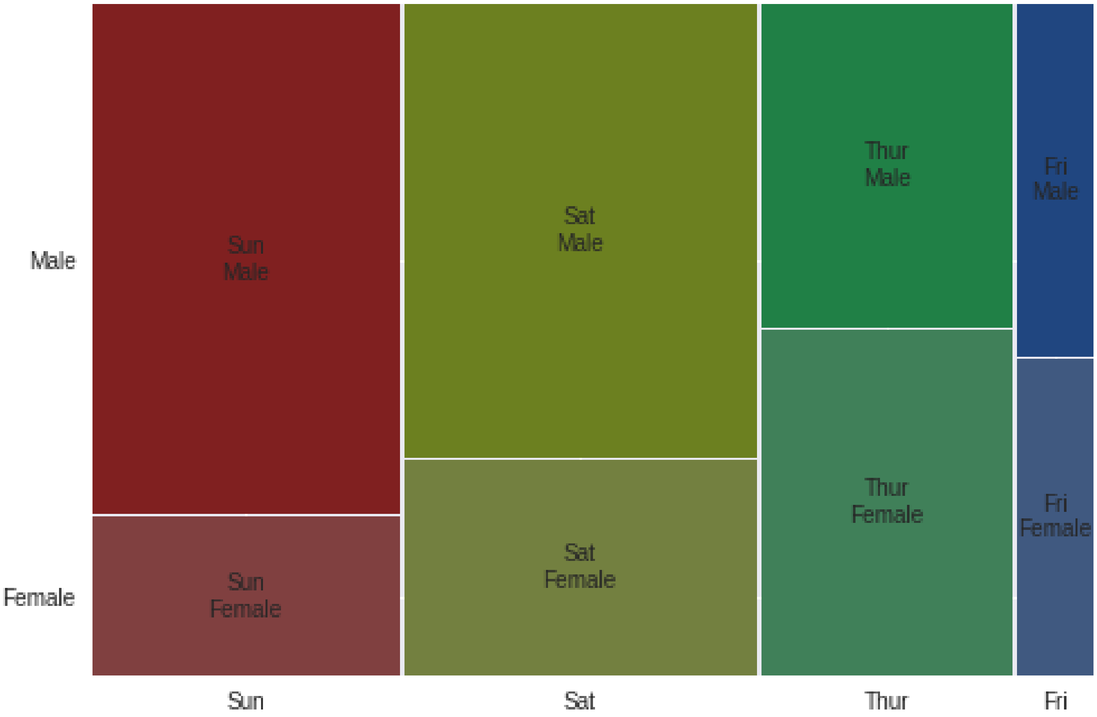
Who pay mostly the bills ? men or women ? and when ? Try to visualise the conditional distributions of Sex given the day of the week, with a mosaic plot

```
In [13]: from statsmodels.graphics.mosaicplot import mosaic
         def answer_12():
             ax=mosaic(data_tips,['day','sex'])

             return ax

         answer_12()
         # men pay mostly and  on Sunday
```

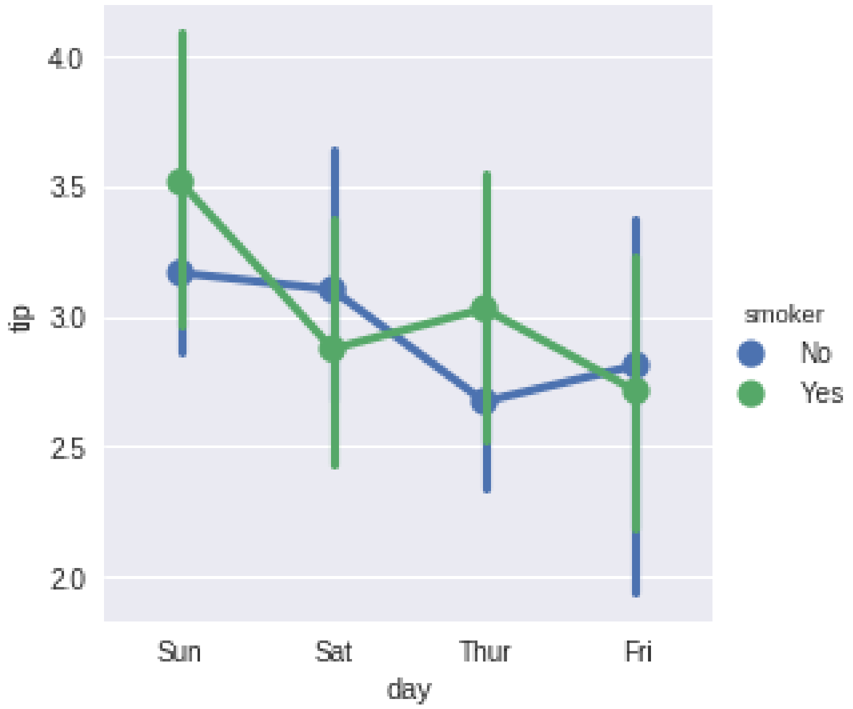
```
Out[13]: (<matplotlib.figure.Figure at 0x7fed048d2048>,
          OrderedDict([(('Sun', 'Female'),
                        (0.0, 0.0, 0.3068723249616409, 0.2360552544151075)),
                       (('Sun', 'Male'),
                        (0.0,
                         0.23937751355132011,
                         0.3068723249616409,
                         0.7606224864486798)),
                       (('Sat', 'Female'),
                        (0.3117984333360252,
                         0.0,
                         0.35128805620608894,
                         0.32076984763432237)),
                       (('Sat', 'Male'),
                        (0.3117984333360252,
                         0.32409210677053502,
                         0.35128805620608894,
                         0.67590789322946487)),
                       (('Thur', 'Female'),
                        (0.6680125979164984,
                         0.0,
                         0.250343212468707,
                         0.51441431786518055)),
                       (('Thur', 'Male'),
                        (0.6680125979164984,
                         0.51773657700139308,
                         0.250343212468707,
                         0.48226342299860675)),
                       (('Fri', 'Female'),
                        (0.9232819187595896,
                         0.0,
                         0.076718081240410 25,
                         0.47211050883021499)),
                       (('Fri', 'Male'),
                        (0.9232819187595896,
                         0.47543276796642764,
                         0.07671808124041025,
                         0.5245672320335723 6))]))
```



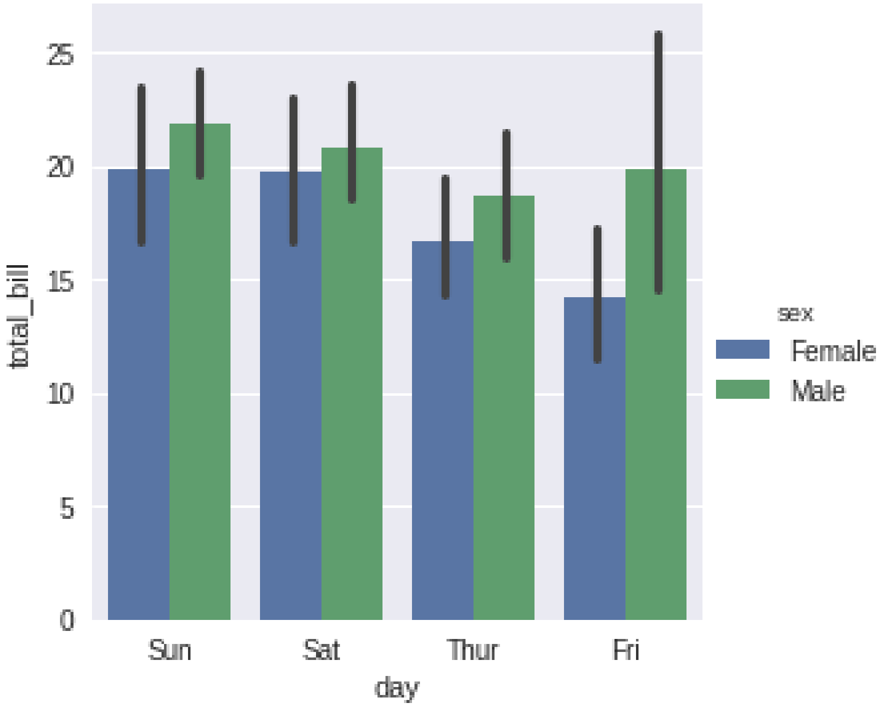
```
In [33]: #You can explore more nice plots  with the seaborn library: http://seaborn
```

```
In [16]: sns.factorplot(x="day", y="tip", hue="smoker", data=data_tips)   # estimto
```

```
Out[16]: <seaborn.axisgrid.FacetGrid at 0x7fecfe982780>
```



```
In [18]: sns.factorplot(x="day", y="total_bill", hue="sex", data=data_tips, kind="b
Out[18]: <seaborn.axisgrid.FacetGrid at 0x7fecfece71d0>
```



```
In [20]: # the plot above shows that Male pay mostly the bills, especially on Sunda
```

1.3 Regression

```
In [22]: # importing statsmodels
         import statsmodels.formula.api as sm
```

1.3.1 Question 13

Before starting with the regression, we will learn how to build dummy variables, which is sometimes useful. Create four new variables, named day_Thur, day_Fri, day_Sat, day_Sun, that take 1 if the dining party was held on that day, 0 otherwise.

```
In [27]: #this function should return a dataframe including the dummies for 'day'
         def answer_13():
             # write your code here:
             data_tips=answer_4()
             return pd.get_dummies(data_tips,columns=['day'])
         answer_13().head(2)

Out[27]:    total_bill   tip     sex smoker    time  size  tip_rate  day_Fri  day_S
         0       16.99  1.01  Female     No  Dinner     2  0.059447        0
         1       10.34  1.66    Male     No  Dinner     3  0.160542        0

            day_Sun  day_Thur
         0        1         0
         1        1         0
```

1.3.2 Question 14

Fit a general linear model with tip rate as a response variable against all the other variables of interest : sex, smoker, time, size, day_Thur, day_Fri, day_Sat, day_Sun

```
In [30]: # this function should fit a general model respecting the requirements and
         #( use :  your_model.summary())
         def answer_14():
             answer_13()
             model=sm.ols(formula="answer_13().tip_rate~answer_13().sex + answer_13
             return model.summary()
         answer_14()

Out[30]: <class 'statsmodels.iolib.summary.Summary'>
         """
                                     OLS Regression Results
         ==================================================================================
         Dep. Variable:     answer_13().tip_rate   R-squared:
```

```
Model:                              OLS   Adj. R-squared:
Method:                   Least Squares   F-statistic:
Date:                  Tue, 18 Jul 2017   Prob (F-statistic):
Time:                          13:44:42   Log-Likelihood:
No. Observations:                   244   AIC:
Df Residuals:                       236   BIC:
Df Model:                             7
Covariance Type:              nonrobust
=========================================================================
                                coef    std err          t      P>|t|
-------------------------------------------------------------------------
Intercept                     0.1459      0.013     11.554      0.000
answer_13().sex[T.Male]      -0.0085      0.008     -1.023      0.307
answer_13().smoker[T.Yes]     0.0036      0.008      0.428      0.669
answer_13().time[T.Lunch]     0.0234      0.026      0.895      0.372
answer_13()['size']          -0.0096      0.004     -2.282      0.023
answer_13().day_Fri           0.0373      0.012      3.049      0.003
answer_13().day_Thur          0.0191      0.020      0.953      0.341
answer_13().day_Sun           0.0540      0.010      5.160      0.000
answer_13().day_Sat           0.0355      0.010      3.590      0.000
=========================================================================
Omnibus:                      214.408   Durbin-Watson:                   2
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             7088
Skew:                           3.189   Prob(JB):
Kurtosis:                      28.623   Cond. No.                     8.72
=========================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is cor
[2] The smallest eigenvalue is 2.97e-29. This might indicate that there ar
strong multicollinearity problems or that the design matrix is singular.
"""
```

1.3.3 Question 15

Fit a model with only the size as an explanatory variable

```
In [32]: def answer_15():
             #write your code here
             data_tips=answer_13()
             model=sm.ols(formula="data_tips.tip_rate~data_tips['size']",data=data_
             return model.summary()

         answer_15()
```

```
Out[32]: <class 'statsmodels.iolib.summary.Summary'>
         """
                                     OLS Regression Results
```

```
=========================================================================
Dep. Variable:     data_tips.tip_rate   R-squared:                       0
Model:                            OLS   Adj. R-squared:                  0
Method:                 Least Squares   F-statistic:                     5
Date:                Tue, 18 Jul 2017   Prob (F-statistic):             0.
Time:                        13:47:08   Log-Likelihood:                 33
No. Observations:                 244   AIC:                            -6
Df Residuals:                     242   BIC:                            -6
Df Model:                           1
Covariance Type:            nonrobust
=========================================================================
                        coef    std err          t      P>|t|      [95.0%
-------------------------------------------------------------------------
Intercept             0.1844      0.011     16.475      0.000         0.16
data_tips['size']    -0.0092      0.004     -2.245      0.026        -0.01
=========================================================================
Omnibus:                      220.122   Durbin-Watson:                   2
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             7618
Skew:                           3.308   Prob(JB):
Kurtosis:                      29.562   Cond. No.
=========================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is cor
"""
```

1.3.4 Question 16

Use a stepwise algorithm with the AIC statistic as a variable selection process to select a good model. Start from the full model of question 13. What do you remark?

```
In [34]: # this function is provided since there is no specific method for aicstat
         # the source code was taken from : http://planspace.org/20150423-forward_s
         import statsmodels.formula.api as smf

         def forward_selected(data, response):
             """Linear model designed by forward selection.

             Parameters:
             -----------
             data : pandas DataFrame with all possible predictors and response

             response: string, name of response column in data

             Returns:
             --------
             model: an "optimal" fitted statsmodels linear model
                    with an intercept
                    selected by forward selection
                    evaluated by adjusted R-squared
             """
             remaining = set(data.columns)
             remaining.remove(response)
             selected = []
             current_score, best_new_score = 0.0, 0.0
             while remaining and current_score == best_new_score:
                 scores_with_candidates = []
                 for candidate in remaining:
                     formula = "{} ~ {} ".format(response,
                                                    ' + '.join(selected + [candidat
                     score = smf.ols(formula, data).fit().rsquared_adj
                     scores_with_candidates.append((score, candidate))
                 scores_with_candidates.sort()
                 best_new_score, best_candidate = scores_with_candidates.pop()
                 if current_score < best_new_score:
                     remaining.remove(best_candidate)
                     selected.append(best_candidate)
                     current_score = best_new_score
             formula = "{} ~ {} ".format(response,
                                            ' + '.join(selected))
             model = smf.ols(formula, data).fit()
             return model
```

```
In [35]: def answer_16():
             data=answer_13().iloc[:,2:10]
             model = forward_selected(data, 'tip_rate')
             return  model.model.formula ,model.rsquared_adj
         answer_16()
```

```
Out[35]: ('tip_rate ~ size + day_Sat ', 0.022243088905636199)
```

Home work Explore the notion of interaction between the Gender and the smoking habit by including explicitely this interaction into a model with size, sex, smoke

1.3.5 Question 17

Check the linear relationship between the tip and the total bill, seen at question 7, with a linear model and interpret the quality of this model

```
In [37]: def answer_17():
             # write your code here
             model=sm.ols(formula="data_tips.tip_rate~data_tips.total_bill",data=da
             return model.summary()
         answer_17()
```

```
Out[37]: <class 'statsmodels.iolib.summary.Summary'>
         """
```

```
                            OLS Regression Results
==========================================================================
Dep. Variable:     data_tips.tip_rate   R-squared:                       0
Model:                            OLS   Adj. R-squared:                  0
Method:                 Least Squares   F-statistic:                     3
Date:                Tue, 18 Jul 2017   Prob (F-statistic):           5.85
Time:                        13:54:37   Log-Likelihood:                 35
No. Observations:                 244   AIC:                            -6
Df Residuals:                     242   BIC:                            -6
Df Model:                           1
Covariance Type:            nonrobust
==========================================================================
                           coef    std err          t      P>|t|      [95.
--------------------------------------------------------------------------
Intercept                0.2068      0.009     22.975      0.000         0
data_tips.total_bill    -0.0023      0.000     -5.599      0.000        -0
==========================================================================
Omnibus:                      224.802   Durbin-Watson:                   2
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             7863
Skew:                           3.420   Prob(JB):
Kurtosis:                      29.957   Cond. No.
==========================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is cor
"""
```

In [ ]: