Lecture 9: Data Aggregation and Group Operations

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Agenda:

- Split a pandas object into pieces using one or more keys (in the form of functions, arrays, or DataFrame column names)
- Calculate group summary statistics, like count, mean, or standard deviation, or a user-defined function
- Apply within-group transformations or other manipulations, like normalization, linear regression, rank, or subset selection
- Compute pivot tables and cross-tabulations
- Perform quantile analysis and other statistical group analyses

GroupBy Mechanics

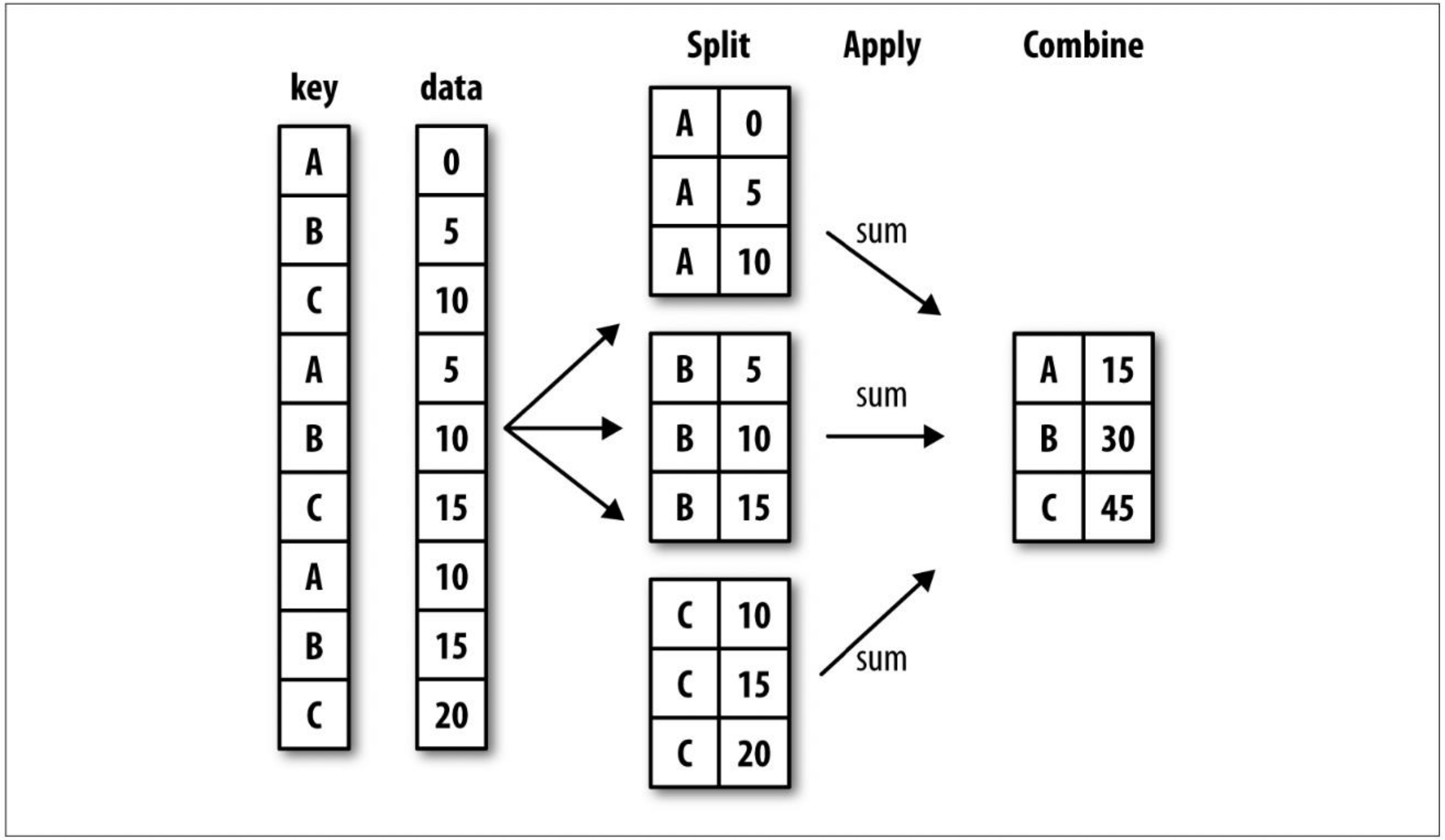


Figure 1. Illustration of a group aggregation

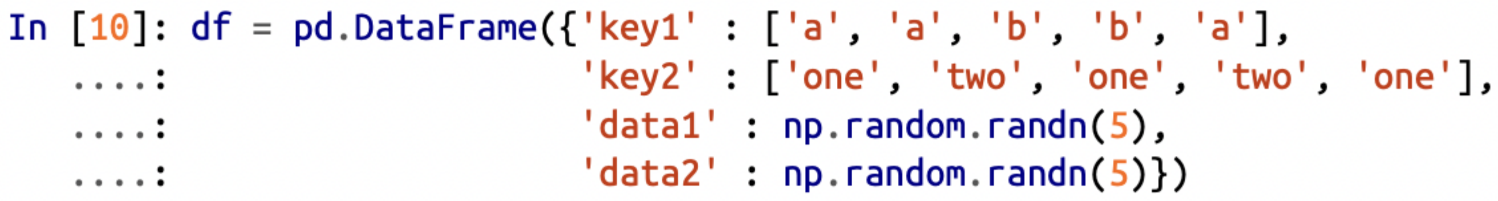
- A list or array of values that is the same length as the axis being grouped

- A value indicating a column name in a DataFrame

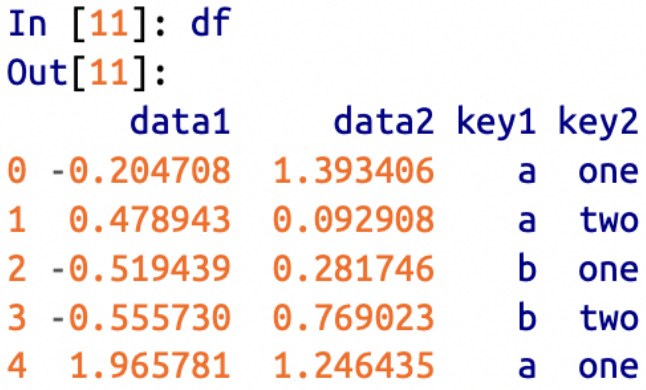
- A dict or Series giving a correspondence between the values on the axis being grouped and the group names

- A function to be invoked on the axis index or the individual labels in the index

let's get started

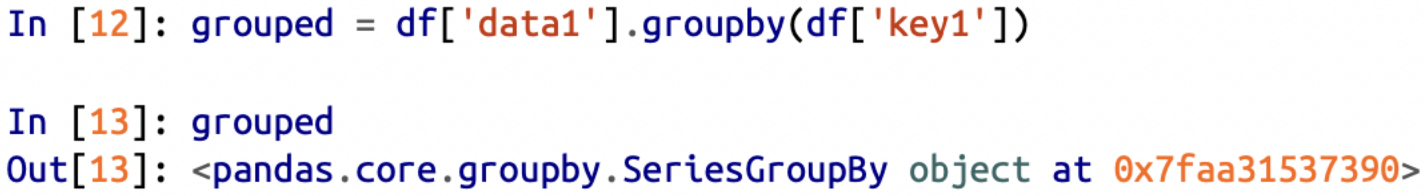


```
In [10]: df = pd.DataFrame({'key1' : ['a', 'a', 'b', 'b', 'a'],
   ....:                    'key2' : ['one', 'two', 'one', 'two', 'one'],
   ....:                    'data1' : np.random.randn(5),
   ....:                    'data2' : np.random.randn(5)})
```



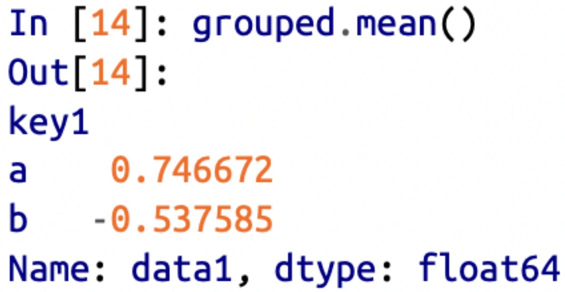
```
In [11]: df
Out[11]:
      data1     data2 key1 key2
0 -0.204708  1.393406    a  one
1  0.478943  0.092908    a  two
2 -0.519439  0.281746    b  one
3 -0.555730  0.769023    b  two
4  1.965781  1.246435    a  one
```

Groupby method with the column (a Series) at key1:



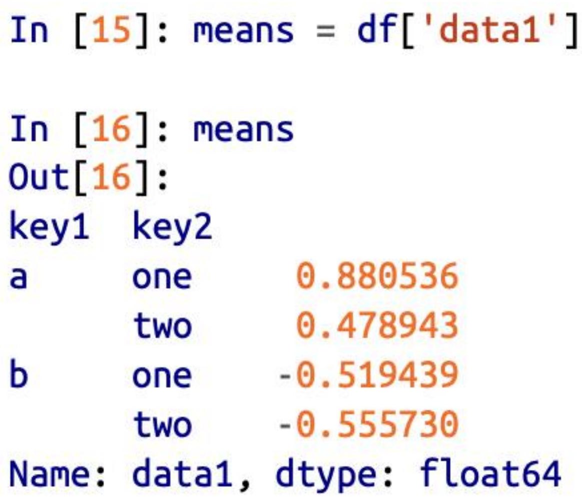
```
In [12]: grouped = df['data1'].groupby(df['key1'])

In [13]: grouped
Out[13]: <pandas.core.groupby.SeriesGroupBy object at 0x7faa31537390>
```

To compute group means we can call the GroupBy's mean method:

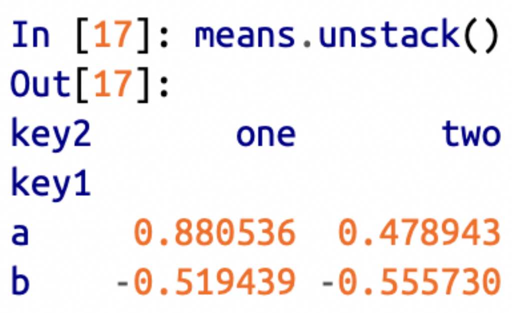


```
In [14]: grouped.mean()
Out[14]:
key1
a    0.746672
b   -0.537585
Name: data1, dtype: float64
```

If instead we had passed multiple arrays as a list, we’d get something different:

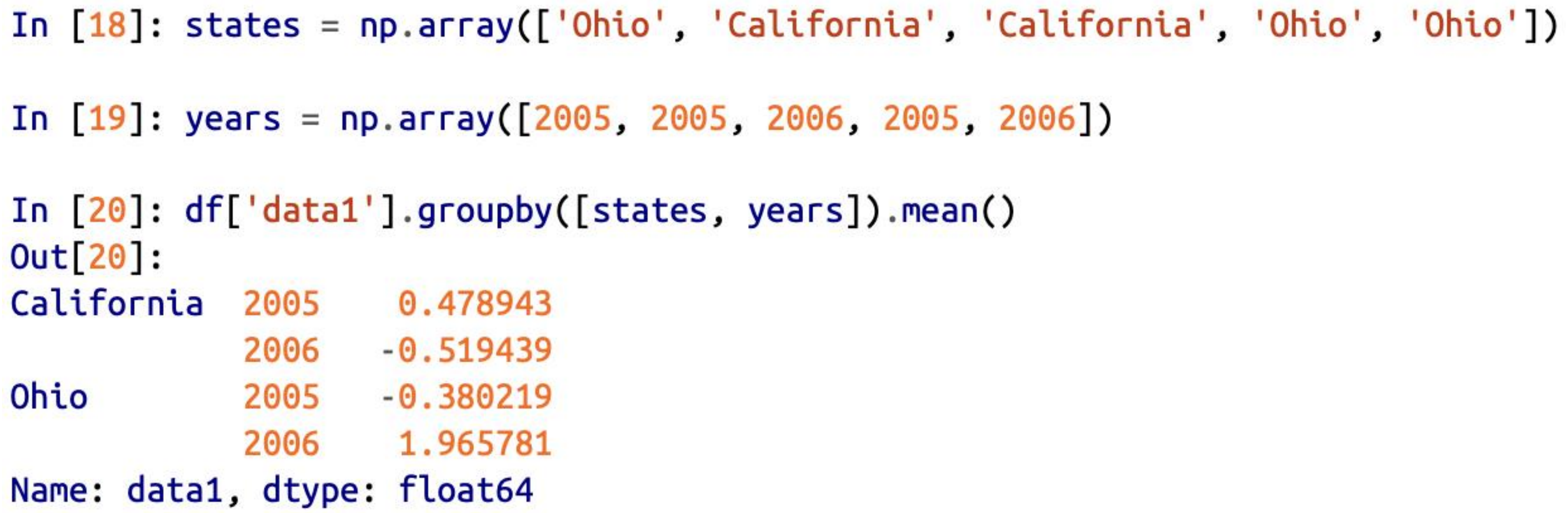


```
In [15]: means = df['data1'].groupby([df['key1'], df['key2']]).mean()

In [16]: means
Out[16]:
key1  key2
a     one      0.880536
      two      0.478943
b     one     -0.519439
      two     -0.555730
Name: data1, dtype: float64
```

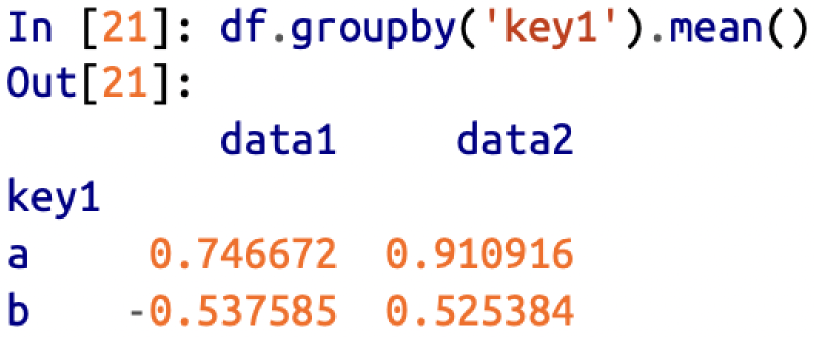


```
In [17]: means.unstack()
Out[17]:
key2        one       two
key1
a      0.880536  0.478943
b     -0.519439 -0.555730
```

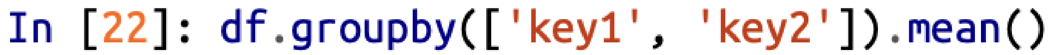
In this example, the group keys are all Series, though they could be any arrays of the right length:



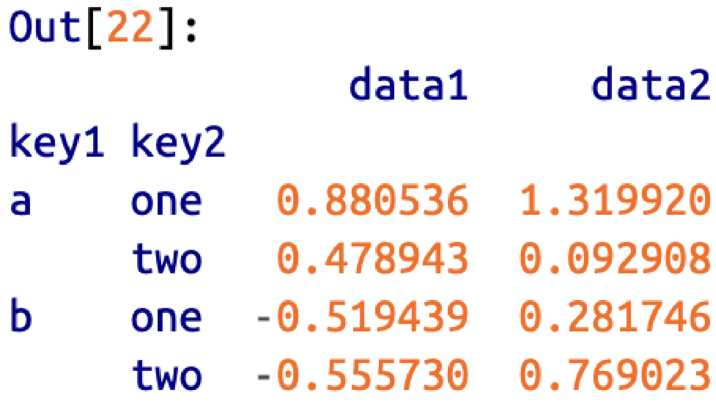
```
In [18]: states = np.array(['Ohio', 'California', 'California', 'Ohio', 'Ohio'])

In [19]: years = np.array([2005, 2005, 2006, 2005, 2006])

In [20]: df['data1'].groupby([states, years]).mean()
Out[20]:
California  2005    0.478943
            2006   -0.519439
Ohio        2005   -0.380219
            2006    1.965781
Name: data1, dtype: float64
```



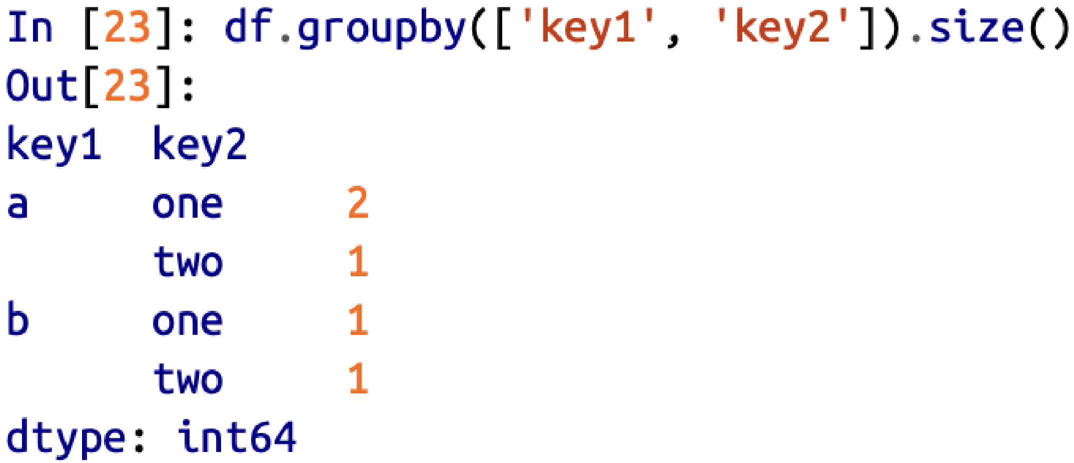
```
In [21]: df.groupby('key1').mean()
Out[21]:
         data1     data2
key1
a     0.746672  0.910916
b    -0.537585  0.525384
```



```
In [22]: df.groupby(['key1', 'key2']).mean()
```



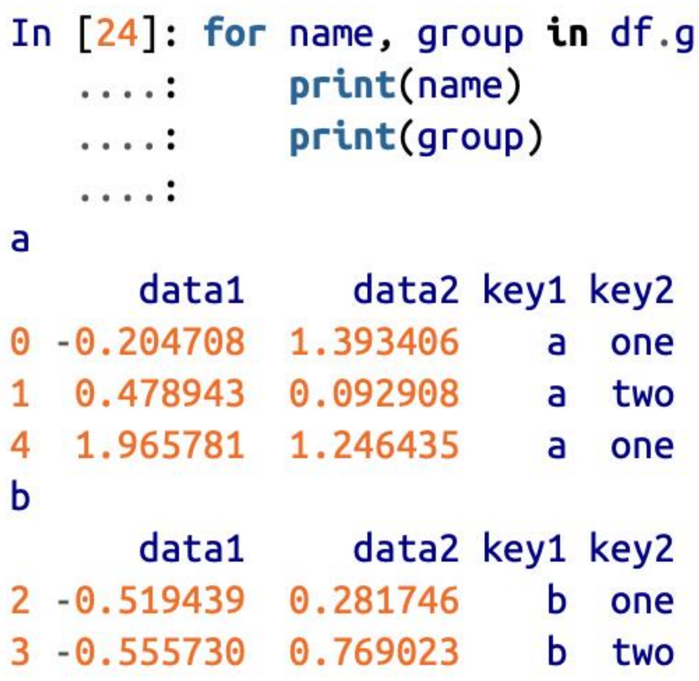
```
Out[22]:
              data1     data2
key1 key2
a    one   0.880536  1.319920
     two   0.478943  0.092908
b    one  -0.519439  0.281746
     two  -0.555730  0.769023
```



```
In [23]: df.groupby(['key1', 'key2']).size()
Out[23]:
key1  key2
a     one     2
      two     1
b     one     1
      two     1
dtype: int64
```

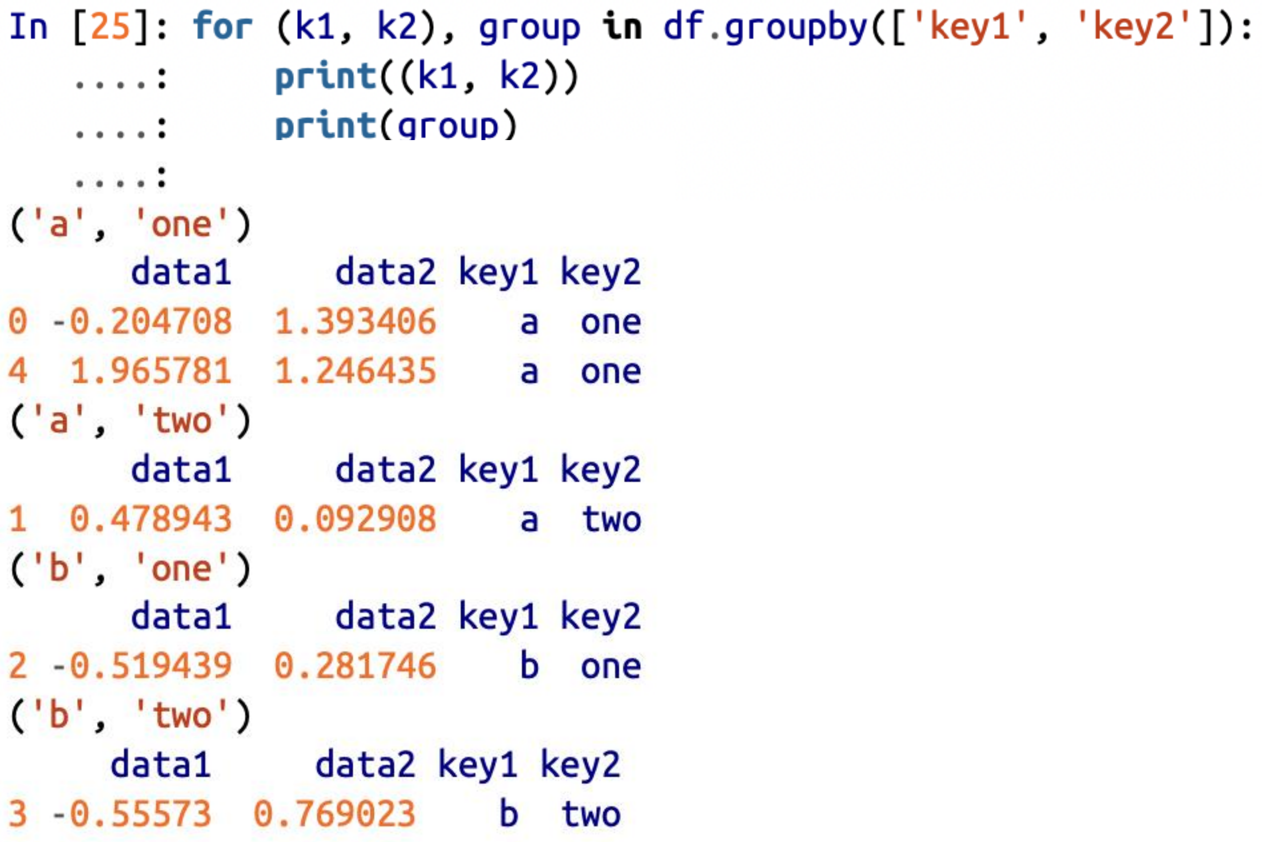
Take note that any missing values in a group key will be excluded from the result.

Iterating Over Groups

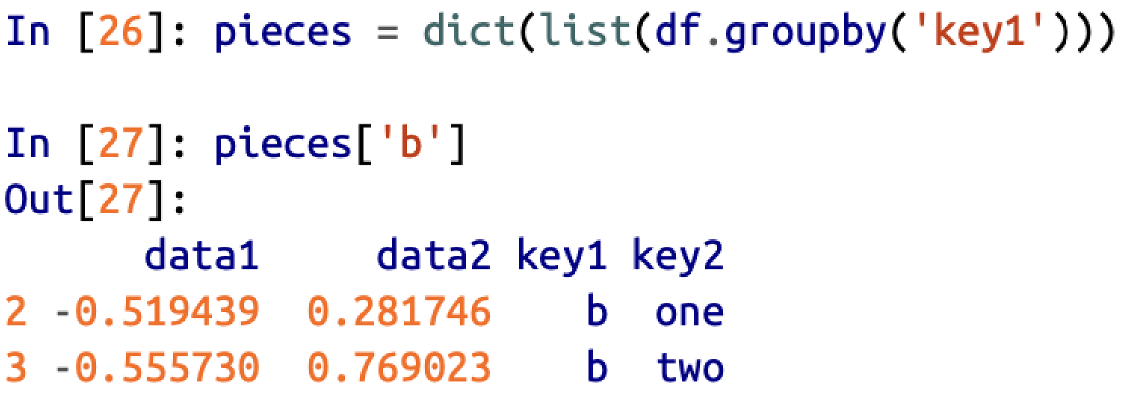


```
In [24]: for name, group in df.groupby('key1'):
   ....:     print(name)
   ....:     print(group)
   ....:
a
      data1     data2 key1 key2
0 -0.204708  1.393406    a  one
1  0.478943  0.092908    a  two
4  1.965781  1.246435    a  one
b
      data1     data2 key1 key2
2 -0.519439  0.281746    b  one
3 -0.555730  0.769023    b  two
```

In the case of multiple keys, the first element in the tuple will be a tuple of key values:

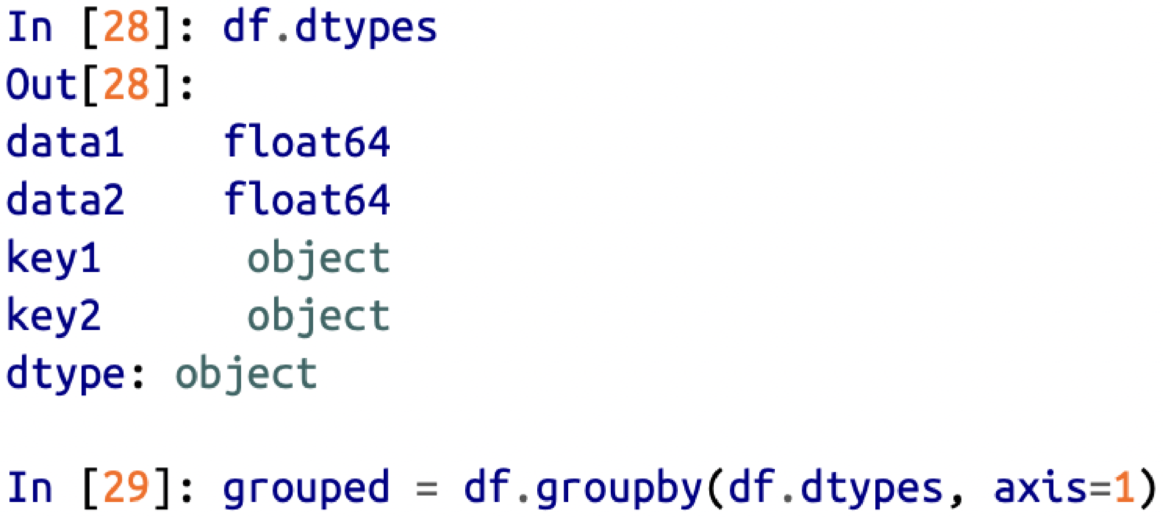


```
In [25]: for (k1, k2), group in df.groupby(['key1', 'key2']):
   ....:     print((k1, k2))
   ....:     print(group)
   ....:
('a', 'one')
      data1     data2 key1 key2
0 -0.204708  1.393406    a  one
4  1.965781  1.246435    a  one
('a', 'two')
      data1     data2 key1 key2
1  0.478943  0.092908    a  two
('b', 'one')
      data1     data2 key1 key2
2 -0.519439  0.281746    b  one
('b', 'two')
     data1     data2 key1 key2
3 -0.55573  0.769023    b  two
```



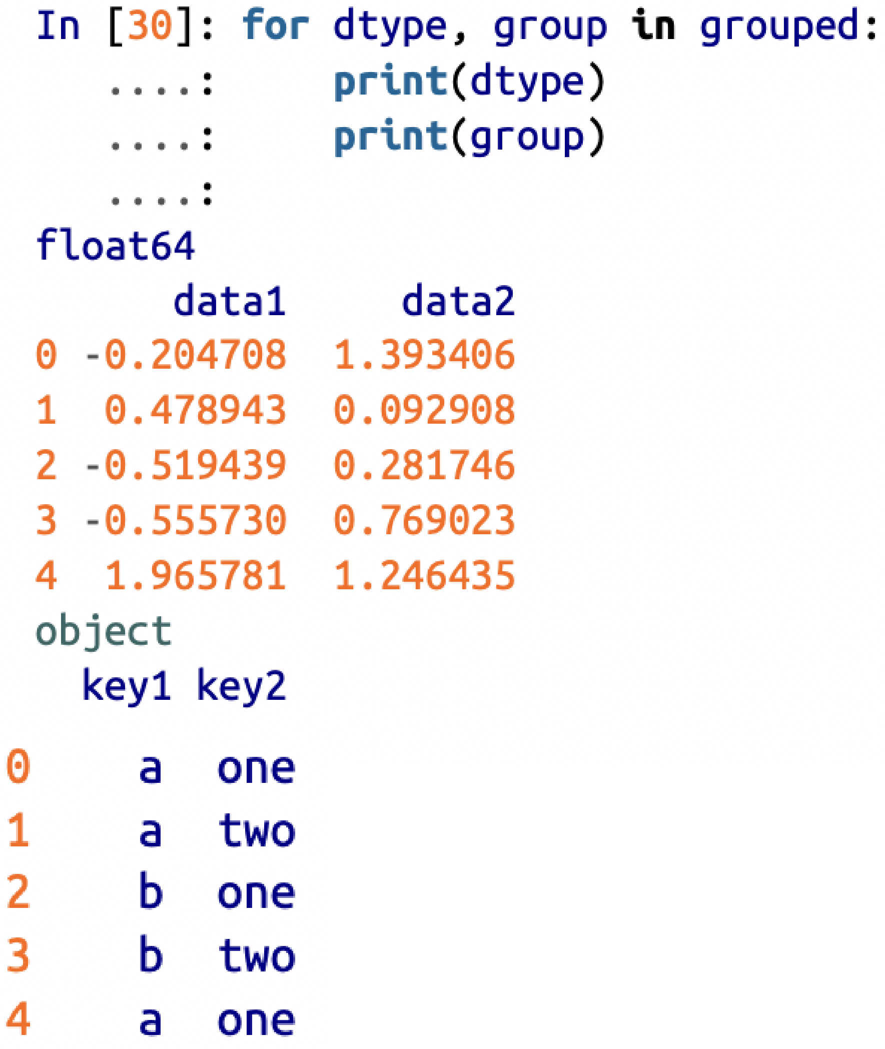
```
In [26]: pieces = dict(list(df.groupby('key1')))

In [27]: pieces['b']
Out[27]:
      data1     data2 key1 key2
2 -0.519439  0.281746    b  one
3 -0.555730  0.769023    b  two
```

By default groupby groups on axis=0, but you can group on any of the other axes.



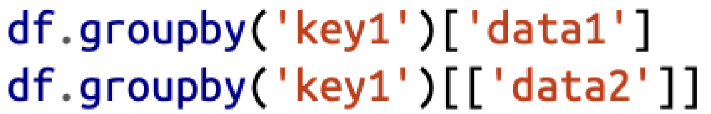
```
In [28]: df.dtypes
Out[28]:
data1     float64
data2     float64
key1       object
key2       object
dtype: object

In [29]: grouped = df.groupby(df.dtypes, axis=1)
```

We can print out the groups like so:

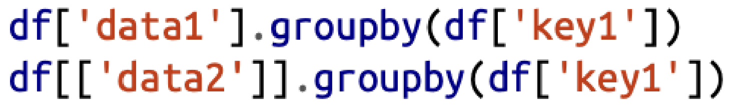


```
In [30]: for dtype, group in grouped:
   ....:     print(dtype)
   ....:     print(group)
   ....:
float64
      data1     data2
0 -0.204708  1.393406
1  0.478943  0.092908
2 -0.519439  0.281746
3 -0.555730  0.769023
4  1.965781  1.246435
object
  key1 key2
0    a  one
1    a  two
2    b  one
3    b  two
4    a  one
```

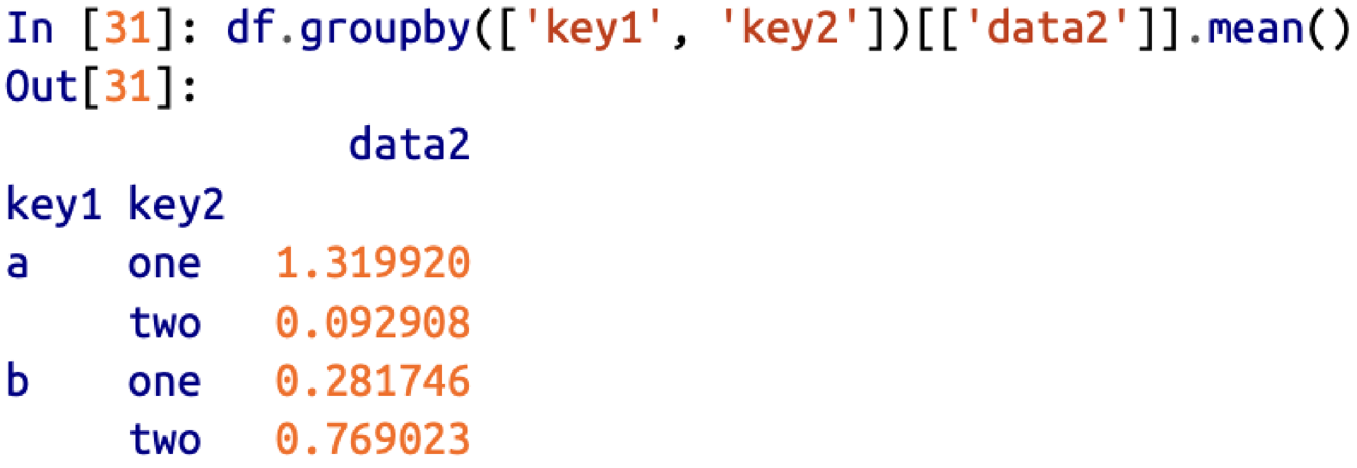
Selecting a Column or Subset of Columns



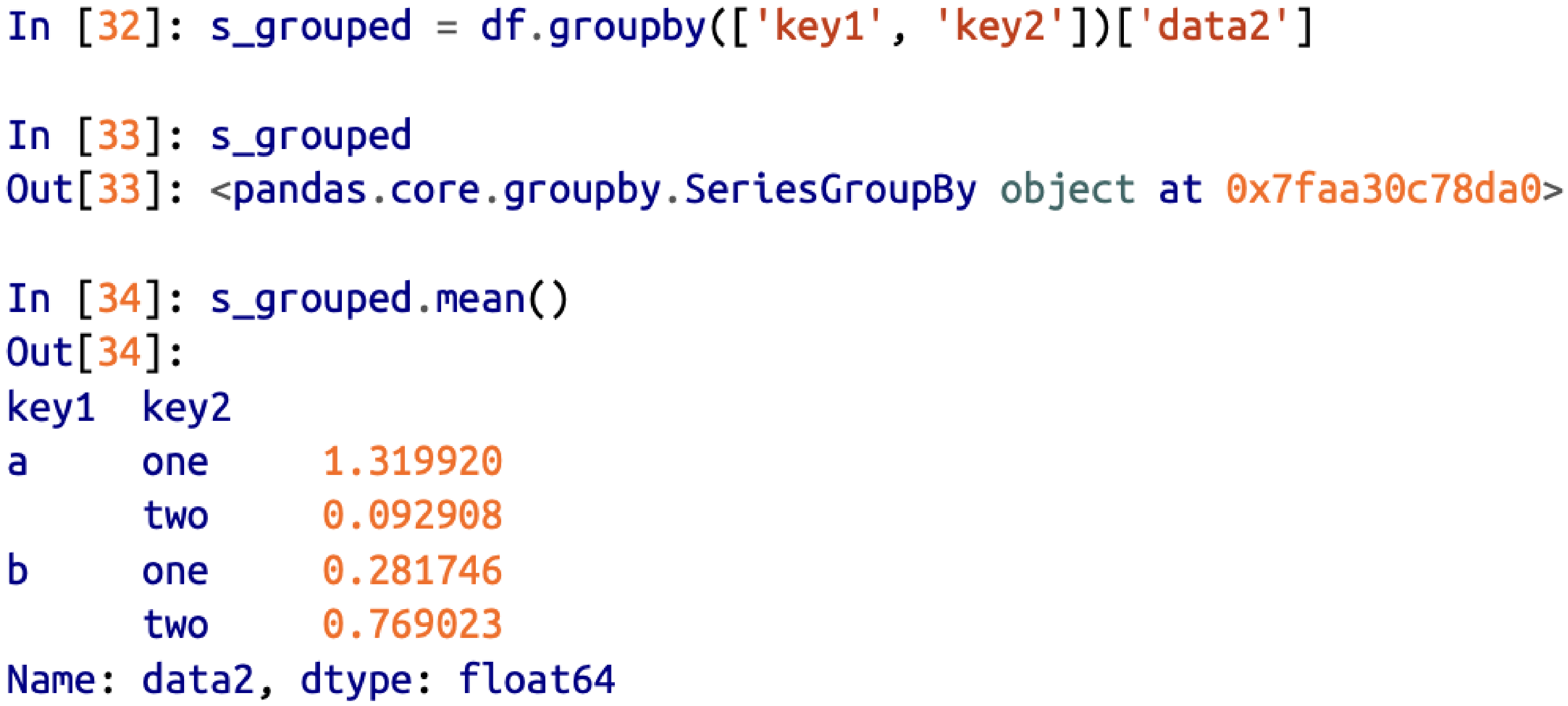
```
df.groupby('key1')['data1']
df.groupby('key1')[['data2']]
```



```
df['data1'].groupby(df['key1'])
df[['data2']].groupby(df['key1'])
```

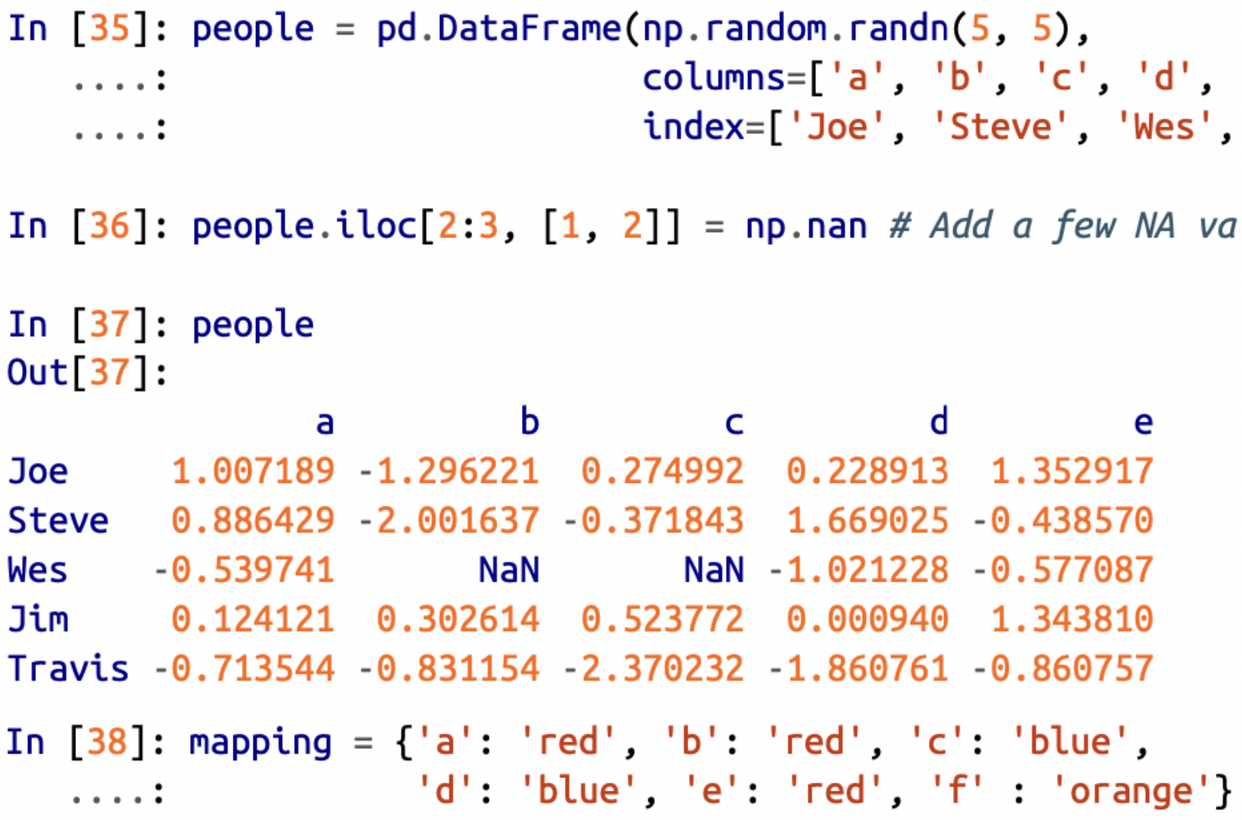


```
In [31]: df.groupby(['key1', 'key2'])[['data2']].mean()
Out[31]:
                data2
key1 key2
a    one    1.319920
     two    0.092908
b    one    0.281746
     two    0.769023
```

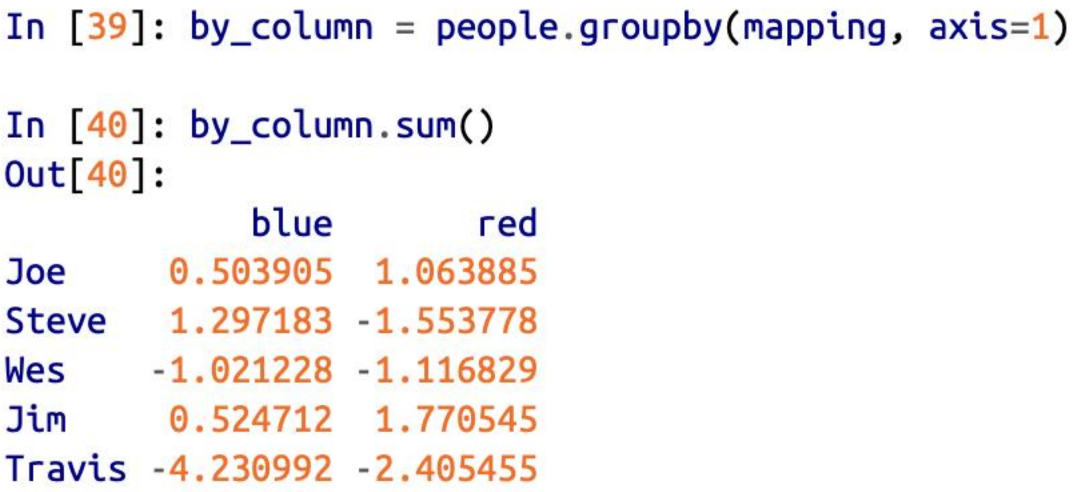


```
In [32]: s_grouped = df.groupby(['key1', 'key2'])['data2']

In [33]: s_grouped
Out[33]: <pandas.core.groupby.SeriesGroupBy object at 0x7faa30c78da0>

In [34]: s_grouped.mean()
Out[34]:
key1  key2
a     one     1.319920
      two     0.092908
b     one     0.281746
      two     0.769023
Name: data2, dtype: float64
```

Grouping with Dicts and Series

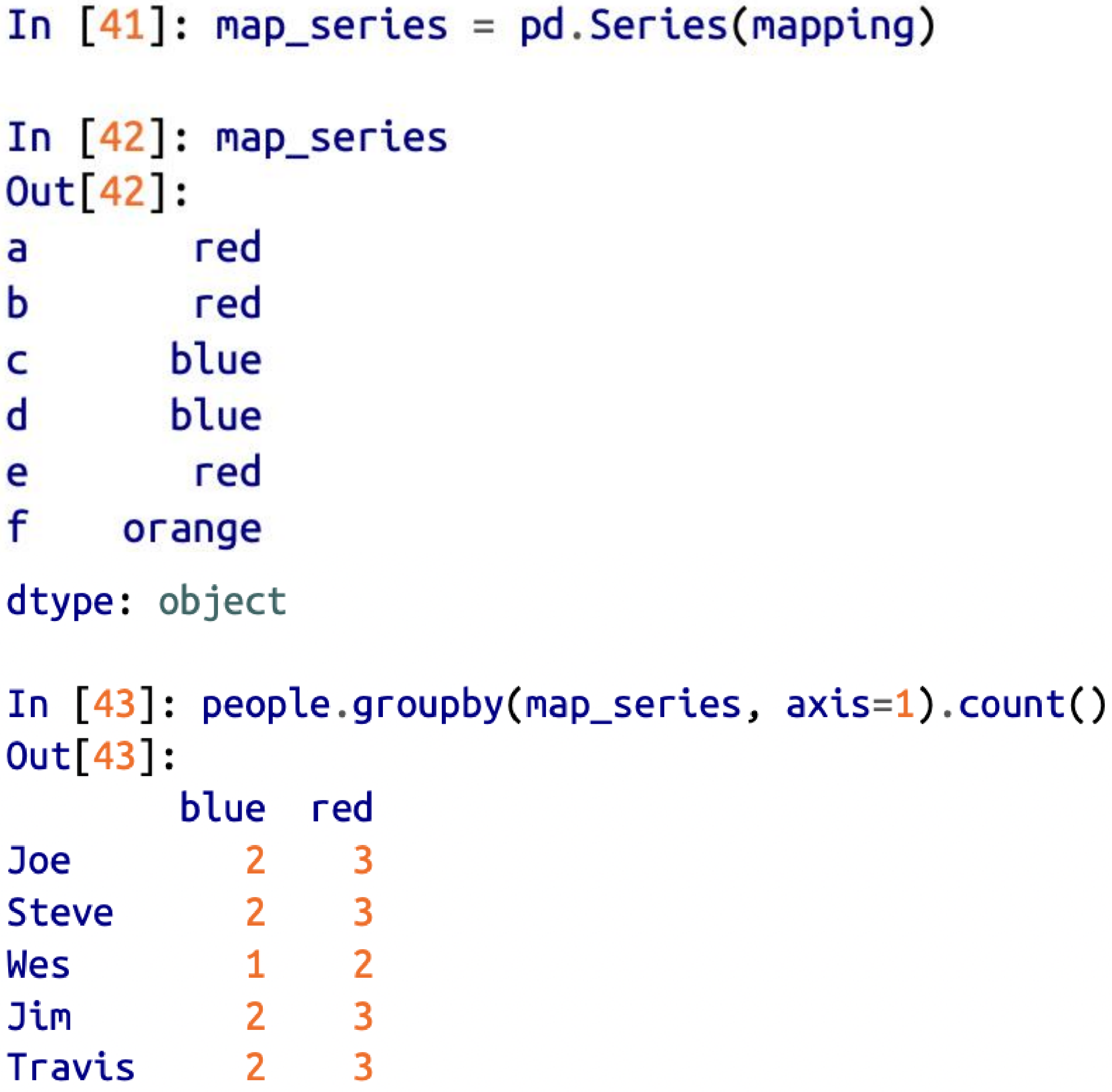


```
In [35]: people = pd.DataFrame(np.random.randn(5, 5),
   ....:                       columns=['a', 'b', 'c', 'd', 'e'],
   ....:                       index=['Joe', 'Steve', 'Wes', 'Jim', 'Travis'])

In [36]: people.iloc[2:3, [1, 2]] = np.nan # Add a few NA values

In [37]: people
Out[37]:
               a         b         c         d         e
Joe     1.007189 -1.296221  0.274992  0.228913  1.352917
Steve   0.886429 -2.001637 -0.371843  1.669025 -0.438570
Wes    -0.539741       NaN       NaN -1.021228 -0.577087
Jim     0.124121  0.302614  0.523772  0.000940  1.343810
Travis -0.713544 -0.831154 -2.370232 -1.860761 -0.860757

In [38]: mapping = {'a': 'red', 'b': 'red', 'c': 'blue',
   ....:            'd': 'blue', 'e': 'red', 'f' : 'orange'}
```



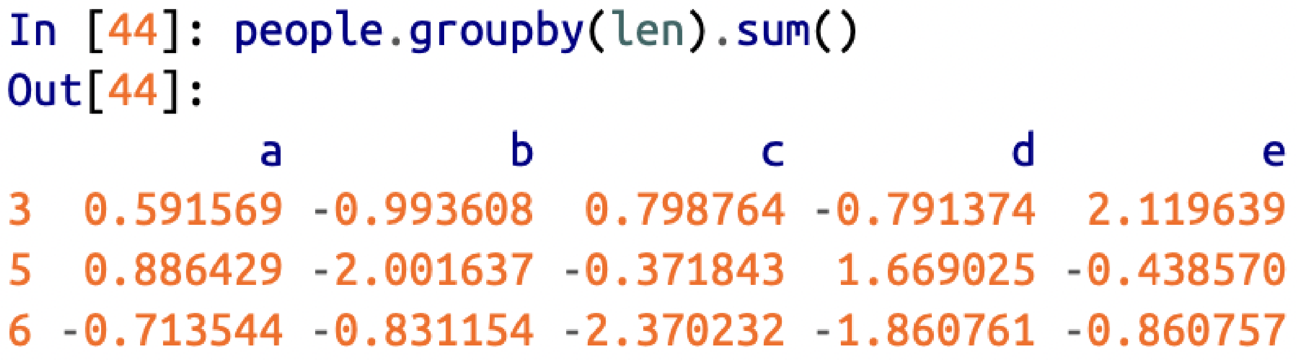
```
In [39]: by_column = people.groupby(mapping, axis=1)

In [40]: by_column.sum()
Out[40]:
            blue       red
Joe     0.503905  1.063885
Steve   1.297183 -1.553778
Wes    -1.021228 -1.116829
Jim     0.524712  1.770545
Travis -4.230992 -2.405455
```

The same functionality holds for Series, which can be viewed as a fixed-size mapping:



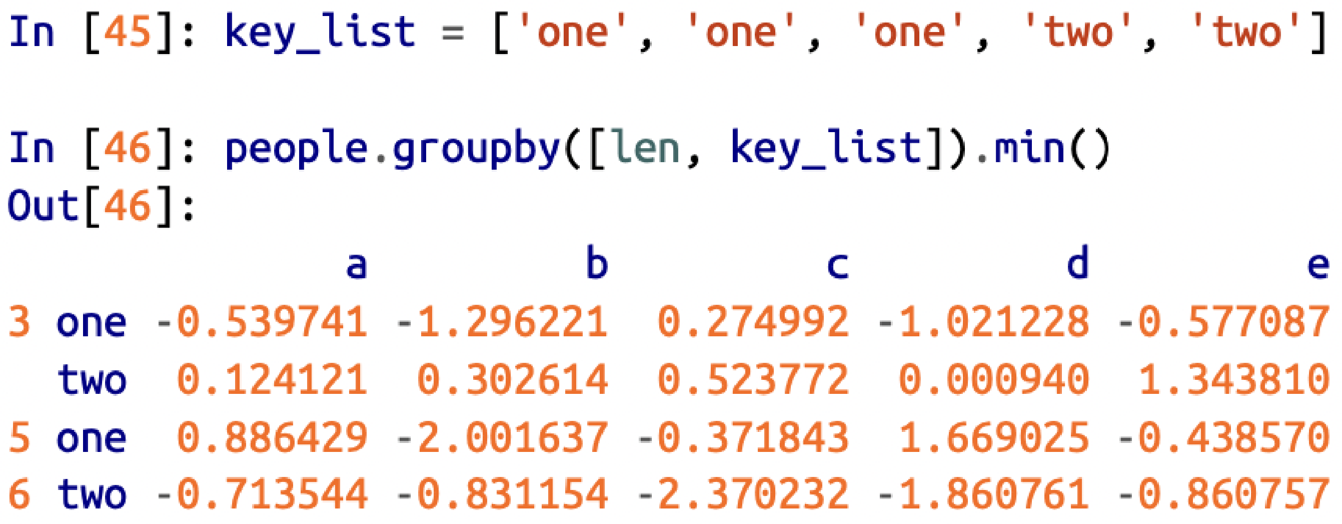
```
In [41]: map_series = pd.Series(mapping)

In [42]: map_series
Out[42]:
a       red
b       red
c      blue
d      blue
e       red
f    orange
dtype: object

In [43]: people.groupby(map_series, axis=1).count()
Out[43]:
        blue  red
Joe        2    3
Steve      2    3
Wes        1    2
Jim        2    3
Travis     2    3
```

Grouping with Functions



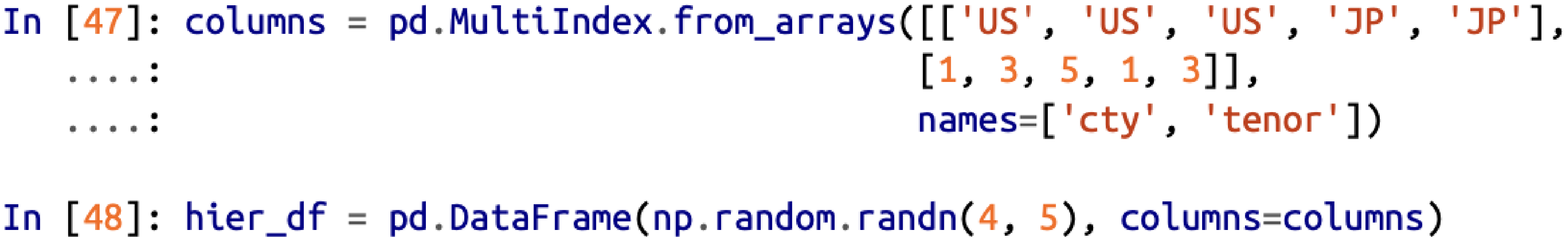
```
In [44]: people.groupby(len).sum()
Out[44]:
          a         b         c         d         e
3  0.591569 -0.993608  0.798764 -0.791374  2.119639
5  0.886429 -2.001637 -0.371843  1.669025 -0.438570
6 -0.713544 -0.831154 -2.370232 -1.860761 -0.860757
```

Mixing functions with arrays, dicts, or Series is not a problem as everything gets converted to arrays internally:

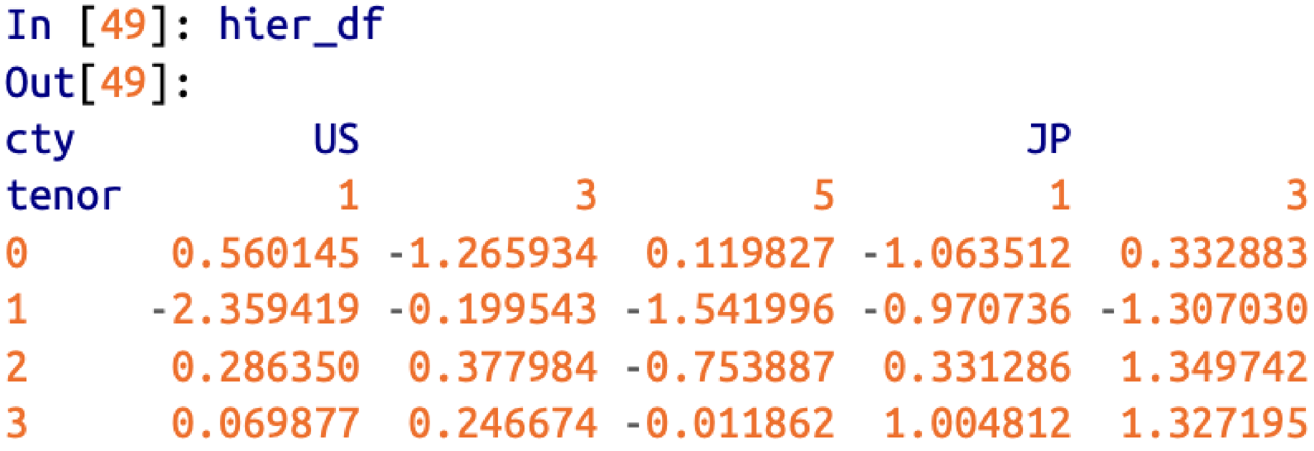


```
In [45]: key_list = ['one', 'one', 'one', 'two', 'two']

In [46]: people.groupby([len, key_list]).min()
Out[46]:
              a         b         c         d         e
3 one -0.539741 -1.296221  0.274992 -1.021228 -0.577087
  two  0.124121  0.302614  0.523772  0.000940  1.343810
5 one  0.886429 -2.001637 -0.371843  1.669025 -0.438570
6 two -0.713544 -0.831154 -2.370232 -1.860761 -0.860757
```

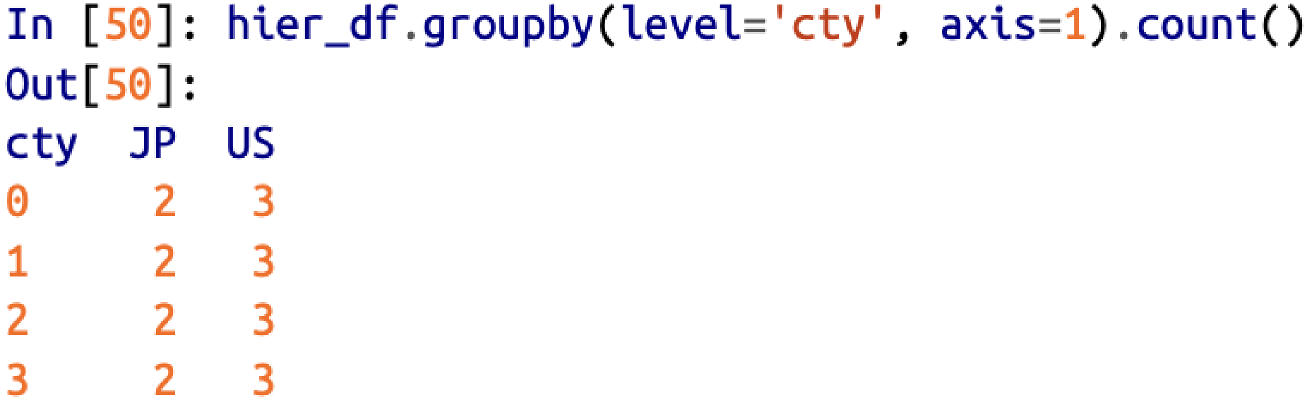
Grouping by Index Levels



```
In [47]: columns = pd.MultiIndex.from_arrays([['US', 'US', 'US', 'JP', 'JP'],
   ....:                                      [1, 3, 5, 1, 3]],
   ....:                                      names=['cty', 'tenor'])

In [48]: hier_df = pd.DataFrame(np.random.randn(4, 5), columns=columns)
```

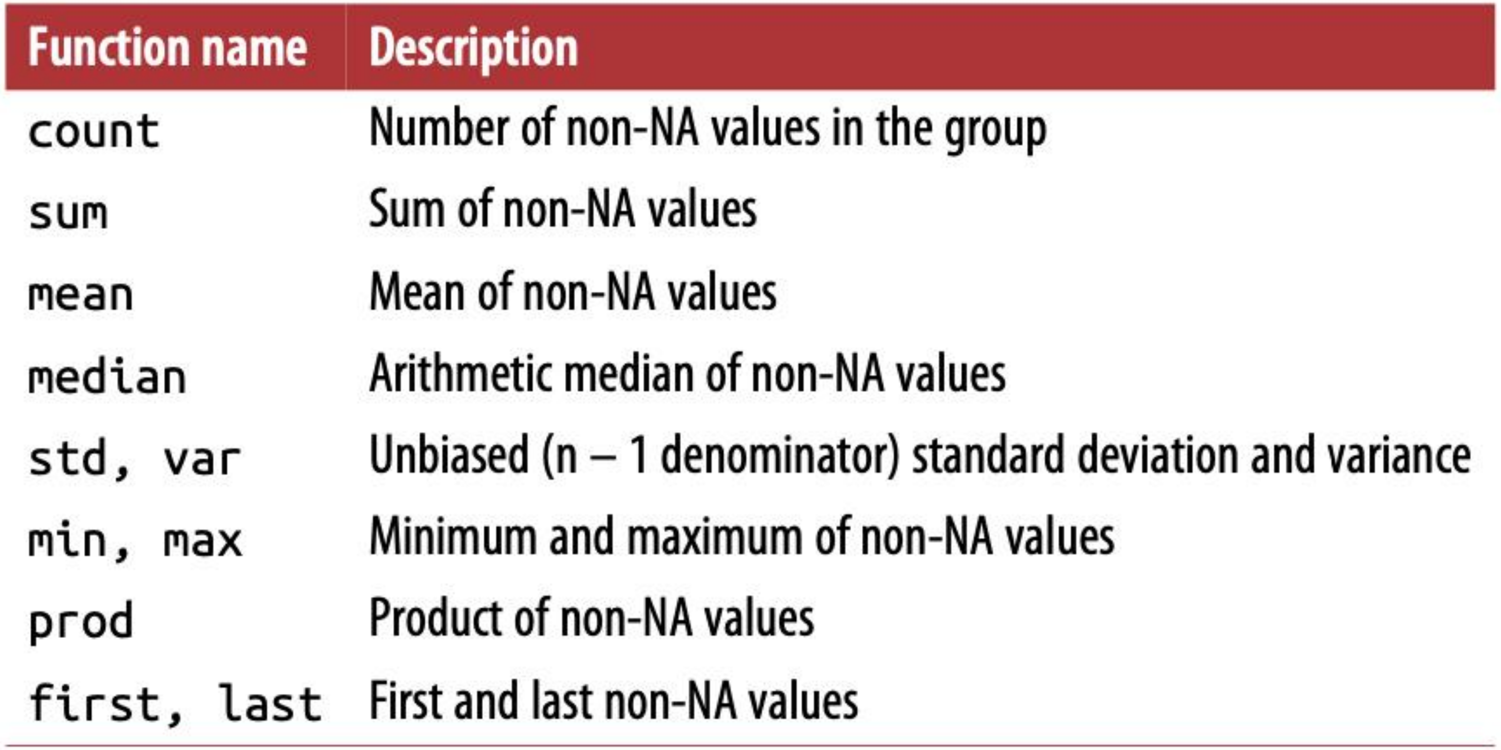


```
In [49]: hier_df
Out[49]:
cty          US                            JP
tenor         1         3         5         1         3
0      0.560145 -1.265934  0.119827 -1.063512  0.332883
1     -2.359419 -0.199543 -1.541996 -0.970736 -1.307030
2      0.286350  0.377984 -0.753887  0.331286  1.349742
3      0.069877  0.246674 -0.011862  1.004812  1.327195
```



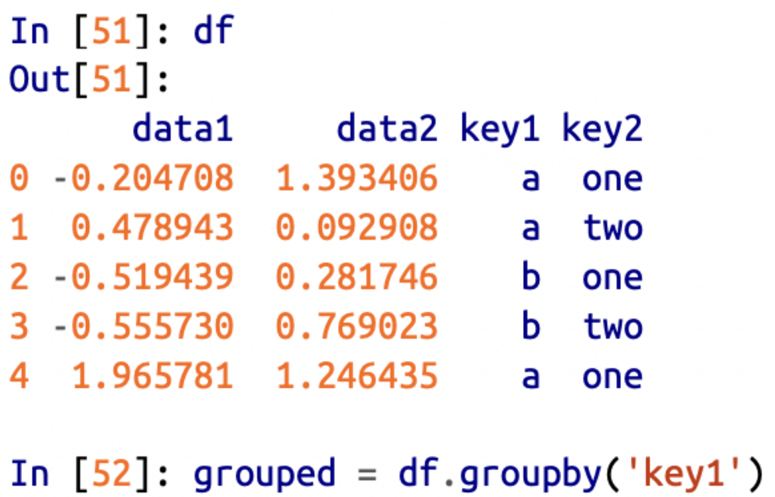
```
In [50]: hier_df.groupby(level='cty', axis=1).count()
Out[50]:
cty  JP  US
0     2   3
1     2   3
2     2   3
3     2   3
```

Data Aggregation

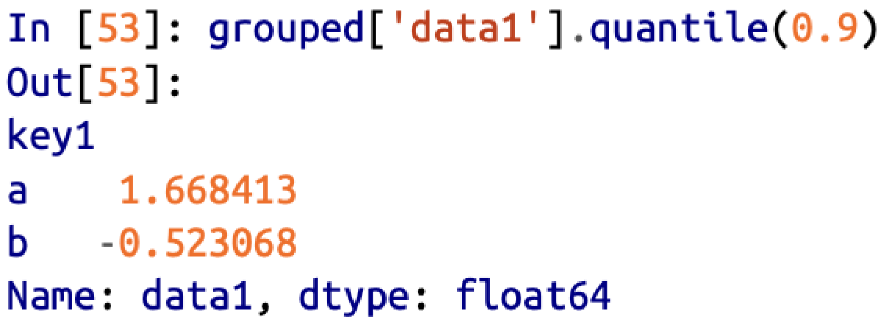


Function name	Description
`count`	Number of non-NA values in the group
`sum`	Sum of non-NA values
`mean`	Mean of non-NA values
`median`	Arithmetic median of non-NA values
`std, var`	Unbiased (n – 1 denominator) standard deviation and variance
`min, max`	Minimum and maximum of non-NA values
`prod`	Product of non-NA values
`first, last`	First and last non-NA values

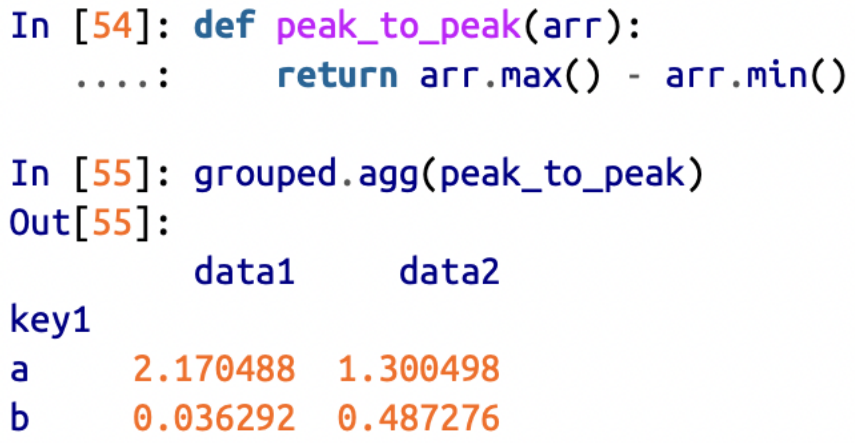
*Optimized **groupby** methods*



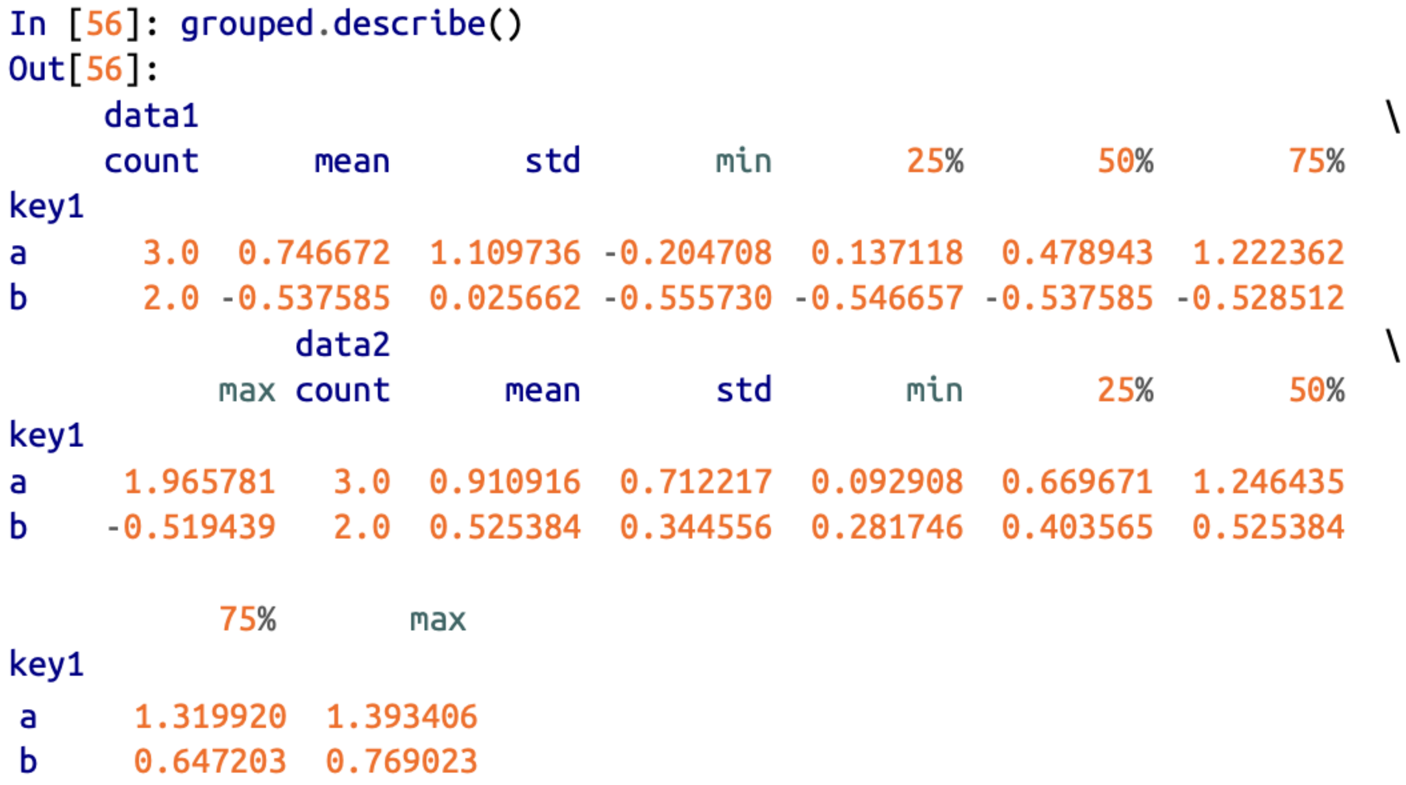
```
In [51]: df
Out[51]:
      data1     data2 key1 key2
0 -0.204708  1.393406    a  one
1  0.478943  0.092908    a  two
2 -0.519439  0.281746    b  one
3 -0.555730  0.769023    b  two
4  1.965781  1.246435    a  one

In [52]: grouped = df.groupby('key1')
```



```
In [53]: grouped['data1'].quantile(0.9)
Out[53]:
key1
a    1.668413
b   -0.523068
Name: data1, dtype: float64
```

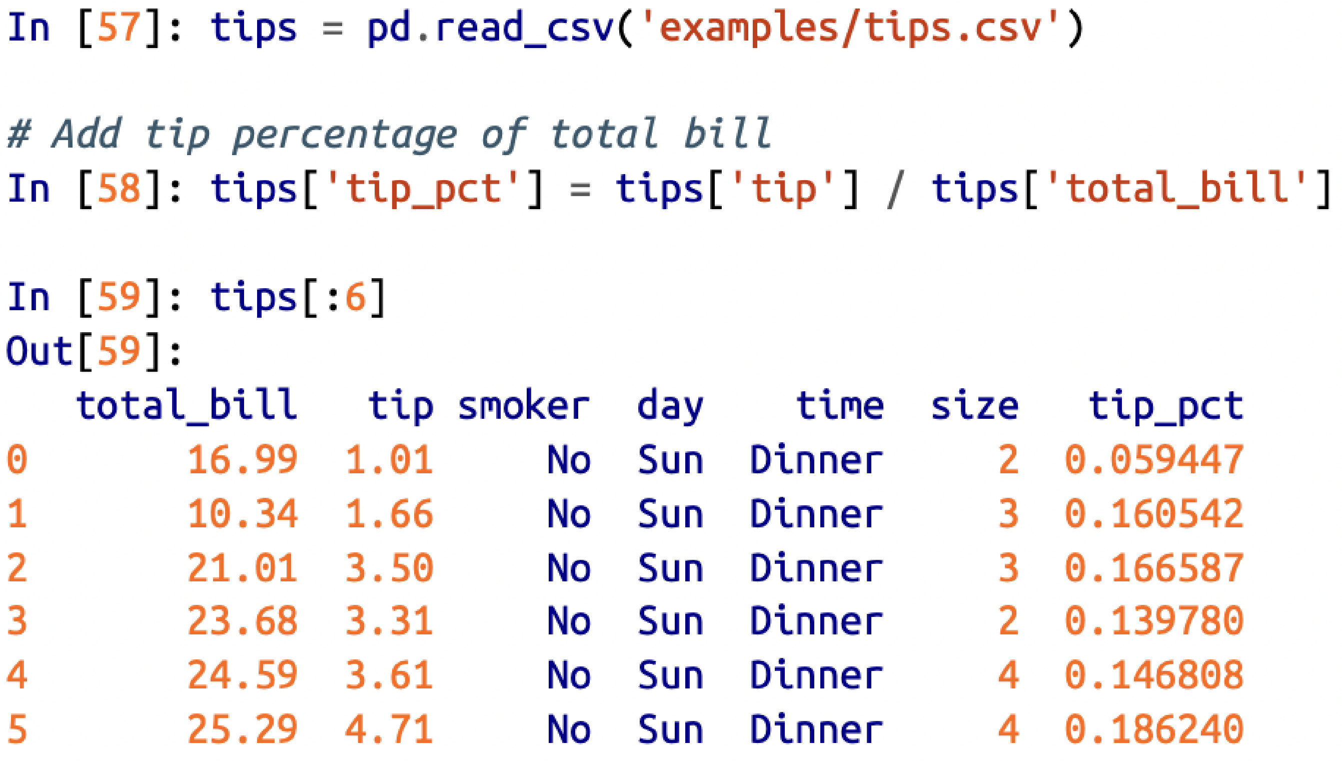


```
In [54]: def peak_to_peak(arr):
   ....:     return arr.max() - arr.min()

In [55]: grouped.agg(peak_to_peak)
Out[55]:
         data1     data2
key1
a     2.170488  1.300498
b     0.036292  0.487276
```

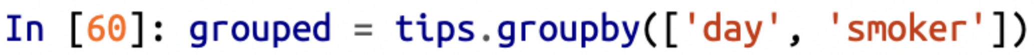


```
In [56]: grouped.describe()
Out[56]:
     data1                                                          \
     count      mean       std       min       25%       50%       75%
key1
a      3.0  0.746672  1.109736 -0.204708  0.137118  0.478943  1.222362
b      2.0 -0.537585  0.025662 -0.555730 -0.546657 -0.537585 -0.528512
                   data2                                            \
           max count      mean       std       min       25%       50%
key1
a     1.965781   3.0  0.910916  0.712217  0.092908  0.669671  1.246435
b    -0.519439   2.0  0.525384  0.344556  0.281746  0.403565  0.525384

           75%       max
key1
a     1.319920  1.393406
b     0.647203  0.769023
```

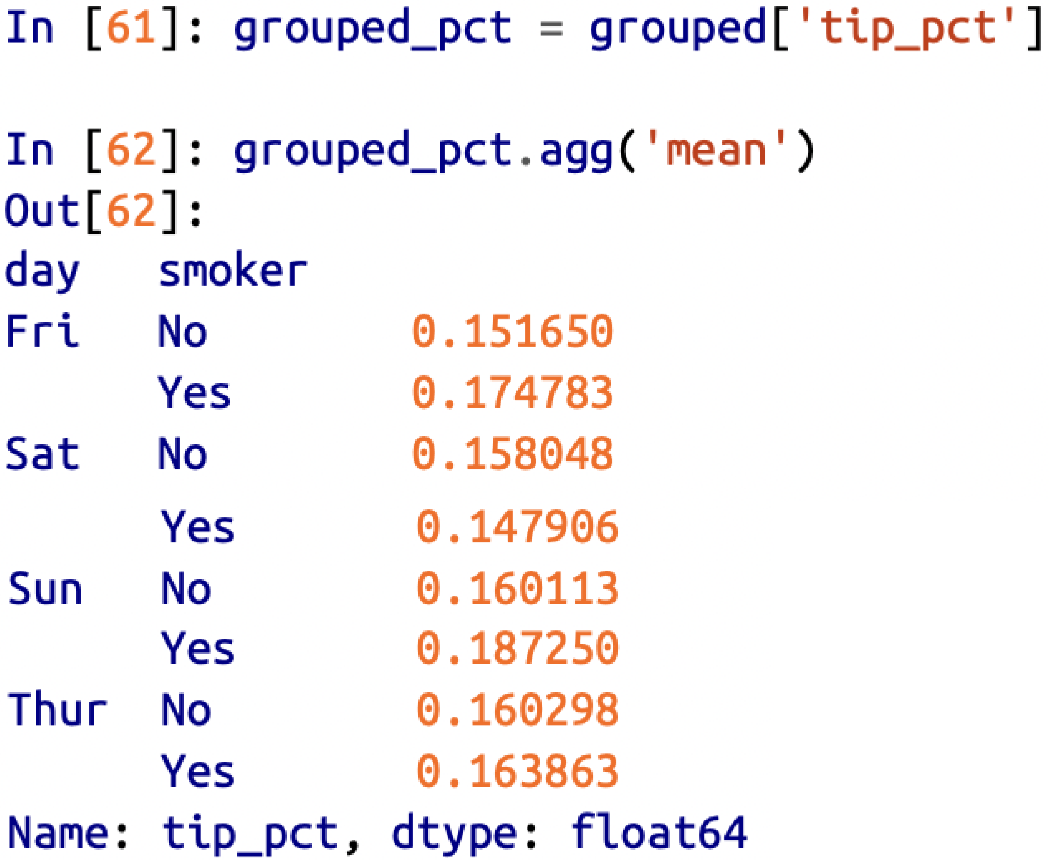
Column-Wise and Multiple Function Application



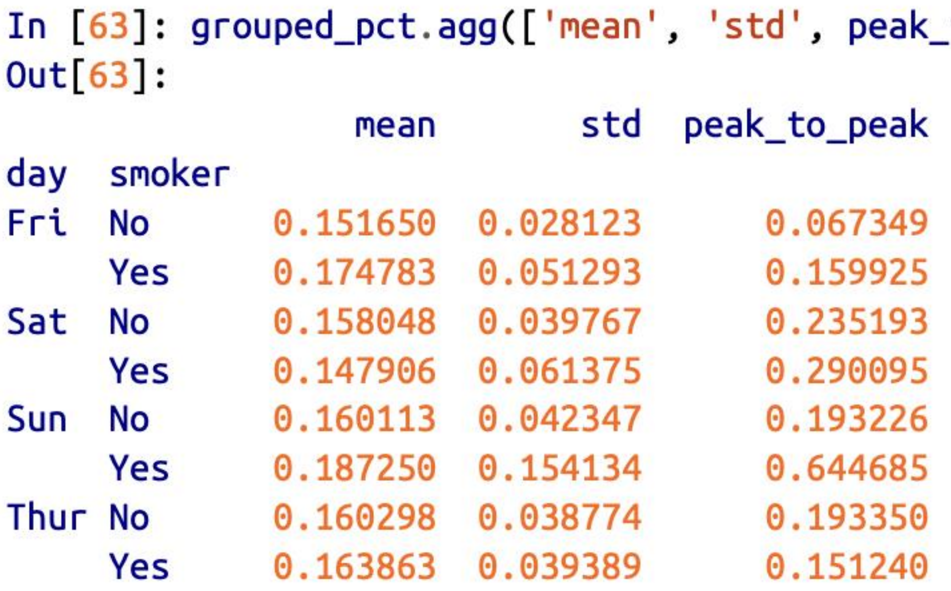
```
In [57]: tips = pd.read_csv('examples/tips.csv')

# Add tip percentage of total bill
In [58]: tips['tip_pct'] = tips['tip'] / tips['total_bill']

In [59]: tips[:6]
Out[59]:
   total_bill   tip smoker  day    time  size   tip_pct
0       16.99  1.01     No  Sun  Dinner     2  0.059447
1       10.34  1.66     No  Sun  Dinner     3  0.160542
2       21.01  3.50     No  Sun  Dinner     3  0.166587
3       23.68  3.31     No  Sun  Dinner     2  0.139780
4       24.59  3.61     No  Sun  Dinner     4  0.146808
5       25.29  4.71     No  Sun  Dinner     4  0.186240
```



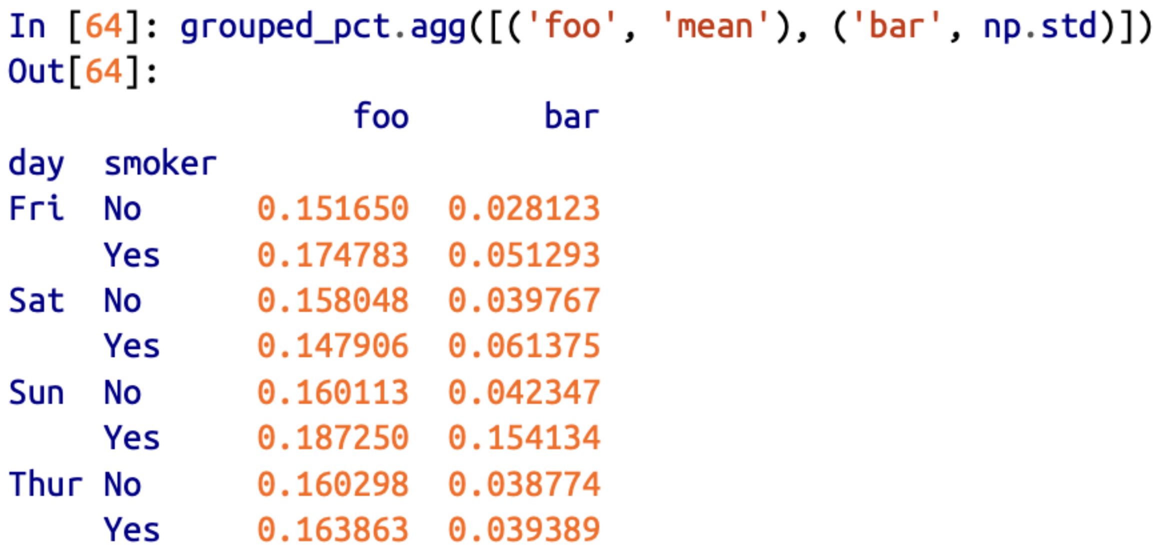
```
In [60]: grouped = tips.groupby(['day', 'smoker'])
```



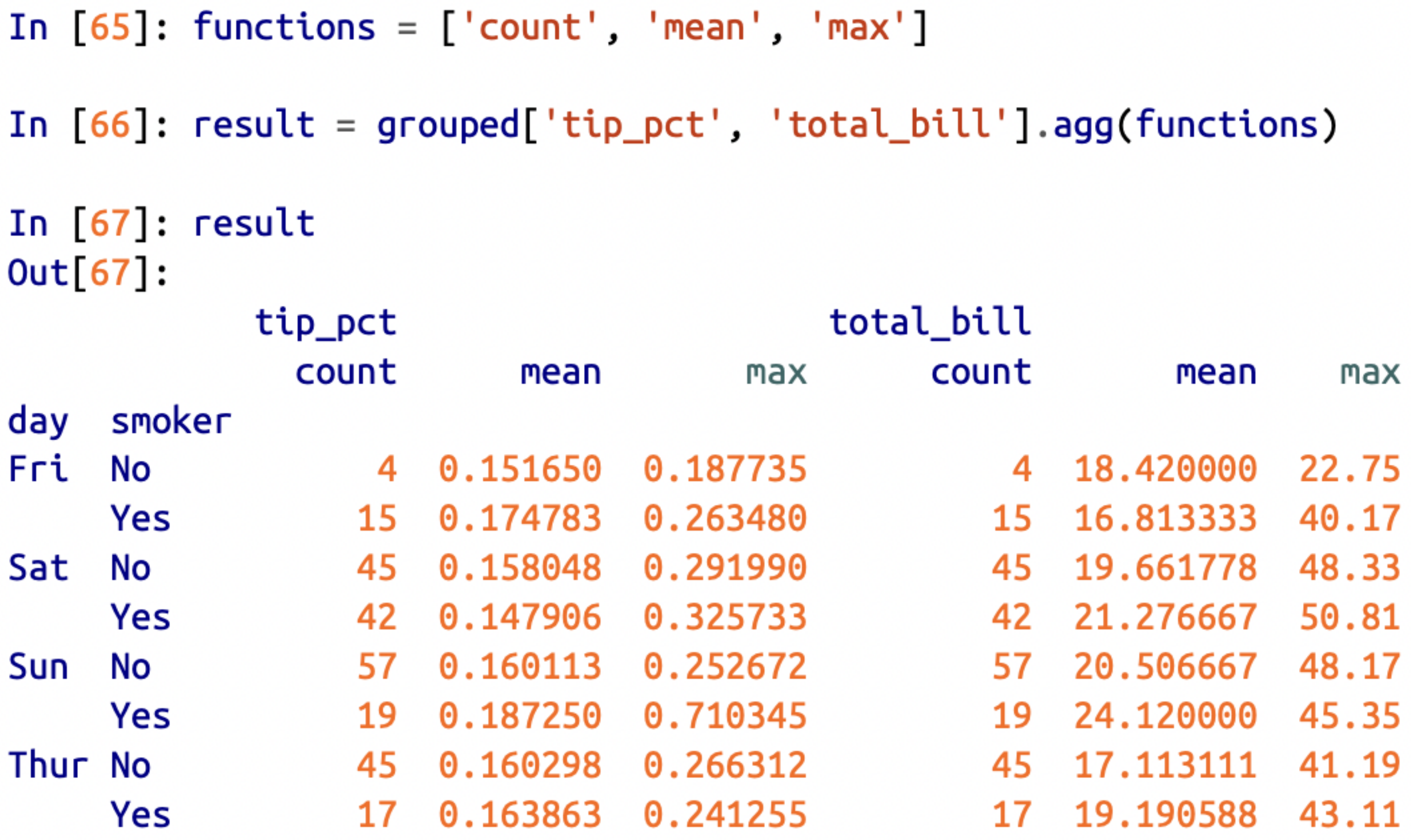
```
In [61]: grouped_pct = grouped['tip_pct']

In [62]: grouped_pct.agg('mean')
Out[62]:
day   smoker
Fri   No        0.151650
      Yes       0.174783
Sat   No        0.158048
      Yes       0.147906
Sun   No        0.160113
      Yes       0.187250
Thur  No        0.160298
      Yes       0.163863
Name: tip_pct, dtype: float64
```



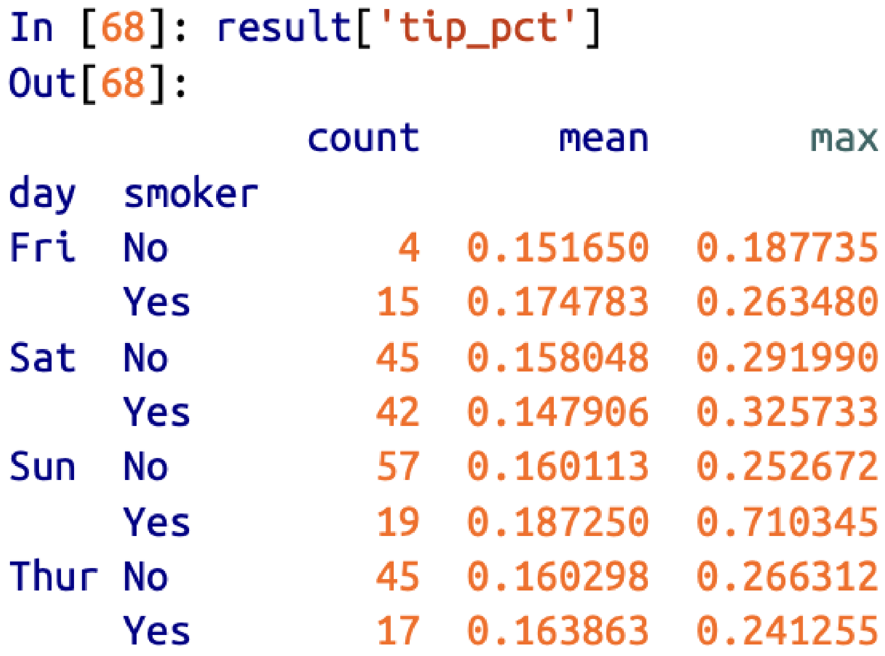
```
In [63]: grouped_pct.agg(['mean', 'std', peak_to_peak])
Out[63]:
                 mean       std  peak_to_peak
day  smoker
Fri  No      0.151650  0.028123      0.067349
     Yes     0.174783  0.051293      0.159925
Sat  No      0.158048  0.039767      0.235193
     Yes     0.147906  0.061375      0.290095
Sun  No      0.160113  0.042347      0.193226
     Yes     0.187250  0.154134      0.644685
Thur No      0.160298  0.038774      0.193350
     Yes     0.163863  0.039389      0.151240
```



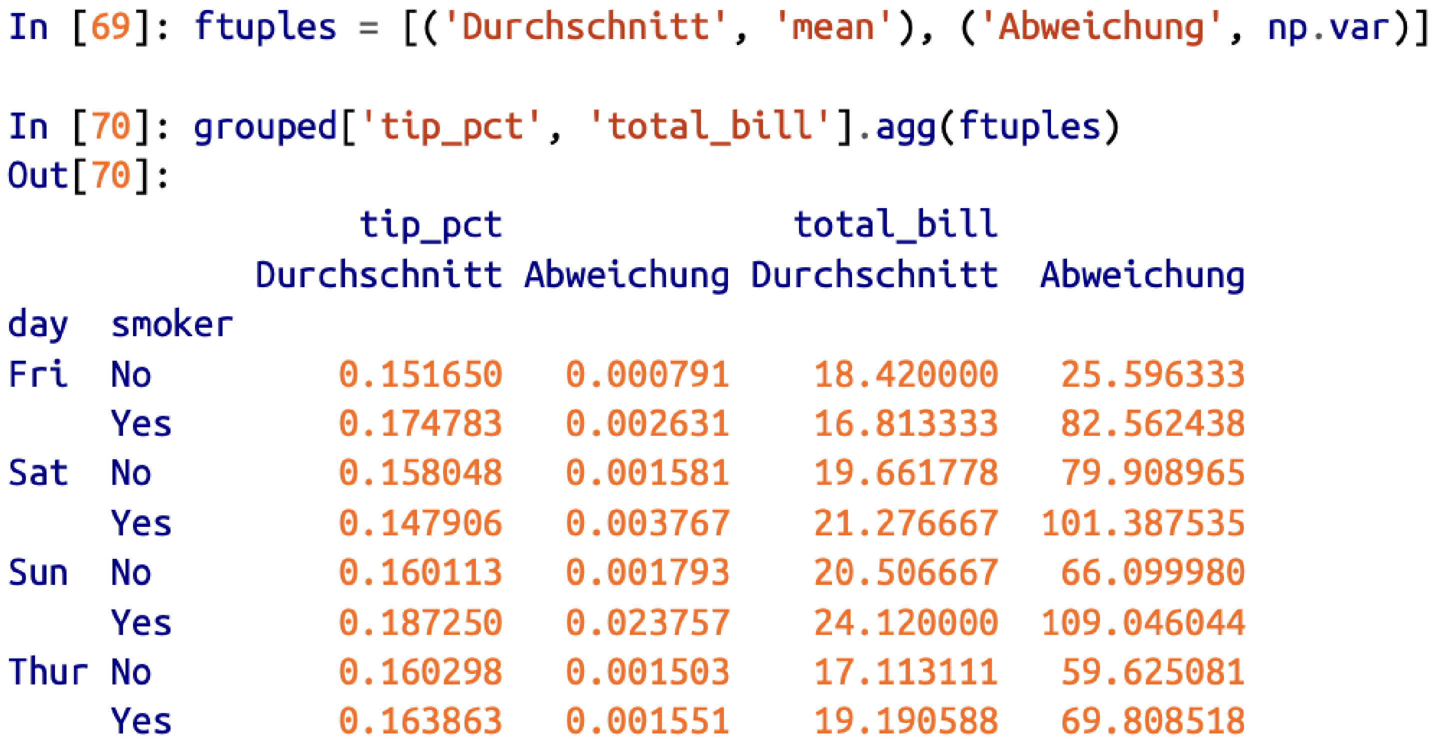
```
In [64]: grouped_pct.agg([('foo', 'mean'), ('bar', np.std)])
Out[64]:
                  foo       bar
day  smoker
Fri  No      0.151650  0.028123
     Yes     0.174783  0.051293
Sat  No      0.158048  0.039767
     Yes     0.147906  0.061375
Sun  No      0.160113  0.042347
     Yes     0.187250  0.154134
Thur No      0.160298  0.038774
     Yes     0.163863  0.039389
```



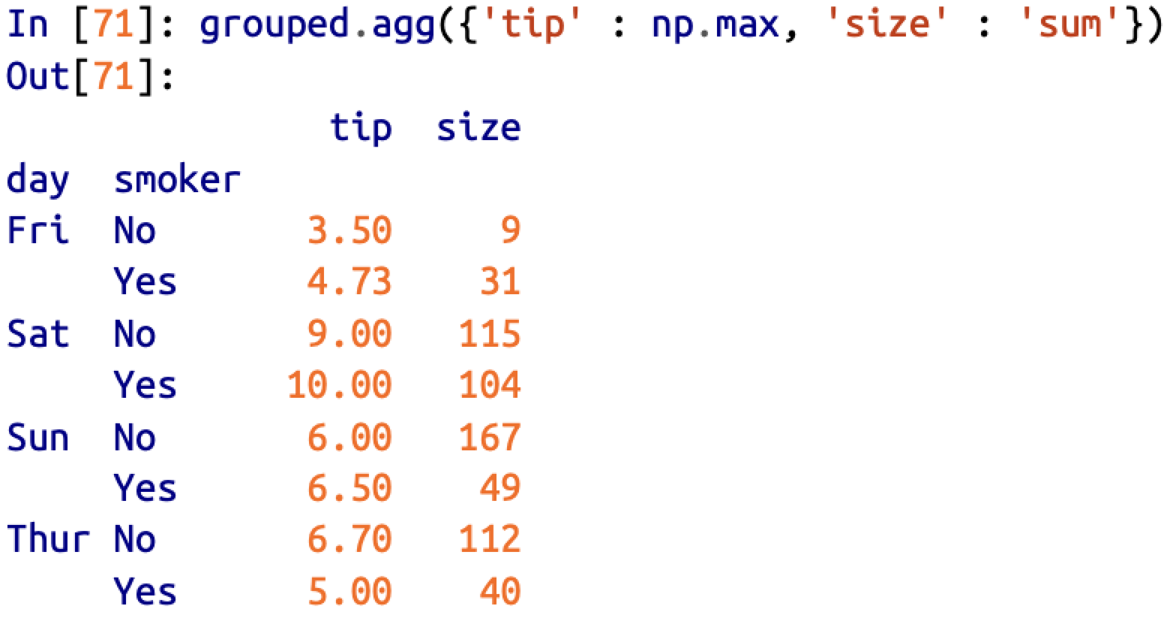
```
In [65]: functions = ['count', 'mean', 'max']

In [66]: result = grouped['tip_pct', 'total_bill'].agg(functions)

In [67]: result
Out[67]:
            tip_pct                     total_bill
              count      mean       max      count       mean    max
day  smoker
Fri  No           4  0.151650  0.187735          4  18.420000  22.75
     Yes         15  0.174783  0.263480         15  16.813333  40.17
Sat  No          45  0.158048  0.291990         45  19.661778  48.33
     Yes         42  0.147906  0.325733         42  21.276667  50.81
Sun  No          57  0.160113  0.252672         57  20.506667  48.17
     Yes         19  0.187250  0.710345         19  24.120000  45.35
Thur No          45  0.160298  0.266312         45  17.113111  41.19
     Yes         17  0.163863  0.241255         17  19.190588  43.11
```



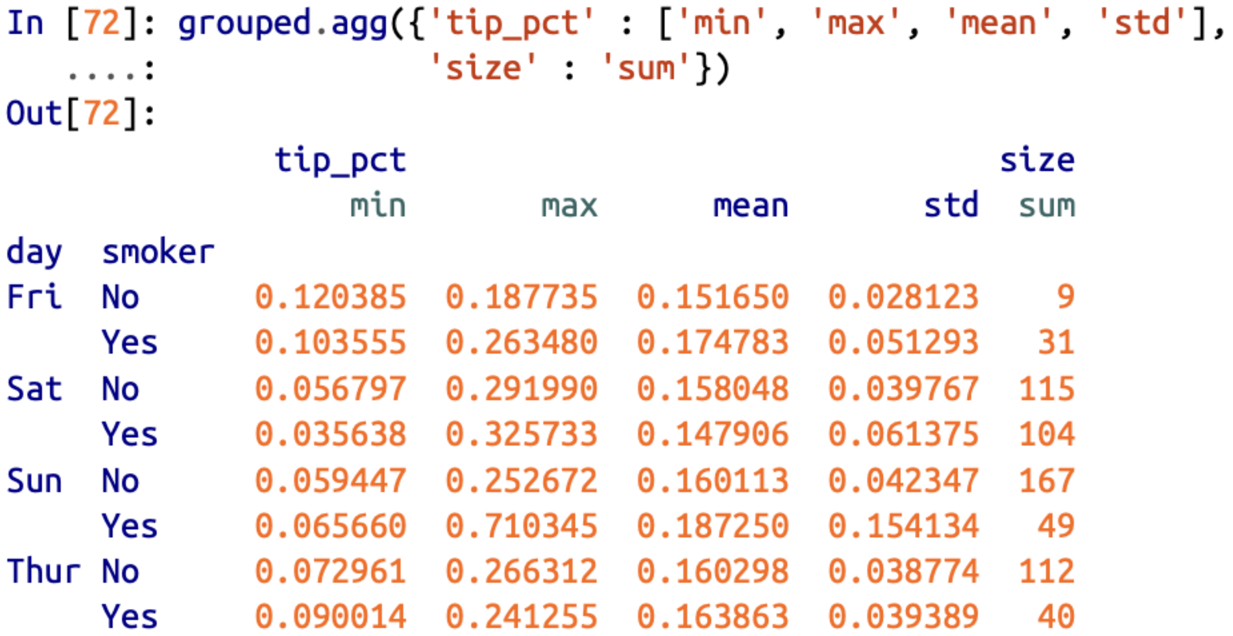
```
In [68]: result['tip_pct']
Out[68]:
             count      mean       max
day  smoker
Fri  No          4  0.151650  0.187735
     Yes        15  0.174783  0.263480
Sat  No         45  0.158048  0.291990
     Yes        42  0.147906  0.325733
Sun  No         57  0.160113  0.252672
     Yes        19  0.187250  0.710345
Thur No         45  0.160298  0.266312
     Yes        17  0.163863  0.241255
```



```
In [69]: ftuples = [('Durchschnitt', 'mean'), ('Abweichung', np.var)]

In [70]: grouped['tip_pct', 'total_bill'].agg(ftuples)
Out[70]:
                 tip_pct               total_bill
            Durchschnitt Abweichung Durchschnitt  Abweichung
day  smoker
Fri  No         0.151650   0.000791    18.420000   25.596333
     Yes        0.174783   0.002631    16.813333   82.562438
Sat  No         0.158048   0.001581    19.661778   79.908965
     Yes        0.147906   0.003767    21.276667  101.387535
Sun  No         0.160113   0.001793    20.506667   66.099980
     Yes        0.187250   0.023757    24.120000  109.046044
Thur No         0.160298   0.001503    17.113111   59.625081
     Yes        0.163863   0.001551    19.190588   69.808518
```

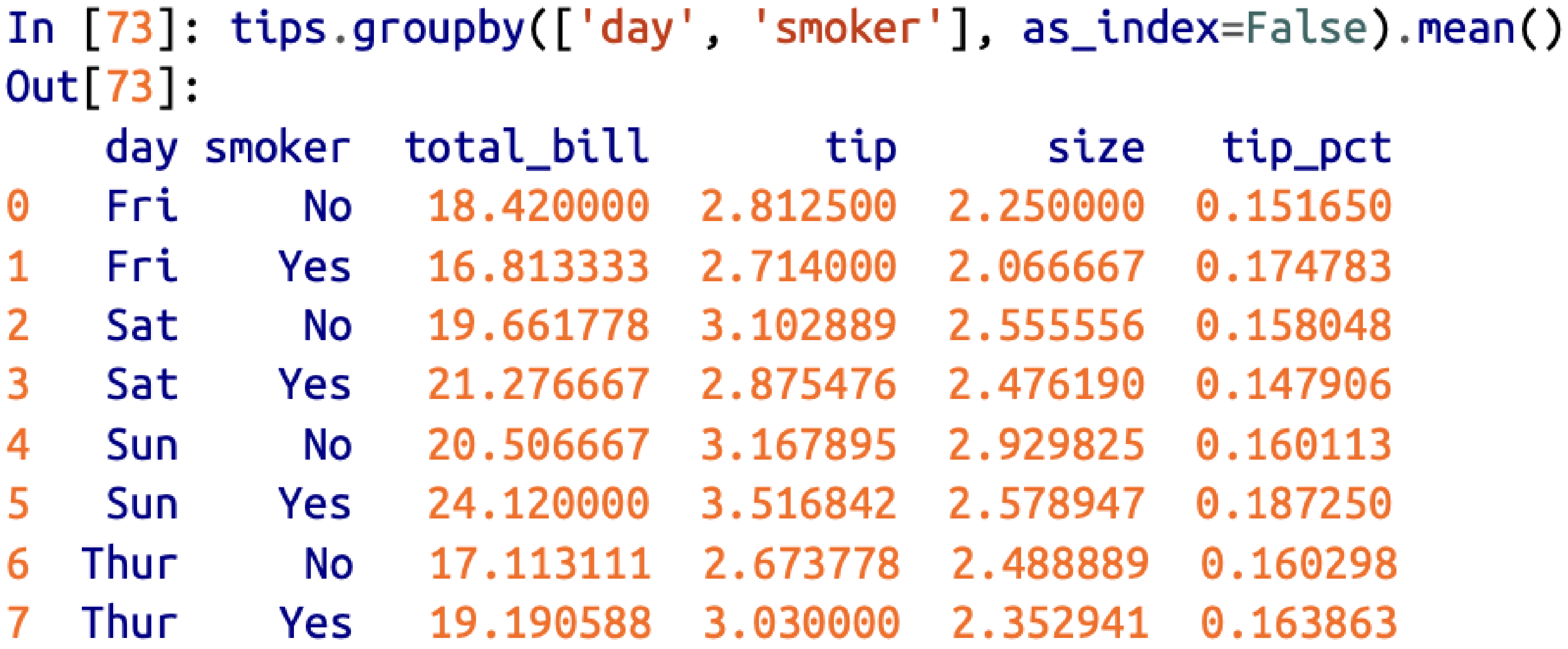


```
In [71]: grouped.agg({'tip' : np.max, 'size' : 'sum'})
Out[71]:
               tip  size
day  smoker
Fri  No       3.50     9
     Yes      4.73    31
Sat  No       9.00   115
     Yes     10.00   104
Sun  No       6.00   167
     Yes      6.50    49
Thur No       6.70   112
     Yes      5.00    40
```



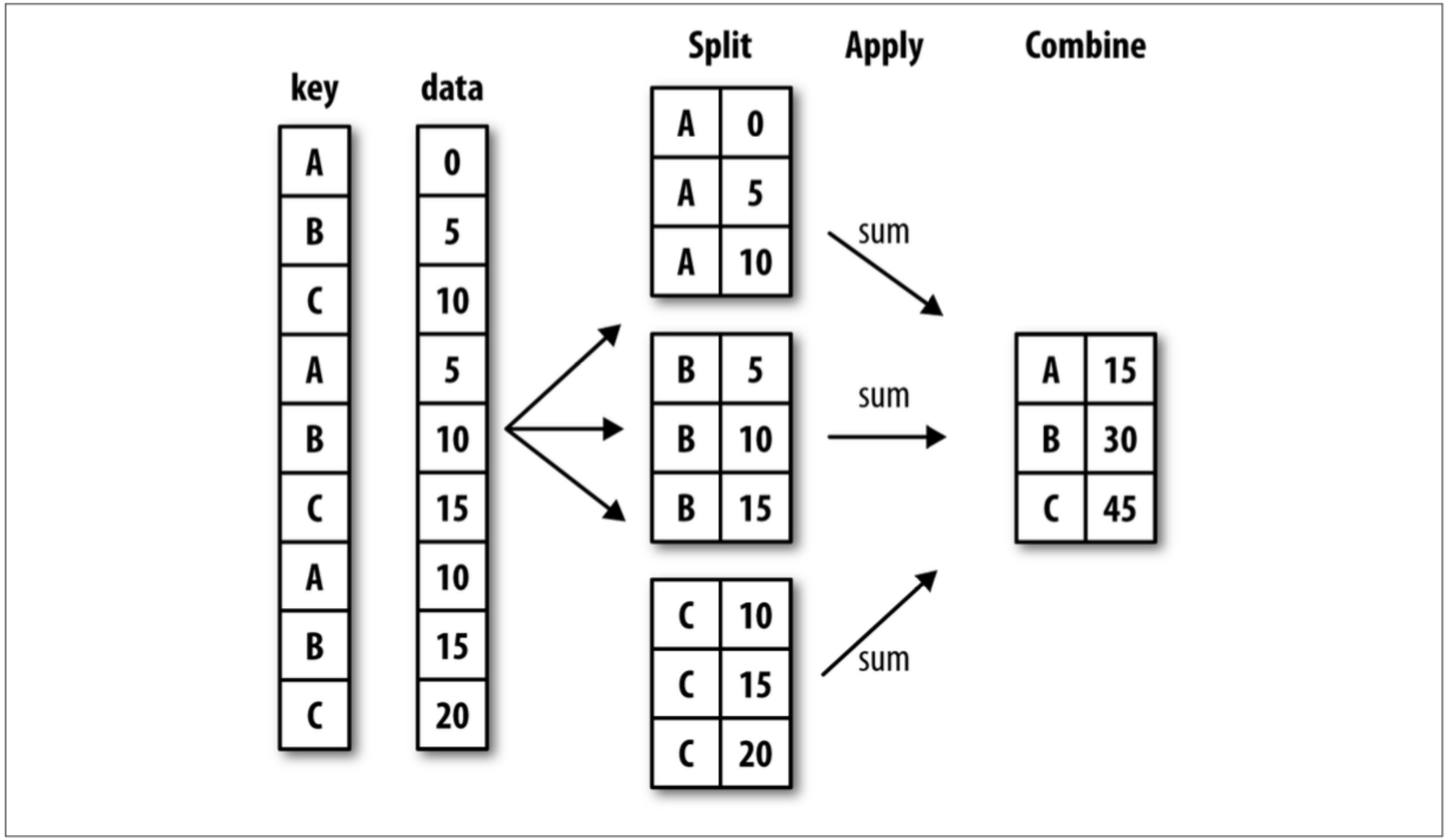
```
In [72]: grouped.agg({'tip_pct' : ['min', 'max', 'mean', 'std'],
   ....:                'size' : 'sum'})
Out[72]:
              tip_pct                               size
                  min       max      mean       std  sum
day  smoker
Fri  No      0.120385  0.187735  0.151650  0.028123    9
     Yes     0.103555  0.263480  0.174783  0.051293   31
Sat  No      0.056797  0.291990  0.158048  0.039767  115
     Yes     0.035638  0.325733  0.147906  0.061375  104
Sun  No      0.059447  0.252672  0.160113  0.042347  167
     Yes     0.065660  0.710345  0.187250  0.154134   49
Thur No      0.072961  0.266312  0.160298  0.038774  112
     Yes     0.090014  0.241255  0.163863  0.039389   40
```

Returning Aggregated Data Without Row Indexes



```
In [73]: tips.groupby(['day', 'smoker'], as_index=False).mean()
Out[73]:
    day smoker  total_bill       tip      size   tip_pct
0   Fri     No   18.420000  2.812500  2.250000  0.151650
1   Fri    Yes   16.813333  2.714000  2.066667  0.174783
2   Sat     No   19.661778  3.102889  2.555556  0.158048
3   Sat    Yes   21.276667  2.875476  2.476190  0.147906
4   Sun     No   20.506667  3.167895  2.929825  0.160113
5   Sun    Yes   24.120000  3.516842  2.578947  0.187250
6  Thur     No   17.113111  2.673778  2.488889  0.160298
7  Thur    Yes   19.190588  3.030000  2.352941  0.163863
```

Apply: General split-apply-combine



key	data
A	0
B	5
C	10
A	5
B	10
C	15
A	10
B	15
C	20

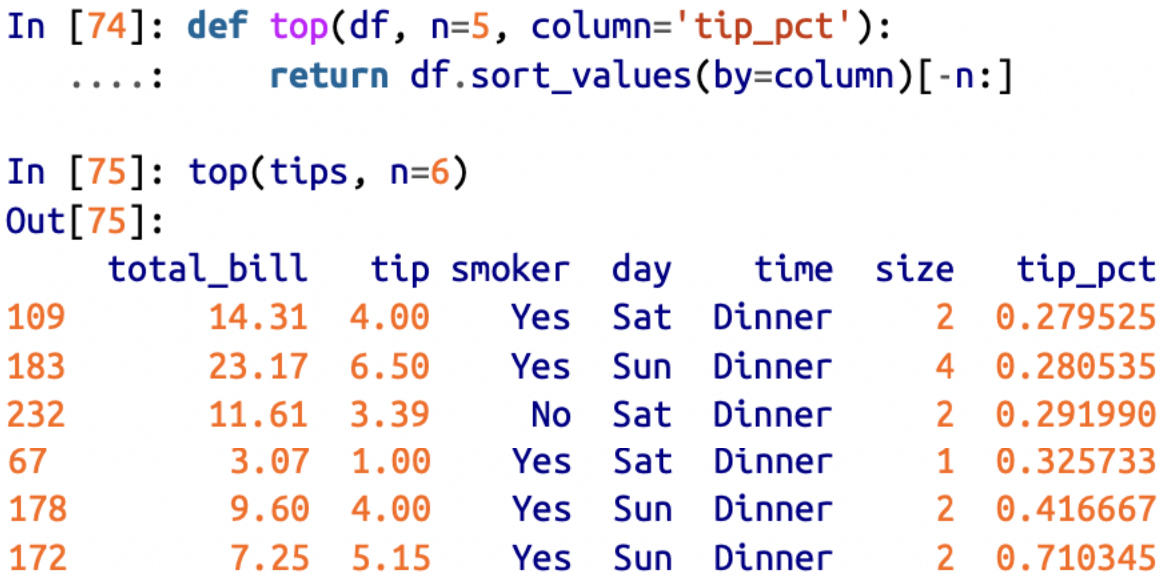
A	0
A	5
A	10

B	5
B	10
B	15

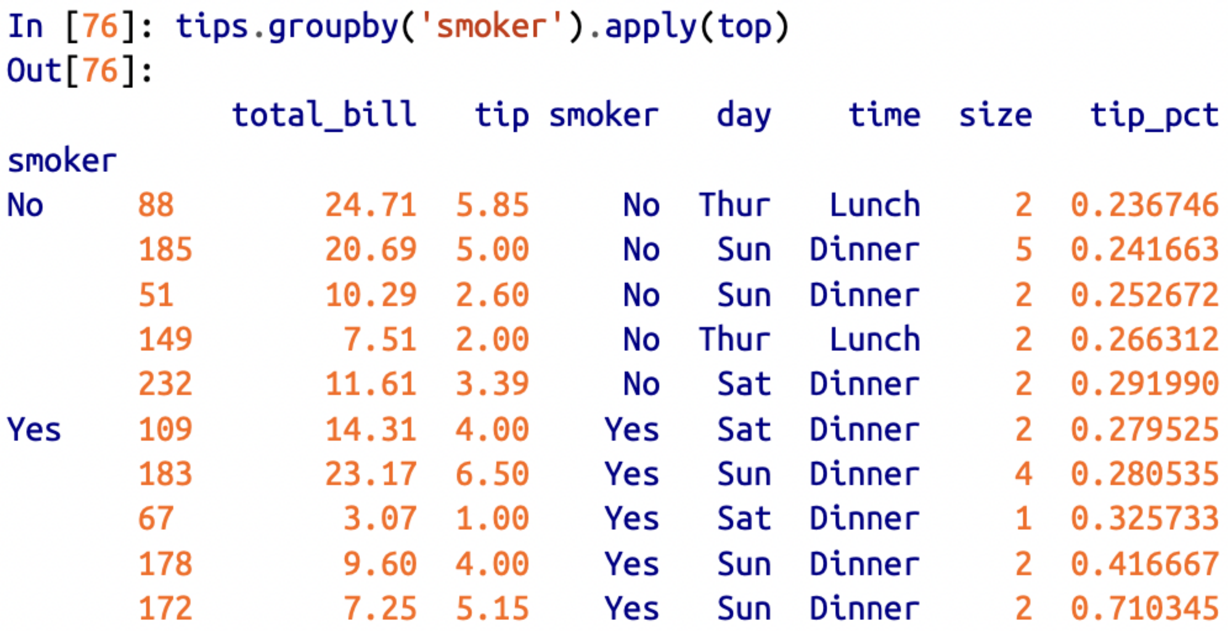
C	10
C	15
C	20

A	15
B	30
C	45

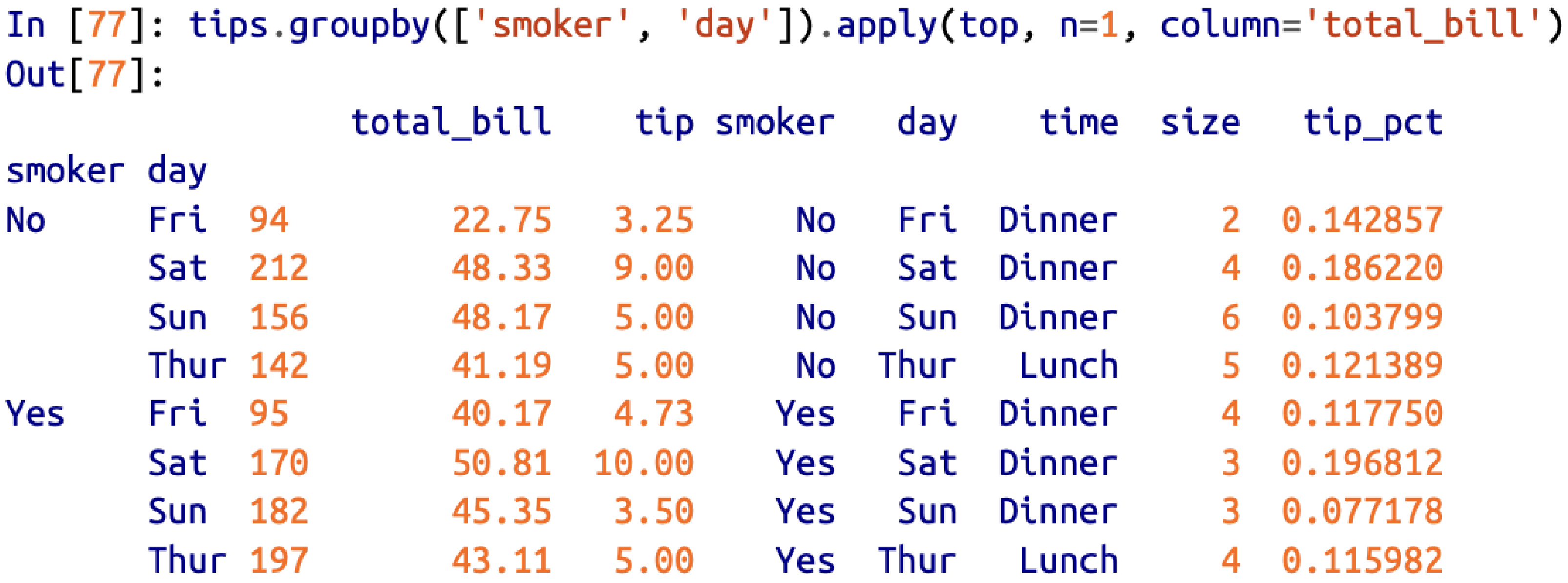
Figure 2. Illustration of a group aggregation



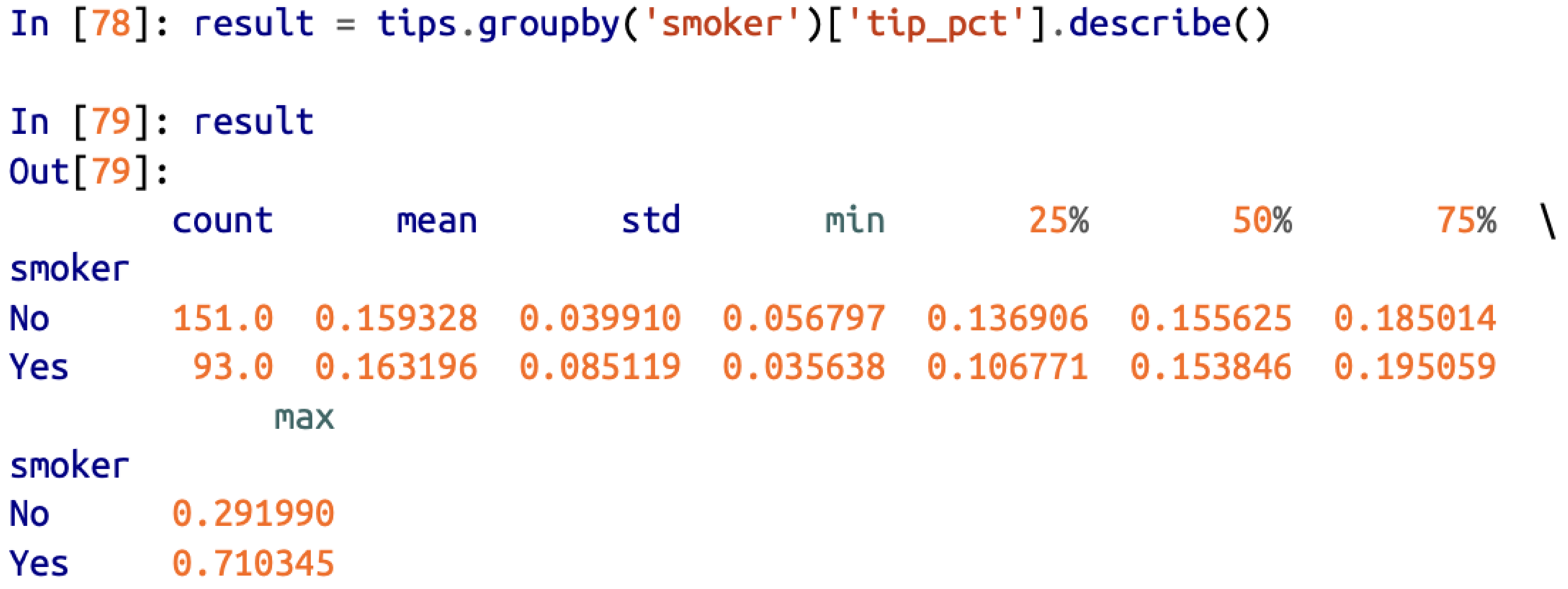
```
In [74]: def top(df, n=5, column='tip_pct'):
   ....:     return df.sort_values(by=column)[-n:]

In [75]: top(tips, n=6)
Out[75]:
     total_bill   tip smoker  day    time  size   tip_pct
109       14.31  4.00    Yes  Sat  Dinner     2  0.279525
183       23.17  6.50    Yes  Sun  Dinner     4  0.280535
232       11.61  3.39     No  Sat  Dinner     2  0.291990
67         3.07  1.00    Yes  Sat  Dinner     1  0.325733
178        9.60  4.00    Yes  Sun  Dinner     2  0.416667
172        7.25  5.15    Yes  Sun  Dinner     2  0.710345
```



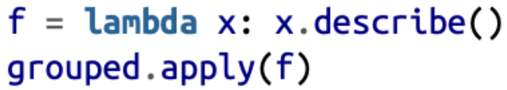
```
In [76]: tips.groupby('smoker').apply(top)
Out[76]:
            total_bill   tip smoker   day    time  size   tip_pct
smoker
No     88        24.71  5.85     No  Thur   Lunch     2  0.236746
       185       20.69  5.00     No   Sun  Dinner     5  0.241663
       51        10.29  2.60     No   Sun  Dinner     2  0.252672
       149        7.51  2.00     No  Thur   Lunch     2  0.266312
       232       11.61  3.39     No   Sat  Dinner     2  0.291990
Yes    109       14.31  4.00    Yes   Sat  Dinner     2  0.279525
       183       23.17  6.50    Yes   Sun  Dinner     4  0.280535
       67         3.07  1.00    Yes   Sat  Dinner     1  0.325733
       178        9.60  4.00    Yes   Sun  Dinner     2  0.416667
       172        7.25  5.15    Yes   Sun  Dinner     2  0.710345
```



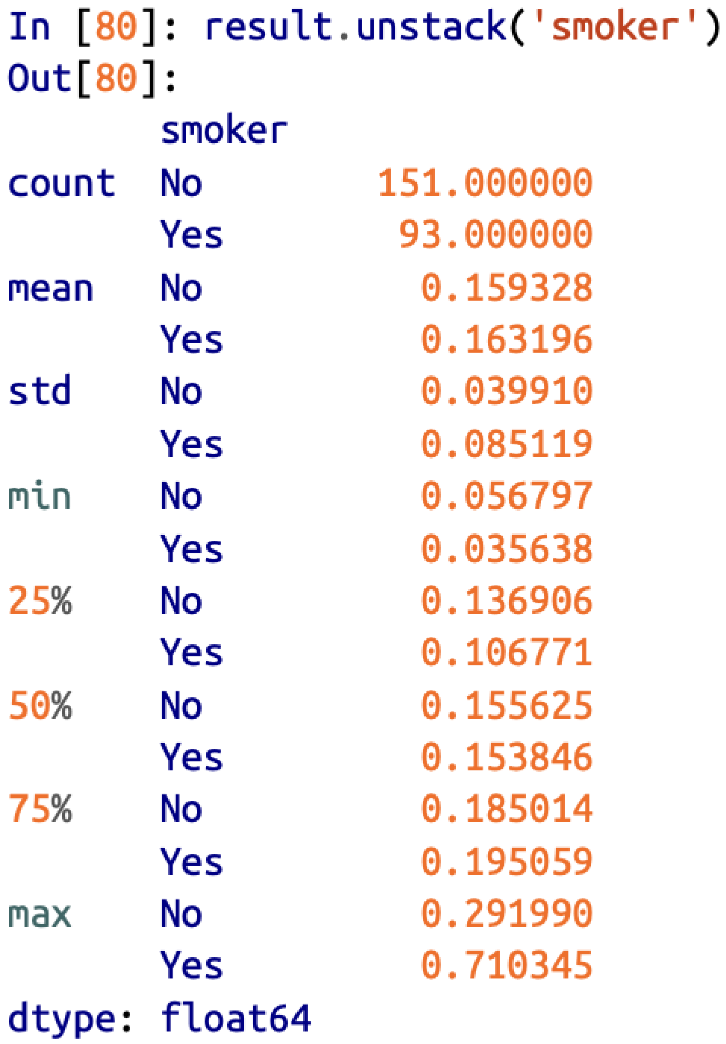
```
In [77]: tips.groupby(['smoker', 'day']).apply(top, n=1, column='total_bill')
Out[77]:
                 total_bill    tip smoker   day    time  size   tip_pct
smoker day
No     Fri  94        22.75   3.25     No   Fri  Dinner     2  0.142857
       Sat  212       48.33   9.00     No   Sat  Dinner     4  0.186220
       Sun  156       48.17   5.00     No   Sun  Dinner     6  0.103799
       Thur 142       41.19   5.00     No  Thur   Lunch     5  0.121389
Yes    Fri  95        40.17   4.73    Yes   Fri  Dinner     4  0.117750
       Sat  170       50.81  10.00    Yes   Sat  Dinner     3  0.196812
       Sun  182       45.35   3.50    Yes   Sun  Dinner     3  0.077178
       Thur 197       43.11   5.00    Yes  Thur   Lunch     4  0.115982
```



```
In [78]: result = tips.groupby('smoker')['tip_pct'].describe()

In [79]: result
Out[79]:
        count      mean       std       min       25%       50%       75%  \
smoker
No      151.0  0.159328  0.039910  0.056797  0.136906  0.155625  0.185014
Yes      93.0  0.163196  0.085119  0.035638  0.106771  0.153846  0.195059
             max
smoker
No      0.291990
Yes     0.710345
```

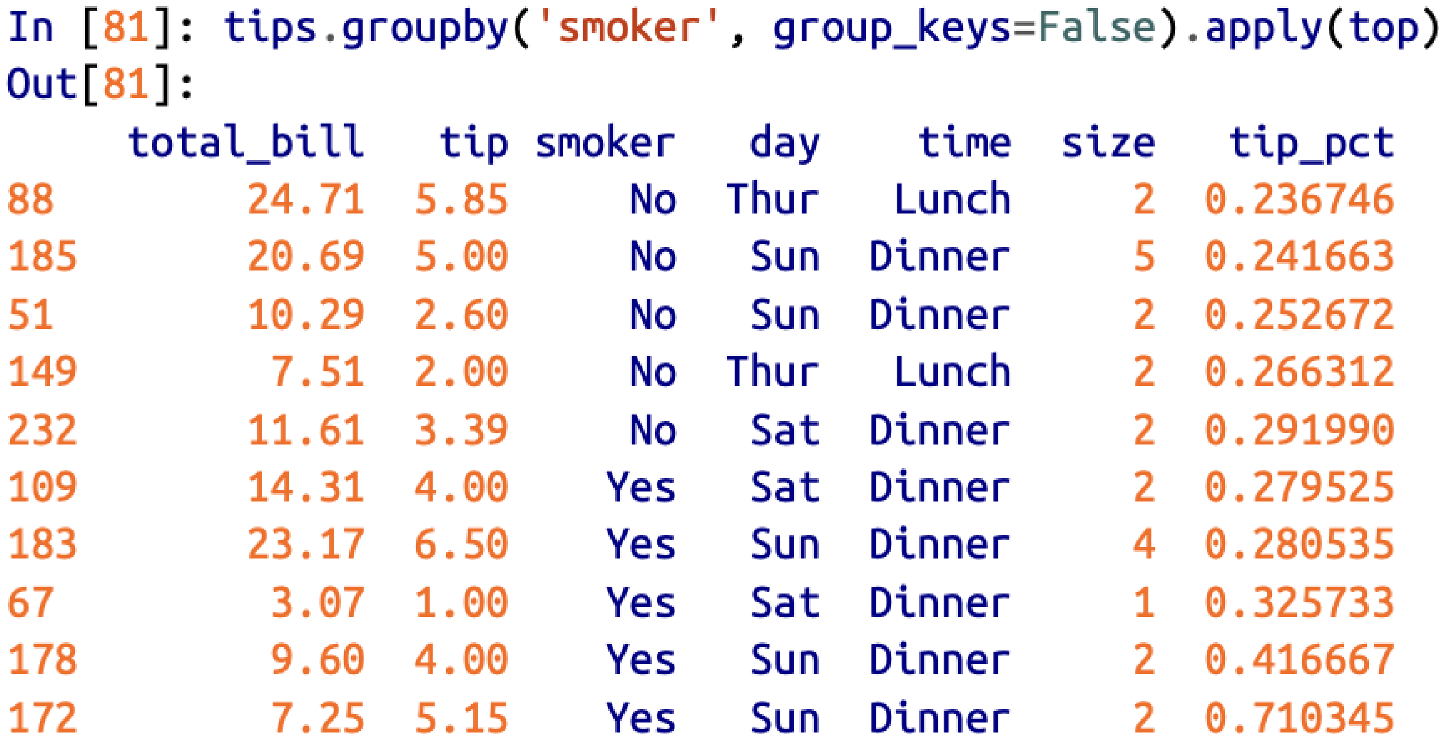


```
f = lambda x: x.describe()
grouped.apply(f)
```



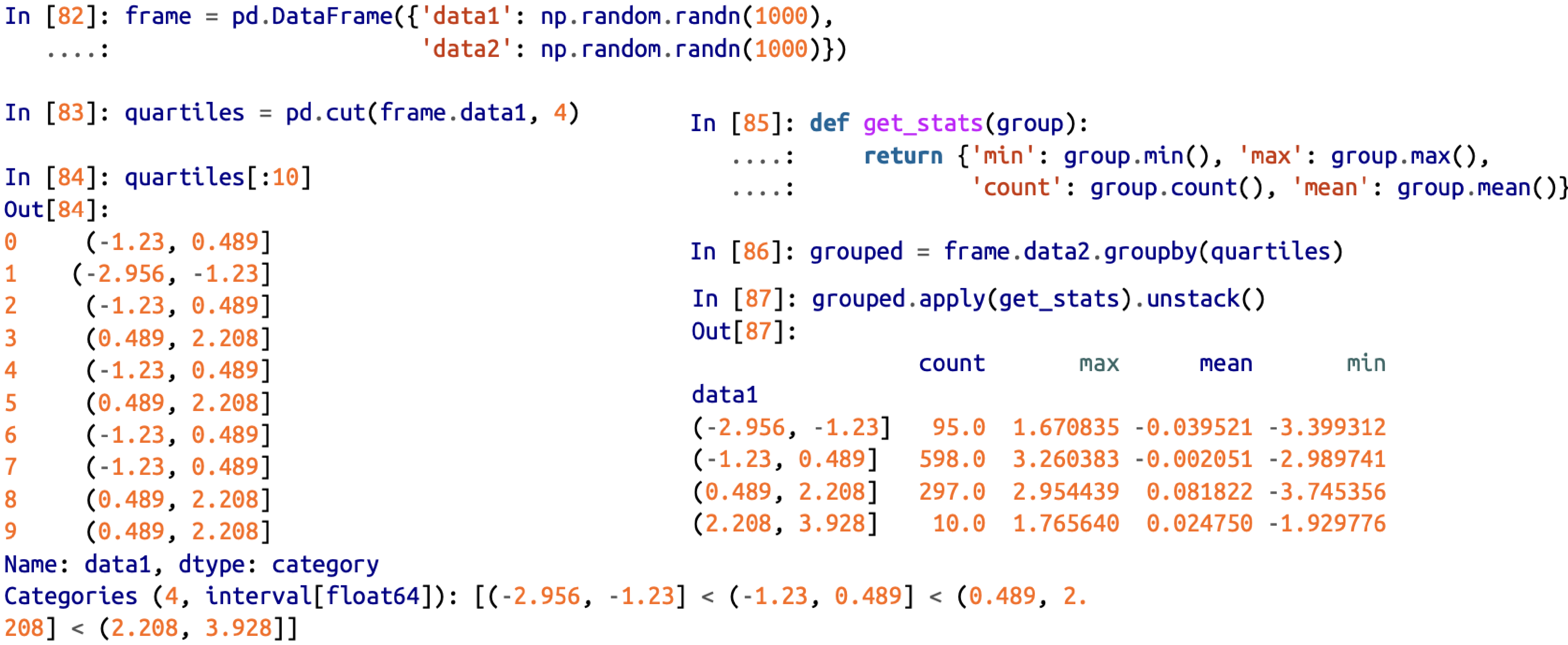
```
In [80]: result.unstack('smoker')
Out[80]:
       smoker
count  No        151.000000
       Yes        93.000000
mean   No          0.159328
       Yes         0.163196
std    No          0.039910
       Yes         0.085119
min    No          0.056797
       Yes         0.035638
25%    No          0.136906
       Yes         0.106771
50%    No          0.155625
       Yes         0.153846
75%    No          0.185014
       Yes         0.195059
max    No          0.291990
       Yes         0.710345
dtype: float64
```

Suppressing the Group Keys



```
In [81]: tips.groupby('smoker', group_keys=False).apply(top)
Out[81]:
     total_bill   tip smoker   day    time  size   tip_pct
88        24.71  5.85     No  Thur   Lunch     2  0.236746
185       20.69  5.00     No   Sun  Dinner     5  0.241663
51        10.29  2.60     No   Sun  Dinner     2  0.252672
149        7.51  2.00     No  Thur   Lunch     2  0.266312
232       11.61  3.39     No   Sat  Dinner     2  0.291990
109       14.31  4.00    Yes   Sat  Dinner     2  0.279525
183       23.17  6.50    Yes   Sun  Dinner     4  0.280535
67         3.07  1.00    Yes   Sat  Dinner     1  0.325733
178        9.60  4.00    Yes   Sun  Dinner     2  0.416667
172        7.25  5.15    Yes   Sun  Dinner     2  0.710345
```

Quantile and Bucket Analysis

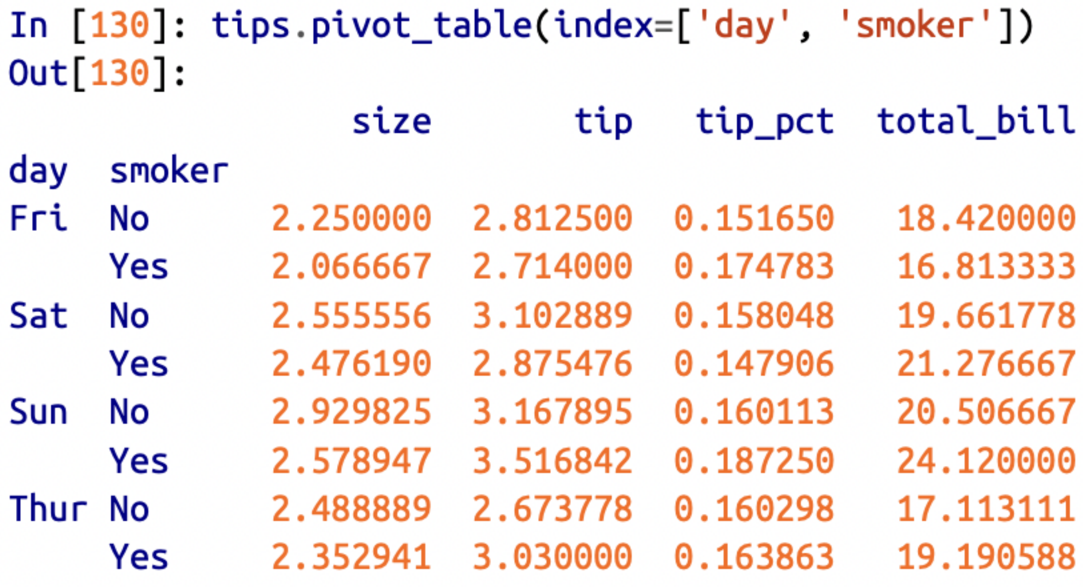


```
In [82]: frame = pd.DataFrame({'data1': np.random.randn(1000),
   ....:                       'data2': np.random.randn(1000)})

In [83]: quartiles = pd.cut(frame.data1, 4)

In [84]: quartiles[:10]
Out[84]:
0     (-1.23, 0.489]
1    (-2.956, -1.23]
2     (-1.23, 0.489]
3     (0.489, 2.208]
4     (-1.23, 0.489]
5     (0.489, 2.208]
6     (-1.23, 0.489]
7     (-1.23, 0.489]
8     (0.489, 2.208]
9     (0.489, 2.208]
Name: data1, dtype: category
Categories (4, interval[float64]): [(-2.956, -1.23] < (-1.23, 0.489] < (0.489, 2.
208] < (2.208, 3.928]]
```

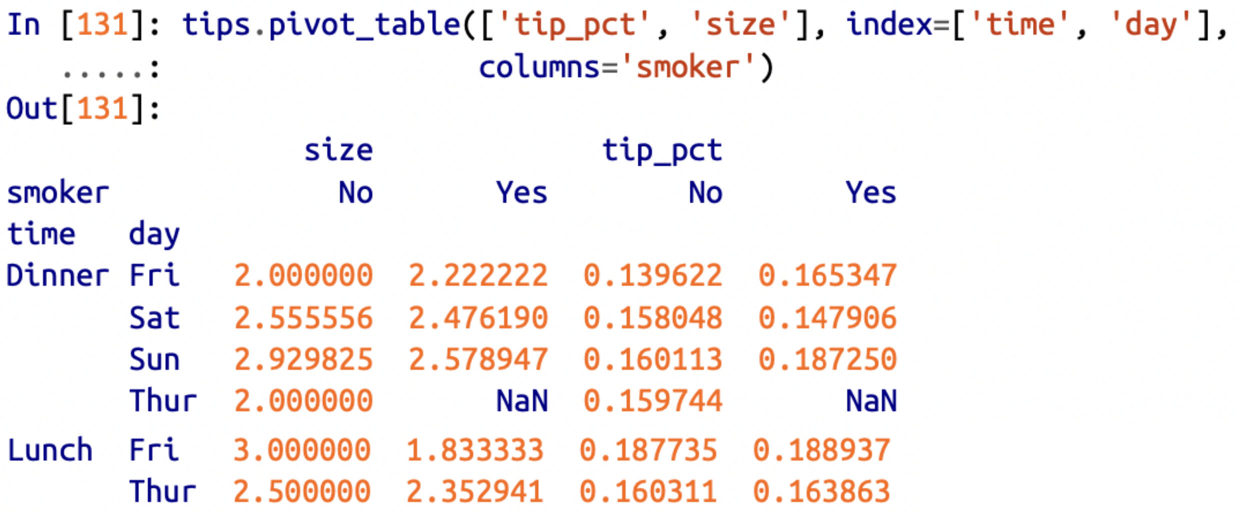
```
In [85]: def get_stats(group):
   ....:     return {'min': group.min(), 'max': group.max(),
   ....:             'count': group.count(), 'mean': group.mean()}

In [86]: grouped = frame.data2.groupby(quartiles)

In [87]: grouped.apply(get_stats).unstack()
Out[87]:
                 count       max      mean       min
data1
(-2.956, -1.23]   95.0  1.670835 -0.039521 -3.399312
(-1.23, 0.489]   598.0  3.260383 -0.002051 -2.989741
(0.489, 2.208]   297.0  2.954439  0.081822 -3.745356
(2.208, 3.928]    10.0  1.765640  0.024750 -1.929776
# Return quantile numbers
In [88]: grouping = pd.qcut(frame.data1, 10, labels=False)

In [89]: grouped = frame.data2.groupby(grouping)

In [90]: grouped.apply(get_stats).unstack()
Out[90]:
       count       max      mean       min
data1
0      100.0  1.670835 -0.049902 -3.399312
1      100.0  2.628441  0.030989 -1.950098
2      100.0  2.527939 -0.067179 -2.925113
3      100.0  3.260383  0.065713 -2.315555
4      100.0  2.074345 -0.111653 -2.047939
5      100.0  2.184810  0.052130 -2.989741
6      100.0  2.458842 -0.021489 -2.223506
7      100.0  2.954439 -0.026459 -3.056990
8      100.0  2.735527  0.103406 -3.745356
9      100.0  2.377020  0.220122 -2.064111
```

Pivot Tables and Cross-Tabulation

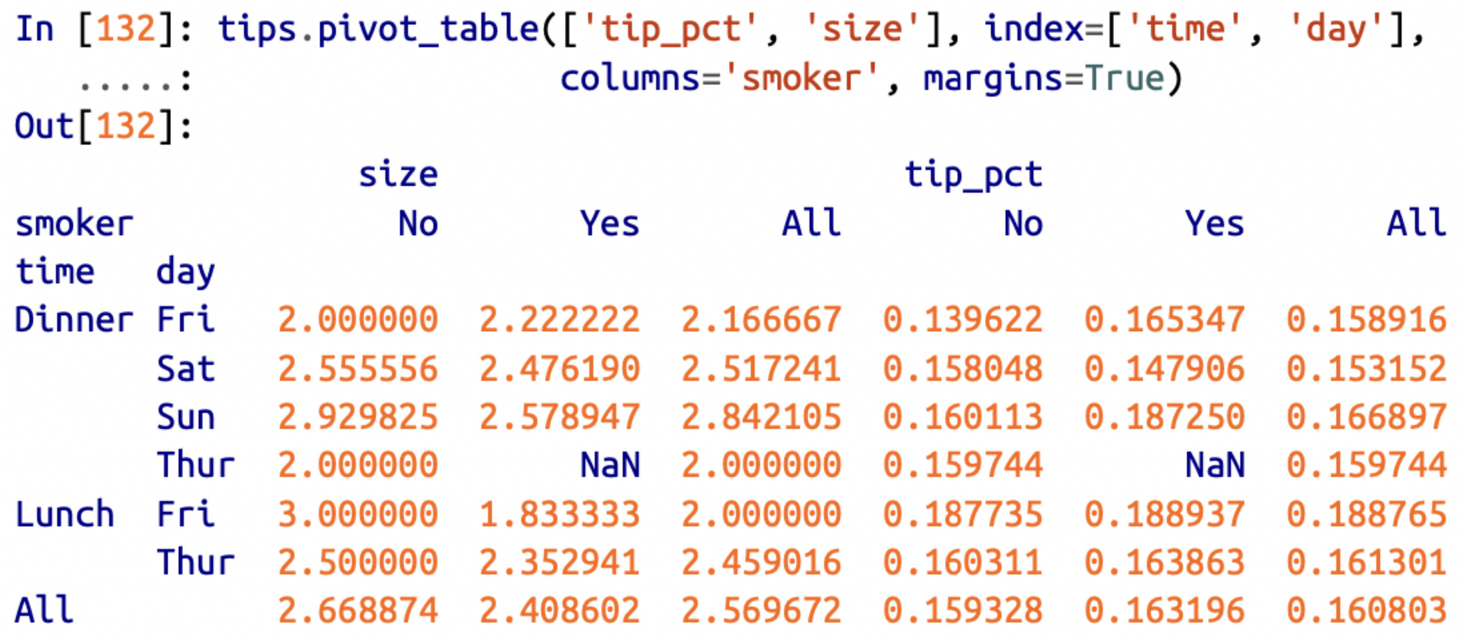
Suppose you wanted to compute a table of group means (the default pivot_table aggregation type) arranged by day and smoker on the rows:



```
In [130]: tips.pivot_table(index=['day', 'smoker'])
Out[130]:
                 size       tip   tip_pct  total_bill
day  smoker
Fri  No      2.250000  2.812500  0.151650   18.420000
     Yes     2.066667  2.714000  0.174783   16.813333
Sat  No      2.555556  3.102889  0.158048   19.661778
     Yes     2.476190  2.875476  0.147906   21.276667
Sun  No      2.929825  3.167895  0.160113   20.506667
     Yes     2.578947  3.516842  0.187250   24.120000
Thur No      2.488889  2.673778  0.160298   17.113111
     Yes     2.352941  3.030000  0.163863   19.190588
```

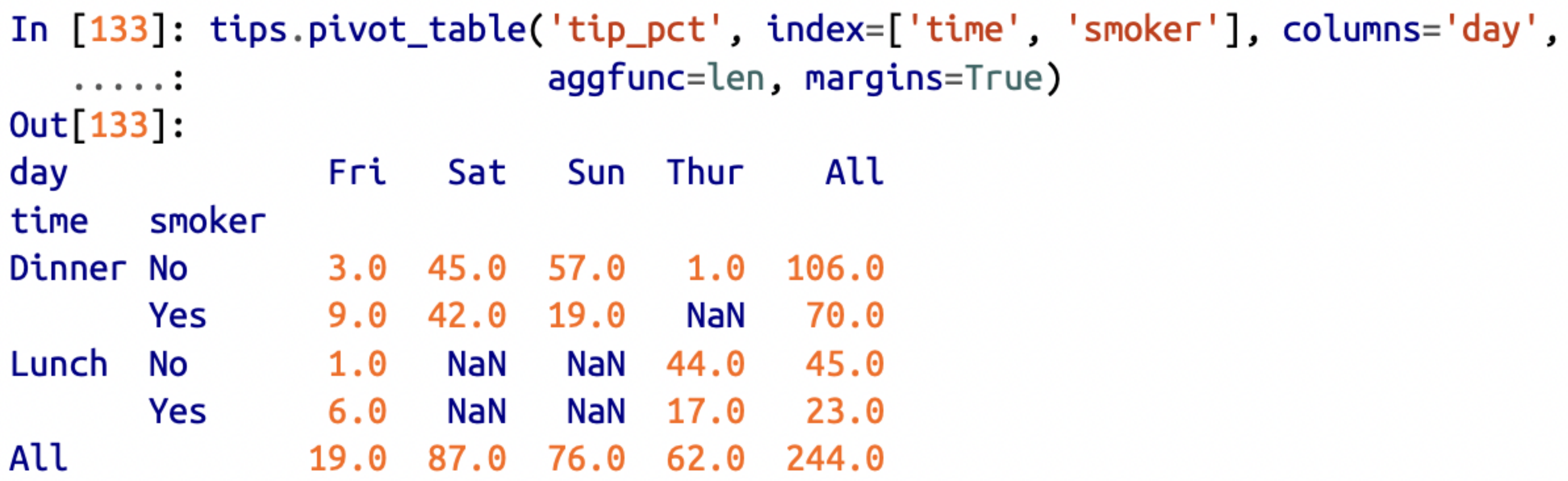


```
In [131]: tips.pivot_table(['tip_pct', 'size'], index=['time', 'day'],
   .....:                  columns='smoker')
Out[131]:
                 size             tip_pct
smoker             No       Yes        No       Yes
time   day
Dinner Fri   2.000000  2.222222  0.139622  0.165347
       Sat   2.555556  2.476190  0.158048  0.147906
       Sun   2.929825  2.578947  0.160113  0.187250
       Thur  2.000000       NaN  0.159744       NaN
Lunch  Fri   3.000000  1.833333  0.187735  0.188937
       Thur  2.500000  2.352941  0.160311  0.163863
```

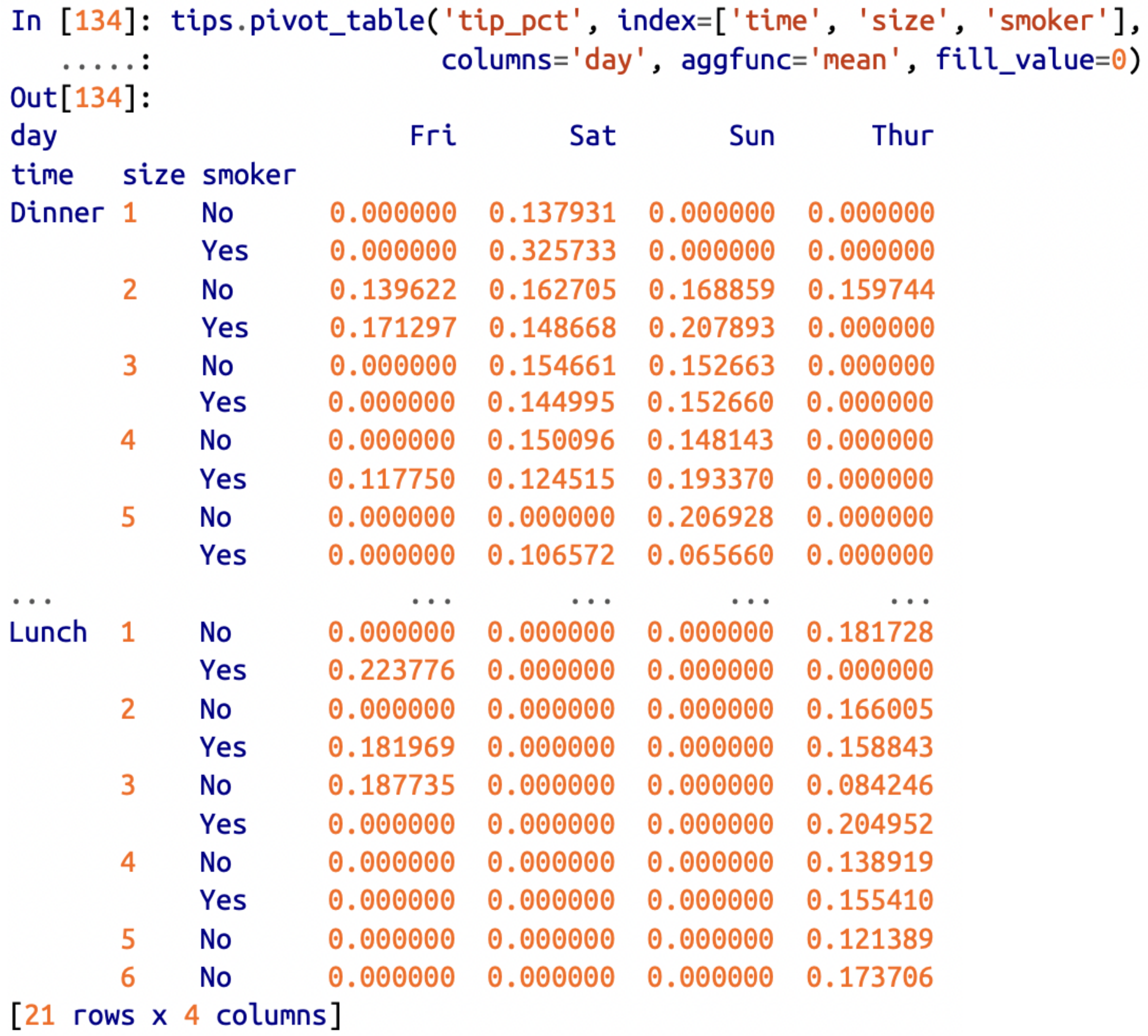


```
In [132]: tips.pivot_table(['tip_pct', 'size'], index=['time', 'day'],
   .....:                  columns='smoker', margins=True)
Out[132]:
                 size                          tip_pct
smoker             No       Yes       All        No       Yes       All
time   day
Dinner Fri   2.000000  2.222222  2.166667  0.139622  0.165347  0.158916
       Sat   2.555556  2.476190  2.517241  0.158048  0.147906  0.153152
       Sun   2.929825  2.578947  2.842105  0.160113  0.187250  0.166897
       Thur  2.000000       NaN  2.000000  0.159744       NaN  0.159744
Lunch  Fri   3.000000  1.833333  2.000000  0.187735  0.188937  0.188765
       Thur  2.500000  2.352941  2.459016  0.160311  0.163863  0.161301
All          2.668874  2.408602  2.569672  0.159328  0.163196  0.160803
```

To use a different aggregation function, pass it to aggfunc.

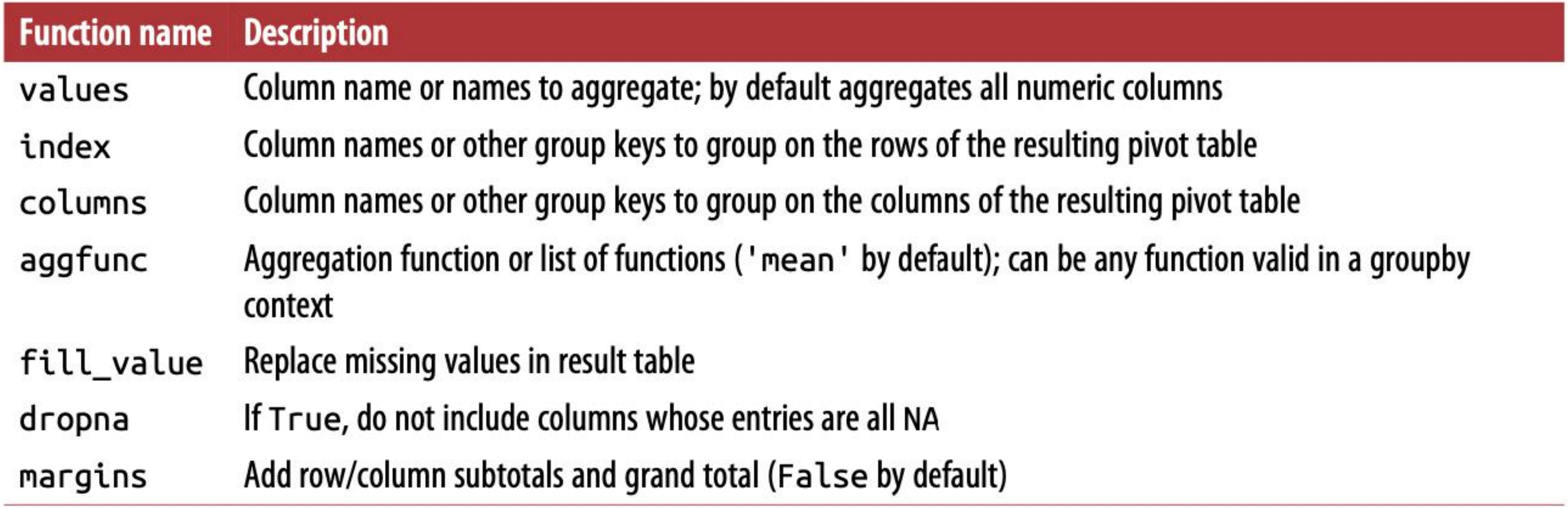


```
In [133]: tips.pivot_table('tip_pct', index=['time', 'smoker'], columns='day',
   .....:                  aggfunc=len, margins=True)
Out[133]:
day             Fri   Sat   Sun  Thur    All
time   smoker
Dinner No       3.0  45.0  57.0   1.0  106.0
       Yes      9.0  42.0  19.0   NaN   70.0
Lunch  No       1.0   NaN   NaN  44.0   45.0
       Yes      6.0   NaN   NaN  17.0   23.0
All            19.0  87.0  76.0  62.0  244.0
```



```
In [134]: tips.pivot_table('tip_pct', index=['time', 'size', 'smoker'],
   .....:                  columns='day', aggfunc='mean', fill_value=0)
Out[134]:
day                      Fri       Sat       Sun      Thur
time   size smoker
Dinner 1    No      0.000000  0.137931  0.000000  0.000000
            Yes     0.000000  0.325733  0.000000  0.000000
       2    No      0.139622  0.162705  0.168859  0.159744
            Yes     0.171297  0.148668  0.207893  0.000000
       3    No      0.000000  0.154661  0.152663  0.000000
            Yes     0.000000  0.144995  0.152660  0.000000
       4    No      0.000000  0.150096  0.148143  0.000000
            Yes     0.117750  0.124515  0.193370  0.000000
       5    No      0.000000  0.000000  0.206928  0.000000
            Yes     0.000000  0.106572  0.065660  0.000000
...                      ...       ...       ...       ...
Lunch  1    No      0.000000  0.000000  0.000000  0.181728
            Yes     0.223776  0.000000  0.000000  0.000000
       2    No      0.000000  0.000000  0.000000  0.166005
            Yes     0.181969  0.000000  0.000000  0.158843
       3    No      0.187735  0.000000  0.000000  0.084246
            Yes     0.000000  0.000000  0.000000  0.204952
       4    No      0.000000  0.000000  0.000000  0.138919
            Yes     0.000000  0.000000  0.000000  0.155410
       5    No      0.000000  0.000000  0.000000  0.121389
       6    No      0.000000  0.000000  0.000000  0.173706
[21 rows x 4 columns]
```

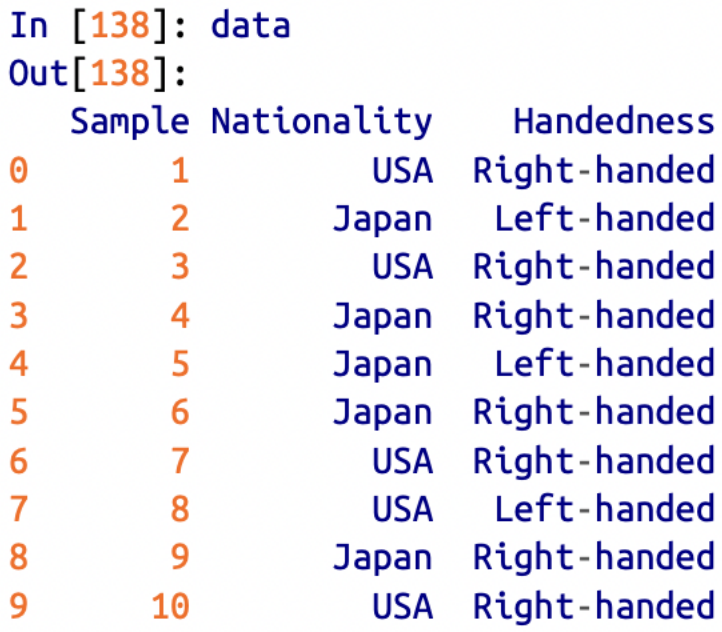
Table 2 for a summary of pivot_table methods.



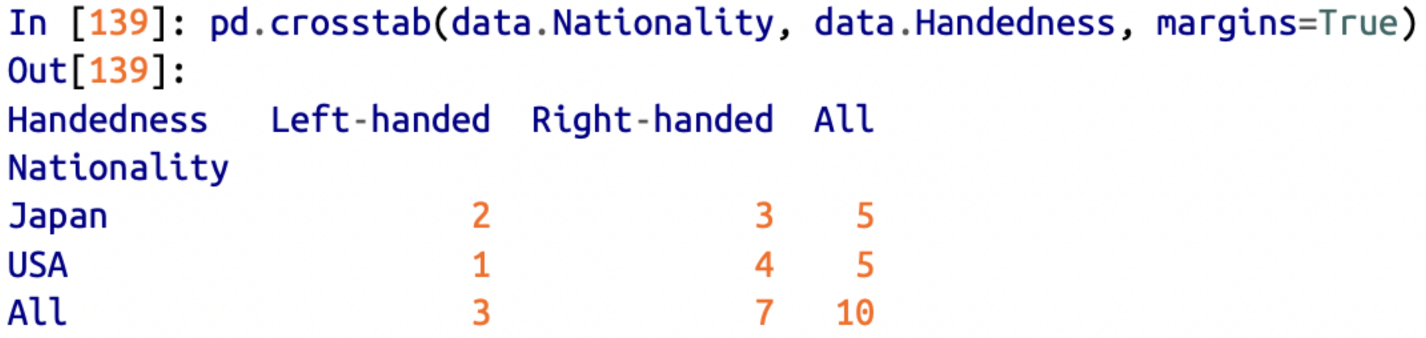
Function name	Description
`values`	Column name or names to aggregate; by default aggregates all numeric columns
`index`	Column names or other group keys to group on the rows of the resulting pivot table
`columns`	Column names or other group keys to group on the columns of the resulting pivot table
`aggfunc`	Aggregation function or list of functions (`'mean'` by default); can be any function valid in a groupby context
`fill_value`	Replace missing values in result table
`dropna`	If `True`, do not include columns whose entries are all NA
`margins`	Add row/column subtotals and grand total (`False` by default)

Cross-Tabulations: Crosstab

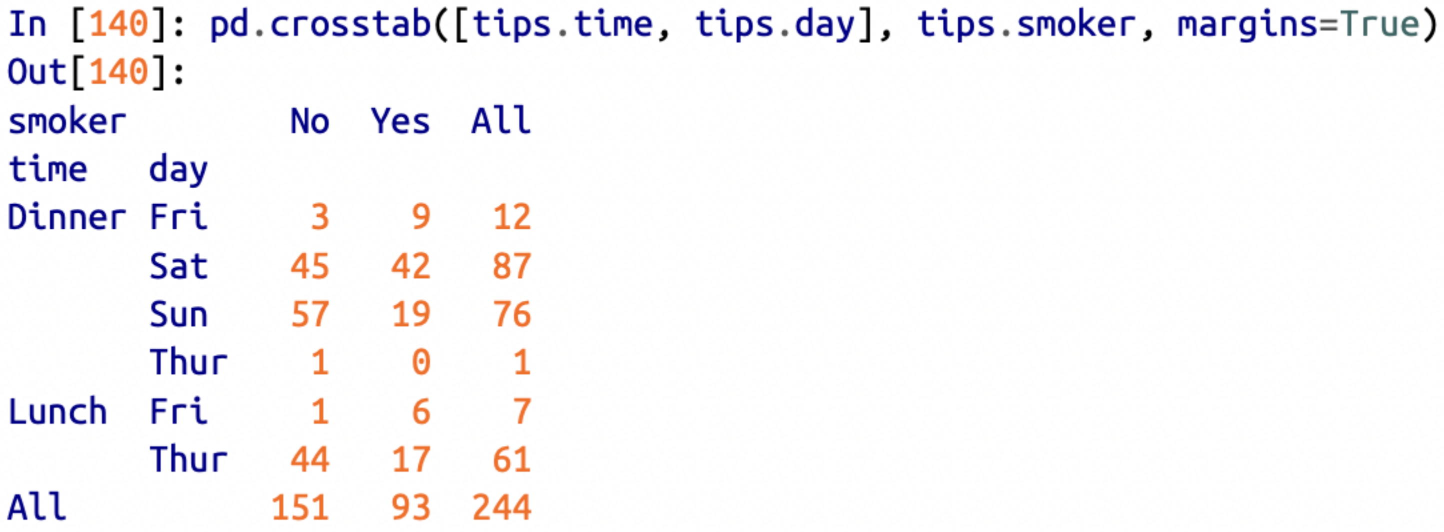
A cross-tabulation (or *crosstab* for short) is a special case of a pivot table that computes group frequencies. Here is an example:



```
In [138]: data
Out[138]:
   Sample Nationality    Handedness
0       1         USA  Right-handed
1       2       Japan   Left-handed
2       3         USA  Right-handed
3       4       Japan  Right-handed
4       5       Japan   Left-handed
5       6       Japan  Right-handed
6       7         USA  Right-handed
7       8         USA   Left-handed
8       9       Japan  Right-handed
9      10         USA  Right-handed
```



```
In [139]: pd.crosstab(data.Nationality, data.Handedness, margins=True)
Out[139]:
Handedness   Left-handed  Right-handed  All
Nationality
Japan                  2             3    5
USA                    1             4    5
All                    3             7   10
```



```
In [140]: pd.crosstab([tips.time, tips.day], tips.smoker, margins=True)
Out[140]:
smoker        No  Yes  All
time   day
Dinner Fri     3    9   12
       Sat    45   42   87
       Sun    57   19   76
       Thur    1    0    1
Lunch  Fri     1    6    7
       Thur   44   17   61
All          151   93  244
```