stats_ch03_visualization

July 31, 2024

1 Modern statistics: Intuition, Math, Python, R

1.1 Mike X Cohen (sincxpress.com)

https://www.amazon.com/dp/B0CQRGWGLY

Code for chapter 3 (visualization)

---

2 About this code file:

2.0.1 This notebook will reproduce most of the figures in this chapter (some figures were made in Inkscape), and illustrate the statistical concepts explained in the text. The point of providing the code is not just for you to recreate the figures, but for you to modify, adapt, explore, and experiment with the code.

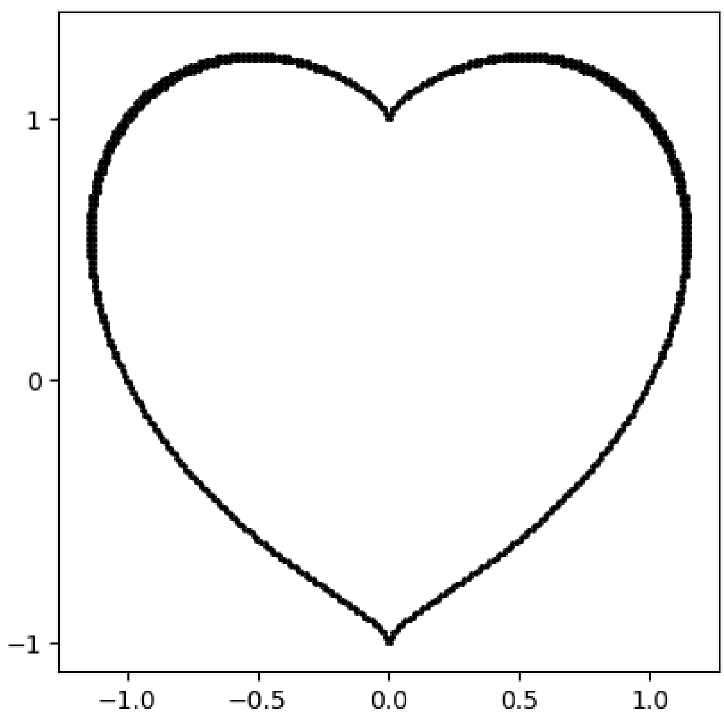
2.0.2 Solutions to all exercises are at the bottom of the notebook.

This code was written in google-colab. The notebook may require some modifications if you use a different IDE.

[3]:
```
# import libraries and define global settings
import numpy as np
import pandas as pd
import seaborn as sns

import matplotlib.pyplot as plt
from matplotlib.patches import Polygon # to create patches

# define global figure properties used for publication
import matplotlib_inline.backend_inline
#matplotlib_inline.backend_inline.set_matplotlib_formats('svg') # display␣
↪figures in vector format
#plt.rcParams.update({'font.size':14,             # font size
#                     'savefig.dpi':300,          # output resolution
#                     'axes.titlelocation':'left',# title location
#                     'axes.spines.right':False,  # remove axis bounding box
#                     'axes.spines.top':False,    # remove axis bounding box
#                     })
```

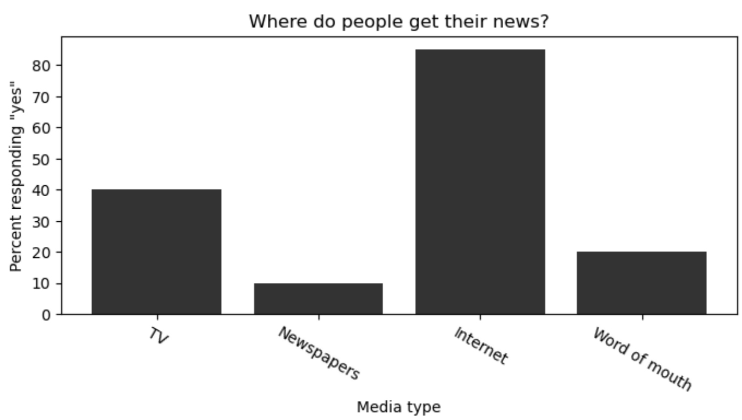
3 Figure 3.2: The math of the heart :)

[2]:
```
import sympy as sym

x,y = sym.symbols('x,y')
expr = (x**2 + y**2 - 1)**3 - x**2 * y**3

# just need the output, not the plot
h = sym.plot_implicit(expr,show=False)

# grab midpoints of intervals and plot those
data = np.array([(x_int.mid, y_int.mid) for x_int, y_int in h[0].
 ↪get_points()[0]])
plt.plot(data[:,0],data[:,1],'k.',markersize=2)
plt.yticks([-1,0,1])
plt.axis('square')

#plt.savefig('vis_heart.png')
plt.show()
```



4 Figure 3.3: Bar plot of news sources

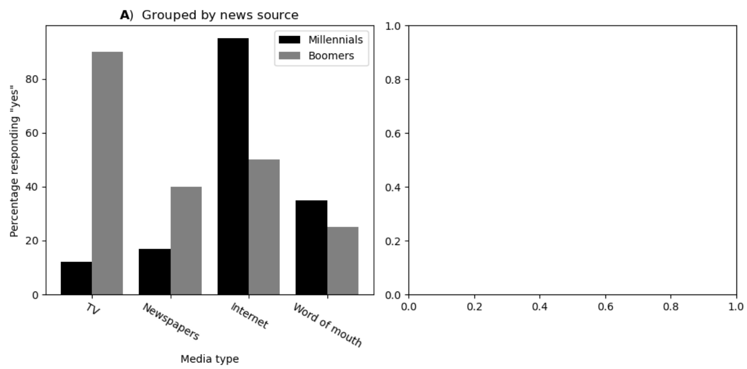
[3]:
```
# specify the bar heights and labels
news_sources = [40,10,85,20]
source_labels = ['TV','Newspapers','Internet','Word of mouth']

# show the bar plot
plt.figure(figsize=(8,3.3))
plt.bar(source_labels,news_sources,color=[.2,.2,.2])

# make the graph look a bit nicer
plt.title('Where do people get their news?',loc='center')
plt.ylabel('Percent responding "yes"')
plt.xlabel('Media type')
plt.xticks(rotation=-30)

#plt.savefig('vis_barplot_news1.png',bbox_inches='tight')
plt.show()
```



5 Figure 3.5: Grouped bar plots

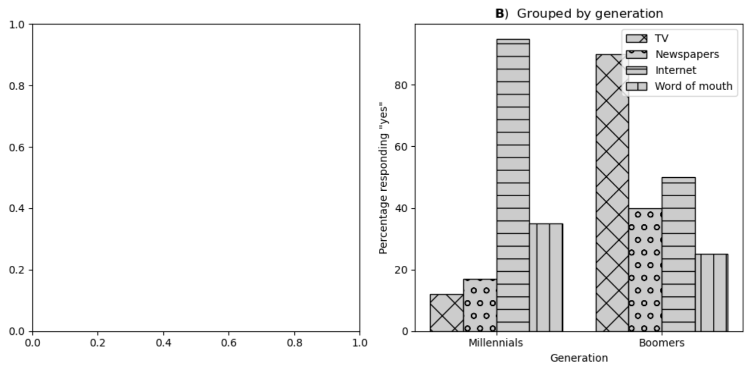
[5]:
```
source_labels = ['TV','Newspapers','Internet','Word of mouth']
news_sources = np.array([[12,17,95,35],
                         [90,40,50,25]] )
agegroups = ['Millennials','Boomers']

# predispongo lo spazio per due grafici affiancati
_,axs = plt.subplots(1,2,figsize=(10,5))

# due colonne di colori diversi
axs[0].bar(np.arange(4)-.2,news_sources[0],width=.4,color='k')
```

```
axs[0].bar(np.arange(4)+.2,news_sources[1],width=.4,color='gray')
# labels degli assi
axs[0].set(xlabel='Media type',ylabel='Percentage responding "yes"',xticks=np.
 ↪arange(4))
# stick labels ruotate
axs[0].set_xticklabels(source_labels,rotation=-30)
# scrivo la legenda
axs[0].legend(agegroups)
# scrivo il titolo
axs[0].set_title(r'$\bf{A}$)  Grouped by news source')

plt.tight_layout()
#plt.savefig('vis_barplot_news2.png')
plt.show()
```



[4]:
```
source_labels = ['TV','Newspapers','Internet','Word of mouth']
news_sources = np.array([[12,17,95,35],
                         [90,40,50,25]] )
agegroups = ['Millennials','Boomers']

# predispongo lo spazio per due grafici affiancati
_,axs = plt.subplots(1,2,figsize=(10,5))

# predispongo la posizione delle quattro colonne
offset = [-.3,-.1,.1,.3]
# questo è un tipo di riempimento (newpapers)
hatches = 'xo-|' # "hatch" is the fill shape

# predispongo il riempimento di tutte le barre
for i in range(4):
  axs[1].bar(np.arange(2)+offset[i],news_sources[:,i],width=.2,
             hatch=hatches[i],color=[.8,.8,.8],edgecolor='k')
```

```
# Note about color: Unless you need grayscale, color is nicer-looking than␣
↪hatches:
# for i in range(4): axs[1].bar(np.arange(2)+offset[i],news_sources[:,i],width=.
↪2)

axs[1].set(xlabel='Generation',ylabel='Percentage responding "yes"',xticks=np.
↪arange(2))
axs[1].set_xticklabels(agegroups)
axs[1].legend(source_labels,fontsize=10)
axs[1].set_title(r'$\bf{B}$)  Grouped by generation')


plt.tight_layout()
#plt.savefig('vis_barplot_news2.png')
plt.show()
```

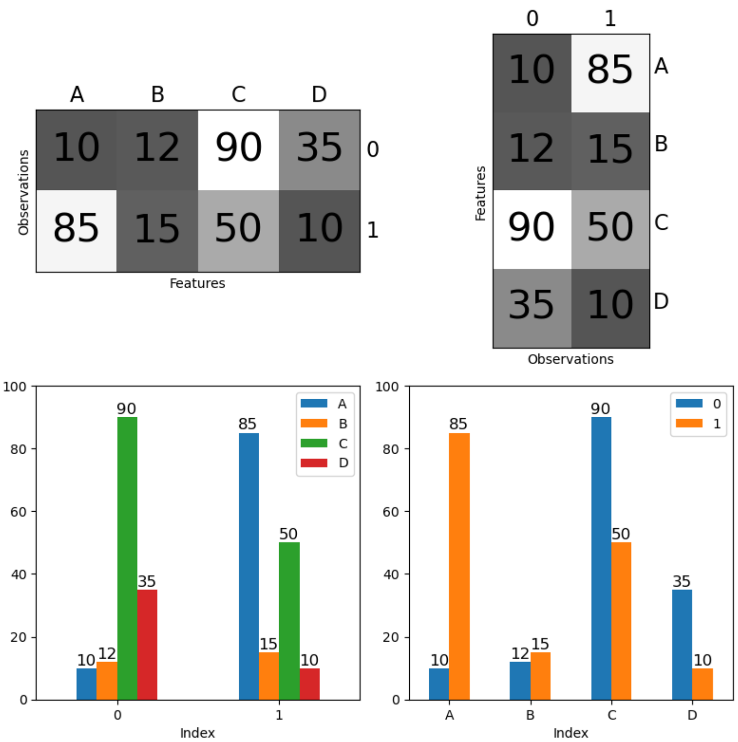


6 Figure 3.6: Note about bars from matrices

[7]:
```
# data are observations (rows) X features (columns)
m = [ [2,5,4,3], [1,1,8,6] ]
m = [ [10,12,90,35], [85,15,50,10] ]

fig,ax = plt.subplots(nrows=2,ncols=2,figsize=(8,8))


### show data as an image
# conceptualizing the data as <row> groups of <columns>
ax[0,0].imshow(m,cmap='gray',vmin=-30,vmax=90)

# add numerical labels
for i in range(len(m)):
  for j in range(len(m[0])):
```

```
    ax[0,0].text(j,i,m[i][j],fontsize=30
                 ,horizontalalignment='center',verticalalignment='center')
ax[0,0].set(xticks=[],yticks=[])
ax[0,0].set(xlabel='Features',ylabel='Observations')


# now other orientation (features X observations)
ax[0,1].imshow(np.array(m).T,cmap='gray',vmin=-30,vmax=90)
for i in range(len(m)):
  for j in range(len(m[0])):
    ax[0,1].text(i,j,m[i][j],fontsize=30
                 ,horizontalalignment='center',verticalalignment='center')
ax[0,1].set(xticks=[],yticks=[])
ax[0,1].set_xlabel('Observations')
ax[0,1].set_ylabel('Features')




#### now for bar plots using pandas dataframe
df = pd.DataFrame(m,columns=['A','B','C','D'])
h = df.plot(ax=ax[1,0],kind='bar',rot=0)
ax[1,0].set_ylim([0,100])

# add text labels
for p in h.patches:
  h.annotate(p.get_height(), [p.get_x()+.06, p.get_height()+1],
             horizontalalignment='center',fontsize=12)

## add text/number indices to rows/columns
for i,l in zip(range(4),'ABCD'):
  ax[0,0].text(i,-.6,l,ha='center',fontsize=16)
  ax[0,1].text(1.65,i,l,ha='center',fontsize=16)

for i in range(2):
  ax[0,0].text(3.65,i,str(i),va='center',ha='center',fontsize=16)
  ax[0,1].text(i,-.6,str(i),ha='center',fontsize=16)


ax[1,0].set_xlabel('Index')

h = df.T.plot(ax=ax[1,1],kind='bar',rot=0)
ax[1,1].set_ylim([0,100])
for p in h.patches:
  h.annotate(p.get_height(), [p.get_x()+.12, p.get_height()+1],
             horizontalalignment='center',fontsize=12)
```

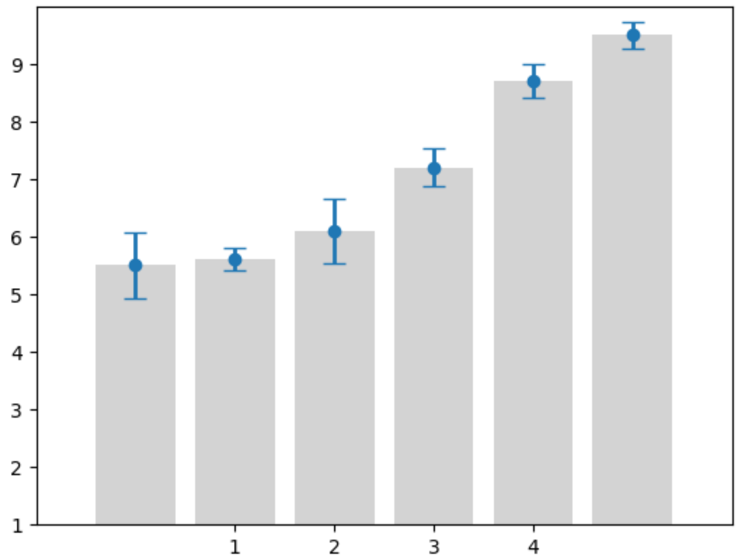
```
ax[1,1].set_xlabel('Index')

plt.tight_layout()
#plt.savefig('vis_barplotOrientations.png')
plt.show()
```



7 Figure 3.7: Error bar plot

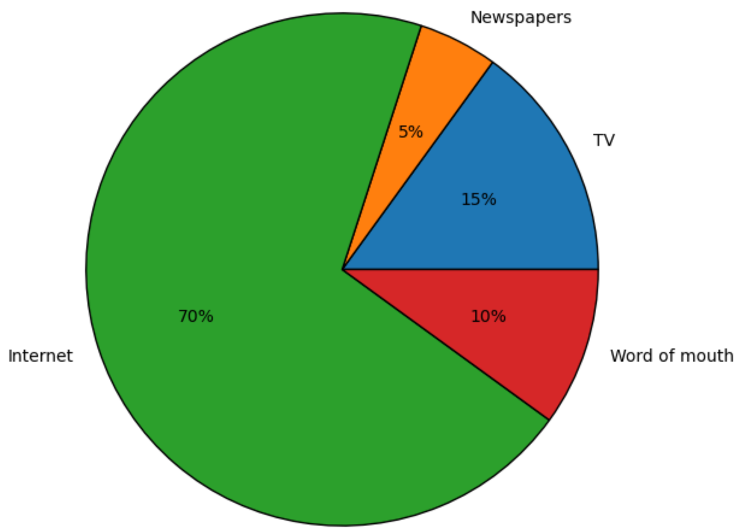
[8]:
```
from matplotlib.pyplot import errorbar
import numpy as np

x = [0,1,2,3,4,5]
y = [5.5,5.6,6.1,7.2,8.7,9.5]

#calculate equation for trendline
z = np.polyfit(x, y, 1)
p = np.poly1d(z)
yerr = abs(y-p(x))

# plot:
fig, ay = plt.subplots()
```

```
ay.errorbar(x, y, yerr, fmt='o', linewidth=2, capsize=6)

ay.set(xlim=(-1, 6), xticks=np.arange(1, 5),
       ylim=(5, 10), yticks=np.arange(1, 10))
plt.bar(x,y,color='lightgray')
plt.show()
```



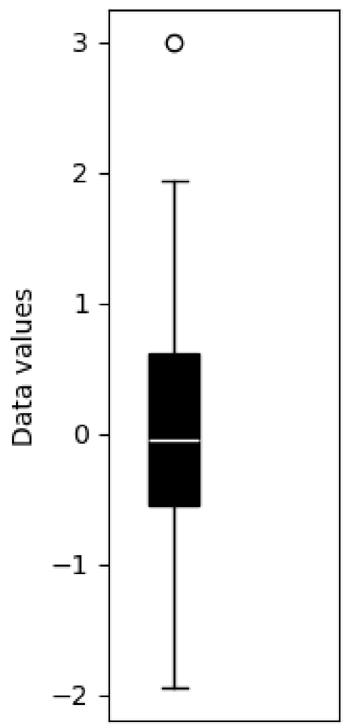
8 Figure 3.8: Pie chart

[9]:
```
# data
source_labels = ['TV','Newspapers','Internet','Word of mouth']
mostNews = [ 15,5,70,10 ]

# make the pie chart
plt.figure(figsize=(6.3,6.3))
plt.pie(mostNews,labels=source_labels,autopct='%.0f%%',
        radius=1.2,wedgeprops={'edgecolor':'k'})

plt.tight_layout()
#plt.savefig('vis_pie.png')
plt.show()
```



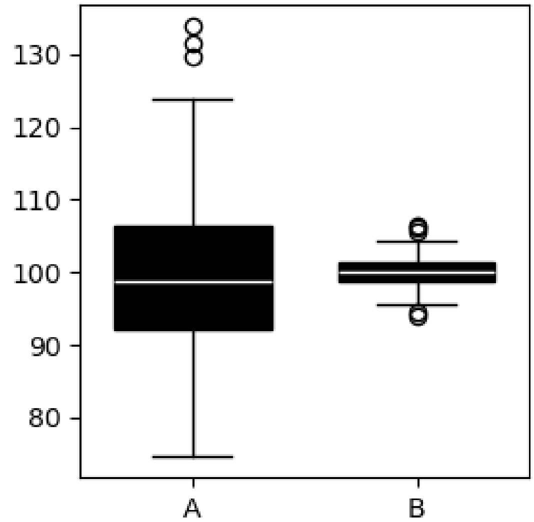
9 Figure 3.9: Box plot

[10]:
```
import numpy as np
# random data with an outlier
data = np.random.randn(100)
data[data>2] = 1
data[data<-2] = -1
data[-1] = 3 # force one outlier



plt.figure(figsize=(2,4))

# draw the boxplot and make some color adjustments
h = plt.boxplot(data,patch_artist=True)
h['boxes'][0].set(color='k')
h['medians'][0].set(color='w')

plt.xlim([.8,1.5])
plt.xticks([])
plt.ylabel('Data values')

plt.tight_layout()
#plt.savefig('vis_boxplotBasic.png')
plt.show()
```



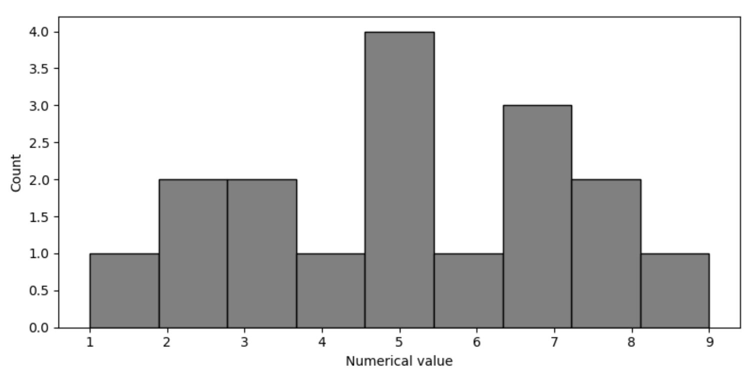
10 Figure 3.10: Box plots for distribution characteristics

[11]:
```
# box plot
data = np.hstack( (np.random.normal(loc=100,size=(200,1),scale=10),
                   np.random.normal(loc=100,size=(200,1),scale=2) ))

# draw the boxplot and make some color adjustments
plt.figure(figsize=(3,3))
h = plt.boxplot(data,patch_artist=True,widths=.7)
for (b,m) in zip(h['boxes'],h['medians']):
  b.set(color='k')
  m.set(color='w')

plt.xlim([.5,2.5])
plt.xticks(range(1,3),['A','B'])
plt.tight_layout()
#plt.savefig('vis_boxplotComp.png')
plt.show()
```



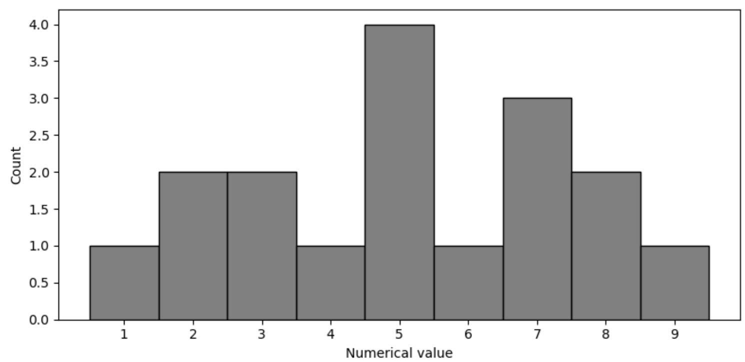
11 Figure 3.11: Histogram

[12]:
```
# version 1

X = [ 1,2,2,3,3,4,5,5,5,5,6,7,7,7,8,8,9 ]

plt.figure(figsize=(8,4))
plt.hist(X,bins=len(set(X)),color='gray',edgecolor='k')
plt.xticks(np.arange(np.min(X),np.max(X)+1))
plt.xlabel('Numerical value')
plt.ylabel('Count')

plt.tight_layout()
#plt.savefig('vis_histOfInts1.png')
plt.show()
```



12 Figure 3.12

[13]:
```
# using different boundaries
plt.figure(figsize=(8,4))
plt.hist(X,bins=np.arange(.5,9.51,step=1),color='gray',edgecolor='k')
plt.xticks(np.arange(np.min(X),np.max(X)+1))
plt.xlabel('Numerical value')
plt.ylabel('Count')

plt.tight_layout()
#plt.savefig('vis_histOfInts2.png')
plt.show()
```

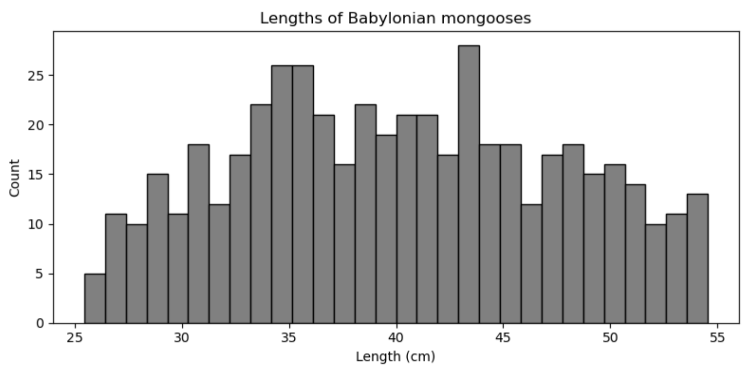


[14]:
```
# the table of bin boundaries
_,x1 = np.histogram(X,bins=len(set(X)))
_,x2 = np.histogram(X,np.arange(.5,9.51,step=1))

for i in range(len(x1)-1):
  print(f'Bin {i+1}:  [{x1[i]:.1f} , {x1[i+1]:.1f}]   [{x2[i]:.1f} , {x2[i+1]:.
 ↪1f}]')
```

```
Bin 1:  [1.0 , 1.9]   [0.5 , 1.5]
Bin 2:  [1.9 , 2.8]   [1.5 , 2.5]
Bin 3:  [2.8 , 3.7]   [2.5 , 3.5]
Bin 4:  [3.7 , 4.6]   [3.5 , 4.5]
Bin 5:  [4.6 , 5.4]   [4.5 , 5.5]
Bin 6:  [5.4 , 6.3]   [5.5 , 6.5]
Bin 7:  [6.3 , 7.2]   [6.5 , 7.5]
Bin 8:  [7.2 , 8.1]   [7.5 , 8.5]
Bin 9:  [8.1 , 9.0]   [8.5 , 9.5]
```

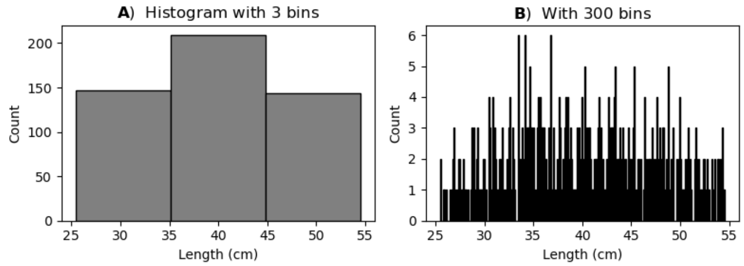
13 Figure 3.14: Histogram of mongoose lengths

[15]:
```
# distribution of mongooses' lengths
mongooses = np.arctanh(np.random.uniform(-.75,.75,size=500))*15+40

plt.figure(figsize=(8,4))
plt.hist(mongooses,bins=30,color='gray',edgecolor='k')

plt.xlabel('Length (cm)')
plt.ylabel('Count')
plt.title('Lengths of Babylonian mongooses',loc='center')

plt.tight_layout()
#plt.savefig('vis_mongeese.png')
plt.show()
```



14 Figure 3.15: Histograms with different bins

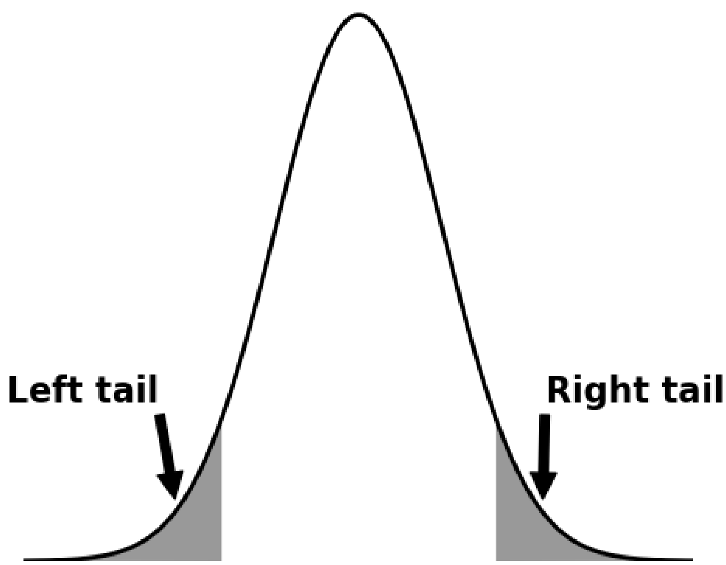
[16]:
```
_,axs = plt.subplots(1,2,figsize=(8,3))

axs[0].hist(mongooses,bins=3,color='gray',edgecolor='k')
axs[0].set_title(r'$\bf{A}$)  Histogram with 3 bins')

axs[1].hist(mongooses,bins=300,color='gray',edgecolor='k')
axs[1].set_title(r'$\bf{B}$)  With 300 bins')

# stylizing
for a in axs:
  a.set_xlabel('Length (cm)')
  a.set_ylabel('Count')

plt.tight_layout()
plt.show()
```



15 Figure 3.16: Distribution showing tails

[17]:
```
import scipy.stats as stats
# create a Gaussian probability curve
x = np.linspace(-4,4,401)
gpdf = stats.norm.pdf(x)

# the find the indices of the 2.5% and 97.5%
lbndi = np.argmin(np.abs(x-stats.norm.ppf(.05)))
ubndi = np.argmin(np.abs(x-stats.norm.ppf(1-.05)))


# plot the probability function and the vertical lines
_,ax = plt.subplots(1,figsize=(5,4))
ax.plot(x,gpdf,'k',linewidth=2)
ax.set(xlim=x[[0,-1]],ylim=[0,.42],xticks=[],yticks=[],
       xlabel='Data value',ylabel='Proportion')


# now create patches for the rejected area
# Note: fill_between() is usually more convenient (and I use it later); here I␣
↪show how to add a polygon patch FYI.
from matplotlib.patches import Polygon

dots = np.zeros((lbndi+2,2))
for i in range(lbndi+1):
  dots[i,:] = x[i],gpdf[i]
dots[-1,:] = x[lbndi],0
ax.add_patch(Polygon(dots,facecolor='k',alpha=.4))

# repeat for the right lobe
dots = np.zeros((len(x)-ubndi+1,2))
for i in range(ubndi,len(x)):
  dots[i-ubndi,:] = x[i],gpdf[i]
dots[-1,:] = x[ubndi],0
```

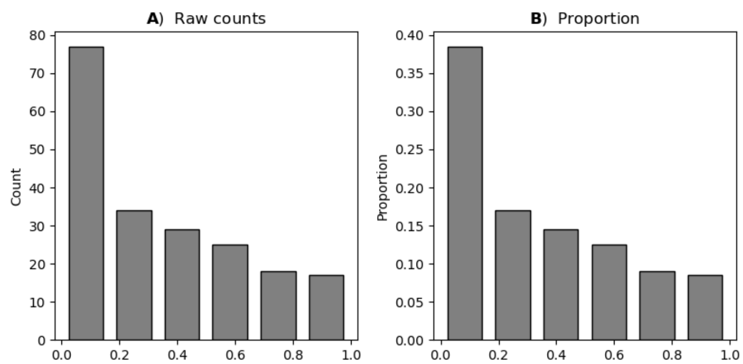
```
ax.add_patch(Polygon(dots,facecolor='k',alpha=.4))

# annotations
tailx = np.argmin(np.abs(x--2.2))
ax.annotate('Left tail',xy=(x[tailx],gpdf[tailx]+.01),
            xytext=(x[tailx]-1.1,gpdf[tailx]+.08),ha='center',
            arrowprops={'color':'k'},weight='bold',size=16)
tailx = np.argmin(np.abs(x-2.2))
ax.annotate('Right tail',xy=(x[tailx],gpdf[tailx]+.01),
            xytext=(x[tailx]+1.1,gpdf[tailx]+.08),ha='center',
            arrowprops={'color':'k'},weight='bold',size=16)

ax.axis('off')
plt.tight_layout()
#plt.savefig('vis_distribution_tails.png')
plt.show()
```



16 Figure 3.17: Histogram raw counts vs proportion

[18]:
```
data = np.random.rand(200)**2

# extract histogram data
counts,x = np.histogram(data,bins='fd')
binCents = (x[:-1]+x[1:])/2

# convert counts to proportion
```

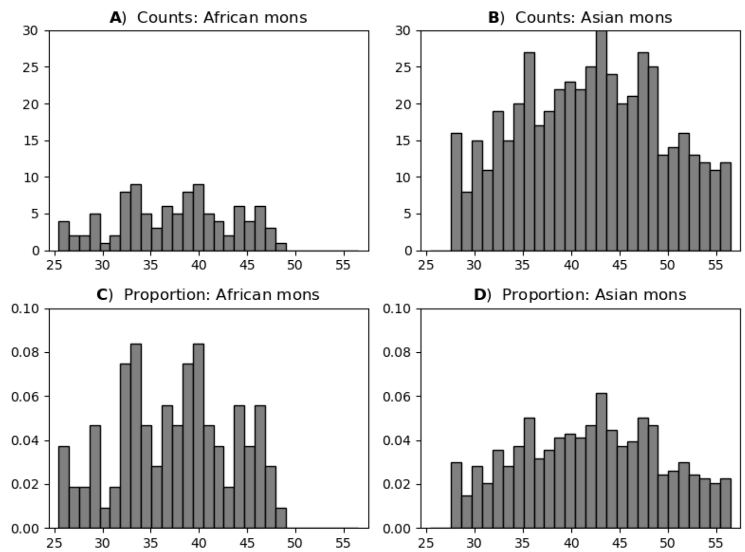
```
proportion = counts / np.sum(counts)

_,axs = plt.subplots(1,2,figsize=(8,4))

axs[0].bar(binCents,counts,width=.12,color='gray',edgecolor='k')
axs[0].set_title(r'$\bf{A}$)  Raw counts')
axs[0].set_ylabel('Count')

axs[1].bar(binCents,proportion,width=.12,color='gray',edgecolor='k')
axs[1].set_title(r'$\bf{B}$)  Proportion')
axs[1].set_ylabel('Proportion')

plt.tight_layout()
#plt.savefig('vis_histCountVsProp.png')
plt.show()
```



17 Figure 3.19: The mongooses experiment

[19]:
```
mongooses_africa = np.arctanh(np.random.uniform(size=100)*1.5-.75)*12+37
mongooses_asia = np.arctanh(np.random.uniform(size=500)*1.5-.75)*15+42

# create common bin boundaries across both datasets
alldata = np.concatenate((mongooses_africa,mongooses_asia))
binbounds = np.linspace(np.min(alldata),np.max(alldata),30)

_,axs = plt.subplots(2,2,figsize=(8,6))

# top two panels show raw histograms
axs[0,0].hist(mongooses_africa,bins=binbounds,color='gray',edgecolor='k')
axs[0,0].set_xlim([binbounds[0]-1,binbounds[-1]+1])
axs[0,0].set_ylim([0,30]) # ylim hard-coded based on N and bins
axs[0,0].set_title(r'$\bf{A}$)  Counts: African mons')
```

```
axs[0,1].hist(mongooses_asia,bins=binbounds,color='gray',edgecolor='k')
axs[0,1].set_xlim([binbounds[0]-1,binbounds[-1]+1])
axs[0,1].set_ylim([0,30])
axs[0,1].set_title(r'$\bf{B}$)  Counts: Asian mons')

# bottom row for proportion
axs[1,0].hist(mongooses_africa,bins=binbounds,density=True,
              color='gray',edgecolor='k')
axs[1,0].set_xlim([binbounds[0]-1,binbounds[-1]+1])
axs[1,0].set_ylim([0,.1])
axs[1,0].set_title(r'$\bf{C}$)  Proportion: African mons')

axs[1,1].hist(mongooses_asia,bins=binbounds,density=True,
              color='gray',edgecolor='k')
axs[1,1].set_xlim([binbounds[0]-1,binbounds[-1]+1])
axs[1,1].set_ylim([0,.1])
axs[1,1].set_title(r'$\bf{D}$)  Proportion: Asian mons')

plt.tight_layout()
plt.show()
```



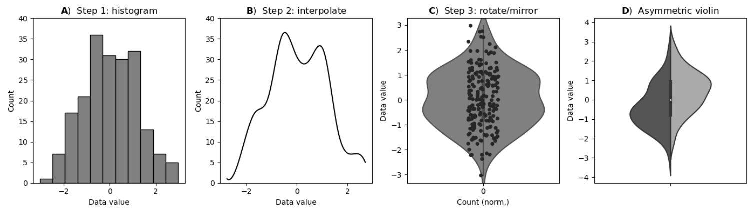
[ ]:

18 Figure 3.21: Violin plot from histogram

[20]:
```
# the data
x1 = np.random.randn(100)-.5
x2 = np.random.randn(100)+.5
X = np.concatenate((x1,x2))

_,axs = plt.subplots(1,4,figsize=(14,4))

# regular histogram
axs[0].hist(X,bins='fd',color='gray',edgecolor='k')
axs[0].set_title(r'$\bf{A}$)  Step 1: histogram')
axs[0].set_ylim([0,40])
axs[0].set_xlabel('Data value')
axs[0].set_ylabel('Count')

# smooth interpolation of histogram
y,x = np.histogram(X,bins='fd')
x = (x[:-1]+x[1:])/2

from scipy import interpolate
interpF = interpolate.interp1d(x,y,kind='cubic')
xx = np.linspace(x[0],x[-1],100)
yy = interpF(xx)


axs[1].plot(xx,yy,'k')
axs[1].set_xlabel('Data value')
axs[1].set_ylabel('Count')
axs[1].set_ylim([0,40])
axs[1].set_title(r'$\bf{B}$)  Step 2: interpolate')


# now for the violin plot (as a dataframe to use seaborn)
df = pd.DataFrame(X)
sns.violinplot(data=df,palette='gray',ax=axs[2])
sns.stripplot(data=df,ax=axs[2],palette='dark:#b2b2b2')
axs[2].set_xlabel('Count (norm.)')
axs[2].set_ylabel('Data value')
axs[2].set_title(r'$\bf{C}$)  Step 3: rotate/mirror')




# NOTE: The code below is actually a solution to Exercise 7, so don't inspect␣
↪this code
#       too carefully if you want the challenge of solving it yourself :)
```

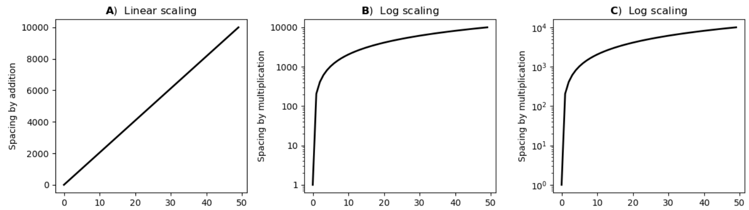
```
df = pd.DataFrame(np.vstack((x1,x2)).T,columns = ['x1','x2'])
df_all = pd.DataFrame( pd.concat((df['x1'],df['x2']),axis=0),columns=['y'])
df_all['distr'] = 'x2'
df_all['distr'][:len(df)] = 'x1' # note: you can safely ignore the warning that␣
↪this line produces
df_all[''] = ' '
sns.
↪violinplot(data=df_all,x='',y='y',palette='gray',ax=axs[3],split=True,hue='distr')
axs[3].legend_.remove()
axs[3].set(xlim=[-.75,.75],ylabel='Data value')
axs[3].set_title(r'$\bf{D}$)  Asymmetric violin')


plt.tight_layout()
#plt.savefig('vis_makeAviolin.png')
plt.show()
```

```
C:\Users\user\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119:
FutureWarning: use_inf_as_na option is deprecated and will be removed in a
future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\user\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119:
FutureWarning: use_inf_as_na option is deprecated and will be removed in a
future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\user\AppData\Local\Temp\ipykernel_72\2828899886.py:48:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df_all['distr'][:len(df)] = 'x1' # note: you can safely ignore the warning
that this line produces
```



19 Figure 3.22: Linear vs logarithmic plot

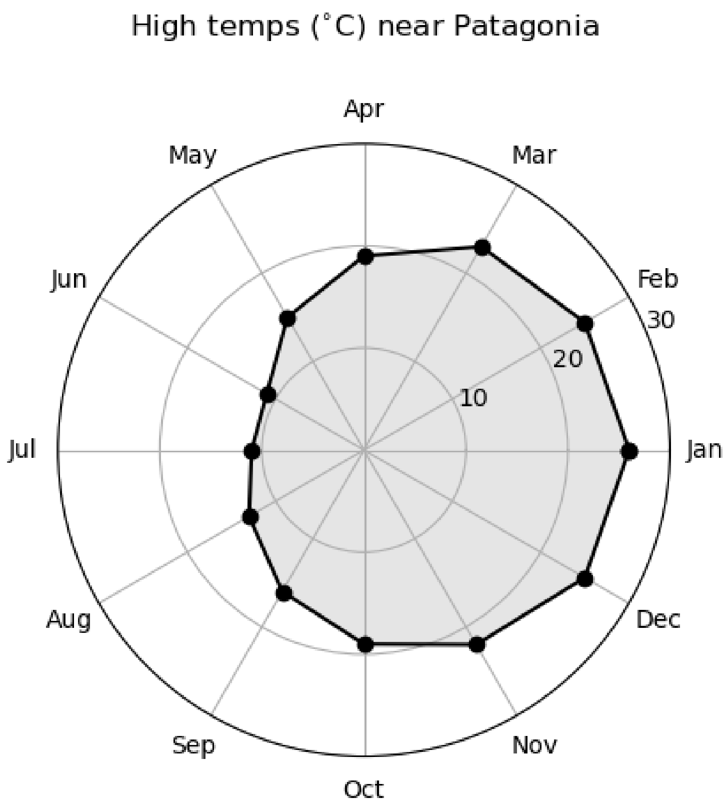
[21]:
```
# simple data... just a line!
y = np.linspace(1,10**4)

# create a figure
_,axs = plt.subplots(1,3,figsize=(12,3.5))

# visualization
for i in range(3):
  # plot the line (same data in all plots!)
  axs[i].plot(y,'k',linewidth=2)

  # adjust the axes for the log plots
  if i>0:
    axs[i].set_yscale('log')
    t = r'$\bf{' + ['B','C'][i-1] + '}$)  Log scaling'
    axs[i].set_title(t)
    axs[i].set_ylabel('Spacing by multiplication')

# log scaling is in scientific notation by default;
# here I change it to scalar format.
from matplotlib.ticker import ScalarFormatter
axs[1].yaxis.set_major_formatter(ScalarFormatter())

# labels
axs[0].set_title(r'$\bf{A}$)  Linear scaling')
axs[0].set_ylabel('Spacing by addition')


plt.tight_layout()
#plt.savefig('vis_linVlog_line.png')
plt.show()
```



[ ]:

20 Figure 3.24: Radial plots

[22]:
```
# data (from https://www.timeanddate.com/weather/%403841798/climate)
tempC = [ 26,25,23,19,15,11,11,13,16,19,22,25 ]
months = [␣
↪'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec' ]

# angles for plotting
theta = np.linspace(0,2*np.pi,len(months)+1)

# repeat first data point so the line wraps around
tempC.append(tempC[0])


## draw the data
ax = plt.subplot(111,polar=True)
ax.plot(theta,tempC,'ko-')
ax.fill(theta,tempC,'k',alpha=.1)

# make the plot look nicer
ax.set_xticks(theta[:-1])
ax.set_xticklabels(months)
ax.set_yticks([10,20,30])
ax.set_ylim([0,30])
ax.set_title('High temps ($^{\circ}$C) near Patagonia',y=1.15,loc='center')


plt.tight_layout()
#plt.savefig('vis_radialGood.png')
plt.show()
```

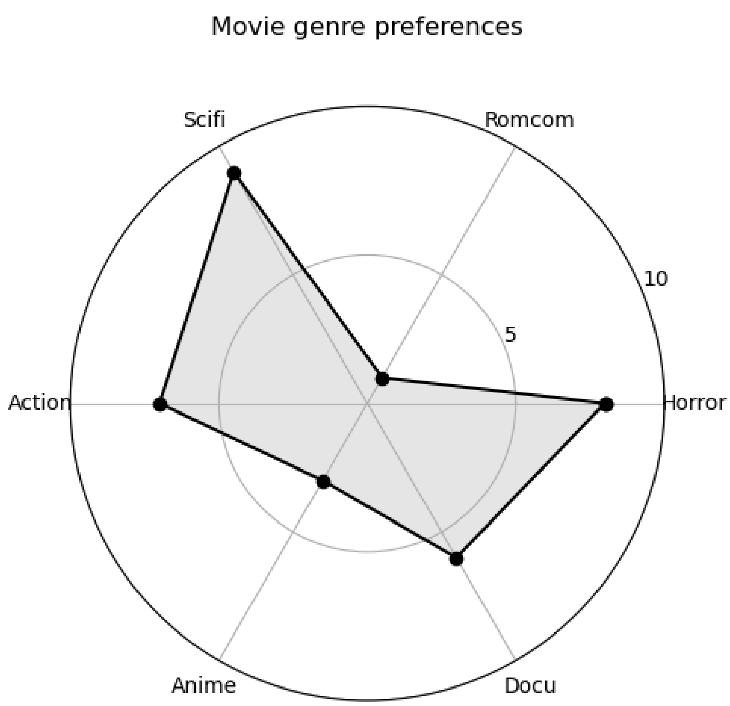


[ ]:

21 Figure 3.25: When not to use a radial plot

[23]:
```
# fake data
data = {
    'Horror' : 8 ,
    'Romcom' : 1 ,
    'Scifi'  : 9 ,
    'Action' : 7 ,
    'Anime'  : 3 ,
    'Docu'   : 6
}

# angles for plotting
theta = np.linspace(0,2*np.pi,len(data)+1)

# repeat first data point so the line wraps around
ratings = list(data.values())
ratings.append(ratings[0])
```

```
## draw the data
ax = plt.subplot(111,polar=True)
ax.plot(theta,ratings,'ko-')
ax.fill(theta,ratings,'k',alpha=.1)

# make the plot look nicer
ax.set_xticks(theta[:-1])
ax.set_xticklabels(data.keys())
ax.set_yticks([5,10])
ax.set_ylim([0,10])
ax.set_title('Movie genre preferences',y=1.1,loc='center')


plt.tight_layout()
#plt.savefig('vis_radialBad.png')
plt.show()
```



[ ]:

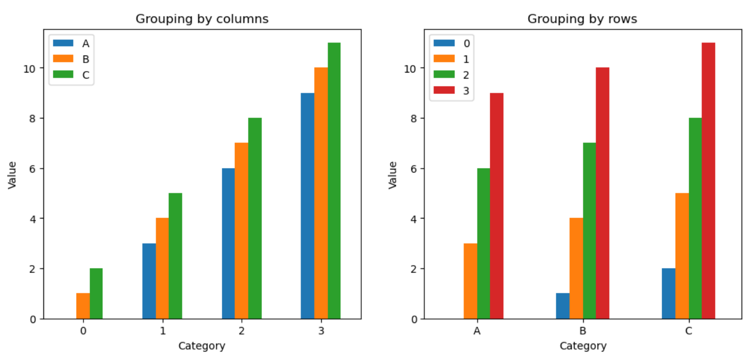
22 Exercise 1

[24]:
```
# grouped bar plots both ways using pandas
df = pd.DataFrame( np.reshape(np.arange(12),(4,3)),
                   columns=['A','B','C'] )
df.T
```

[24]:

	0	1	2	3
A	0	3	6	9
B	1	4	7	10
C	2	5	8	11

[25]:
```
fig,axs = plt.subplots(1,2,figsize=(12,5))

df.plot(kind='bar',ax=axs[0],title='Grouping by columns',
        xlabel='Category',ylabel='Value',rot=0)

df.T.plot(kind='bar',ax=axs[1],title='Grouping by rows',
        xlabel='Category',ylabel='Value',rot=0)
plt.show()
```



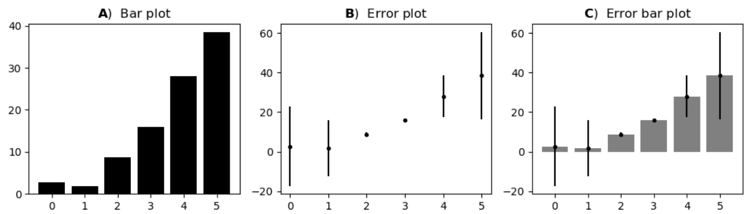
[ ]:
```
```

23 Exercise 2 (Figure 3.7)

[26]:
```
## create data for the bar plot

# data sizes
m = 30 # rows
n =  6 # columns

# generate data
data = np.zeros((m,n))
```

```
for i in range(n):
  # You can implement the equation directly based on mean=0 and std=1
  data[:,i] = 30*np.random.randn(m) * (2*i/(n-1)-1)**2 + (i+1)**2

  # or you can specify mu and sigma as parameters
  # data[:,i] = np.random.normal(loc=(i+1)**2, scale=30*(2*i/(n-1)-1)**2, size=m)
```

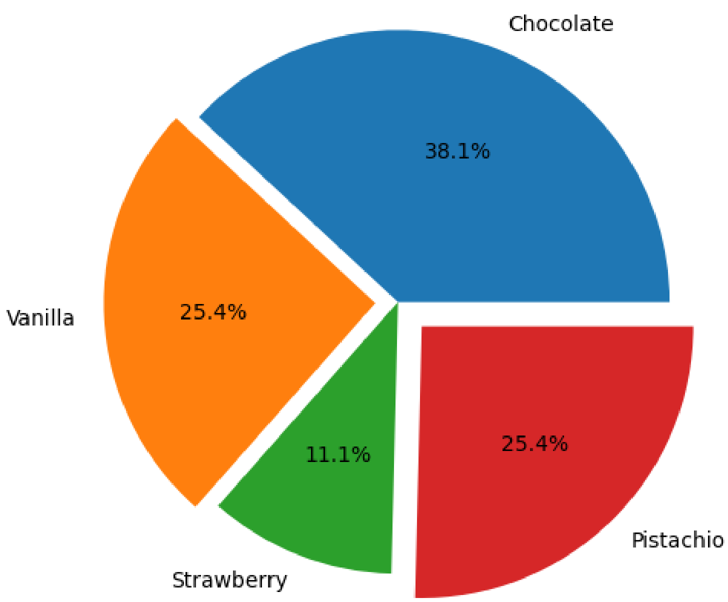
[27]:
```
# show the bars!

fig,ax = plt.subplots(1,3,figsize=(10,3))

# 'naked' bars
ax[0].bar(range(n),np.mean(data,axis=0),color='k')
ax[0].set_xticks(range(n))
ax[0].set_title(r'$\bf{A}$)  Bar plot')

# just the error bars
ax[1].errorbar(range(n),np.mean(data,axis=0),np.std(data,axis=0,ddof=1),
               marker='.',linestyle='',color='k')
ax[1].set_xticks(range(n))
ax[1].set_title(r'$\bf{B}$)  Error plot')

# both
ax[2].bar(range(n),np.mean(data,axis=0),color='gray')
ax[2].set_xticks(range(n))
ax[2].errorbar(range(n),np.mean(data,axis=0),np.std(data,axis=0,ddof=1),marker='.
 ↪',linestyle='',color='k')
ax[2].set_title(r'$\bf{C}$)  Error bar plot')

plt.tight_layout()
#plt.savefig('vis_errorbar.png')
plt.show()
```



[ ]:

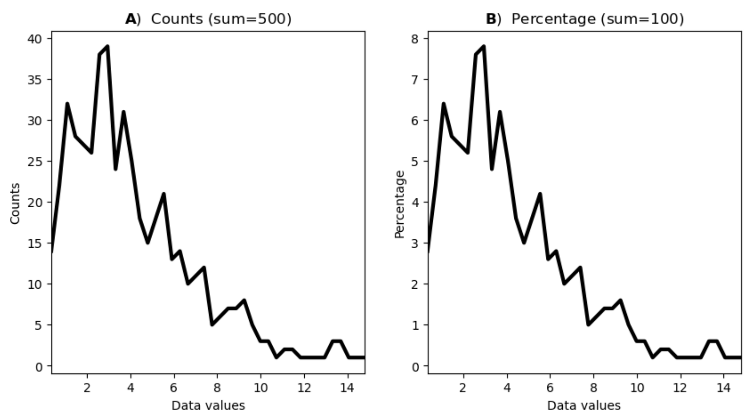
24 Exercise 3

[28]:
```python
# A pie chart is appropriate here because the data
# can be converted to proportion (although they are
# not given as proportion, so transformation is needed).

# data and labels, specified in a dictionary
d = {
    'Chocolate': 24,
     'Vanilla' : 16,
  'Strawberry' :  7,
   'Pistachio' : 16
   }


# note that plt.pie() automatically computes proportion
plt.pie(d.values(), labels=d.keys(),
        explode=[0,.1,0,.15],autopct='%.1f%%',radius=1.2 )

# you can also do it manually:
# x = list( d.values() )
# x = x/np.sum(x)
# plt.pie(x, labels=d.keys() )

#plt.savefig('vis_ex_pie.png')
plt.show()
```



25 Exercise 4

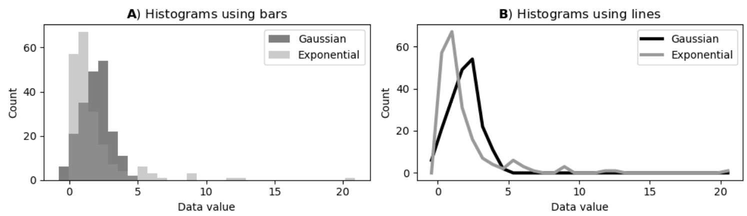
[29]:
```
data = np.random.gamma(2,2,size=500)

# raw histogram values
y,x = np.histogram(data,bins=40)
x = (x[:-1]+x[1:])/2

# normalize to percent
yp = (100*y) / np.sum(y)

_,axs = plt.subplots(1,2,figsize=(10,5))

axs[0].plot(x,y,linewidth=3,color='k')
axs[0].set_title(r'$\bf{A}$)  Counts (sum=%g)' %np.sum(y))
axs[0].set_ylabel('Counts')
axs[0].set_xlabel('Data values')
axs[0].set_xlim(x[[0,-1]])


axs[1].plot(x,yp,linewidth=3,color='k')
axs[1].set_title(r'$\bf{B}$)  Percentage (sum=%g)' %np.sum(yp))
axs[1].set_ylabel('Percentage')
axs[1].set_xlabel('Data values')
axs[1].set_xlim(x[[0,-1]])

plt.savefig('vis_ex_histCountPerc.png')
#plt.tight_layout()
plt.show()
```



[ ]:
```
```

26 Exercise 5

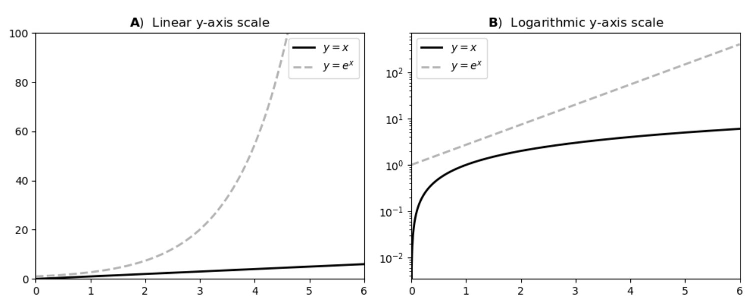
[30]:
```
# parameters
N = 200 # sample sizes
k = 30 # number of bins

# create the data
d1 = np.random.randn(N) + 2
d2 = np.exp( np.random.randn(N) )

# define the bins
alldata = np.hstack((d1,d2))
bins = np.linspace(np.min(alldata),np.max(alldata),k+1)

# get histogram values using numpy
y1,x1 = np.histogram(d1,bins=bins)
y2,x2 = np.histogram(d2,bins=bins)
xx = (x1[:-1]+x1[1:])/2


### now for plotting
_,axs = plt.subplots(1,2,figsize=(10,3))

# draw the histograms using matplotlib
axs[0].hist(d1,bins=bins,label='Gaussian',alpha=.5,color=(0,0,0))
axs[0].hist(d2,bins=bins,label='Exponential',alpha=.5,color=(.6,.6,.6))
axs[0].set_title(r'$\bf{A}$) Histograms using bars')

# now draw lines
axs[1].plot(xx,y1,linewidth=3,label='Gaussian',color=(0,0,0))
axs[1].plot(xx,y2,linewidth=3,label='Exponential',color=(.6,.6,.6))
axs[1].set_title(r'$\bf{B}$) Histograms using lines')

for a in axs:
  a.set_xlabel('Data value')
  a.set_ylabel('Count')
  a.legend()


plt.tight_layout()
#plt.savefig('vis_ex_histBarsLines.png')
plt.show()
```



[ ]:

27 Exercise 6

[31]:
```
x = np.linspace(0,6,1001)

# plot same function in both axes
_,axs = plt.subplots(1,2,figsize=(10,4))
for i,a in enumerate(axs):
  a.plot(x,x, linewidth=2, label='$y=x$', color=[0,0,0])
  a.plot(x,np.exp(x), '--', linewidth=2, label='$y=e^x$', color=[.7,.7,.7])
  a.legend()
  a.set_title([r'$\bf{A}$)',r'$\bf{B}$)'][i] + '  ' +␣
 ↪['Linear','Logarithmic'][i] + ' y-axis scale')
  a.set_xlim([np.min(x),np.max(x)])


# axis-specific adjustments
axs[0].set_ylim([0,100])
axs[1].set_yscale('log')

# save and display
plt.tight_layout()
#plt.savefig('vis_ex_linlog.png')
plt.show()
```

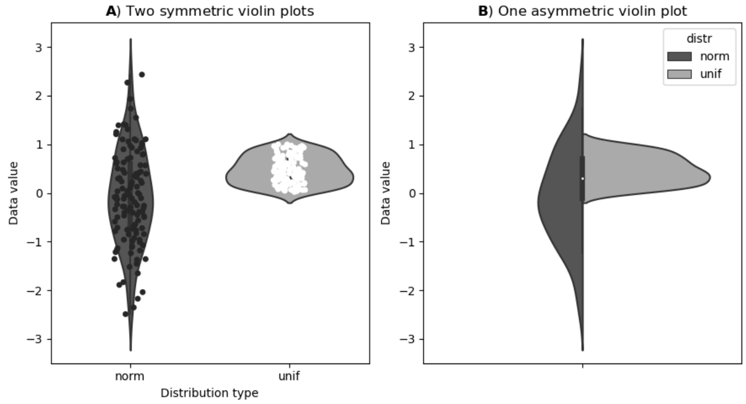


```
[ ]: ### Comment about using -x instead of x:
# The left plot (linear scale) shows the expected result.
# The right plot (log scale) is missing the linear function.
#   This happens because the log of a negative number does not exist in the real␣
↪numbers.
#   Therefore, logarithmic y-axis scaling is valid only for positive-valued data.
#
```

```
[ ]:
```

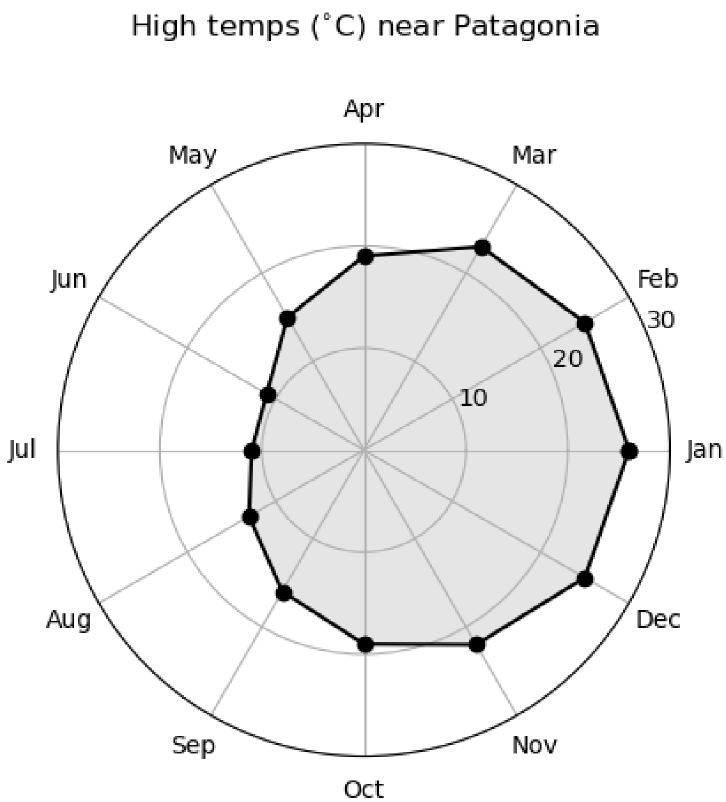
28 Exercise 7

```
[33]: # create data

df = pd.DataFrame(np.hstack((np.random.randn(123,1),np.random.rand(123,1))),
                  columns = ['norm','unif'])
x = np.random.randn(123,1)
icount = -1
for i in range(0,123):
    icount +=1
    x[i] = icount

_,axs = plt.subplots(1,2,figsize=(9,5))
# questoè il grafico a sinistra simmetrico
sns.violinplot(data=df,palette='gray',ax=axs[0])
sns.stripplot(data=df,ax=axs[0],palette='dark:w')
axs[0].set(xlabel='Distribution type',ylabel='Data value',ylim=[-3.5,3.5])
axs[0].set_title(r'$\bf{A}$) Two symmetric violin plots')

# need to combine the columns into one
df_all = pd.DataFrame( pd.concat((df['norm'],df['unif']),axis=0),columns=['y'])
# and create a separate column to indicate the distribution type
df_all['distr'] = 'unif'
df_all['distr'][:len(df)] = 'norm' # note: you can safely ignore the warning␣
↪that this line produces
df_all[''] = ' '

# now we can create a split violin plot
sns.violinplot(data=df_all,x='',y='y',palette='gray',
               ax=axs[1],split=True,hue='distr')
axs[1].set(xlim=[-.5,.5],ylabel='Data value',ylim=[-3.5,3.5])
axs[1].set_title(r'$\bf{B}$) One asymmetric violin plot')

plt.tight_layout()
#plt.savefig('vis_ex7.png')
plt.show()
```



29 Exercise 8

[34]:
```
# data (from https://www.timeanddate.com/weather/%403841798/climate)
tempC = [ 26,25,23,19,15,11,11,13,16,19,22,25 ]
months = [␣
↪'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec' ]

# angles for plotting
theta = np.linspace(0,2*np.pi,len(months)+1)

# repeat first data point so the line wraps around
tempC.append(tempC[0])


## draw the data
ax = plt.subplot(111,polar=True)
ax.plot(theta,tempC,'ko-')
ax.fill(theta,tempC,'k',alpha=.1)

# make the plot look nicer
ax.set_xticks(theta[:-1])
ax.set_xticklabels(months)
ax.set_yticks([10,20,30])
ax.set_ylim([0,30])
ax.set_title('High temps ($^{\circ}$C) near Patagonia',y=1.15,loc='center')


plt.tight_layout()
#plt.savefig('vis_radialGood.png')
plt.show()
```


High temps (°C) near Patagonia
Apr
Mar
May
Feb
Jun
30
20
10
Jul
Jan
Aug
Dec
Sep
Nov
Oct