stats_ch18_bias

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1 Modern statistics: Intuition, Math, Python, R

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

Code for chapter 18 (bias)

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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.

[1]:
```
# import libraries and define global settings
import numpy as np
import scipy.stats as stats
import matplotlib.pyplot as plt

import pandas as pd
import seaborn as sns

# define global figure properties used for publication
import matplotlib_inline.backend_inline
```

3 Exercise 1

[2]:
```
# generate random data, trim smallest values
N = 30

# create new data
data = np.random.randn(N)
```

```python

# trim
idx = np.argsort(data)
dataTrim = data[idx[2:]]

# ttests
ttestO = stats.ttest_1samp(data,0)
ttestT = stats.ttest_1samp(dataTrim,0)

# report the results
print(f'Full: t({ttestO.df}) = {ttestO.statistic:.3f}, p = {ttestO.pvalue:.3f}')
print(f'Trim: t({ttestT.df}) = {ttestT.statistic:.3f}, p = {ttestT.pvalue:.3f}')
```

```
Full: t(29) = 1.195, p = 0.242
Trim: t(27) = 1.939, p = 0.063
```

[3]:

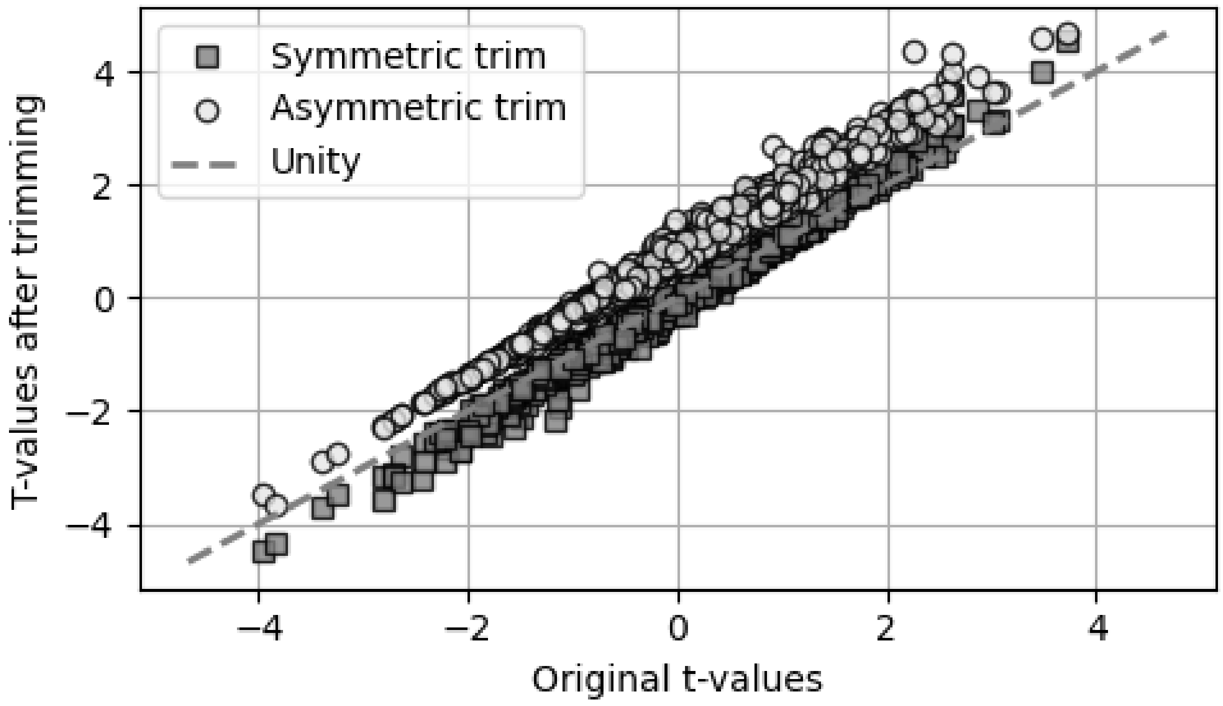
```python
# generate random data, trim smallest or extremiest values

N = 30
numreps = 1000

pLessThan05 = np.zeros((numreps,3))
tValues = np.zeros((numreps,3))

for expi in range(numreps):
  # create new data
  data = np.random.randn(N)

  # trim
  idx = np.argsort(data)
  dataTrimL = data[idx[2:]]
  dataTrimB = data[idx[1:-1]]

  # ttests
  ttestO = stats.ttest_1samp(data,0)      # O = original
  ttestL = stats.ttest_1samp(dataTrimL,0) # L = left side trimmed
  ttestB = stats.ttest_1samp(dataTrimB,0) # B = both sides trimmed

  # store "significances"
  pLessThan05[expi,0] = ttestO.pvalue<.05
  pLessThan05[expi,1] = ttestL.pvalue<.05
  pLessThan05[expi,2] = ttestB.pvalue<.05

  # store t-values
  tValues[expi,0] = ttestO.statistic
  tValues[expi,1] = ttestL.statistic
  tValues[expi,2] = ttestB.statistic
```

```python
# report the output
print(f'   Without data trimming: {np.sum(pLessThan05[:,0],dtype=int):>3}/
 ↪{expi+1} with p<.05 ({100*np.mean(pLessThan05[:,0]):>5.2f}%)')
print(f' With symmetric trimming: {np.sum(pLessThan05[:,2],dtype=int):>3}/
 ↪{expi+1} with p<.05 ({100*np.mean(pLessThan05[:,2]):>5.2f}%)')
print(f'With asymmetric trimming: {np.sum(pLessThan05[:,1],dtype=int):>3}/
 ↪{expi+1} with p<.05 ({100*np.mean(pLessThan05[:,1]):>5.2f}%)')
```

```
   Without data trimming:  60/1000 with p<.05 ( 6.00%)
 With symmetric trimming:  96/1000 with p<.05 ( 9.60%)
With asymmetric trimming: 130/1000 with p<.05 (13.00%)
```

[4]:

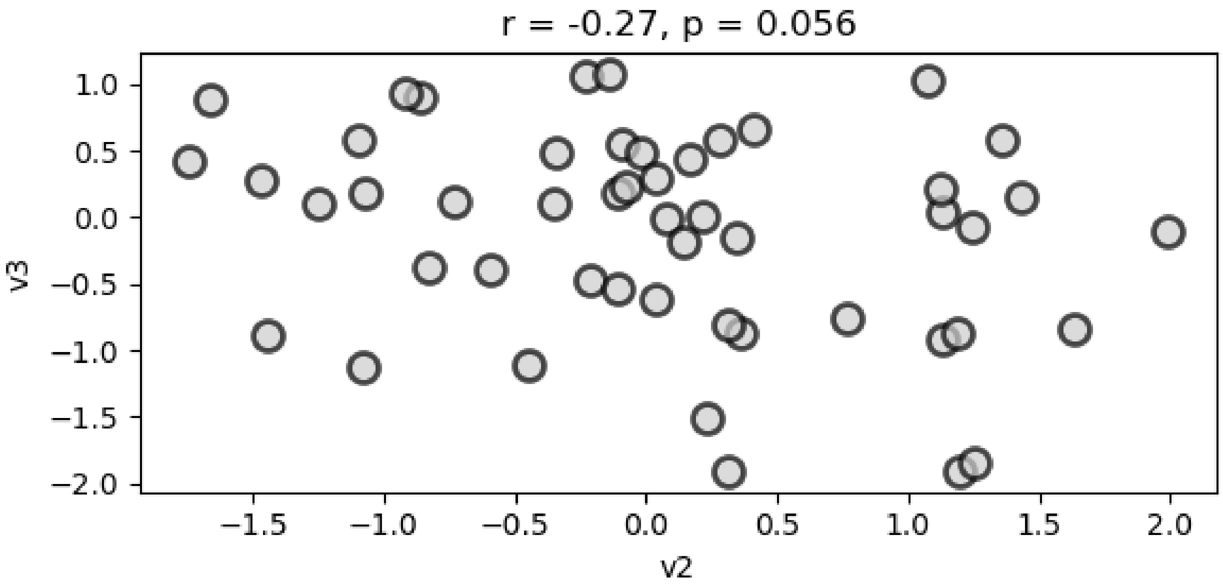
```
# visualize the change in t-values
plt.figure(figsize=(5,3))

# plot the t-values
plt.plot(tValues[:,0],tValues[:,2],'ks',markersize=6,alpha=.8,markerfacecolor=(.
 ↪5,.5,.5),label='Symmetric trim')
plt.plot(tValues[:,0],tValues[:,1],'ko',markersize=6,alpha=.8,markerfacecolor=(.
 ↪9,.9,.9),label='Asymmetric trim')

# plot the unity line
extT = np.max(np.abs(tValues))
plt.
 ↪plot([-extT,extT],[-extT,extT],linewidth=2,linestyle='--',color='gray',label='Unity')

plt.xticks(range(-4,5,2))
plt.yticks(range(-4,5,2))
plt.xlabel('Original t-values')
plt.ylabel('T-values after trimming')
plt.legend()
plt.grid()

plt.tight_layout()
#plt.savefig('bias_ex1.png')
plt.show()
```



4 Exercise 2

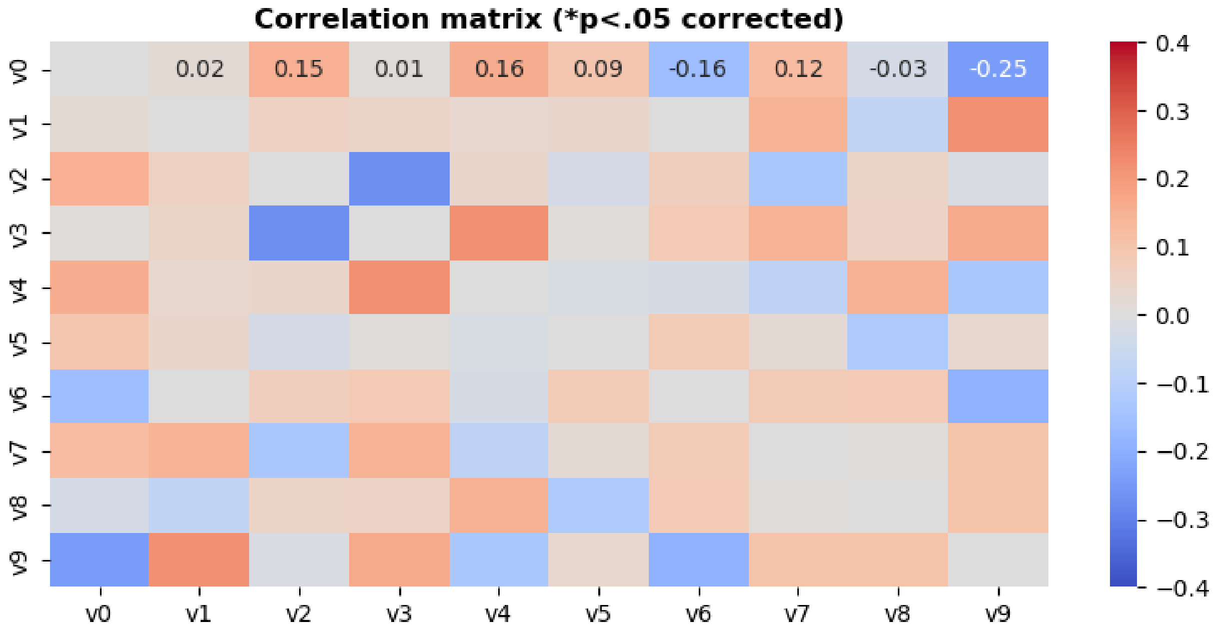
[5]:

```
# generate some data in a DataFrame
df = pd.DataFrame(np.random.randn(50,10), columns=[f'v{i}' for i in range(10)])

# Pearson correlation matrix
R = df.corr()

# Mask the diagonal to ignore r=1
np.fill_diagonal(R.values,0)

# find indices of max pair
xi,yi = np.where(R.abs()==np.max(R.abs().values))[0]

# get p-value
pval = stats.pearsonr(df.iloc[:,xi],df.iloc[:,yi])[1]

# Scatter plot of the variables with the highest correlation
plt.figure(figsize=(6,3))
sns.scatterplot(data=df, x=df.columns[xi], y=df.columns[yi],
                s=100,edgecolor='k',facecolor=(.8,.8,.8),linewidth=2,alpha=.7)
plt.title(f'r = {R.iloc[xi,yi]:.2f}, p = {pval:.3f}',loc='center')

plt.tight_layout()
#plt.savefig('bias_ex2.png')
plt.show()
```



[6]:

```python
### Code below is modified from Exercise 12.11

# convert R to dataframes for seaborn
R_df = pd.DataFrame(R,columns=df.columns,index=df.columns)

# Bonferroni correction [ formula is (M*(M-1))/2 ]
num_comparisons = (df.shape[1]*(df.shape[1]-1)) / 2
bonferroni_thresh = .05 / num_comparisons
# Create a matrix of annotations
annot_array = R_df.astype(str).values

# loop through all elements of the matrix and create a string to display
for i in range(R_df.shape[0]):
  for j in range(R_df.shape[1]):
    # get the p-value and determine significance
    pval = stats.pearsonr(df.iloc[:,i],df.iloc[:,j])[1]
    significant = pval < bonferroni_thresh
    # the string depends on the significance
    if not significant:
      # if non-significant, just the correlation coefficient
      annot_array[i,j] = f'{R_df.iloc[i, j]:.2f}'
    else:
      # if significant, add an asterisk to the coefficient
      annot_array[i,j] = f'{R_df.iloc[i, j]:.2f}*'
    # don't need to report the diagonals
    if i==j:
      annot_array[i,j] = ''

## now show the image
plt.figure(figsize=(8,4))
sns.heatmap(R_df,annot=annot_array,fmt='s',cmap='coolwarm',vmin=-.4,vmax=.4,
            xticklabels=R_df.columns,yticklabels=R_df.columns)
plt.title('Correlation matrix (*p<.05 corrected)',loc='center',weight='bold')
plt.tight_layout()
plt.show()
```


Correlation matrix (*p<.05 corrected)
v0
v1
v2
v3
v4
v5
v6
v7
v8
v9