Part a

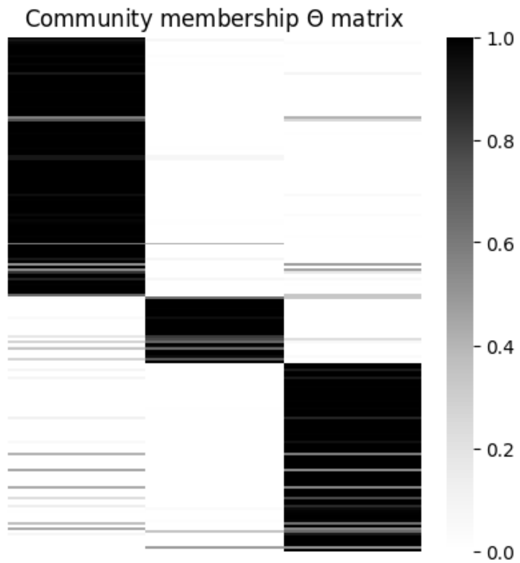
```
import numpy as np
import pandas as pd
import matplotlib.pylab as plt
import seaborn as sns
```

```
samples=np.random.dirichlet((0.05,0.015,0.035),200)
```

```
n_0=0
n_1=0
n_2=0
for i in range(samples.shape[0]):
  if samples[i,0]>samples[i,1] and samples[i,0]>samples[i,2]:
    n_0=n_0+1
  if samples[i,1]>samples[i,0] and samples[i,1]>samples[i,2]:
    n_1=n_1+1
  if samples[i,2]>samples[i,1] and samples[i,2]>samples[i,0]:
    n_2=n_2+1
```

```
ordered=[]
for i in range(samples.shape[0]):
  if samples[i,0]>samples[i,1] and samples[i,0]>samples[i,2]:
    ordered.append(samples[i])

for i in range(samples.shape[0]):
  if samples[i,1]>samples[i,0] and samples[i,1]>samples[i,2]:
    ordered.append(samples[i])

for i in range(samples.shape[0]):
  if samples[i,2]>samples[i,1] and samples[i,2]>samples[i,0]:
    ordered.append(samples[i])

n_ordered=np.array(ordered)
```

```
plt.figure(figsize=(5,5))
heat_map = sns.heatmap( n_ordered,cmap="Greys",xticklabels=False,yticklabels=False)

#heat_map = sns.heatmap( theta,cmap=sns.cubehelix_palette(as_cmap=True))
plt.title( "Community membership ${\Theta}$ matrix" )
plt.show()
```



Answer

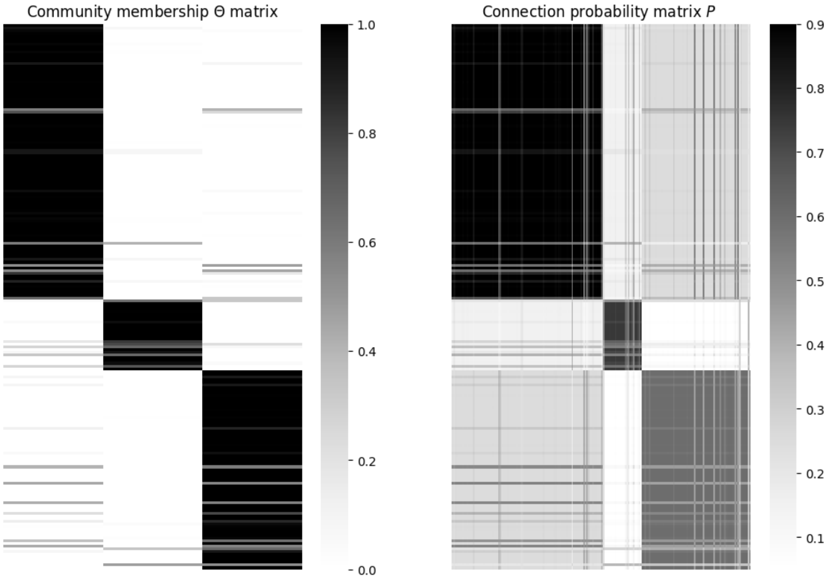
How does this Θ matrix differ from the Θ matrix created in Homework 11 Question 1 Part a? (You may refer to the key for Homework 11 in answering this question if necessary.) **Now each element is not a 100% probable to belong to a community. Now there is a probability to belong to different communities. We can notice clusters, because there is a higher probability to belong to a cluster than others. But, even though there is a high probability to belong to a community, there is some smaller probability to belong to other communities. For this reason, we notice clusters in the community matrix where in certain column the value is almost zero but with some values different of zero in such rows.**

Part b

```
theta=n_ordered
theta_T=theta.transpose()
B=[[0.9,0.15,0.25],[0.15,0.75,0.05],[0.25,0.05,0.6]]
P=theta.dot(B).dot(theta_T)
```

```
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(12, 8))

heat_map1 = sns.heatmap(theta,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text('Community membership ${\Theta}$ matrix ')


heat_map2 = sns.heatmap( P,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text('Connection probability matrix $P$ ')
```

```
ax2.title.set_text('Connection probability matrix $P$ ')
```



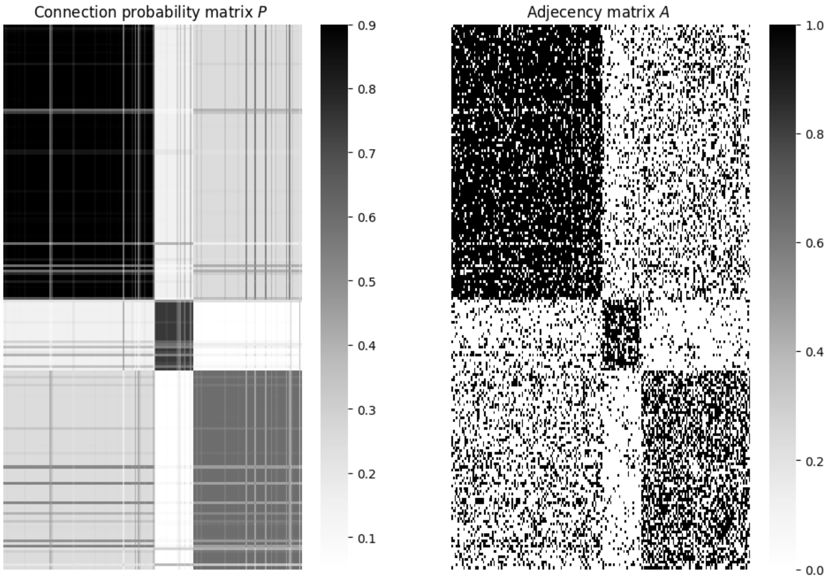
Answer

How does the matrix differ from the matrix created in Homework 11 Question 1 Part b? **The probability for each matrix element in a community is NOT longer the same. We can notice some rectangular patterns in the visualization of the probability matrix.**

Part c

```
R=np.random.uniform(size=[P.shape[0],P.shape[0]])
R1=np.triu(R)+np.transpose(np.triu(R))
A=1*(R1<P)
A1=A-np.diag(np.diag(A))
```

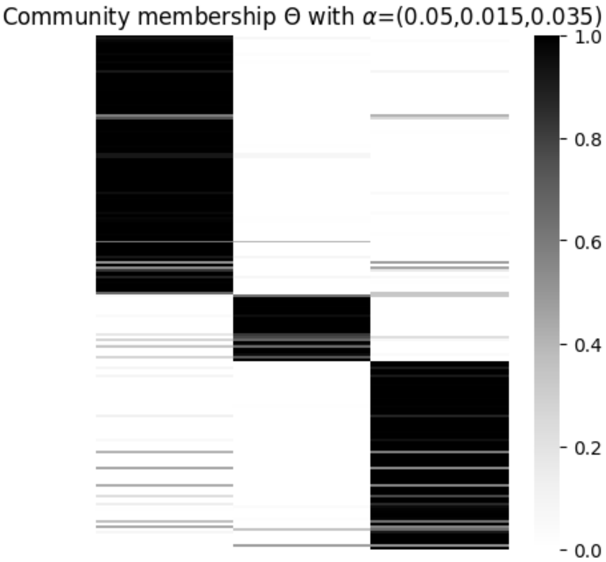
```
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(12, 8))

heat_map1 = sns.heatmap(P,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text('Connection probability matrix $P$  ')


heat_map2 = sns.heatmap( A,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text('Adjecency matrix $A$  ')
```



Part d

```
plt.figure(figsize=(5,5))
heat_map = sns.heatmap( theta,cmap="Greys",xticklabels=False,yticklabels=False)
```

```
#heat_map = sns.heatmap( theta,cmap=sns.cubehelix_palette(as_cmap=True))
plt.title(r"Community membership $\Theta$ with ${\alpha}$=(0.05,0.015,0.035)")
plt.show()
```

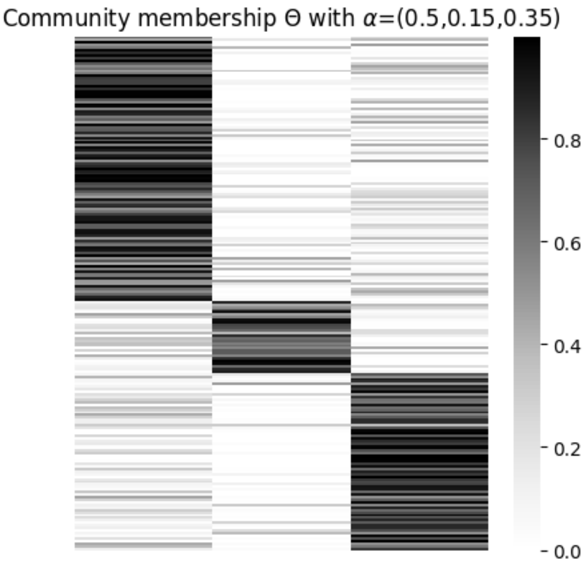


Answer

How does this Θ matrix differ from the Θ matrix created in Homework 11 Question 1 Part a? (You may refer to the key for Homework 11 in answering this question if necessary.) **Now each element is not a 100% probable to belong to a community. Now there is a probability to belong to different communities. We can notice clusters, because there is a higher probability to belong to a cluster than others. But, even though there is a high probability to belong to a community, there is some smaller probability to belong to other communities. For this reason, we notice clusters in the community matrix where in certain column the value is almost zero but with some values different of zero in such rows.**

```
def ordered_matrix(samples):
  n_0=0
  n_1=0
  n_2=0
  for i in range(samples.shape[0]):
    if samples[i,0]>samples[i,1] and samples[i,0]>samples[i,2]:
      n_0=n_0+1
    if samples[i,1]>samples[i,0] and samples[i,1]>samples[i,2]:
      n_1=n_1+1
    if samples[i,2]>samples[i,1] and samples[i,2]>samples[i,0]:
      n_2=n_2+1
  ordered=[]
  for i in range(samples.shape[0]):
```

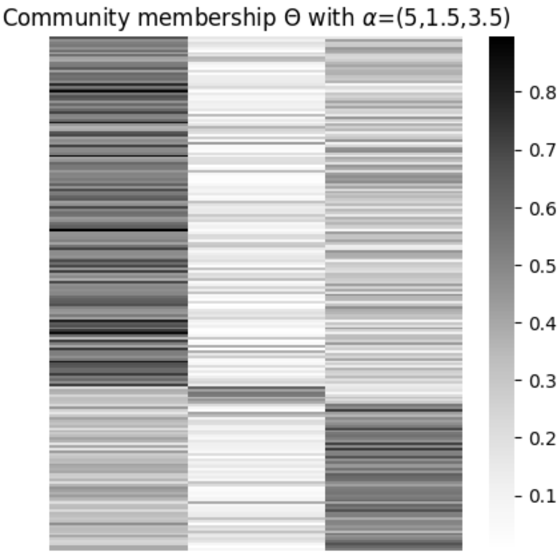
```
    if samples[i,0]>samples[i,1] and samples[i,0]>samples[i,2]:
      ordered.append(samples[i])

  for i in range(samples.shape[0]):
    if samples[i,1]>samples[i,0] and samples[i,1]>samples[i,2]:
      ordered.append(samples[i])

  for i in range(samples.shape[0]):
    if samples[i,2]>samples[i,1] and samples[i,2]>samples[i,0]:
      ordered.append(samples[i])

  n_ordered=np.array(ordered)
  return n_ordered



samples_2=np.random.dirichlet((0.5,0.15,0.35),200)
samples_3=np.random.dirichlet((5, 1.5,3.5),200)

theta_2=ordered_matrix(samples_2)
theta_3=ordered_matrix(samples_3)




plt.figure(figsize=(5,5))
heat_map = sns.heatmap( theta_2,cmap="Greys",xticklabels=False,yticklabels=False)

#heat_map = sns.heatmap( theta,cmap=sns.cubehelix_palette(as_cmap=True))
plt.title(r"Community membership $\Theta$ with ${\alpha}$=(0.5,0.15,0.35)")
plt.show()
```



Answer

How does this Θ matrix differ from the Θ matrix created in Homework 11 Question 1 Part a? (You may refer to the key for Homework 11 in answering this question if necessary.)**We can notice that many of the elements there is a high probability to belong to different clusters. We can notice communities, however some of the elements the probability to belong different clusters is almost the same as the probability of the cluster they belong to.**

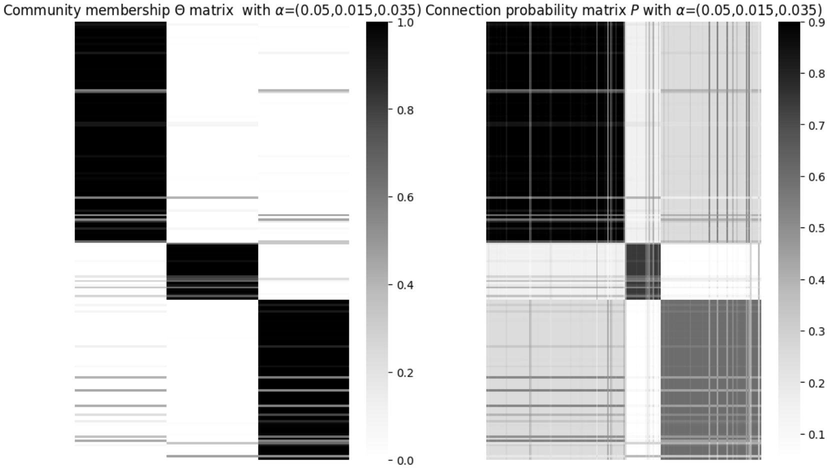
```
plt.figure(figsize=(5,5))
heat_map = sns.heatmap( theta_3,cmap="Greys",xticklabels=False,yticklabels=False)

#heat_map = sns.heatmap( theta,cmap=sns.cubehelix_palette(as_cmap=True))
plt.title(r"Community membership $\Theta$ with ${\alpha}$=(5,1.5,3.5)")
plt.show()
```



How does this Θ matrix differ from the Θ matrix created in Homework 11 Question 1 Part a? (You may refer to the key for Homework 11 in answering this question if necessary.)**We can notice that many of the elements there is a high probability to belong to different clusters. We can notice communities, however MANY of the elements the probability to belong different clusters is almost the same as the probability of the cluster they belong to.**

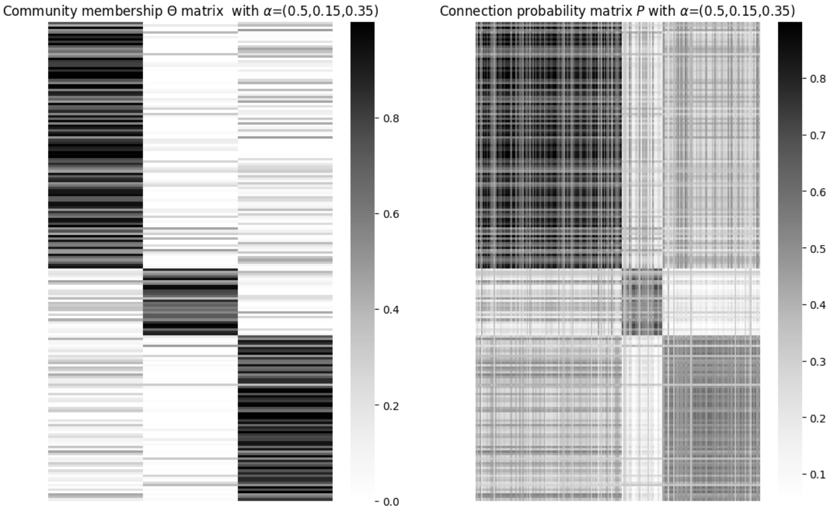
```
theta_T_2=theta_2.transpose()
P2=theta_2.dot(B).dot(theta_T_2)

theta_T_3=theta_3.transpose()
P3=theta_3.dot(B).dot(theta_T_3)
```

```python
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(12, 7))

heat_map1 = sns.heatmap(theta,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Community membership ${\Theta}$ matrix  with ${\alpha}$=(0.05,0.015,0.035)')


heat_map2 = sns.heatmap( P,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Connection probability matrix $P$ with ${\alpha}$=(0.05,0.015,0.035) ')
```



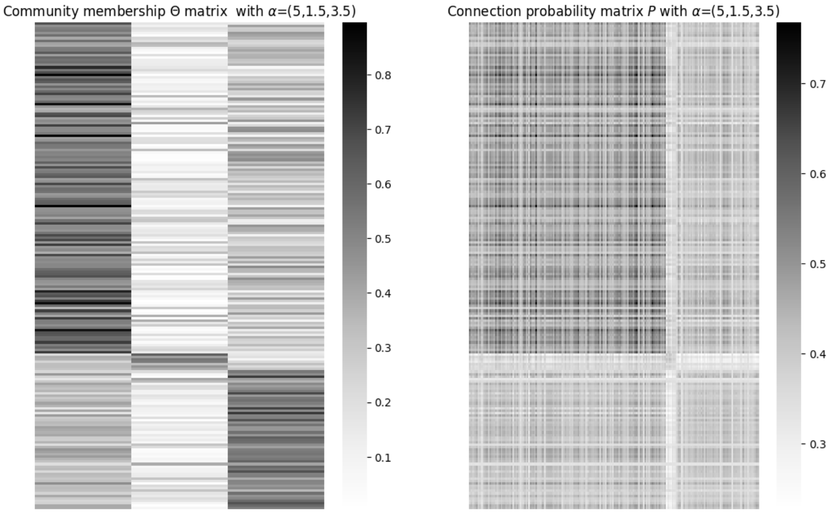
How does the matrix differ from the matrix created in Homework 11 Question 1 Part b? **The probability for each matrix element in a community is NOT longer the same. We can notice some rectangular patterns in the visualization of the probability matrix.**

```python
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(13, 8))

heat_map1 = sns.heatmap(theta_2,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Community membership ${\Theta}$ matrix  with ${\alpha}$=(0.5,0.15,0.35)')


heat_map2 = sns.heatmap( P2,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Connection probability matrix $P$ with ${\alpha}$=(0.5,0.15,0.35) ')
```



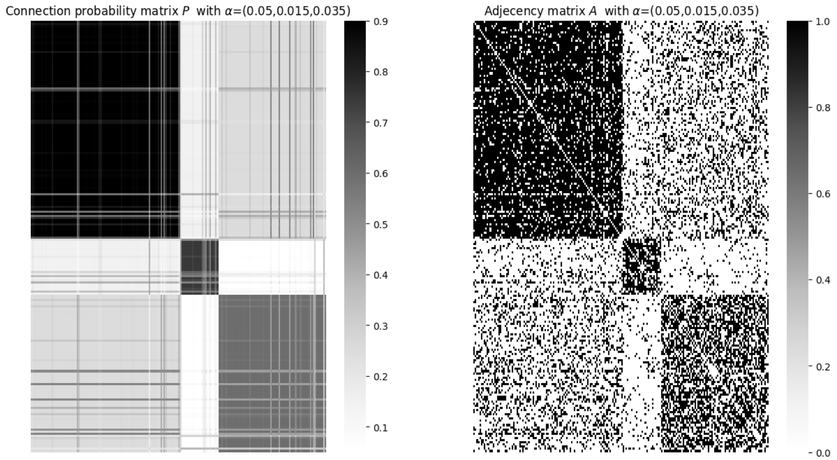
How does the matrix differ from the matrix created in Homework 11 Question 1 Part b? **The probability for each matrix element in a community is NOT longer the same. We can notice many rectangular patterns in the visualization of the probability matrix.**

```
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(13, 8))

heat_map1 = sns.heatmap(theta_3,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Community membership ${\Theta}$ matrix  with ${\alpha}$=(5,1.5,3.5)')


heat_map2 = sns.heatmap( P3,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Connection probability matrix $P$ with ${\alpha}$=(5,1.5,3.5) ')
```

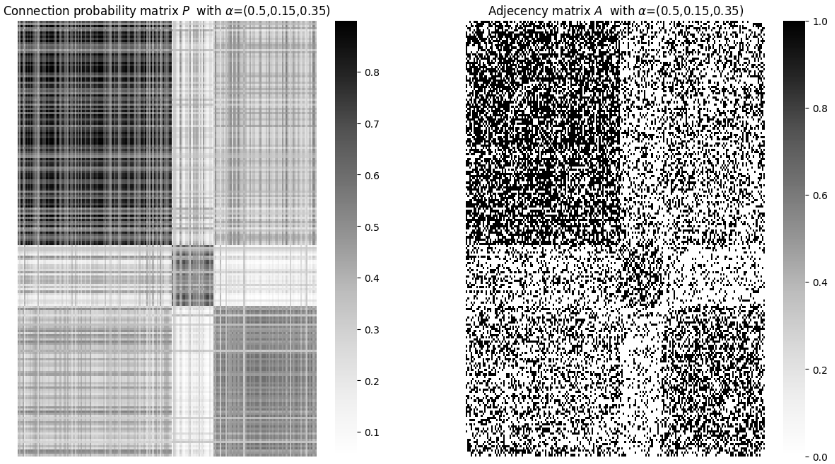


How does the matrix differ from the matrix created in Homework 11 Question 1 Part b? **The probability for each matrix element in a community is NOT longer the same. There is not clear clustering of communities with similar probabilities.**

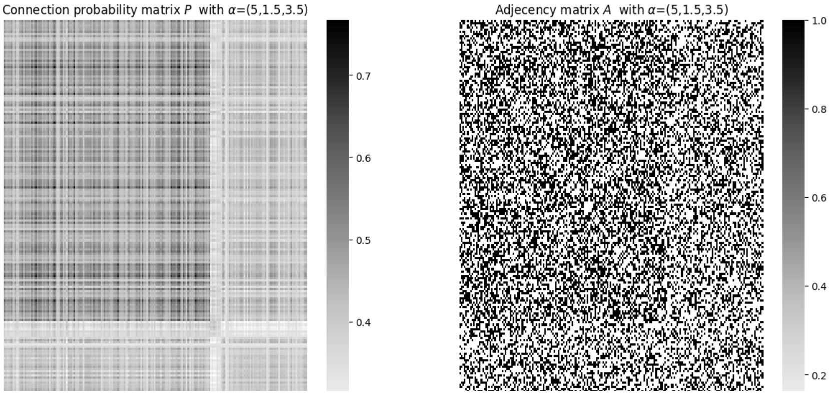
```
R=np.random.uniform(size=[P2.shape[0],P2.shape[0]])
R1=np.triu(R)+np.transpose(np.triu(R))
A=1*(R1<P2)
A2=A-np.diag(np.diag(A))


fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(15, 8))

heat_map1 = sns.heatmap(P,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Connection probability matrix $P$  with ${\alpha}$=(0.05,0.015,0.035) ')


heat_map2 = sns.heatmap( A1,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Adjecency matrix $A$  with ${\alpha}$=(0.05,0.015,0.035)')
```



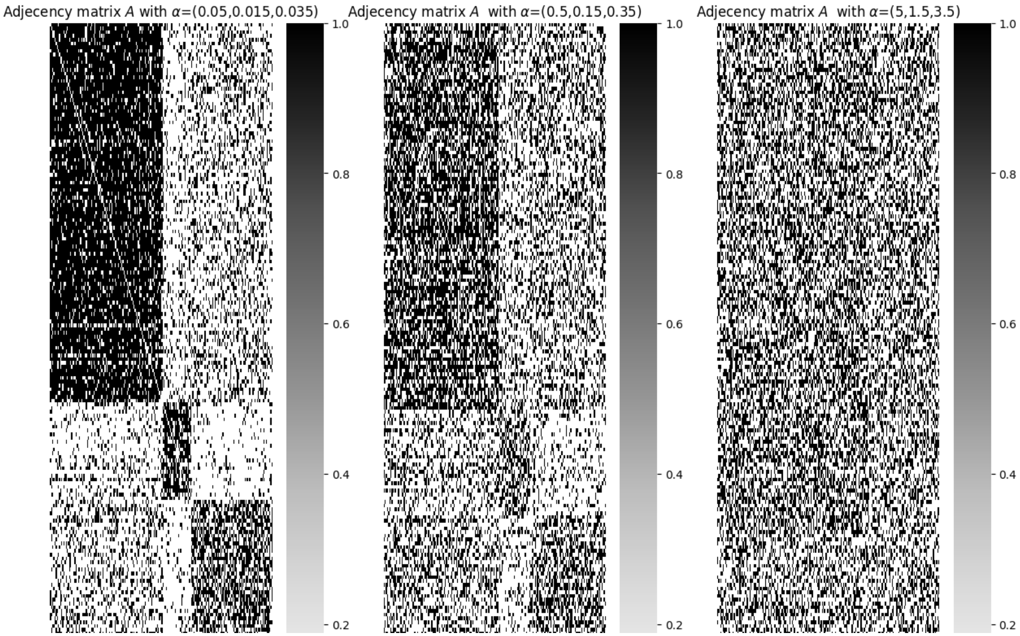

```
fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(15, 8))

heat_map1 = sns.heatmap(P2,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Connection probability matrix $P$  with ${\alpha}$=(0.5,0.15,0.35) ')


heat_map2 = sns.heatmap( A2,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Adjecency matrix $A$  with ${\alpha}$=(0.5,0.15,0.35)')
```




```
R=np.random.uniform(size=[P3.shape[0],P3.shape[0]])
R1=np.triu(R)+np.transpose(np.triu(R))
A=1*(R1<P3)
A3=A-np.diag(np.diag(A))


fig, (ax1, ax2) = plt.subplots(1, 2,figsize=(15, 8))

heat_map1 = sns.heatmap(P3,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Connection probability matrix $P$  with ${\alpha}$=(5,1.5,3.5) ')


heat_map2 = sns.heatmap( A3,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Adjecency matrix $A$  with ${\alpha}$=(5,1.5,3.5)')
```




```
fig, (ax1, ax2,ax3) = plt.subplots(1, 3,figsize=(15, 12))

heat_map1 = sns.heatmap(A1,cmap="Greys",ax=ax1,xticklabels=False,yticklabels=False)
ax1.title.set_text(r'Adjecency matrix $A$ with ${\alpha}$=(0.05,0.015,0.035) ')


heat_map2 = sns.heatmap( A2,cmap="Greys",ax=ax2,xticklabels=False,yticklabels=False)
ax2.title.set_text(r'Adjecency matrix $A$  with ${\alpha}$=(0.5,0.15,0.35)')


heat_map3 = sns.heatmap( A3,cmap="Greys",ax=ax3,xticklabels=False,yticklabels=False)
ax3.title.set_text(r'Adjecency matrix $A$  with ${\alpha}$=(5,1.5,3.5)')
```



Answer

How does the specification of the mixture parameters for affect the network generated? Discuss how the connections within and across blocks change for different specifications.**As we increase the parameter values, the clusters are more difficult to distinguish. When have made the parameters $\alpha = (5, 1.5, 3.5)$ the ajacency matrix looks like noise, there is not a clear visibility of clustering. When we have $\alpha = (0.5, 0.15, 0.35)$ we can easily notice two clusters, the middle cluster is not that easy to distinguish. And when we use, $\alpha = (0.05, 0.015, 0.035)$ we can notice three clusters.**

7s completed at 2:15 PM