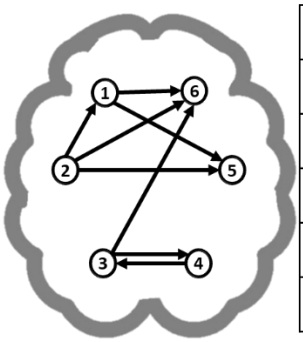
Neuroengineering 2022-2023

March 28th 2024

Part II

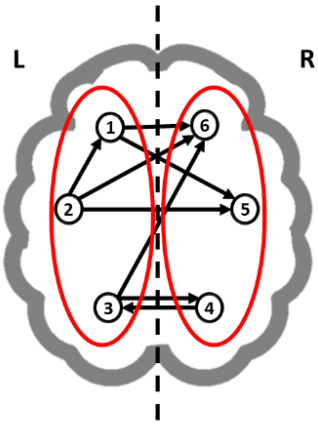
Solutions

Q1.1: Adjacency matrix:



0	0	0	0	1	1
1	0	0	0	1	1
0	0	0	1	0	1
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Q1.2:



A=

g_{OUT} \ g_{IN}	1	0	1	1	2	3	
2	0	0	0	0	1	1	1
3	1	0	0	0	1	1	1
2	0	0	0	1	0	1	1
1	0	0	1	0	0	0	2
0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	2
	1	1	1	2	2	2	

$N = 6$

$L = 8$

C=[1 1 1 2 2 2]

$$D = \frac{L}{L + \sum_{i,j=1}^{N} a_{ij}\left[1 - \delta(C_i, C_j)\right]}$$

$$D = \frac{8}{8+7} = \mathbf{0.53} \qquad D \in [0.5, 1]$$

$$Q = \frac{1}{L}\sum_{i,j=1}^{N}(a_{ij} - \frac{{g_i}^{OUT}{g_j}^{IN}}{L})\delta(C_i, C_j)$$

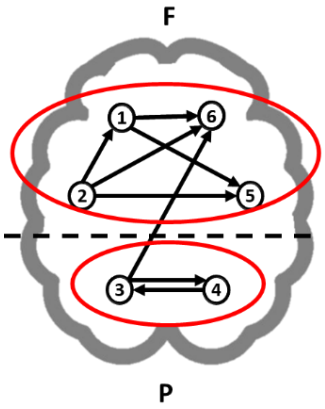
$$Q = \frac{1}{8}\left[1 - \frac{({g_1}^{OUT}+{g_2}^{OUT}+{g_3}^{OUT})({g_1}^{IN}+{g_2}^{IN}+{g_3}^{IN})}{8} + 0 - \frac{({g_4}^{OUT}{g_5}^{OUT}+{g_6}^{OUT})({g_4}^{IN}{g_5}^{IN}+{g_6}^{IN})}{8}\right] =$$

$$= \frac{1}{8}\left[1 - \frac{(2+3+2)(1+0+1)}{8} + 0 - \frac{(1+0+0)(1+2+3)}{8}\right] = \frac{1}{8}[1 - 1.75 + 0 - 0.75] = \mathbf{-0.19}$$

Existence of intra-community links

Probability of random links between the nodes

Q1.3:



A=

g_{OUT} \ g_{IN}	1	0	1	1	2	3	
2	0	0	0	0	1	1	1
3	1	0	0	0	1	1	1
2	0	0	0	1	0	1	2
1	0	0	1	0	0	0	2
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
	1	1	2	2	1	1	

$N = 6$

$L = 8$

$C=[1\ 1\ 2\ 2\ 1\ 1]$

$$D = \frac{L}{L + \sum_{i,j=1}^{N} a_{ij}\left[1 - \delta(C_i, C_j)\right]}$$

$$D = \frac{8}{8+1} = \mathbf{0.89} \qquad D \in [0.5, 1]$$

$$Q = \frac{1}{L}\sum_{i,j=1I}^{N}(a_{ij} - \frac{g_i{}^{OUT} g_j{}^{IN}}{L})\delta(C_i, C_j)$$

$$Q = \frac{1}{8}\left[5 - \frac{(g_1{}^{OUT}+g_2{}^{OUT}+g_5{}^{OUT}+g_6{}^{OUT})(g_1{}^{IN}+g_2{}^{IN}+g_5{}^{IN}+g_6{}^{IN})}{8} + 2 - \frac{(g_3{}^{OUT}g_4{}^{OUT})(g_3{}^{IN}g_4{}^{IN})}{8}\right] =$$

$$= \frac{1}{8}\left[5 - \frac{(2+3+0+0)(1+0+2+3)}{8} + 2 - \frac{(2+1)(1+1)}{8}\right] = \frac{1}{8}[5 - 3.75 + 2 - 0.75] = \mathbf{0.31}$$

Existence of intra-community links

Probability of random links between the nodes

Q2: Given the results obtained, the fronto-parietal division in classes corresponds to a more segregated and less integrated network. In fact, both divisibility and modularity are higher than in the left-right division. In particular, L-R shows a divisibility close to its minimum value (=0.5) and a negative modularity, indicating that the two classes don't act as modules, while F-P shows a divisibility close to its maximum (=1) and a positive modularity, indicating that the two classes are more internally organized than an average group of nodes randomly chosen in the network.

	Divisibility	**Modularity**	
Left-Right	0.53	-0.19	Lower segregation/higher integration
Fronto-Parietal	0.89	0.31	Higher segregation/lower integration