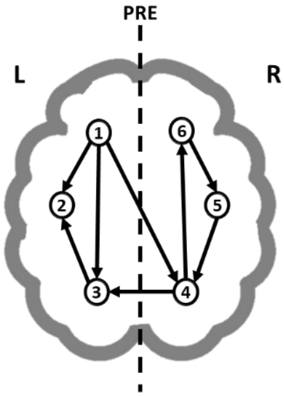
Neuroengineering 2022-2023

July 12th 2023

Part II (old modalities)

Solutions

A1.1-A1.4



g_{IN} (top row), g_{OUT} (left column), A=

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

$N = 6$

$L = 8$

C=[1 1 1 2 2 2]

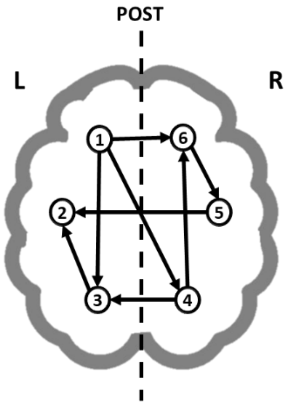
$$k = \frac{L}{N} = \frac{8}{30} = 0.27$$

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

$$D = \frac{8}{8+2} = \mathbf{0.8} \qquad D \in [0.5, 1]$$

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

$$Q = \frac{1}{8}\left[3 - \frac{(g_1{}^{OUT}+g_2{}^{OUT}+g_3{}^{OUT})(g_1{}^{IN}+g_2{}^{IN}+g_3{}^{IN})}{8} + 3 - \frac{(g_4{}^{OUT}g_5{}^{OUT}+g_6{}^{OUT})(g_4{}^{IN}g_5{}^{IN}+g_6{}^{IN})}{8}\right] =$$
$$= \frac{1}{8}\left[3 - \frac{(3+0+1)(0+2+2)}{8} + 3 - \frac{(2+1+1)(2+1+1)}{8}\right] = \frac{1}{8}[3-2+3-2] = \mathbf{0.25}$$



g_{IN} (top row), g_{OUT} (left column), A=

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

$N = 6$

$L = 8$

C=[1 1 1 2 2 2]

$$k = \frac{L}{N} = \frac{8}{30} = 0.27$$

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

$$D = \frac{8}{8+4} = \mathbf{0.67} \qquad D \in [0.5, 1]$$

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

$$Q = \frac{1}{8}\left[2 - \frac{(g_1{}^{OUT}+g_2{}^{OUT}+g_3{}^{OUT})(g_1{}^{IN}+g_2{}^{IN}+g_3{}^{IN})}{8} + 2 - \frac{(g_4{}^{OUT}g_5{}^{OUT}+g_6{}^{OUT})(g_4{}^{IN}g_5{}^{IN}+g_6{}^{IN})}{8}\right] =$$
$$= \frac{1}{8}\left[2 - \frac{(3+0+1)(0+2+2)}{8} + 2 - \frac{(2+1+1)(1+1+2)}{8}\right] = \frac{1}{8}[2-2+2-2] = \mathbf{0}$$

A2. *Both Divisibility and Modularity computed considering the left and the right hemisphere as classes are decreased after the rehabilitative intervention. Since they are both measures of segregation, this means that the two hemispheres are less segregated (and therefore more integrated) as a result of the rehabilitation. As it is stated in the text that the integration between the hemispheres is a target of the intervention, we can conclude that the rehabilitation was successful.*

	Divisibility	**Modularity**	
PRE	0.8	0.25	Higher segregation/lower integration
POST	0.67	0	Lower segregation/higher integration

A3. *The text specifies that the regions to be included in the analysis are cortical ones. This, together with the fact that the subjects enrolled must not undergo surgery (as it is usually the case for post-stroke patients), suggests that scalp EEG is the best option for the recordings.*

<u>Pros:</u> scalp EEG is non-invasive, inexpensive, easy to use, and portable, it has the same (excellent) temporal resolution as invasive methods, and allows face-to-face interaction between the subjects.

<u>Cons:</u> spatial blur (attenuation and spread of the potential with distance), low signal-to-noise ratio, multiple sources contribute to the single electrode signal and, conversely, near electrodes record partially overlapped (correlated) signals. However, all these limitations are stronger for deeper regions, while here we are only interested in cortical ones.

A4. *The text indicates that we are interested in an analysis of causality in the statistical sense. This restricts the choice to the Granger Test or the Partial Directed Coherence (in fact, the other estimator, the Ordinary Coherence, is not a measure of causality). Since it is specified that, to avoid fatigue in the patients, the duration of the recording is kept short, we can infer that the amount of data available is not sufficient to compute PDC, which requires long data segments or many trials due to the number of parameters to be estimated for the multivariate model. Therefore, the Granger Test is the best option.*

<u>Pros</u>: it is a measure of causality, and it doesn't require long recordings.

<u>Cons</u>: it is bivariate (problem of the hidden source, that can result in a reduced accuracy), it is not a spectral measure.