Vulnerability of the structural connectome to stroke in older adults

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Background

• Lesions in particular locations have disproportionate effects on brain function

• Strategic infarctions – lesions of critical points in functional networks for movement and cognition

• Strategic lesions might disrupt global properties of the brain’s connectome
The brain as a network

Graph theory tools allow us to investigate complex properties of brain networks (Rubinov & Sporns, 2010)

Connectome – the wiring diagram of the brain
The brain as a network

Network elements:
- Nodes
- Edges

Two groups of network measures:
- Measures of network integration
- Measures of network segregation
  (Rubinov & Sporns, 2010)
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Aim

• To examine the effect of simulated lesions on the global properties of the structural connectome

• Effect of lesions in two sets of locations:

Rich-club nodes  Subcortical nodes
Methods

- 39 healthy older adults, aged 53-93 yrs.
- Exclusion criteria: moderate/severe head injury; history of alcohol or drug abuse; previous stroke; known peripheral, cervical or coronary artery disease; heart failure; report of previous memory symptoms; contraindications to MRI

- Diffusion-weighted MRI: 3T GE HDx system, twice refocused spin-echo EPI sequence, 2.4 mm isotropic voxels, TE = 87 ms, $b = 1,200 \text{ s/mm}^2$, 30 isotropically distributed directions, 3 non-diffusion-weighted scans

- Whole-brain tractography: deterministic tracking algorithm, step size 1.0 mm, FA threshold 0.15, angle threshold 45°
Methods

- Construction of the connectome
Methods

• Lesion simulation: removing a node and its connections from the graph
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• Lesion simulation: removing a node and its connections from the graph

• Proportional change in global efficiency

• Comparison between sets of nodes and correlation with age
Results

Lesions of rich-club nodes lead to larger reductions in global efficiency than lesions outside the rich club ($t=21.0$, $p < .001$).

Lesions of both precunei produce the largest effect.
Results

Lesions of both thalami produce the largest effect of the subcortical nodes examined.

Their effect is smaller than for cortical hubs (2.7% vs 6.2% for precunei).
Results

Positive correlation with age:

- right thalamus ($r = .463, p = .003$)
- left thalamus ($r = .337, p = .036$)
- right temporal superior pole ($r = .363, p = .023$)
Discussion

- Structural connectome of healthy individuals over 50 is vulnerable to strategic lesions of rich-club nodes.
- Some vulnerable sites are rarely affected by stroke in practice.
- Thalamic lesions have a large global impact that increases with age. This is likely a factor in the influence of age on stroke outcome.
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