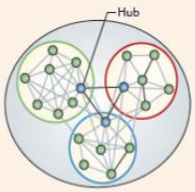
Human Brain Networks and the Effects of Psychedelics
Beckley / Imperial Research Programme

What are brain networks?

- **Neural networks** are different regions of the brain that work together to perform a particular function, (e.g. hearing, seeing, paying attention, daydreaming, etc.).
  - Typically, no function corresponds to a singular brain region. Instead, to perform a given function, several regions form networks and work together.
  - Networks normally are distinct – like colours – so it is possible to define them – like green or red (although they do of course overlap to some degree).
- Within the brain's networks, certain key regions act as '**hubs.**' They form multiple connections with other brain areas and have a strong influence on overall network organisation.



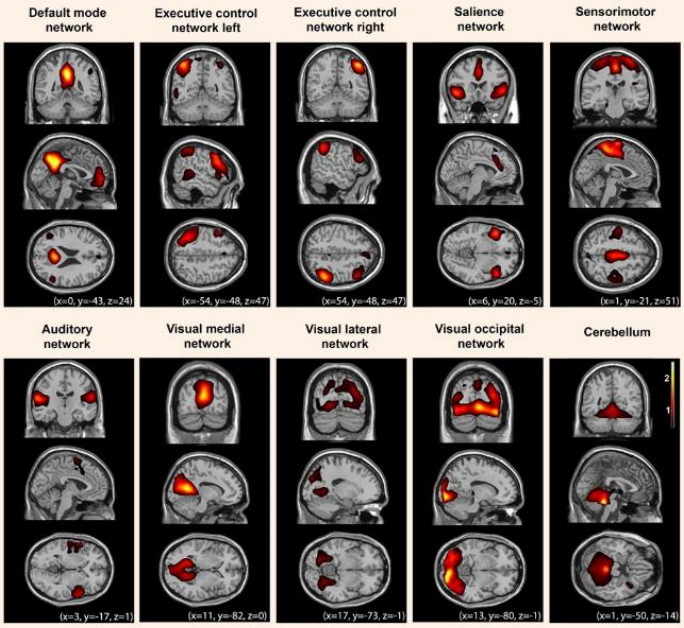
How is brain connectivity measured?

- Brain imaging can help visualise the interconnections among and between networks, mapping the structural and functional connectivity of the human brain.
  - **Structural connectivity** refers to direct anatomical links between brain regions (white matter pathways of axons and dendrites).
  - **Functional connectivity** refers to synchronised activity – the degree to which different brain regions 'work together.' Regions that 'fire' together are assumed to be functionally connected and consequently to work together.
- One way to measure brain connectivity is to look at activity within and between **pre-defined functional networks** (established by examining hundreds of healthy brains as part of the Human Connectome Project (www.humanconnectomeproject.org).

What brain networks are there?

- **Task-specific networks** are activated when we perform specific functions - these depend on the task.
- **Resting-state networks** are those that are active when we are at rest, that is, while *not* engaging in any specific task (the brain never actually rests).
- The key networks include:
  - The Default Mode Network (DMN) (introspection, mental time travel, sense of self)
  - The Salience Network (noticing things, or finding them important enough to attend to them, switching between task and rest)
  - The Executive Control Network (attention and high-level cognitive function)
  - The Sensorimotor Network (sensation and movement)
  - The Auditory Network (hearing)
  - Up to three different visual networks (seeing)

Where in the brain are the key networks?

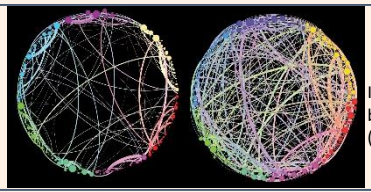


From Heine et al. (2012)

What do psychedelics do to neural networks?

NETWORK 'DESEGREGATION' = Increased connectivity *between* brain networks.

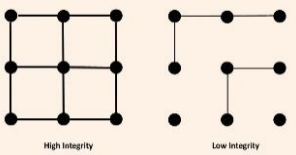
Normally distinct brain networks become **more connected to one another** – that is, they lose their 'separateness,' allowing for wider and more integrated communication.



Increased communication between networks after psilocybin (from Petri et al, 2014).

NETWORK 'DISINTEGRATION' = Loss of integrity/stability *within* brain networks.

Under the effect of psychedelics, the functional connections among regions that make up certain networks diminish. The activity of these networks becomes less synchronised and more erratic.



- Nodes or regions
- Connectivity

Why is this important?

- Connectivity between brain areas that are not *usually* connected can facilitate the formation of new concepts and ideas, leading to increased 'cognitive flexibility' and a more fluid style of thinking.
- When loss of integrity occurs within networks that normally exert control over other regions, this facilitates the amplification of normally supressed activity.
- Evidence suggests that certain mental illnesses, e.g. depression, stem from the over-activity of the DMN and entrenched patterns of thinking and behaviour. In engendering the desegregation and disintegration of networks, especially the DMN, psychedelics can help to disrupt these patterns and establish new ones.

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