Professor Kate Jeffrey (University College London) – Conference Thought Provoker: How the brain makes maps

Abstract

Memory and navigation are 'bound together by nature'. Our spatial behaviour can, among other things, be influenced by where objects are placed in reference to the body; it can operate on autopilot in an environment that is well known to the individual, or can activate an internal representation of space based on experience. Research with rats suggests that certain nerve cells are activated when rats move to particular locations in the environment and other cells were activated at other locations. More so, it has been shown that other parts of the brain help rats navigate across featureless terrain.

If utilised for infrastructure, cognitive neuroscience can help make space, such as cities, more navigable.

- The brain controls spatial navigation in mammals by activating functionally specialized cell types
- **Key components of the spatial mapping system are place cells, grid cells and head direction cells**

- The brain moves to autopilot if a place is known well to the individual
- When the known environment changes, the Hippocampus activates an internal representation of space to navigate the environment
    - The Hippocampus is responsible for memory and navigation, therefore both are 'bound together by nature'

- **Place cells** are active only when the animal is entering a specific location in the environment
- Place cells produce single activity hotspots in the environment and seem to function to encode specific places

- **Head direction cells** increase their firing rate whenever a rat faces within a range of heading directions, irrespective of its location within the environment
- Experiments with rats have shown that there are cells for all different locations – like a compass in the brain

- **Grid cells** become active periodically and at very regular distances as animals walk around, forming a grid-like structure of activity hot-spots

- Grid cells represent where an animal is located within its environment - they fire in patterns that show up as geometrically regular, triangular grids when plotted on a map of a navigated surface
- The grid cell network is organized as grid cells clustered in distinct and independent grid maps with distinct scales, orientations and asymmetries
- Grid cells are co-localized with head direction cells and border cells, which contain information about the direction in which the animal is moving and the boundaries of the environment

- Research has shown that navigational demands stimulate brain development
- London taxi drivers not only have larger-than-average memory centres in their brains, but also that their intensive training is responsible for the growth
- In addition, London taxi drivers had more gray matter in their posterior hippocampi than people who were similar in age, education and intelligence, but who did not drive taxis