

Active and Inactive Cells in the Brain's Memory System

Tübingen neuroscientists are the first to find evidence of differing morphology in neurons

For the first time, Tübingen neuroscientists were able to differentiate between active and inactive cells in the brain morphologically, i.e. based on the cells' structure. Investigating granule cells in the rat's brain, they found a much larger proportion of inactive than active cells.

Many things we think we know about the world have their origin in popular culture, not science. The most well-known false 'fact' about the brain is the misconception that we only use ten percent of the brain's overall capacity. This so-called 'ten percent myth', while accepted as such by neuroscientists, still regularly figures in advertisement, but also in books and short stories as well as films. As with any myth, however, there is a kernel of truth at the core of the matter: many neurons remain dormant for most if not all of our life, even while their direct neighbours show regular activity.

A team of neuroscientists led by Dr. Andrea Burgalossi of the Werner Reichardt Centre for Integrative Neuroscience (CIN) at the University of Tübingen have now taken an important step towards understanding why some neurons are active and others are not: they can tell them apart morphologically. To be able to do so, the investigators employed so-called juxtacellular recordings in freely-moving rats. With this technique, electrodes are inserted right next to individual, functioning neurons in live organisms. This allows recording action potentials from these neurons while they work, and while simultaneously identifying the cells that the recordings are taken from for later analysis.

During this analysis, morphological traits of the analysed cells are identified, most importantly their dendritic arbors, i.e. the filament structures which receive input signals from other neurons. The cells under investigation were granule cells (GCs) in the rat's dentate gyrus (DG). Dentate GCs have been shown to be intimately connected to individual memories of places and individuals, and thus playing a central role in memory tasks.

The researchers recorded from 190 GCs, only 27 of which they found to be active (ca. 14 percent). While this seems to give credibility to the 'ten percent myth', the team actually expected this outcome, as the DG is a brain structure where in any given task, only a very small percentage of neurons take part, while their neighbours remain dormant, waiting for their 'cue', as it were. Memory functions in the brain work according to a principle that neuroscientists call 'sparse coding', i.e. a comparatively small number of neurons encode complex information – possibly to make overlap between different memories more unlikely.

Using a smaller subsample, the scientists looked for correlations between active and passive functionality and the respective cells' morphology. Their results show that active GCs have much more complex dendritic arbors. They not only transfer and receive information from many more neurons than the inactive ones, they also have better cellular 'infrastructure' to do so. Despite their as of yet limited sampling, the scientists are positive that they can now tell apart active and inactive GCs, mostly by merely looking at them. "Explaining the causes of activity in some and inactivity in other neurons may still take a long time", cautions Burgalossi, leader of the research group. "But finding a direct link between function and morphology is an important step forward. It will be even more challenging to find evidence of causality. But we are on the right track."

Publication:

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