Mouse study shows how fault tolerance works in the brain

April 14 2016, by Bob Yirka

Credit: martha sexton/public domain

(Medical Xpress)—A team of researchers working at Howard Hughes Medical Institute has found a form of fault-tolerance in the brains of mice. In their paper published in the journal *Nature*, the team describes their experiments with mice, what they found and its implications for further understanding how the brain works. Byron Yu, with Carnegie Mellon University has published a *News & Views* paper on the work done by the team in the same journal issue, explaining how the study was done.

To help ensure the integrity of data in computer systems, engineers have developed many different fault-tolerance strategies, from error correction routines that cause data packets to be resent if trouble is found, to redundant hard drives or processor mirroring systems—all are meant to ensure that data is held or used in the intended manner. Now it appears the same is true for the mouse brain. In this new effort, the researchers have found a form of mirroring between brain hemispheres, where data is swapped from one to the other if information is lost.

Imagine you just learned how to bounce a basketball, but are suddenly hit in the head by a player—you might forget how to bounce the ball for a second or two, but then it comes back to you and you go on playing. That is what the researchers investigated—they taught mice how to move their tongues in a certain way to get a treat, then caused the part of their brain in just one hemisphere that was responsible for holding onto that ability, to suddenly lose it. The mouse forgot, but just for a moment—after just a few seconds it remembered again. This occurred, the researchers found, because memory data for the licking trick was stored in both hemispheres—when it was lost in one hemisphere, data was restored to it automatically from the other.

The team discovered this fault-tolerance in the brain by genetically engineering mice to have brain cells in the premotor cortex regions (the part involved in conducting the tongue trick) respond to a blue light. This allowed the researchers the ability to turn that region on and off at will. Turning off the area prevented neural activity, disabling an ability—when the areas was allowed to function again, the researchers could see the data being swapped to it from the other hemisphere. To test their theory, they disconnected the two hemispheres, preventing the exchange of data and found that it prevented the fault-tolerance from occurring. Similarly, erasing data in both hemispheres prevented the return of the ability to do the tongue trick permanently as there was no back-up data left to access.

More information: Nuo Li et al. Robust neuronal dynamics in premotor cortex during motor planning, *Nature* (2016). DOI: 10.1038/nature17643

Abstract

Neural activity maintains representations that bridge past and future events, often over many seconds. Network models can produce persistent and ramping activity, but the positive feedback that is critical for these slow dynamics can cause sensitivity to perturbations. Here we use electrophysiology and optogenetic perturbations in the mouse premotor cortex to probe the robustness of persistent neural representations during motor planning. We show that preparatory activity is remarkably robust to large-scale unilateral silencing: detailed neural dynamics that drive specific future movements were quickly and selectively restored by the network. Selectivity did not recover after bilateral silencing of the premotor cortex. Perturbations to one hemisphere are thus corrected by information from the other hemisphere. Corpus callosum bisections demonstrated that premotor cortex hemispheres can maintain preparatory activity independently. Redundancy across selectively coupled modules, as we observed in the premotor cortex, is a hallmark of robust control systems. Network models incorporating these principles show robustness that is consistent with data.