A varied life boosts the brain's functional networks, shows mouse study

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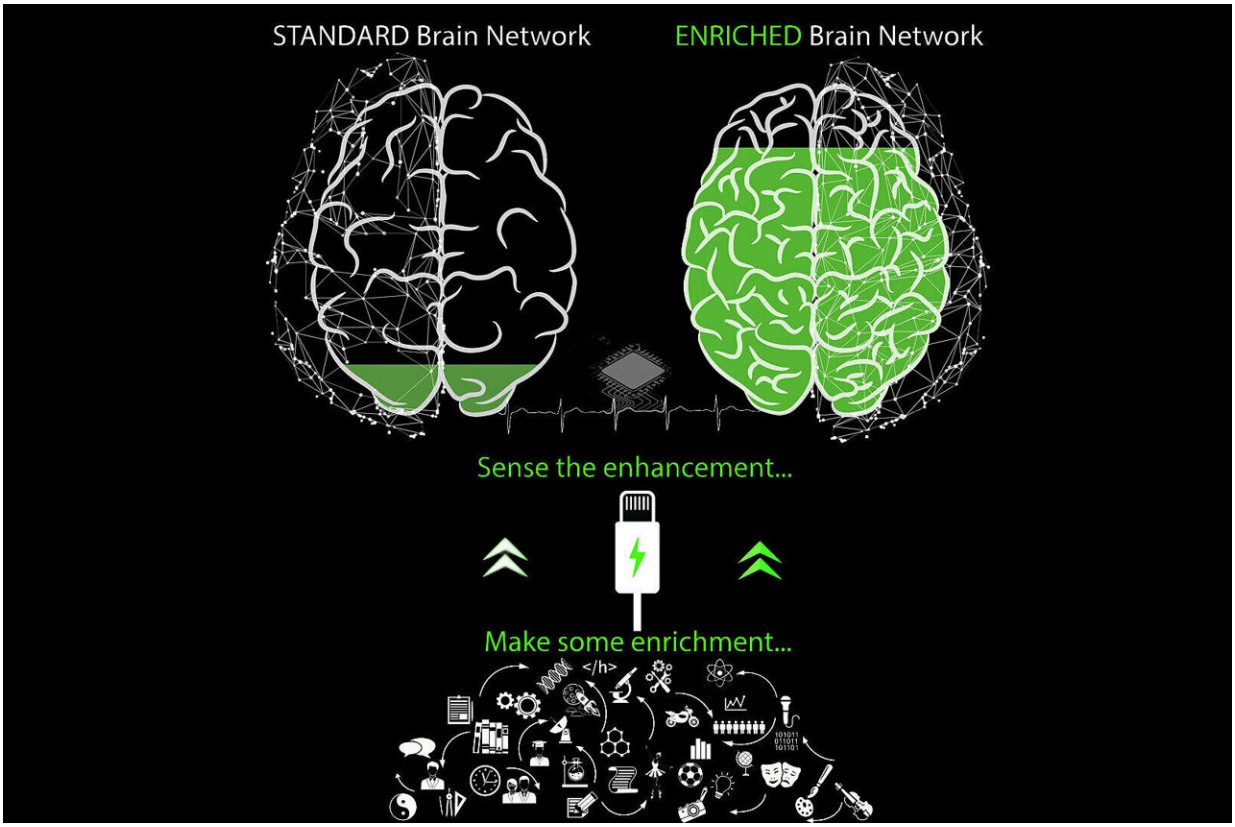

Researchers in Dresden, Germany, have presented evidence that a varied and active lifestyle positively shapes the brain by enhancing neural connections. Credit: DZNE / Amin Lab (BIONICS)

The fact that experiences leave their trace in the connectivity of the

brain has been known for a while, but a pioneering study by researchers at the German Center for Neurodegenerative Diseases (DZNE) and TUD Dresden University of Technology now shows how huge these effects really are.

The findings, in mice, provide unprecedented insights into the complexity of large-scale neural networks and brain plasticity. Moreover, they could pave the way for new brain-inspired artificial intelligence methods. The results, based on an innovative "brain-on-chip" technology, are published in the journal *Biosensors and Bioelectronics*.

The Dresden researchers explored the question of how an enriched experience affects the brain's circuitry.

For this, they deployed a so-called neurochip with more than 4,000 electrodes to detect the electrical activity of brain cells. This innovative platform enabled registering the "firing" of thousands of neurons simultaneously.

The area examined—much smaller than the size of a human fingernail—covered an entire mouse hippocampus. This brain structure, shared by humans, plays a pivotal role in learning and memory, making it a prime target for the ravages of dementias like Alzheimer's disease.

For their study, the scientists compared brain tissue from mice that were raised differently to each other. While one group of rodents were raised in standard cages, which did not offer any special stimuli, the others were housed in an "enriched environment" that included rearrangeable toys and maze-like plastic tubes.

"The results by far exceeded our expectations," said Dr. Hayder Amin, lead scientist of the study. The team developed the technology and analysis tools used in this study. "Simplified, one can say that the

neurons of mice from the enriched environment were much more interconnected than those raised in standard housing. No matter which parameter we looked at, a richer experience literally boosted connections in the neuronal networks. These findings suggest that leading an active and varied life shapes the brain on whole new grounds."

Unprecedented insight into brain networks

Prof. Gerd Kempermann, who co-leads the study and has been working on the question of how physical and cognitive activity helps the brain to form resilience towards aging and neurodegenerative disease, says, "All we knew in this area so far has either been taken from studies with single electrodes or imaging techniques like magnetic resonance imaging. The spatial and temporal resolution of these techniques is much coarser than our approach. Here we can literally see the circuitry at work down to the scale of single cells. We applied advanced computational tools to extract a huge amount of details about network dynamics in space and time from our recordings."

"We have uncovered a wealth of data that illustrates the benefits of a brain shaped by rich experience. This paves the way to understand the role of plasticity and reserve formation in combating neurodegenerative diseases, especially with respect to novel preventive strategies," Prof. Kempermann said, who, in addition to being a DZNE researcher, is also affiliated with the Center for Regenerative Therapies Dresden (CRTD) at TU Dresden. "Also, this will help provide insights into disease processes associated with neurodegeneration, such as dysfunctions of brain networks."

"By unraveling how experiences shape the brain's connectome and dynamics, we are not only pushing the boundaries of brain research," states Dr. Amin. "Artificial intelligence is inspired by how the brain computes information. Thus, our tools and the insights they allow to

generate could open the way for novel machine learning algorithms."

More information: Brett Addison Emery et al, High-resolution CMOS-based biosensor for assessing hippocampal circuit dynamics in experience-dependent plasticity, *Biosensors and Bioelectronics* (2023). DOI: 10.1016/j.bios.2023.115471

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