Medical Xpress

Complex environments push 'brain' evolution

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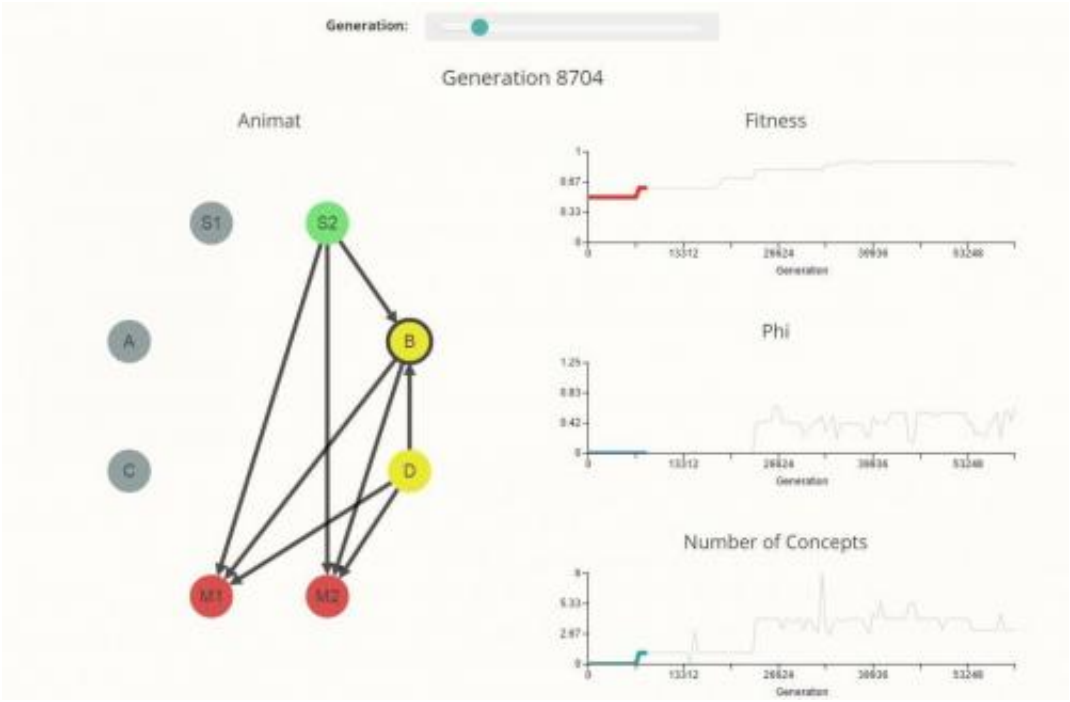

Little animations trying to master a computer game are teaching neuroscience researchers how the brain evolves when faced with difficult tasks.

Neuroscientists at the University of Wisconsin-Madison and Michigan State University have programmed animated critters that they call "animats." The critters have a rudimentary neural system made of eight nodes: two sensors, two motors, and four internal computers that

coordinate sensation, movement and memory.

The researchers watched as the critters played a video game in which they tried to "catch" falling blocks, learning to detect where they would land. Then the scientists selected the best players of each generation and allowed them to replicate. The computer code that makes up the animats' "DNA" codes for the wiring between the parts of the "brain" and also allows for random mutations, some of which made the animats better block-catchers.

While some animats played simpler versions of the game, which resembles the old video game "Tetris," other animats played more and more complex versions over and over. At the end of 60,000 generations, they all had evolved more complex wiring in their neural networks, but the animats that did well in more complex versions of the game had developed particularly intricate neural networks.

"This shows that by adapting to a more complex environment, the organism itself becomes more complex," says UW-Madison researcher Larissa Albantakis, the study's lead author. More complexity in the environment requires the animats to develop more neural functions. But because the size of their brains was limited to the eight nodes, the animats adapted to complexity by creating more integration between the nodes. Neuroscientists have proposed this as a strategy for brain evolution.

"In principle, integration in the brain is not necessary if the brain could just keep growing indefinitely, but in reality, there is an energetic cost to big brains. Integrated neural networks are just more economic, because they can implement the same number of functions with fewer nodes," Albantakis explains.

Co-authors Chris Adami and Arend Hintze, of Michigan State

University, have evolved animats with larger brains that can master mazes and recognize hand-written numbers.

But Albantakis says her study was more interested in the question of how the brain evolved to environments of different complexity and whether that evolution looks like what is predicted by Integrated Information Theory (IIT). The animats were a simplified system for studying integration in the brain, albeit one that strains the ability of computers, given the need to analyze 60,000 generations of neural connections.

Albantakis is a postdoctoral researcher in the laboratory of the study's senior author, Giulio Tononi, professor of psychiatry in the UW School of Medicine and Public Health. Tononi has proposed IIT as a comprehensive theory of consciousness. According to the theory, consciousness reflects a system's capacity for information integration (quantified by a measure of complexity called PHI). The theory accounts for many experimental facts about consciousness and the brain, has led to testable predictions, and permits inferences and extrapolations.

The current study looks at how such systems with high PHI evolve. It found that over thousands of generations, the animats learn a larger number of concepts about the game and they integrate more of the information, but that their learning and integration depend on being presented with a more complex environment—for example, a more difficult level of the game.

"This shows that a rich environment is a driving force towards developing both complexity and integration," Albantakis says.

Animations can be viewed in detail at
integratedinformationtheory.org/animats.html

More information: The study was published in the online journal

PLOS Computational Biology: journals.plos.org/ploscompbiol … journal.pcbi.1003966