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Digital critters shed light on sleep, and language, evolution; Artificial organisms that learn to "sleep" when energy is scarce are helping to show why sleep evolved and could make gadgets more energy efficient

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DIGITAL "organisms" that learn to sleep when energy is scarce and harvest it when it's abundant could help explain why sleep evolved in animals. The lifelike programs might also make gadgets more energy efficient.

To simulate early life forms, Benjamin Beckman and colleagues at Michigan State University in East Lansing created 3600 self-replicating digital organisms each with its own refillable energy store and a "genome" made of computer code to govern when the organism replenishes its store.

Every time one of the organisms replicates, a portion of its energy store gets used up. To keep stores topped up, the organism executes a simple logic operation that uses up some energy, but results in it getting more back.

At the start of the experiment, the digital critters were given a constant supply of energy, so that every time they executed the logic operation they got more energy back. Then, after 10,000 generations, energy was shut off periodically. During these times, executing the logic operation depleted the organism's energy store rather than replenishing it. This effectively created "days", when attempts to harvest energy were fruitful, and "nights", when attempts were not. A 0.75 per cent chance of a mutation during every replication allowed the organisms to evolve new behaviours, so Beckman could observe how they adapted to the new situation.

After multiple generations, some kept attempting to harvest energy through the night, but then quickly ran out of it, limiting their ability to replicate. Others stopped harvesting during the night, as if they were sleeping. These more effective replicators eventually supplanted their sleepless cousins.

It's a simplistic simulation of how real organisms may have evolved, Beckman admits, but he believes that the work strengthens the suspicion that animals evolved sleep to cope with limited access to food. Sleep specialist Patrick McNamara of Boston University agrees, but describes access to resources as the "icing on the cake" of sleep evolution. As sleep also allows the body to perform crucial maintenance on brain circuitry and tissue, those factors would also have influenced its evolution.

The digital organisms evolved another property of sleep too. Beckman found that they learned to start the logic operation shortly before energy became available, as if they were anticipating morning - analogous to animals rising just

before sunrise. "We have evidence suggesting that the adage 'early to bed, early to rise' describes an evolved behaviour," he writes in a paper presented at the European Conference on Artificial Life in Lisbon, Portugal, earlier this month.

Together with colleague Philip McKinley, Beckman is adapting the organisms to enable them to regulate energy consumption in wireless sensor networks. "Energy efficiency is probably the driving issue in this field," McKinley says. The tiny computer nodes that make up these networks rely on either solar power or batteries for power, but drain their supply by being active at night or when their batteries are low. Adaptive sleep patterns would allow them to adjust consumption to match supply.

...And how Language developed

Michael Reilly

As well as the origins of sleep, digital organisms are providing clues about how language might have evolved.

It is thought early humans communicated in the way that primates do today, using holistic or "proto-languages" in which single sounds convey ideas such as "a snake is about to bite you". This is an inefficient way of communicating, though, as a separate word is needed for each idea.

"Compositional" languages, which have separate words for, say, snake and bite, are more efficient as they require fewer words overall. Paul Vogt of Tilburg University in the Netherlands argues that as human groups grew, proto-languages became too time-consuming to be taught to all members of a group, leading compositional ones to evolve.

Vogt built a computer simulation in which organisms capable of random utterances played games with nine shapes and nine colours. At first the organisms used one utterance to convey "red square" and another for "blue square", but as Vogt increased the population from 10 to 300, utterances took on more specific meanings, with one to communicate red and another for square. Only 18 words are needed to label the colours and shapes like this, whereas 81 are needed if each shape-colour pair has its own word. Vogt says this supports the idea that early humans started to develop compositional language as population size grew.

The finding also supports the idea that compositional language developed through social interaction rather than as a result of a biological mechanism. Marco Mirolli, a specialist in artificial life and language at the Italian National Research Council (CNR) in Rome has found similar results in his work.

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