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PRESS RELEASE

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An algorithm reveals how our brain is motivated

By crossing AI and neuroscience, a team from UNIGE, Harvard and McGill has revealed the computational potential of a brain area at the heart of motivation.

A small region of the brain, known as the ventral tegmental area (VTA), plays a key role in how we process rewards. It produces dopamine, a neuromodulator that helps predict future rewards based on contextual cues. A team from the universities of Geneva (UNIGE), Harvard, and McGill has shown that the VTA goes even further: it encodes not only the anticipated reward but also the precise moment it is expected. This discovery, made possible by a machine learning algorithm, highlights the value of combining artificial intelligence with neuroscience. The study is published in the journal *Nature*.

The ventral tegmental area (VTA) plays a key role in motivation and the brain's reward circuit. As the main source of dopamine, this small cluster of neurons sends this neuromodulator to other brain regions to trigger an action in response to a positive stimulus.

“Initially, the VTA was thought to be merely the brain's reward centre. But in the 1990s, scientists discovered that it doesn't encode reward itself, but rather the prediction of reward,” explains Alexandre Pouget, full professor in the Department of Basic Neurosciences in the UNIGE Faculty of Medicine.

Experiments on animals have shown that when a reward consistently follows a light signal, for example, the VTA eventually releases dopamine not at the moment of the reward, but as soon as the signal appears. This response therefore encodes the prediction of the reward—linked to the signal—rather than the reward itself.

A much more sophisticated function

This “reinforcement learning”, which requires minimal supervision, is central to human learning. It's also the principle behind many artificial intelligence algorithms that improve performance through training—such as AlphaGo, the first algorithm to defeat a world champion in the game of Go.

In a recent study, Alexandre Pouget's team, in collaboration with Naoshige Uchida of Harvard University and Paul Masset of McGill University, shows that the VTA's coding is even more sophisticated than previously thought. “Rather than predicting a weighted sum of future rewards, the VTA predicts their temporal evolution. In other words, each gain is represented separately, with the precise moment at which it is expected,” explains the UNIGE researcher, who led this work.

High resolution pictures

“While we knew that VTA neurons prioritised rewards close in time over the ones further in the future- on the principle that a bird in the hand is worth two in the bush -we discovered that different neurons do so on different time scales, with some focusing on the reward possible in a few seconds’ time, others on the reward expected in a minute’s time, and others on more distant horizons. This diversity is what allows the encoding of reward timing. This much finer representation gives the learning system great flexibility, allowing it to adapt to maximise immediate or delayed rewards, depending on the individual’s goals and priorities.”

AI and neuroscience: a two-way street

These findings stem from a fruitful dialogue between neuroscience and artificial intelligence. Alexandre Pouget developed a purely mathematical algorithm that incorporates the timing of reward processing. Meanwhile, the Harvard researchers gathered extensive neurophysiological data on VTA activity in animals experiencing rewards.

“They then applied our algorithm to their data and found that the results matched perfectly with their empirical findings.” While the brain inspires AI and machine learning techniques, these results demonstrate that algorithms can also serve as powerful tools to reveal our neurophysiological mechanisms.

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