Medical press

New method proves long-held theory about dopamine modulation during decision-making processes

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Mathematical computing techniques developed by Dr Emili Balaguer-Ballester at Bournemouth University, and a team of neuroscientists at Indiana Purdue University in US, the University of Heidelberg in Germany and British Columbia in Canada have been used to map the effects of neurotransmitters, such as dopamine, on neural activities and behaviour. This has enabled the team to prove a long-held assumption in computational neuroscience: that cognitive decisions seem to be represented by temporarily stable states of neural dynamics which are modulated by dopamine. Until the publication of a new study, based on the application of their method, this theory remained insufficiently evidenced.

"The methodology takes techniques from functional analysis, machine learning and dynamical systems and applies them to areas such as neuroscience," explains Dr Balaguer-Ballester. "By mixing up approaches from different subject areas, the theory has allowed researchers in the US and Canada to prove a theoretical hypothesis proposed by neuro-computational models over fifteen years ago."

"The methodology allows for the reliable identification of the neural dynamics from recordings gathered from monitoring animal behaviour," said Dr Balaguer-Ballester, "For example, a neuroscience study looking at decision making in rats might be able to gather data on simultaneous brain activity in about 100-1000 neurons.

"This provides only a small part of the picture, relative to the number of neurons involved in the decision making process, but our methodology enables the identification of an expanded state space where patterns of neural activity associated with "metastable" states of the network, are robustly represented.

"The states identified are cross-validated through multiple trials of a particular behavioural task, which ensures their reliability. This is a particularly useful novel approach, because the enhancement method makes it easier to spot wider trends and dynamic patterns in relation to behaviours which are not accessible by classical approaches."

The method was originally published in *PLoS Computational Biology* in 2011, but until this year, had not been used in practice. A joint project by universities in the UK, America, Canada and Germany used this method of data analysis to demonstrate the effects of amphetamines in rats. The study was published in the *Journal of Neuroscience* in July.

Thanks to the enhancement of the recorded data provided by this method, researchers were able to demonstrate that after receiving a low dose of amphetamine; stable states associated with cognitive decisions became more stable, while the rats consistently improved their performance in making correct decisions in a maze task. At higher doses, the higher dopamine concentration in frontal areas caused the disruption of such stable states rendering the rats unable to make the correct decisions.

Speaking about the next steps of his research, Dr Balaguer-Ballester explained, "I intend to use what we have learned through this study to continue to improve the original methodology.

In time, I hope that it will be able to prove how metastable neural states naturally emerge and evolve, which will help to establish a causal link between behaviours and the decision making process."

More information: Amphetamine Exerts Dose-Dependent Changes in Prefrontal Cortex Attractor Dynamics during Working Memory The *Journal of Neuroscience*, 15 July 2015, 35(28): 10172-10187; DOI: 10.1523/JNEUROSCI.2421-14.2015

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