Our brain's secret strategist: choosing how to choose

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DISSEMINATION DIVERSE

I like to bake cookies. It's a simple pleasure, but even in the kitchen, our brains are making complex choices. Imagine the recipe says, "bake for 10 minutes." That's your initial plan. But after just eight minutes, a strong aroma of browning sugar wafts from the oven. Now, your brain must decide which piece of information to rely on: the timer on the oven or the smell of potentially burning cookies? Do you pull them out immediately, giving more weight to your senses? Or do you stick to the recipe's timing, trusting its instructions over what you smell? Or perhaps decide to weigh both pieces of evidence equally and give it just another minute. This choice, of which evidence to prioritise and how to act on it, is a decision strategy. Our brains are constantly making these kinds of choices about how to choose. Understanding this strategic process is not just an academic curiosity; it's key to understanding how we adapt, learn and even why our decision-making can falter under stress or in certain neurological conditions. Yet, how the brain manages this remarkable ability remains largely an open question.

My new scientific project, DIVERSE, at the CNRS (Centre National de la Recherche Scientifique) in France, will explore this very puzzle. Over the next five years, this European Research Council-supported research will investigate the neural circuits and mechanisms that allow our brains to maintain and select from a varied repertoire of decision-making strategies, each involving different ways of processing and weighing information.

For a long time, it was assumed that the brain operated somewhat like a spotlight, focusing its main computational efforts on the one strategy being used at that moment. If you chose to rely on the cookie timer, that plan would be 'under the spotlight.' The DIVERSE project, however, proposes that our brain is doing much more behind the scenes: it might actually be juggling multiple potential strategies at once, keeping several options illuminated, even if dimly.

Think back to those cookies. Even if you've decided, for now, to trust the timer (your active strategy, 'under the spotlight'), our work suggests your brain doesn't completely shut down the 'smell-check' strategy (the 'dimly illuminated' option). It's as if, while the main timer is ticking, smaller, secondary timers or sensors related to alternative ways of judging 'doneness' are still running in the background. Your brain might still be subtly monitoring the aroma, even if it's not the primary driver of your action. It's not just *remembering* that smelling them is an option; it's keeping that sensory channel somewhat open and processing that information in parallel.

Our hypothesis is that if the smell suddenly intensifies, your brain can rapidly switch its primary focus. The 'smell-check' strategy, which was dimly illuminated but actively monitored, can quickly come to the forefront and override the 'timer' strategy. This is possible precisely because it wasn't completely ignored. This parallel vigilance for alternative ways of solving the problem is what allows for such flexible adaptation.

The foraging mouse: navigating a virtual world of decisions

To explore how the brain juggles these different decision strategies, we work with a common and effective animal model: the mouse. While baking cookies might seem far removed from a mouse's world, the underlying principles of weighing evidence and choosing a course of action are fundamental to survival for all creatures. For mice, a critical daily challenge is foraging—the search for food. This natural behaviour provides a good framework for studying decision-making, especially when the availability of resources is uncertain.

We have designed a kind of video game where mice navigate a virtual world and encounter 'food patches'. Their task is to decide whether to stay at a patch hoping for more sugary water rewards or leave to find a better one. This task is built so mice can use different strategies to decide, each reflecting a unique way of calculating if a patch is still worth their effort.

For example, a mouse might start with a basic strategy: stay if rewarded, consider leaving if not. But we can make the game harder by increasing uncertainty, making rewards less predictable, or making patches run out faster. This challenges the mouse to adapt. Will it learn to integrate information over longer periods, like counting several failed attempts before leaving? Or will it try to estimate the hidden chance of being rewarded at each patch?

This virtual setup lets us precisely control the 'rules of the game' and observe how mice shift their strategies as conditions change. Our previous work shows that some mice are remarkably flexible, readily changing their approach. Now, we aim to understand the brain mechanisms behind this adaptability.

Looking inside the deciding brain: from neural chatter to precise control

So, how does our team peek into the mouse's brain as it plays its virtual foraging game and switches decision strategies? We use an array of advanced neuroscience techniques.

Firstly, we employ large-scale electrophysiological recordings. Tiny, sophisticated probes called Neuropixels can simultaneously 'listen in' on the electrical chatter of hundreds of individual brain cells (neurons) across many different brain regions. This provides a panoramic view of brain activity as strategies are selected—which parts of the brain become active when the mouse relies on recent rewards, versus when it starts to count consecutive failures?

Secondly, the team uses optical manipulation. A key aspect of this involves optogenetics, which allows scientists to use light to turn specific groups of neurons on or off. But we will push this further, employing cutting-edge holographic stimulation. This remarkable technique allows researchers to project precise 3D patterns of light into the brain, activating not just a general area, but specific, chosen ensembles of neurons simultaneously, almost like playing a specific chord on a piano with brain cells. This level of precision is crucial for testing if activating a particular neural 'melody' can directly trigger a specific decision strategy.

All this rich data—the mouse's behaviour in the virtual world and the simultaneous brain activity—is then analysed using computational methods. These mathematical tools help us find meaningful patterns in the complex neural signals and link them directly to the decision strategies observed.

Why our internal state and experience matter

Let's briefly return to our cookie-baking dilemma. The strategy you choose—trusting the timer versus your senses—isn't just about the external evidence. Internal states, like being in a rush or feeling very hungry, can shift how you weigh information and which strategy feels right. Experience also shapes our strategies; an expert baker intuitively trusts their senses more than a generic timer, while a novice might cling to the recipe. We aim to understand how these internal factors and individual differences are reflected in brain activity, influencing which decision is selected. It's not just about *if* the brain can use different strategies, but *why* it chooses a particular one at a particular time.

The key questions

So, what specific mysteries about our brain's adaptability is our team trying to solve?

We already have clues that certain brain areas, in the front of the brain, can hold multiple decision strategies simultaneously, like a 'reservoir' of options. We want to expand on this, identifying the broader network of brain regions that are key players when we actually select one strategy from this available repertoire.

Second, we plan to investigate how these brain areas talk to each other. When we need to switch strategies—perhaps because a task gets harder, or we become tired or stressed—how does the communication change between different brain regions to make that switch happen?

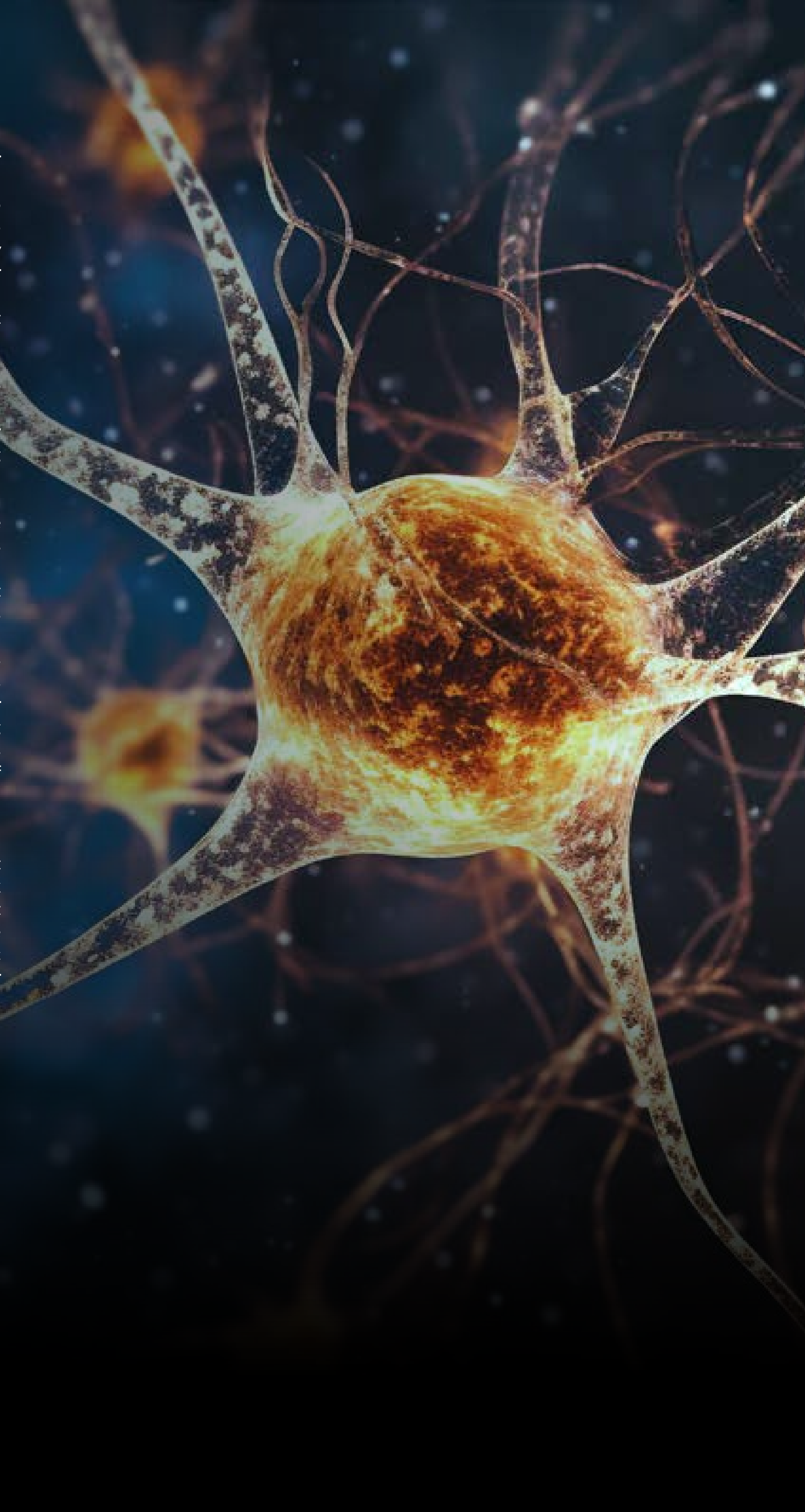
Finally, the team wants to see if they can directly 'activate' a specific decision strategy in the brain. If they can stimulate the exact pattern of brain cells associated with, say, the 'trust your senses' cookie strategy, will the individual actually adopt that way of deciding? This would show a direct link between brain cell activity and our chosen strategies.

Understanding our diverse decision-making

The potential impact of this research is far-reaching, extending well beyond the laboratory. Understanding how our brains flexibly manage multiple ways of weighing evidence could fundamentally change how we view everyday learning, problem-solving and our ability to adapt to our complex, ever-changing world. It's not just about *what* decision we make, but *how* we arrive at it—a process deeply influenced by our internal states, past experiences and even our unique personality.

This research has profound relevance for understanding healthy, flexible behaviour. But it also opens a new window onto why decision-making can sometimes go awry. Consider the impact of stress: many of us know that when we're under pressure, our decision-making can change, sometimes for the worse. We might become more impulsive or get stuck in a rut, unable to see alternative solutions. Our research could help uncover the neural mechanisms behind how stress, or other internal states, hijack our usually flexible decision 'toolkit,' perhaps forcing us to rely on less optimal strategies.

Furthermore, we seek to understand the natural diversity in how individuals make decisions. We don't all approach problems in the same way, and that's not necessarily a flaw. Different strategies can be beneficial in different contexts. By understanding the neural basis of this variety, we can appreciate the richness of animal cognition. Importantly, for individuals whose decision-making processes consistently lead to difficulties that negatively impact their quality of life—perhaps due to an inability to switch strategies appropriately, or an over-reliance on a narrow set of approaches—this research could be transformative. It could provide a much clearer framework for understanding these challenges at a biological level, potentially paving the way for new insights on novel therapeutic approaches aimed at restoring or enhancing cognitive flexibility. Ultimately, this research aims to provide a foundation for appreciating the spectrum of decision-making, helping us understand both the brilliance of our adaptive minds and how to support those whose decision 'blueprint' leads them astray.



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DIVERSE

PROJECT SUMMARY

Our brains can imagine diverse solutions and rapidly switch between them, but how this flexibility works is unclear, especially beyond simple behaviours. This project aims to understand how the brain switches between decision strategies. It hypothesises that the brain runs multiple decision processes in parallel, allowing for quick adaptation.

Using mice in foraging tasks, researchers combine novel computational methods with advanced electrophysiological recording and optical manipulation. Key objectives are to identify: (1) neural circuits for strategy selection, (2) mechanisms controlling strategy changes, and (3) how to trigger specific strategies.

The project hopes to deliver a rich dataset and a new conceptual framework for behavioural flexibility, ultimately deepening our understanding of decision-making and the diversity of behaviours.

PROJECT LEAD PROFILE

Fanny Cazettes is a research scientist from the French Center for Scientific Research (CNRS) working at the Timone Neuroscience Institute. She investigates neural circuits for flexible behaviour and decision-making. Her career includes a PhD from Albert Einstein College of Medicine (USA), a postdoc at Champalimaud Foundation (Portugal), and her current CNRS position, focusing on adaptation in dynamic environments.

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