Study here reveals role of brain regions in regulating impulsivity
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Study here reveals role of brain regions in regulating impulsivity

Findings could lead to more effective management of ADHD and addiction

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A study here has uncovered how different regions of the brain interact to enable self-control by suppressing impulsive behaviours and enabling individuals to act at the right moment.

These findings advance the understanding of conditions such as attention-deficit hyperactivity disorder (ADHD) and addiction, and could lead to more effective management of these disorders, said the researchers from the Nanyang Technological University's Lee Kong Chian School of Medicine (LKCMedicine).

Their research examined three areas of the brain involved in reasoning and complex cognitive functions – the anterior insular cortex, the posterior parietal cortex and the dorsomedial frontal cortex. These areas are thought to be crucial in controlling impulses.

Each of the three regions plays a different role, said the study's corresponding author Tsukasa Kamigaki, assistant professor of systems neuroscience at LKCMedicine.

The dorsomedial frontal cortex works like a brake pedal, inhibiting impulsive actions and promoting patience, while the anterior insular cortex acts like an accelerator, driving impulsivity, noted Prof Kamigaki.

The posterior parietal cortex, meanwhile, acts like an internal clock, regulating how the brain tracks the passage of time, he added.

The study involved examining self-control in mice, with researchers designing a task in which the animals were trained to wait before being allowed to lick a water port.

Mice that licked the port too soon would not receive a reward.

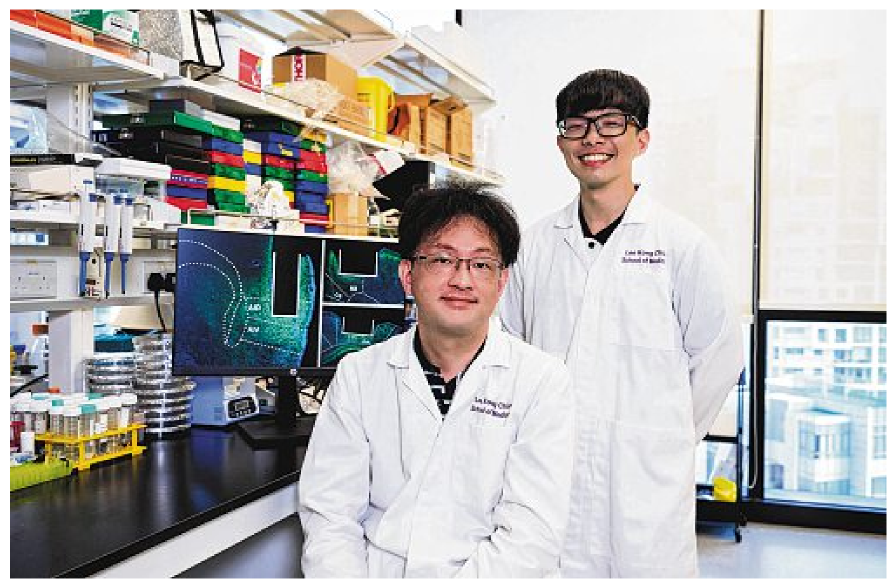
The trials employed optogenetics – a technique that involves the use of light to control the activity of cells – to inhibit the different regions of the brains of the mice.

The researchers found that the mice waited for a shorter time before licking the water port when the dorsomedial frontal cortex was inhibited, but were able to wait longer when the anterior insular cortex was inactivated.

Inhibiting the posterior parietal cortex led to inconsistent waiting behaviour, suggesting that this region contributes to self-control by stabilising timing.

Measuring the activity of neurons in these regions, researchers discovered that some neurons in the posterior parietal cortex fired in a sequential manner – similar to the ticking of a clock – which helped the animals track how much time had passed during the waiting period.

The researchers' findings were published in peer-reviewed journal Science Advances in October 2025.



Lee Kong Chian School of Medicine's (LKCMedicine) Assistant Professor Tsukasa Kamigaki (left) and research fellow Malcolm Ho are part of a team that studied how brain regions work together to enable self-control. PHOTO: LKCMEDICINE, NTU

While the functions associated with different regions of the brain have been mapped before, what these findings show is that self-control is not a single, unified process, but rather, a "coordinated computation involving at least three distinct circuit brain systems", said Prof Kamigaki.

"This means that by precisely targeting each different brain region, in principle, we can shift the dial of the impulsive behaviour in a controlled way," he said.

"This has profound implications for how we think about the people who struggle with self-control."

Without discounting the influence of factors such as genetics or environmental factors, Prof Kamigaki said the study provides a "clear map" on what sections of the brain to target when trying to treat people with conditions such as addiction or ADHD.

Though there are still ethical and practical issues surrounding the use of optogenetics in humans, the findings could help in the future development of therapies for such conditions, he noted.

Associate Professor Jimmy Lee, a psychiatrist at the Institute of Mental Health, who was not involved in the study, said: "By identifying the specific roles of different brain regions in regulating impulsivity, we are moving towards a more nuanced understanding of conditions such as ADHD, which could eventually lead to more targeted treatments of these disorders.

"Importantly, this work reinforces that impulse control differences have clear neurobiological bases, which helps validate these as legitimate medical conditions rather than personal failings."

Prof Kamigaki said the next steps in the research will involve learning more about the mechanisms behind interactions between the different regions of the brain, as well as how these mechanisms are disrupted in various disorders and testing treatments that target such disorders.

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