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Field

The Claustrum: Your shield from distraction

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ABSTRACT

The claustrum is a mysterious brain structure with vast connections, whose anatomy has limited investigation. We found a new approach for studying claustral neurons, which uncovered a role for the claustrum in conferring resilience to distraction.

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Being able to filter out irrelevant information is a crucial ability for any animal. Consider for a moment the number of sensations you can currently feel. Maybe someone is shouting in the background, has a strong perfume, or perhaps you have an itch? Even subtler is the feeling of your back against the chair. And yet, until you focused on these distractions just now, the information of this text was at the center of your awareness. Our senses are constantly assaulted by this barrage of information, of which only a fraction is relevant at any given point in time. How does our brain allow us to navigate these potential distractors? How do we focus on what is important?

While the brain is a single organ, it contains intricate networks of electrically communicating cells called neurons, which form the modular structure of our brain. Different brain regions process sensory information, perform cognitive functions, and send out motor commands to the body. You might expect, then, that somewhere in the brain exists a structure which functions to suppress the neural representation of irrelevant, distracting signals. A sort of equalizer of the brain.

A central hub like this would 1) likely have widespread connections to the rest of the sensory brain in order to modulate it, and 2) would receive information from brain regions that are responsible for directing attention. The *claustrum*, a small brain structure sitting deep within the brain, has just these properties, making it a good candidate for the job. However, its tiny size and hidden location (claustrum comes from the Latin word for 'enclosed', think claustrophobia), have made it very hard to study. In fact, very little is known about the function of the claustrum.

We utilized a mouse model to look closer at this understudied region. Lab mice have a double advantage: they have brains which are remarkably similar to ours, including a claustrum. In addition, mice can be genetically modified. We used a virus-based technique in a transgenic mouse, which allowed us to specifically infect claustral neurons, and make them express a fluorescent marker, allowing us to visualize their connections with other areas of the brain. More importantly, we could, for the first time, block the electrical activity of claustral neurons while the mouse is alive, awake, and behaving.

This allowed us to test if the claustrum is involved in the capability to ignore distractions. To do so we set up the following experiment: we taught mice to patiently wait for a light cue to appear; the light cue would indicate which of two ports would provide access to a reward. Once mice learned to follow the cue, we tested their ability to do so while ignoring a distracting sound. Healthy mice could ignore the distractor quite well, and did not show any decrease in performance. Considering that all animals, including humans, perform this kind of filtering almost at any given moment, this is perhaps not so surprising. Remarkably, mice whose claustrum was inhibited, made significantly more errors when exposed to the same distractor, even though they were fine as long as it was not playing.

Addressing a behavior that is more natural to mice, we measured the time it takes for mice mothers to retrieve their pups to the nest. The experiment showed that the auditory distractor hampered claustrum-silenced mothers, which took much longer to retrieve their pups. Healthy mothers, in turn, were not impacted by the distracting sound.

These results convinced us that the claustrum plays a role in ignoring distractors. In order to understand how it does so, we recorded electrical activity from cortical neurons responsible for auditory processing. We found that auditory cells in the brain were less responsive to the same sound when the claustrum was artificially activated, than when it was not. This shows that the claustrum could function as a filter, or an equalizer. Further work, using other types of distractors, needs to be done in order to test if this is true for the whole range of sensory experiences.

Resilience to distraction is a critical ability that allows us to function in a sensory environment that would otherwise be overwhelming. Singling out the claustrum as important for this function has implications for the diagnosis and therapy of many brain disorders that involve disruptions of attention, such as Attention Deficit Hyperactivity Disorder (ADHD) and autism, as well as psychotic disorders in which hallucinations and delusions occur. Additionally, these findings may change the way we understand attention in the brain. Are focusing on relevant stimuli, and ignoring irrelevant ones two sides of the same coin? Or are these two separate processes in the brain? Do we have neural mechanisms which are recruited only when a task is difficult? These are open questions, which we are currently addressing.