Brain plasticity after vision loss has an 'on-off switch'

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KU Leuven biologists have discovered a molecular on-off switch that controls how a mouse brain responds to vision loss. When the switch is on, the loss of sight in one eye will be compensated by the other eye, but also by tactile input from the whiskers. When the switch is off, only the other eye will take over. These findings may help improve patient susceptibility to sensory prosthetics such as cochlear implants or bionic eyes.

Our brain adjusts to changes of all kind. This brain plasticity is useful for neural development and learning, but also comes into play when the nervous system is damaged. For instance, when we lose sight in one eye, our brain no longer receives sensory input from that eye, but it will compensate for that loss.

Research in adult mice has revealed two types of neuroplasticity in response to vision loss. "When a mouse loses sight in one eye, the remaining eye starts sending additional signals to the area in the brain that used to be served by the lost eye," biochemist Julie Nys from the KU Leuven Laboratory for Neuroplasticity and Neuroproteomic s explains. "After a while, the whiskers of the mouse - its sense of touch - step in as well. After a couple of weeks, the 'lost' area in the brain is entirely reclaimed and its brain activity is almost as high as it was before." This phenomenon, whereby the brain responds to sensory loss by combining input from several sensory systems, is known as cross-modal neuroplasticity.

Age-related response to vision loss

The KU Leuven researchers discovered that cross-modal plasticity is age-dependent in an unexpected way: "In adult mice both the remaining eye and the whiskers compensate for the lack of vision in one eye. But in adolescent mice, only the functioning eye takes over. And yet, you would expect more plasticity in younger animals, because the brain undergoes major transformations during adolescence."

What is more, the study shows that the adolescent response can also be triggered in the brain of adult mice. "When you expose adult mice to darkness before removing their eye, they recover differently: their other senses take over to a smaller degree, similar to what happens in adolescent mice. The brain's response, in other words, rejuvenates when adult mice spend time in the dark."

On-off switch in the brain

The brain controls which senses compensate for the loss of sight in one eye, but the underlying process has always been a mystery - until now. "Adolescent and adult mice have the same brain structure, so that cannot explain their different responses to sensory loss. Instead, we discovered a molecular on-off switch that controls whether or not the whiskers take over."

"After comparing different molecules with an impact on brain activity, we decided to manipulate neuroplasticity with indiplon, a sedative that affects the communication between brain cells and is thus similar to the activity-reducing neurotransmitter GABA. In adult mice, indiplon suppressed cross-modal plasticity: the lack of vision in one eye was compensated by the remaining eye, but not by the whiskers. You could say that we managed to 'turn off' the whiskers."

Clinical applications

In view of medical applications, the new insights into neuroplasticity - involving one or more senses - are crucial, Professor Lut Arckens explains: "Deaf or hard-of-hearing people can benefit from cochlear implants. In young patients who were treated in time, these work very well. In other patients, however, the treatment is no longer effective, as the auditory areas in their brain have already been taken over by other senses. This outcome is difficult to reverse, but we might be able to prevent it by suppressing cross-modal plasticity. In other cases, by contrast, we could support optimal recovery by boosting cross-modal plasticity. But these applications require a lot of further research. Our study paves the way by showing that we need to pay more attention to how sensory systems influence each other in the brain, for instance after surgery."

Provided by KU Leuven