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PRIMARY eye care

Is the window of brain plasticity for vision perhaps wider than we thought?

New research shows that the window of brain plasticity, for at least some visual tasks, extends much further than previously thought.

For many decades, neuroscientists believed there was a "critical period" in which the brain could learn to make sense of visual input, and that this window closed around the age of 6 or 7. but recent work by MIT Professor Pawan Sinha has shown that the picture is more nuanced than that. In many studies of children in India who had congenital cataracts surgically removed after the age of 7, these older children have been able to learn visual tasks such as recognizing faces, distinguishing objects from a background, and discerning motion.

Image credit: pexels-yan-krukau-8819155

The new study by Sinha and colleagues, published earlier this year in Proceedings of the National Academy of Sciences, showed that anatomical changes occur in the brains of these children after their sight is restored. These changes, seen in the structure and organization of the brain's white matter, appear to underlie some of the visual improvements that the researchers observed and their findings support the idea that the window of brain plasticity, for at least some visual tasks, extends much further than previously thought.

White matter plasticity

In developed nations infants born with cataracts are treated within a few weeks of birth. However, in developing nations such as India, a higher percentage of these cases go untreated. Nearly 20 years ago, Professor Sinha launched an initiative called Project Prakash, with the mission to offer medical treatment to blind and vision-impaired children in India.

Each year, the project screens thousands of children, many of whom are provided with glasses or more advanced interventions such as surgical removal of cataracts. Some of these children, with their families' permission, also participate in studies of how the brain's visual system responds after sight is restored.

In this study, the researchers wanted to explore whether they could detect any anatomical changes in the brain that might correlate with the behavioral changes that they have previously seen in children who received treatment. They scanned 19 participants, ranging in age from 7 to 17 years of age, at several time points after they had surgery to remove congenital cataracts.

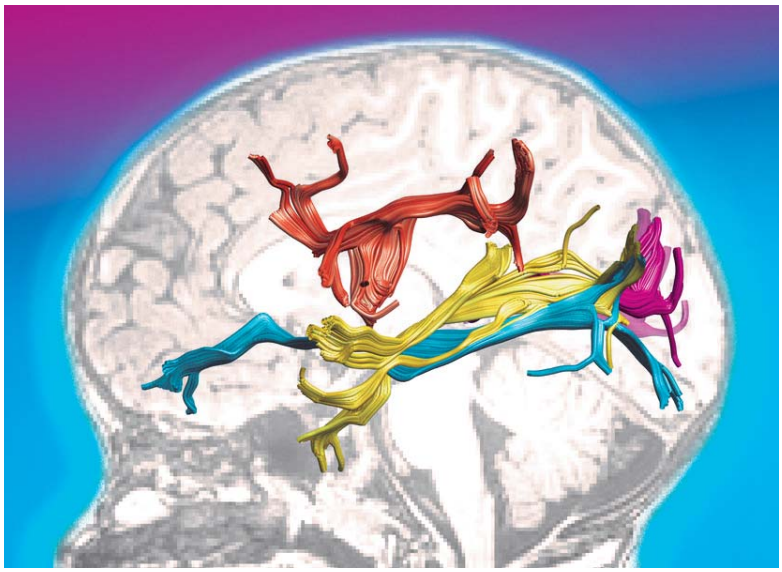
To analyze anatomical changes in the brain, the researchers used diffusion tensor imaging, a type of MRI which can reveal changes in the organization of the white matter connecting different regions of the brain.

The imaging revealed the signs that the nerve fibers were growing in volume and they were getting more organized in terms of their alignment.

The researchers observed these changes specifically in white matter pathways that are part of the later stages of the visual system, which is believed to be involved in higher-order functions such as face perception. These improvements occurred gradually over several months following surgery.

The imaging revealed anatomical changes in the white matter, but in separate studies using functional neuroimaging, the researchers could also see increasing specialization, as a function of visual experience, similar to what happens in typical development..

The research team also tested the participants' performance on a variety of visual tasks and found that their ability to distinguish faces from other objects was correlated with the amount of structural change in the white matter pathways associated with higher-order visual function.



MIT neuroscientists discovered anatomical changes that occur in the white matter pathways linking visual-processing areas of the brain in children who have congenital cataracts surgically removed. This image shows the late-visual pathways in the brain.

Image Credit: Courtesy of the researchers, edited by MIT News

In comparison, while the treated children showed some improvements in visual acuity their distance acuity never fully recovered, and they showed only minimal changes in the white matter organization of the early visual pathways.

The notion that plasticity is a time-limited resource and that past a certain window we can't expect much improvement does seem to hold true for low-level visual function like acuity. But the study shows that for a higher-order visual skill, like telling a face from a non-face, behavioral improvements can be observed over time. Noteably, the researchers found correlation between behavioural improvement and anatomical changes.

Benefits of treatment

The researchers also found that children who had cataracts removed at a younger age showed greater, and faster, gains in face-perception ability than older children. However, all of the children showed at least some improvement in this skill, along with changes in the structure of the white matter.

The findings suggest that older children can benefit from this kind of surgery.

Sinha's lab is now analyzing additional imaging data from Project Prakash patients. In one study, the researchers are investigating whether the patients show any changes in the thickness of their gray matter, especially in the brain's sensory processing areas, after treatment.

The researchers are also using functional MRI to try to localize visual functions such as face perception, to see if they arise in the same parts of the brain that they do in people born with normal sight.

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Citation: White matter plasticity following cataract surgery in congenitally blind patients Caterina A. Pedersini, Nathaniel P. Miller, Tapan K. Gandhi, Sharon Gilad-Gutnick, Vidur Mahajan, Pawan Sinhaand Bas Rokers. PNAS May 1, 2023 https://doi.org/10.1073/pnas.2207025120

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