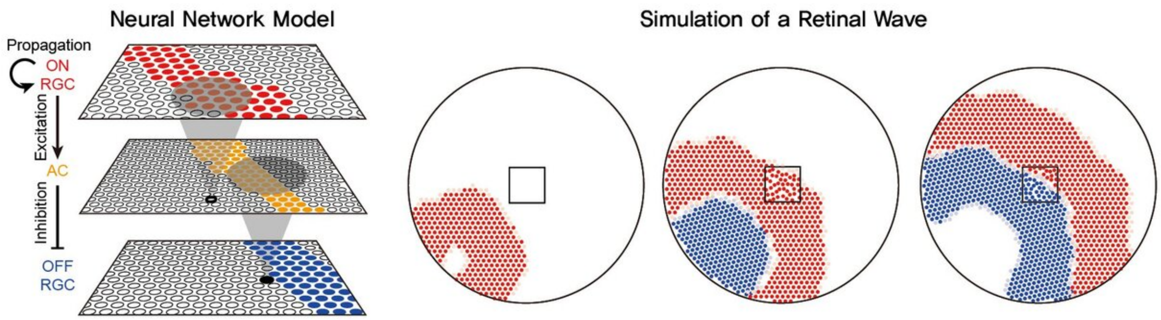
Before eyes open, they get ready to see

August 25 2020



Computational simulation of retinal waves in model neural networks. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

A KAIST research team's computational simulations demonstrated that the waves of spontaneous neural activity in the retinas of still-closed eyes in mammals develop long-range horizontal connections in the visual cortex during early developmental stages.

This new finding featured in the August 19 edition of *Journal of Neuroscience* as a cover article has resolved a long-standing puzzle for understanding visual neuroscience regarding the early organization of functional architectures in the mammalian visual cortex before eye-opening, especially the long-range horizontal connectivity known as "feature-specific" circuitry.

To prepare the animal to see when its eyes open, neural circuits in the brain's visual system must begin developing earlier. However, the proper development of many brain regions involved in vision generally requires sensory input through the eyes.

In the primary visual cortex of the higher mammalian taxa, cortical neurons of similar functional tuning to a visual feature are linked together by long-range horizontal circuits that play a crucial role in visual information processing.

Surprisingly, these long-range horizontal connections in the primary visual cortex of higher mammals emerge before the onset of sensory experience, and the mechanism underlying this phenomenon has remained elusive.

To investigate this mechanism, a group of researchers led by Professor Se-Bum Paik from the Department of Bio and Brain Engineering at KAIST implemented computational simulations of early visual pathways using data obtained from the retinal circuits in young animals before eye-opening, including cats, monkeys, and mice.

From these simulations, the researchers found that spontaneous waves propagating in ON and OFF retinal mosaics can initialize the wiring of long-range horizontal connections by selectively co-activating cortical neurons of similar functional tuning, whereas equivalent random activities cannot induce such organizations.

The simulations also showed that emerged long-range horizontal connections can induce the patterned cortical activities, matching the topography of underlying functional maps even in salt-and-pepper type organizations observed in rodents. This result implies that the model developed by Professor Paik and his group can provide a universal principle for the developmental mechanism of long-range horizontal connections in both higher mammals as well as rodents.

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Professor Paik said, "Our model provides a deeper understanding of how the functional architectures in the visual cortex can originate from the spatial organization of the periphery, without sensory experience during early developmental periods. We believe that our findings will be of great interest to scientists working in a wide range of fields such as neuroscience, vision science, and developmental biology."

More information: Jinwoo Kim et al. Spontaneous Retinal Waves Can Generate Long-Range Horizontal Connectivity in Visual Cortex, *The Journal of Neuroscience* (2020). DOI: 10.1523/JNEUROSCI.0649-20.2020

Provided by The Korea Advanced Institute of Science and Technology (KAIST)