Under natural viewing conditions, a single depthful percept of the world is consciously seen. However, when dissimilar images are presented to corresponding regions of the two eyes, binocular rivalry may occur, during which the brain consciously perceives alternating percepts through time. These percepts and their temporal properties provide important clues into how the brain is designed to see the world in depth. How do the same brain mechanisms that generate a single depthful percept of the world also cause perceptual bistability, notably binocular rivalry? What properties of brain representations correspond to consciously seen percepts? A laminar cortical model of how cortical areas V1, V2, and V4 generate depthful percepts was developed by researchers Yongqiang Cao, Stephen Grossberg, Guru Swaminathan, and Arash Yazdanbakhsh in the NSF Center of Excellence for Learning in Education, Science, and Technology (CELEST) to explain and quantitatively simulate binocular rivalry data. The model proposes how mechanisms of cortical development, perceptual grouping, and figure-ground perception lead to single and rivalrous percepts. The model’s perceptual grouping circuits quantitatively simulate many challenging rivalry properties under experimental conditions where they are seen. These data explanations follow from model brain mechanisms that assure non-rivalrous conscious percepts and contribute to an emerging general theory, called the 3D LAMINART model, of how the laminar circuits of visual cortex see.

The left column shows the behavior of model neurons in response to 18 Hz flickering gratings. The left eye input grating is perpendicular to the right eye grating. Although the left/right eye inputs are swapped every 333 ms, the model binocular response (top row) exhibits “stimulus rivalry” with oscillations similar to those during a non-swapping condition. In the right column, however, the stimulus contrast of the gratings is doubled and the swapping rate is slower. The model shows rapid “eye rivalry” alternations in the binocular cells (top row), rather than the slow, irregular changes that are characteristic of stimulus rivalry.