Modeling Traveling Waves in Binocular Rivalry

Joao Xavier-Cardoso*[1], Li Hsin-Hung[2,3], David J. Heeger[2,3], and Laura Dugué*[4]

[1]Centre Neurosciences intégratives et Cognition / Integrative Neuroscience and Cognition Center – Centre National de la Recherche Scientifique, Université Paris Cité – France
[2]Center for Neural Science [New York] – États-Unis
[3]NYU Department of Psychology [New-York University] – États-Unis
[4]Centre Neurosciences intégratives et Cognition / Integrative Neuroscience and Cognition Center – Centre National de la Recherche Scientifique, Université Paris Cité, Institut Universitaire de France, Paris, France – France

Résumé

Visual illusions allow researchers to unravel different types of computations performed by the visual system. Binocular rivalry is a perceptual illusion in which perception alternates between rival images presented to each eye. Under the right conditions, the dynamics of these alternations form a wave-like pattern starting where one rival image locally becomes the dominant percept. Studies have shown a link between these perceptual traveling waves and waves of brain activity in primary visual cortex (Lee et al., 2005). Here, we replicate and extend previous psychophysics studies of perceptual waves observed in binocular rivalry (e.g., Wilson et al., 2001), and fit a computational model to the behavioral data.

A pair of orthogonal gratings, each windowed by an annulus of three possible sizes (5.6, 8.8, 12 degrees of visual angle) and projected to one eye, were presented to human participants (n=21). Replicating previous results, a local contrast increment in one eye induced perceptual dominance that emerged locally and progressively expanded as it rendered invisible the stimulus presented to the other eye. Participants pressed a key when a perceptual wave reached a target area enabling us to measure propagation speed. We observed (1) slower speeds for more eccentric annuli, commensurate with differences in cortical magnification; (2) morning participants perceived faster waves than afternoon participants, interpreted as circadian variations in cortical excitability; (3) allocating attention to the annulus was necessary for perceptual waves to be perceived; and (4) rhythmic, local contrast increments induced rhythmic perceptual waves. Finally, we adapted a previously proposed binocular rivalry model (Li, et al. 2017), which incorporates the role of attention and explains many binocular rivalry's perceptual signatures, so it can reproduce both temporal and spatial patterns of perceptual waves. The model could replicate our main findings, along with features reported by other studies, such as changes in propagation speed as a function of attention, input strength and recurrent excitation.

Understanding these spatiotemporal dynamics of visual perception provides insights into specific neural computations without the need of neuroimaging. It highlights the broader significance of traveling waves as a fundamental aspect of cortical dynamics and their role in shaping visual perception. Together, our research aims to develop a computational framework for understanding perceptual traveling waves in binocular rivalry.

*Intervenant

Mots-Clés: Modeling, Traveling Waves, Binocular Rivalry, Visual Illusions