Active Encoding of Space through Time

Michele Rucci[1, 2] and Jonathan D. Victor[3]

[1]*Department of Brain and Cognitive Sciences and* [2]*Center for Visual Science, University of Rochester, USA.*
[3]*Feil Family Brain and Mind Research Institute, Weill Cornell Medical College, 1300 York Avenue, New York, NY 10065, USA*

Unlike other sensory modalities, in which spatial information needs to be extracted from the incoming signals, visual perception starts with a sophisticated imaging system, the eye, which explicitly encodes space in the position of retinal receptors. This may lead to the assumption that human vision is predominantly a passive spatial process: all that is needed is to transmit the retinal image to the cortex, like uploading a digital photograph, to establish a map of the scene. However, this deceptively simple analogy is inconsistent with theoretical models and experiments that study visual perception in the context of motor behavior. Here, we will discuss the theory of active space-time encoding, the proposal that---as with other sensory modalities---vision relies heavily on motor strategies to encode spatial information in the temporal domain. We will (a) describe the way different types of eye movements transform a spatial scene into luminance modulations on the retina, (b) examine how the characteristics of the resulting visual signals relate to the response properties of retinal neurons; and (c) review recent experimental evidence in support of this theory.

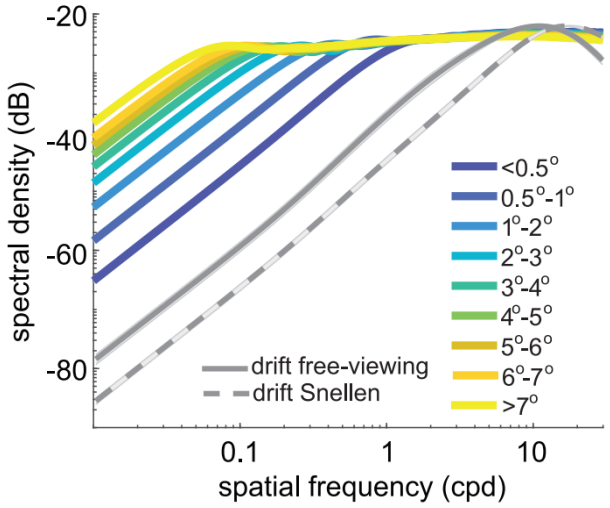

Figure 1. Strength of the luminance modulations delivered by distinct eye movements. Each curve represents the total power of a fixed-amplitude grating that a given movement makes available in the form of luminance modulations within the temporal range of human sensitivity. Colored lines represent the power resulting from saccades of various amplitudes (data from [1]). Gray lines represent the power from the eye drifts recorded during free-viewing and during examination of the 20/20 line in a Snellen chart (data from [2]). Shaded areas represent SEM across subjects.

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[1] N. Mostofi, Z. Zhao, J. Intoy, M. Boi, J.D. Victor, and M. Rucci, (2020), Spatiotemporal content of saccade transients, Current Biology, 30(20): 3999-4008.

[2] J. Intoy and M. Rucci, (2020), Finely tuned eye movements enhance visual acuity, Nature Communications, 11(795):1-11.