

Comment

Competitive dynamics in the brain
Comment on “Information flow dynamics in the brain”
by M.I. Rabinovich et al.

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Rabinovich et al. [1] motivate the importance of itinerant and competitive dynamics when considering the brain as an information processing device [2,3]. They treat us to a rich series of insights afforded by a dynamical perspective that emphasizes metastability and winnerless competition. Their review pursues a compelling tradition of trying to understand neuronal activity in terms of attractor dynamics and how the resulting dynamics are coupled to the sensorium [4–11].

The authors start by making a key point — to properly understand neural processing one has to move beyond classical information theoretic approaches and look at the itinerant dynamics that underpin self-organization in nonequilibrium systems, like the brain, that maintain a steady state or homeostasis [6,11,12]. Rabinovich et al. cover many themes. I will focus on the broad implications for understanding brain function from the Helmholtzian perspective on the brain as an inference machine [12–14]. In this view, the brain tries to model its sensory exchanges with the world, where this modelling gives rise to perception and the selection of sensory evidence that we know as behavior. Winnerless competition and metastable dynamics are absolutely central to this notion, given the metastability of the world we are obliged to model. A nice example here is communication among conspecifics that has a deep hierarchical structure and a separation of temporal scales. One perspective, on this remarkable capacity of higher organisms, is that their brains contain the same central pattern generators or stable heteroclinic channels that are coupled through sensory exchanges. Rabinovich et al. look at this in terms of the binding of stable heteroclinic channels [15]. It is interesting to reflect on the nature of this binding in the context of language [16]. To cut a long story short, it is possible for the itinerant pattern generators in a speaker to entrain equivalent dynamics in a listener, if the listener uses his pattern generator to predict the behavior (i.e., speech) of the speaker. This leads naturally to a view of the brain in terms of predictive coding [17], where prediction errors bind metastable orbits in different brains and, indeed, hierarchical levels of a single brain [12].

The key thing here is that winnerless competition and competitive dynamics provide a model or prior beliefs about the unfolding world and therefore provide a basis for predicting our sensory impressions of that world [18]. Exactly the same perspective can be applied to action, where kinaesthetic or proprioceptive predictions produce movements through classical reflex arcs. Rabinovich et al. provide a beautiful example of this in the Mollusc *Clione* limacina. They consider the competitive dynamics between statocyst receptor neurons and how these provide command signals

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for swimming and hunting [19]. Crucially, they contrast winner-take-all and winnerless competition as two different modes of metastability — that produce routine swimming and hunting behavior respectively. This reflects the controllability of metastable dynamics [16] and provides a nice metaphor for action selection that fits almost perfectly with current theories about motor control, such as affordance competition [20] and active inference [12]. In this view stable heteroclinic channels provide the dynamical form of prior beliefs inherent in a Bayesian modelling of the world [14, 18] that has all the requisite features; namely, sequential dynamics, flexibility, implicit memory and self-organization. There are many exciting developments hinted at in this review that speak to a deeper understanding of perception and action in the brain; for example, the control of fast stable heteroclinic channels by slower orbits or, more generally, the enrichment of other formal approaches in neuroscience, such as optimal control and information theory.

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