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  Nonlinear integration by premotor circuits in the binocular VOR pathway and its implications: A modeling study

  Gain modulation is believed to be a common integration mechanism employed by neurons to combine information from various sources and modalities. Gain fields have been shown to widely exist in some cortical and subcortical areas of the brain and are believed to be the basis for some fundamental brain functions such as coordinate transformation. Nevertheless the existence of gain fields has not been explored in lower brain areas like the brainstem. In this modeling study, a physiologically relevant control system model is developed for both slow and quick phases of the angular vestibulo-ocular reflex (VOR). This model is used to show that if nonlinear gain fields are embedded in the response of VOR premotor neurons (in contrast to generally assumed linear neurons) viewing-context-dependent behavior of the VOR results automatically. This shows that, in principle, reflex modulations with sensori-motor context could be the outcome of local premotor nonlinearities, and not complex cortical computations. Interestingly, similar nonlinearities have been previously discovered in the spinal circuits. Simulations of this hybrid nonlinear model predicts that disconjugate eye movements during the VOR are an inevitable consequence of the existence of such gain fields in the central bilateral VOR pathway. Behavioral data collected from normal human subjects during the angular VOR in darkness have indeed shown large disconjugate components and are fully compatible with the model predictions.

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