Orientation adaptation without plasticity

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Orientation selectivity is a key characteristic of visual cortical neurons and it is first exhibited in primary visual cortex. This selectivity is not a static property of cortical neurons, but rather depends on the recent stimulus history. In particular, even a brief exposure to an oriented stimulus is known to result in shifts of orientation tuning curves. These shifts are typically interpreted as signs of short-term plasticity in primary visual cortex. This interpretation, however, ignores that visual cortical cells are part of a dynamical system with recurrent connections through which information on stimulus history becomes embedded in the neural response. We investigated whether these dynamics can explain the reported adaptation effects. **Methods:** We implemented a network model of orientation selectivity based on recurrent lateral interactions to study the temporal dynamics of orientation tuning and its dependence on stimulus history. **Results:** When presented with pairs of gratings, the model replicated the shifts in tuning curves that have been observed experimentally. No changes in model parameters or addition of new parameters were necessary to obtain these shifts; rather, they emerged naturally as a consequence of the network not reaching its steady state response during the rapid presentation of multiple stimuli. **Conclusion:** This finding has important implications for the interpretation of changes in neural responses that depend on recent history; our simulations show that such changes need not involve any plasticity and could be caused by neural population dynamics, which are slow due to the recurrent connections. These implications are not limited to the orientation tuning networks of V1 but extend to any recurrently connected neural network.