Rapid gain adaptation optimizes pursuit accuracy

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1. Introduction and Experiments:
In the natural world, the statistics of sensory stimuli fluctuate across a wide range. In theory, the brain could maximize information recovery if sensory neurons adaptively rescale their sensitivity to match the limited response bandwidth to the current range of inputs. Such adaptive coding has been observed in a variety of systems, but the premise that adaptation optimizes behavior has not been tested. Here we show that adaptation in cortical sensory neurons maximizes information about visual motion, and minimizes tracking errors in pursuit eye movements guided by that cortical activity. Thus, efficient sensory coding is not simply an ideal standard but rather a compact description of real sensory computation that manifests in improved behavioral performance.

2. Rescaling of response gain with stimulus variance in MT neurons and pursuit:

3. Mutual information:

4. Optimal gain for minimizing pursuit error:

5. Gain adaptation depends on experienced stimulus values:

6. Variance shift detection on single trials:

7. Discussion:
The theory of efficient coding is linked to the idea that neural systems maximize information relevant to behavioral performance that can influence survival. Observations of neural responses in many organisms have demonstrated a capacity for efficient coding, but the consequences for behavior have not been explored. In our work, we demonstrate for the first time that efficient coding applies to a neural system as a whole, improving the accuracy of the movements it generates, and not solely to individual sensory neurons. We have exploited the close connection between cortical motion estimates and smooth pursuit eye movements to demonstrate parallel adaptation effects in sensory neurons and movement behavior. We find that adaptation to motion variance optimizes the encoding of motion information by MT neurons, with a behavioral impact of optimizing information in pursuit eye movements, minimizing visual tracking errors, and thereby improving vision of moving objects.

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