A HYPOTHESIS FOR PARALLEL FIBER CODING IN THE CEREBELLUM.

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A hypothesis based on information theory is presented for the parallel fiber encoding of mossy fiber inputs to the cerebellum. Conditions are derived under which interactions between the mossy fiber inputs, the granule cells, and the Golgi interneurons approximate a sparsely-distributed, statistically-independent representation in the parallel fibers. A representation of this type minimizes coding redundancy and maximizes the mutual information between the mossy fibers and the parallel fibers. The number of mossy fiber inputs is much less than the number of granule cells and a given set activates only a small fraction. This suggests that the parallel fibers activities are the coefficients of an overcomplete basis set spanning the mossy fiber input space. In an overcomplete basis, a given input can be represented by multiple patterns of activity on the output neurons. The pattern which minimizes the number of active granule cells is obtained through inhibitory feedback from the Golgi cells, creating a sparse parallel fiber code. Learning rules for synaptic plasticity in the granular layer further reduce the redundancy of the parallel fiber code over the ensemble of mossy fiber input patterns. In this model, the ongoing Golgi cell inhibitory feedback, in addition to setting the firing thresholds of granule cells, can also change in real-time the direction of the granule cells sensitivity in mossy fiber input space. This modulation may allow the parallel fibers to flexibly encode specific spatio-temporal patterns of mossy fibers activity. Moreover, a sparse parallel fiber representation simplifies the learning controlled by climbing fiber inputs at the Purkinje cells and cerebellar interneurons. Supported by a McDonnell-Pew Foundation Grant, a William Girling Watson Fellowship, the Australian Research Council and Howard Hughes Medical Institute.