# Multi-sensory integration by constrained self-organization

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## Abstract

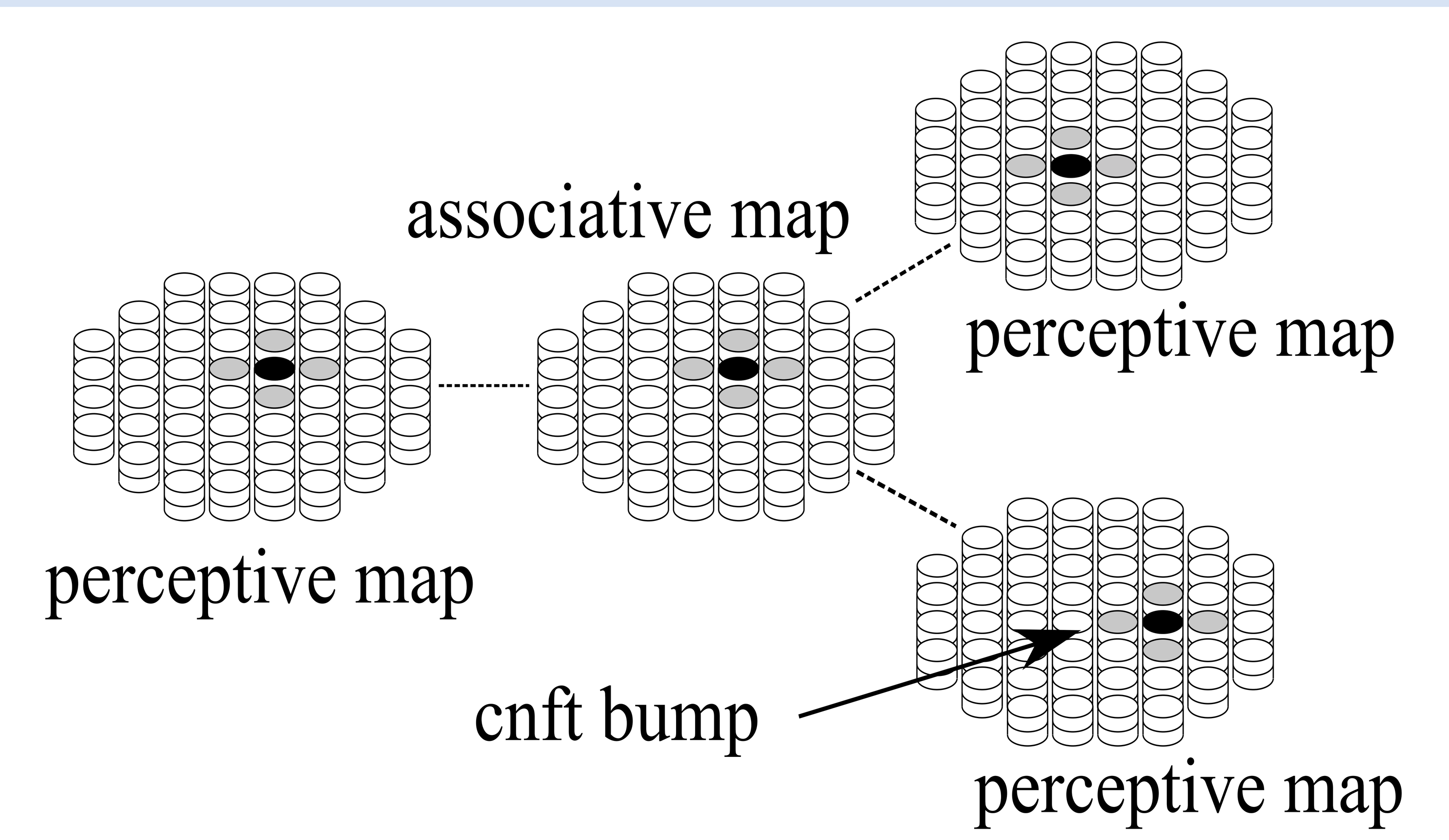
We develop a model for multi-sensory integration to perform sensorimotor tasks. The aim of this model is to provide missing modality recall and generalization using cortically-inspired mechanisms. The architecture consists of several multilevel cortical maps with a generic structure. Each map has to self-organize with a continuous, decentralized and unsupervised learning which provides robustness and adaptability. These self-organizations are constrained by the multimodal context to obtain multi-sensory generalization.

## Mechanisms of the model

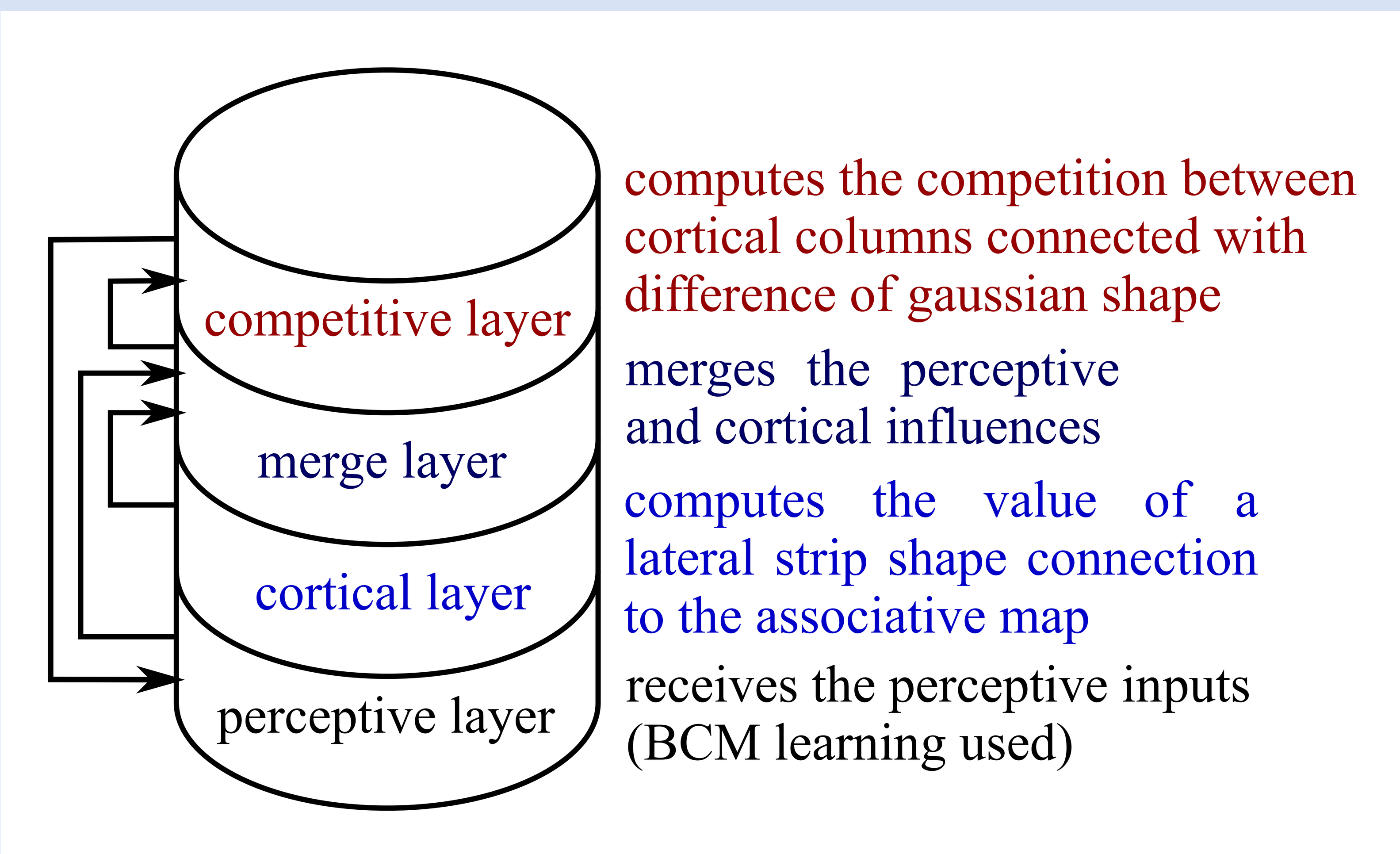
- continuous, decentralized and unsupervized learning
- perception represented by a neural map
- multi-sensory integration through associative map
- emergence of perception by a competitive mechanism (Continuous Neural Field Theory)
- emergence of a multimodal perception thanks to the relaxation of multi-sensory constraints
- neural map self-organization constrained by the multi-sensory context

## Description of the model

### *Multi-sensory interactions*




### *Neural maps: cortical column view*



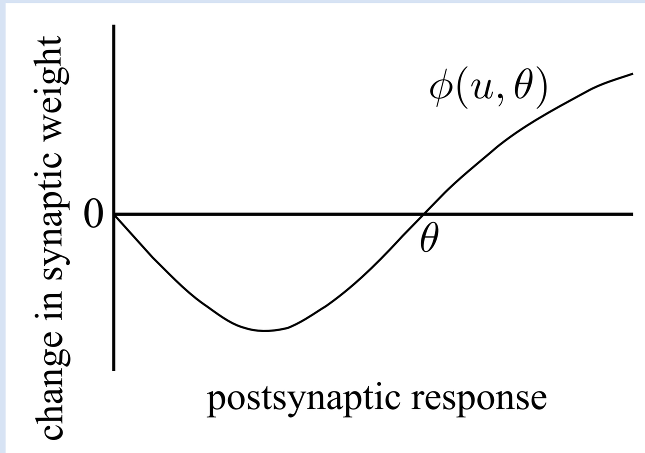

## Perceptive layer: BCM's learning rule

### *BCM's learning rule*

$$u = w.x$$

$$\theta = E_\tau[u^2]$$

$$\Delta w = \eta * x * \phi(u,\theta)$$




### *BCM's properties*

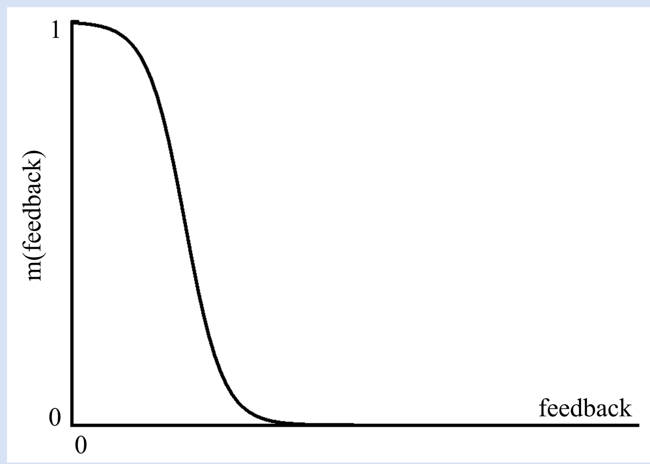
- spatial competition leading to stimulus selectivity
- weights regulation thanks to the sliding threshold

## Modification of the BCM's learning rule

### *Feedback modulation of BCM*

- modulation of the neuron activity influences the neuron selectivity
- activity bump is used as feedback modulation signal
- spatial coherence of the bump creates self-organization at the map level

### *Unlearning mechanism in BCM*



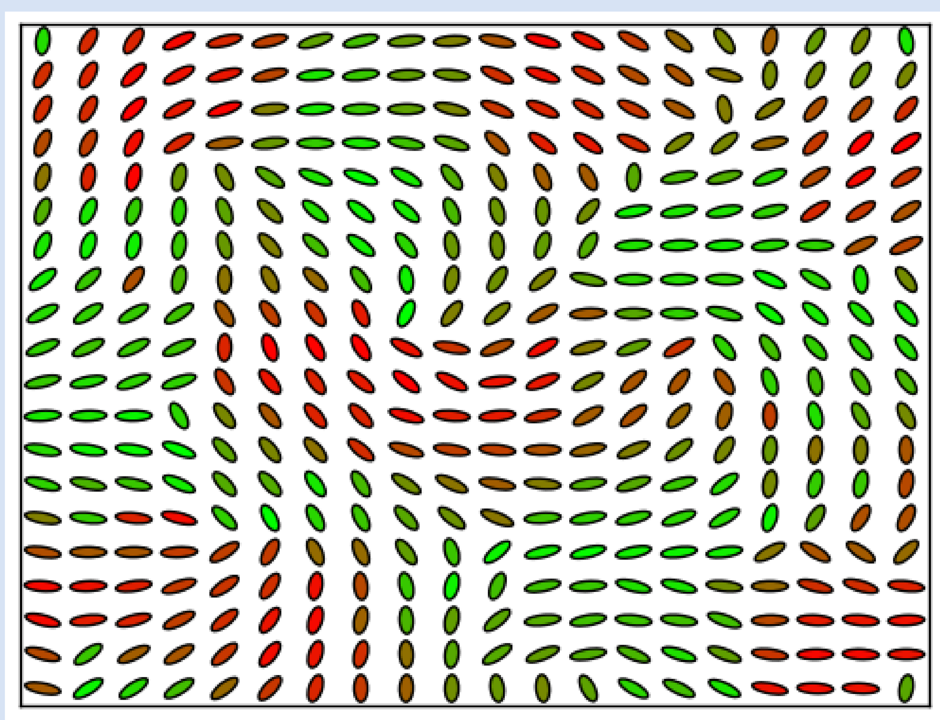

$$u = w * x + f(feedback)$$

$$\theta = E_\tau[u^2]$$

$$\Delta w = \eta * x * u * (u - \theta - \alpha * m(feedback) * \chi * u^2)$$

- decreases weights when an inconsistence is detected ($u$ high and *feedback* low)
- useful for bootstrapping (neuron selectivity has to develop before feedback can be consistent)
- helps to relax multimodal constraints
- must allow the addition of a new perception in a incremental way

## Results



Map self-organization (orientation + colour)

## Conclusion

With the modified learning rule, we obtain the self-organization of the map, which can be influenced by the multi-sensory context.