Plasticity and Sensitive Periods in Self-Organising Maps

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Plasticity and the Brain

• Within the brain there are systems that exhibit different plastic qualities:

-The somatosensory cortex adapts quickly and retains its plasticity into adulthood (Braun et al. 2001).

- In the language system, the ability of adults to learn phonological distinctions outside their language appears reduced in comparison to children (McCandliss et al. 2002).

How is plasticity lost or retained with age in self-organising systems?

SOFMs: An Approach

• Self-organising feature maps (SOFMs) are an unsupervised learning system, in which the similarity of exemplars is represented topographically.

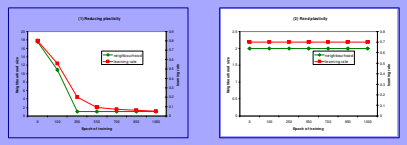
• Changes in plasticity in SOFMs are characterised by changes in learning rate and neighbourhood distance over training.

• Typically, these values decrease over training, as the map organises and then fine tunes the representations.

In our simulations we explored the ability of SOFMs to modify their category representations in two systems with contrasting plasticity.

154 dimensional feature space consisting of 9 categories, with 15-30 exemplars per category.

Parameter changes over time

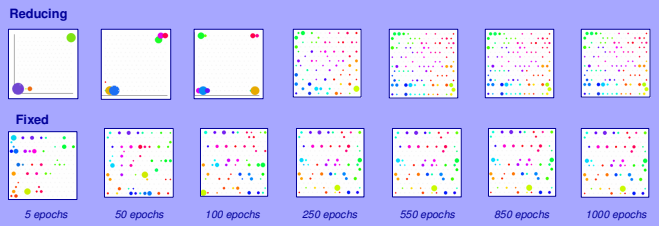


Comparing Reducing and Fixed Plasticity Maps

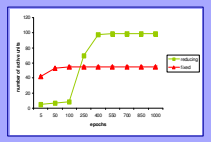
(i) Development

• Fixed plasticity maps develop their representations quicker, but show little subsequent change or expansion.

• The granularity of these representations is different for the two systems.



A comparison of active units for reducing and fixed maps

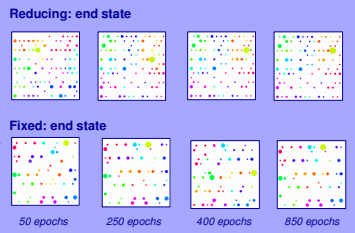


(ii) Effective plasticity across training

• Probed by introducing a new category at a later point in training.

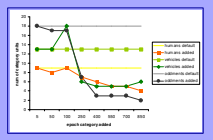
•For reducing maps adding a new category in the early stages of learning resulted in better overall representations.

• **Interference:** new categories positioned themselves nearest the most similar existing category, causing disruption to existing representations.

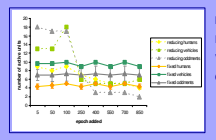


(point in training new category added at)

Deterioration of category learning with decreasing plasticity



A comparison of category activity for reducing and fixed maps



Key:
Humans = high similarity
Vehicles = lower similarity
Oddments = low similarity

(graphs showing the size of the added category upon completion of training)

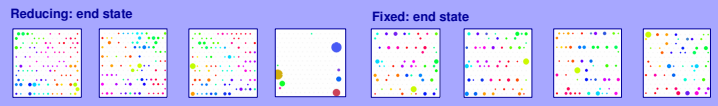
(iii) Thresholds

- How do thresholds impact upon plasticity and category learning?

•Constant thresholds seem to act as an impediment to learning.

• Fixed plasticity maps seem more resistant to the adverse effects of thresholds.

Suggested threshold function



(iv) Atypical categorisation and developmental disorders

-Perhaps poor maps produce impaired categorisation?

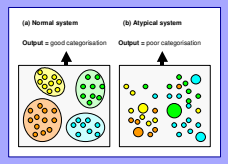
• For a poor map to result in impaired categorisation behaviour (Gustafsson, 1997):

-Downstream output must be topographically organised for poor input topology to matter (Oliver et al. 2000).

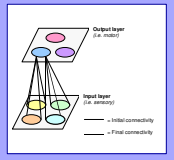
- Must have initial full connectivity between input and output.

- Connectivity must be pruned back during the learning process, and pruning must produce receptive fields.

Categorisation in normal and atypical systems



Input, output and topology



References:

• *Braun, C., Heinze, U., Schweizer, R., Weich, K., Blitbaumer, N., & Topka, H. (2001). Dynamic organization of the somatosensory cortex induced by motor activity. Brain, 124 2259-2267.*

• *Gustafsson, L. (1997). Inadequate cortical feature maps: A neural circuit theory of autism. Biological Psychiatry, 42, 1138-1147.*

•*Oliver, A., Johnson, M.H., Karmiloff-Smith, A., & Pennington, B. (2000). Deviations in the emergence of representations: A neuroconstructivist framework for analysing developmental disorders. Developmental Science, 3, 1-23.*

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