A connectionist model of developmental regression in Autism

Michael S.C. Thomas, Victoria C.P. Knowland & Annette Karmiloff-Smith
University of London

developmental neurocognition lab

Birkbeck UNIVERSITY OF LONDON

Regression

Behavioural regression is the loss of acquired skills. It is a highly unusual trajectory yet seen in around 20-40% of Autism cases. Regression in Autism is marked by variability with regard to the timing, severity and speed of loss, as well as the extent of recovery.

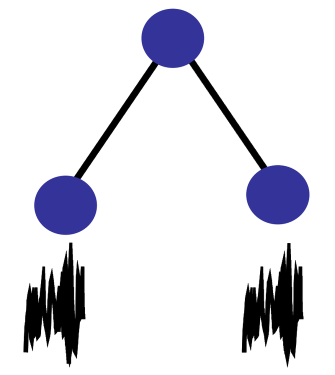
Here we asked **what mechanism causes developmental regression in Autism?**

We hypothesised that the cause is aberrant, overaggressive pruning. Pruning is a phase of brain development in which under-used synaptic connections are removed, following a period of exuberant growth in connectivity. Over-pruning may result in a loss of functional connections, reflected behaviourally in the loss of acquired skills.

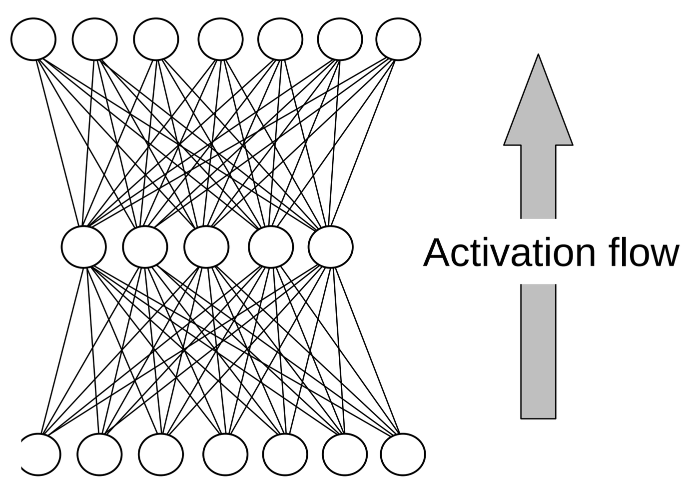
Connectivity

Additional variability was explained through the protective and risk factors: *pruning probability, speed of connection weight change* and *network size.* These factors all acted via the

common causal pathway of connectivity.



Population modelling of learners

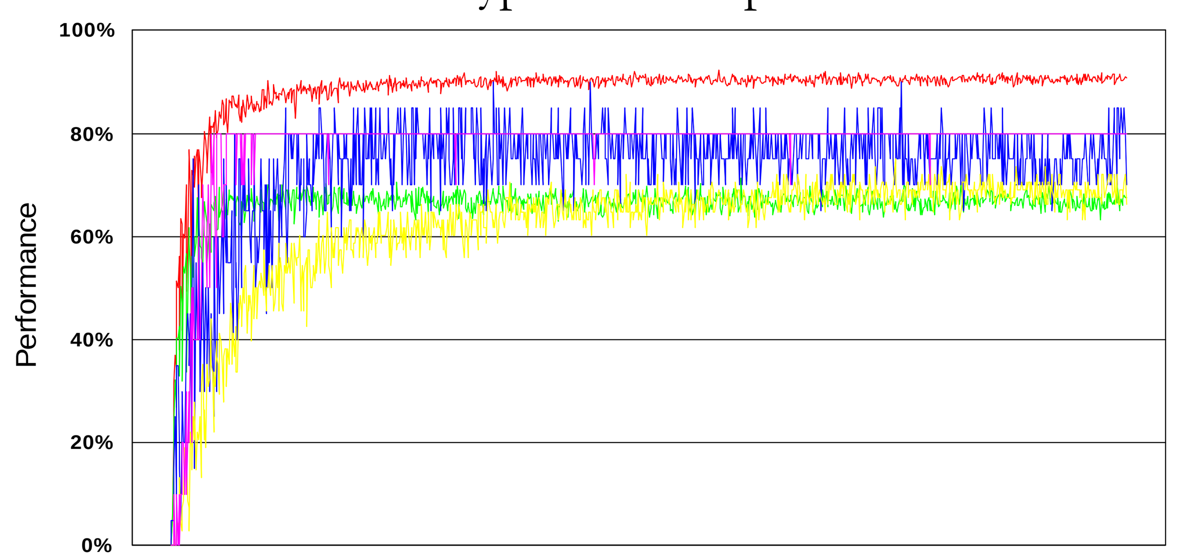


1000 associator networks learnt an abstract mapping problem consisting of five patterns (either easy regular patterns or harder exception patterns). Variability between individual networks was introduced via:

- The **genome**. 14 neurocomputational parameters were manipulated. These related to *Network Construction*, *Activation*, *Adaptation* and *Maintenance* (including the timing of pruning onset, the threshold for pruning and the probability of pruning given that threshold). Threshold determines whether a connection is used or not – small connections don't contribute to function
- The **environment**, with the richness of the training set varying (0-1)

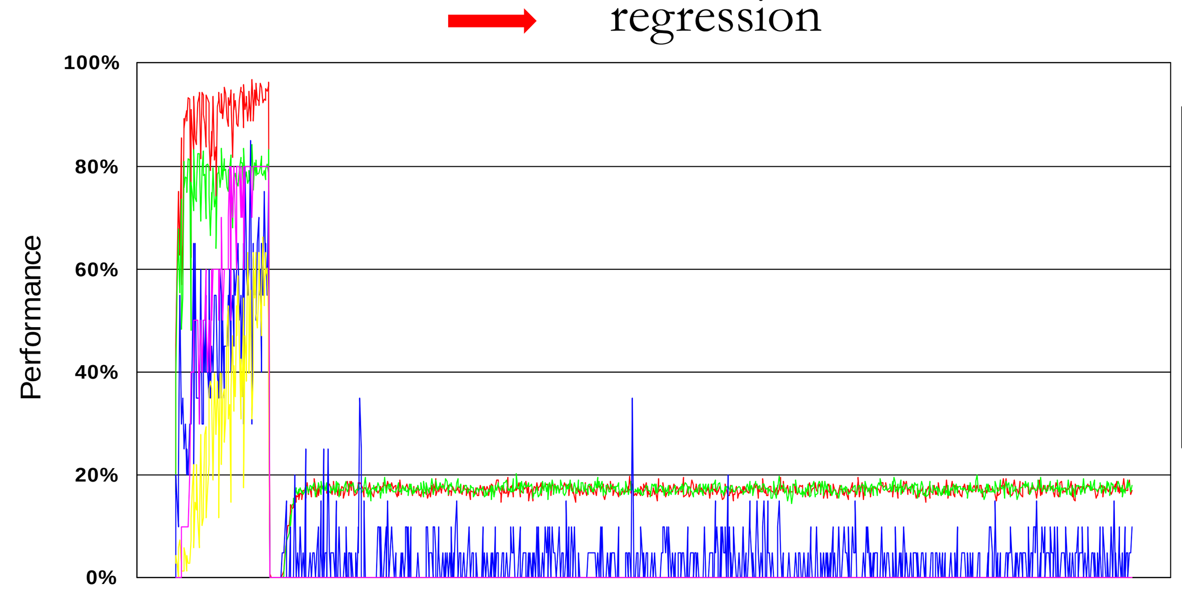
Only the manipulation of **pruning threshold** generated patterns of developmental regression

Small pruning threshold (0.4) - normal → typical development



Age (amount of training)

Large pruning threshold (3.0) - aggressive → regression

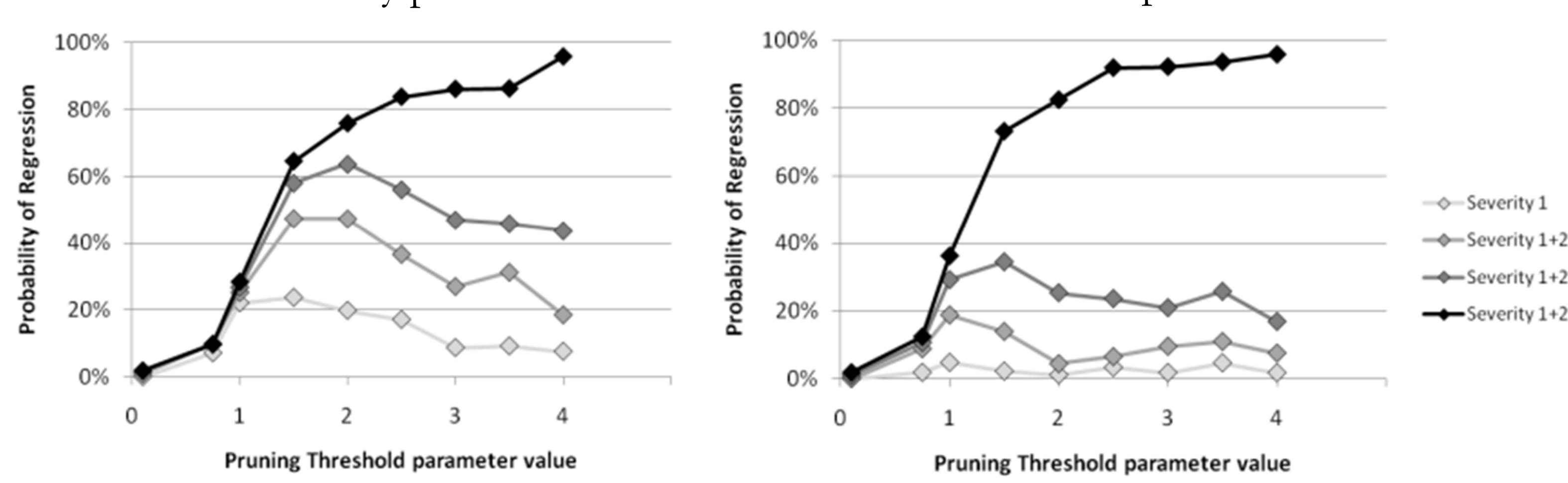


Age (amount of training)

Different coloured trajectories represent the development of different repertoires of behaviour (from easy to hard)

The severity of regression was rated (0-4) for all networks over each pattern:

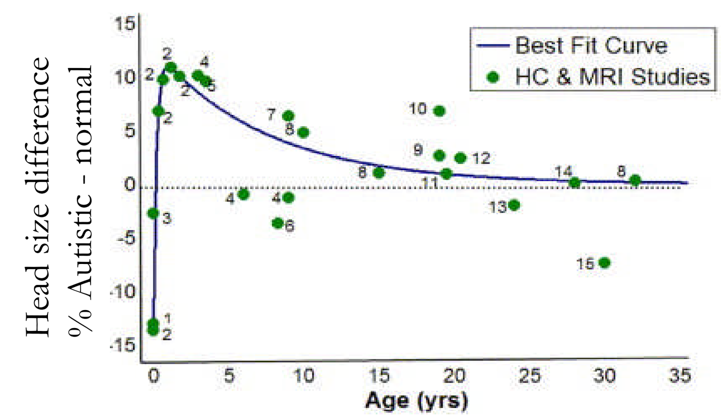
- A probabilistic relationship emerged between a high pruning threshold and developmental regression.
- The relationship between regression and threshold was non-linear and modulated by the robustness of the target behaviour.



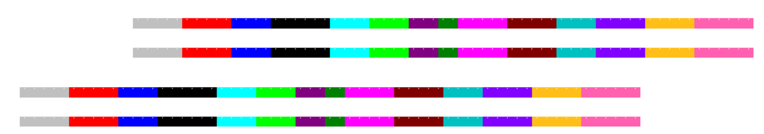
The cumulative probability of regression per severity level

Explaining empirical phenomena

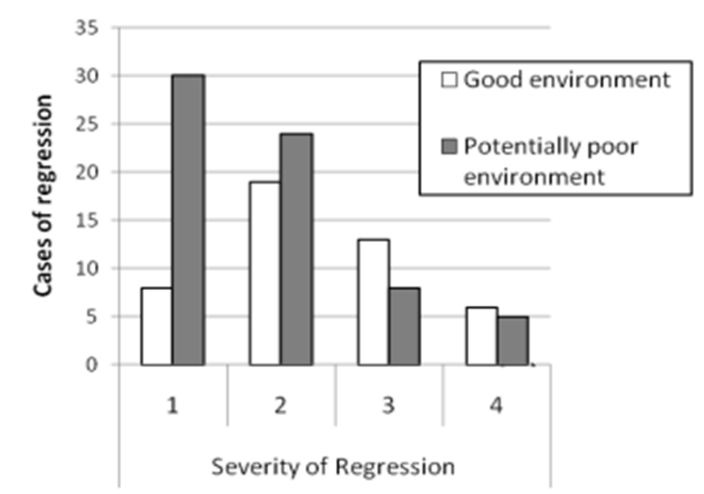
1. **Large head size** is associated with high IQ in typical development *and* Autism in the first year of life (see Redcay & Courchesne, 2005). In our model, dense networks were associated with good performance given low pruning thresholds *and* regression given high pruning thresholds.



2. **Overlap with SLI:** a common gene variant on chromosome 7 has been found more frequently in both Autism and Specific Language Impairment (Vernes et al., 2008). In our model, a *network activation* parameter acted as both a risk factor for regression and a direct cause of delayed development.



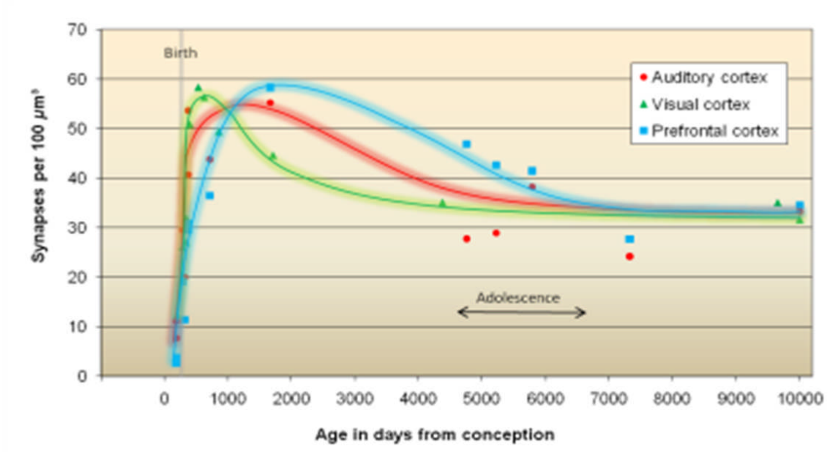
3. **Quasi autism:** extreme environmental deprivation is associated with autistic-like behaviours (Rutter et al., 1999). In our model, a population of networks 'at-risk' for impoverished training sets showed in a higher percentage of cases of mild regression. Impoverished environments resulted in small, connections, more vulnerable to even mildly aggressive pruning.



A novel prediction

The timing of synaptic pruning is not uniform across the brain. It occurs at different times in different neural systems (see Huttenlocher, 2002). Therefore if regression is caused by an aberrant pruning process, systems which show ontogenetically earlier pruning should also be the first to show regression.

Sensorimotor behaviours should regress before language and social skills.



Synaptogenesis and pruning by cortical region

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