A saturation model for impaired learning with enhanced plasticity

based on work in preparation by: T.D. Barbara Nguyen-Vu, Grace Q. Zhao, Han-Mi Lee, SL, Surya Ganguli, Carla J. Shatz, Jennifer L. Raymond

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July 9, 2013



Impaired learning with enhanced plasticity

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└─Outline

- VOR learning and the cerebellum
- 2 The effects of enhanced plasticity and saturation
- Modelling approach
- 4 Modelling results

Section 1

VOR learning and the cerebellum

The effects of enhanced plasticity and saturation

Section 2

The effects of enhanced plasticity and saturation

Questions

- Can we find a purely synaptic explanation of these results?
- Can the saturation effect overcome the enhanced plasticity?
- How can a little reverse bias help, but too much hurt?

Impaired learning with enhanced plasticity

The effects of enhanced plasticity and saturation

Questions

Can we find a purely synaptic explanation of these results?

Can the saturation effect overcome the enhanced plasticity?
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Section 3

Modelling approach

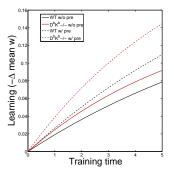


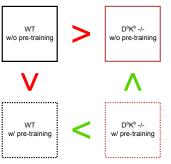
Section 4

Modelling results

Binary synapse









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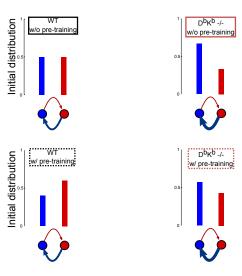
Modelling results

 \sqsubseteq Binary synapse

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1. understand why next slide

Binary synapse: initial distributions



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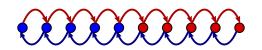
Modelling results

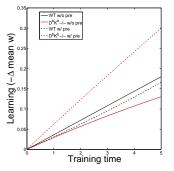
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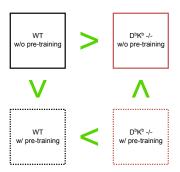
Binary synapse: initial distributions

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Serial synapse







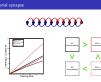


Impaired learning with enhanced plasticity

Modelling results

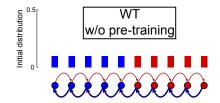
└─Serial synapse

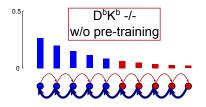
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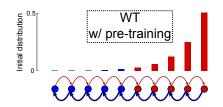


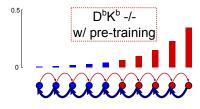
1. understand why next slide

Serial synapse: initial distributions









Impaired learning with enhanced plasticity

Modelling results

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Serial synapse: initial distributions



—Serial synapse: initial distributions

1. understand why next slide

Learning rate
$$\sim \mathbf{p}_{M/2}^{\infty} \left(\frac{q^{\text{dep}}}{q^{\text{pot}}} \right) = \mathcal{N} \left(\frac{q^{\text{pot}}}{q^{\text{dep}}} \right)^{\frac{M}{2} - 1}$$
.

For M > 2, larger $q^{\text{dep}} \implies$ slower learning.

For M=2, larger $q^{\text{dep}} \implies \text{larger } \mathcal{N} \implies \text{faster learning}$.

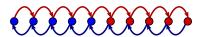
Impaired learning with enhanced plasticity -Modelling results └─ Mathematics

Serial synapse: $\mathbf{p}_{i}^{\infty} \sim \mathcal{N}\left(\frac{g^{mn}}{g^{mp}}\right)^{i}$.

Essential features

The success od the serial model relies on two features:

- Enhancing the effect of saturation,
- Metaplasticity repeated potentiation makes subsequent depression harder.



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Modelling results

Essential features

The success of the serial model relies on two features:

• Enhancing the effect of saturation,

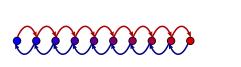
• Metaplasticity – reputed potentiation makes subsequent depression harder.

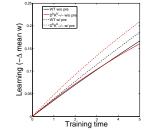
Essential features

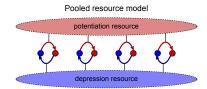
- 1. due to exponential decay
- 2. push away from boundary where signal generated
- 3. borne out by other models that fail/succeed

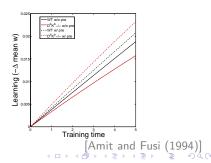
Other models that fail

Multistate model









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Modelling results



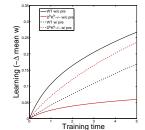
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Other models that fail

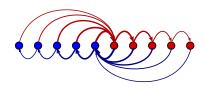
Other models that work

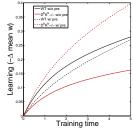
Non-uniform multistate model





Cascade model





[Eusi et al. (2005)]

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Other models that work



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References I



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