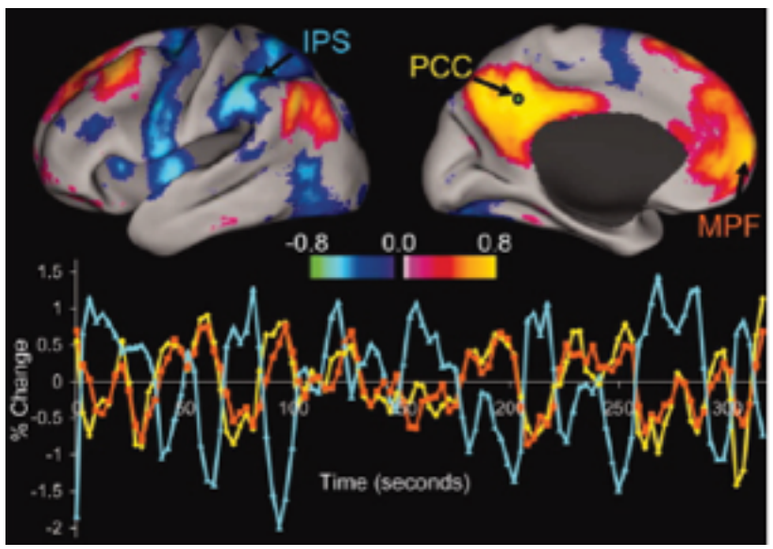
Efficient Signal Processing in Random Networks that Generate Variability:

A comparison of internally and externally induced variability

Sakyasingha Dasgupta*, Isao Nishikawa, Kazuyuki Aihara & Taro Toyoizumi*
*Lab for Neural Computation & Adaptation, RIKEN Brain Science Institute, Japan

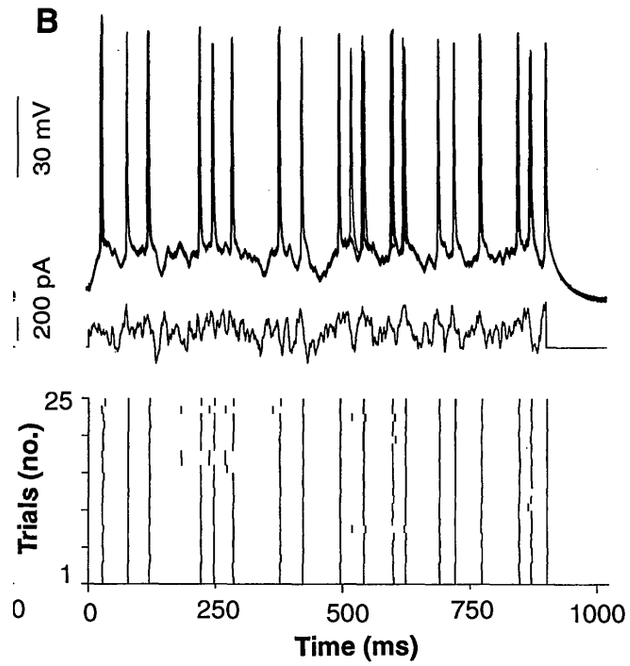
What is the source of cortical variability and its effect on computation?

resting state is highly irregular



Fox et al. PNAS 2005

neurons are reliable in isolation.



Mainen and Sejnowski Science1995

Deterministic and stochastic networks exhibit the same spontaneous activity

MODEL

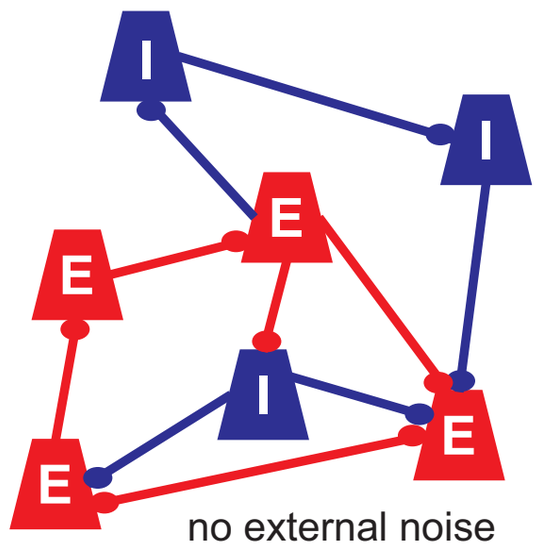
Balanced Randomly connected quadratic-integrate-and-fire neurons

$$\tau_V \dot{V}_i = (V_i - V_0)(V_i - V_1) + \sum_j J_{ij} r_j + I_i$$

$$\tau_r \dot{r}_i = -r_i + \tau_V \delta(V - V_\infty)$$

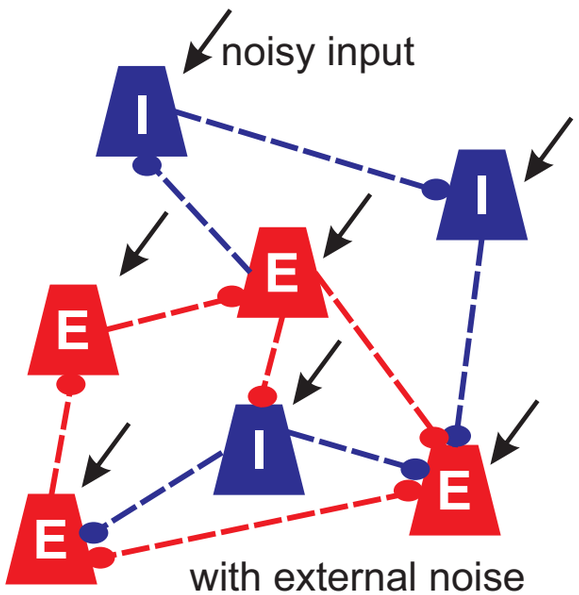
Deterministically chaotic

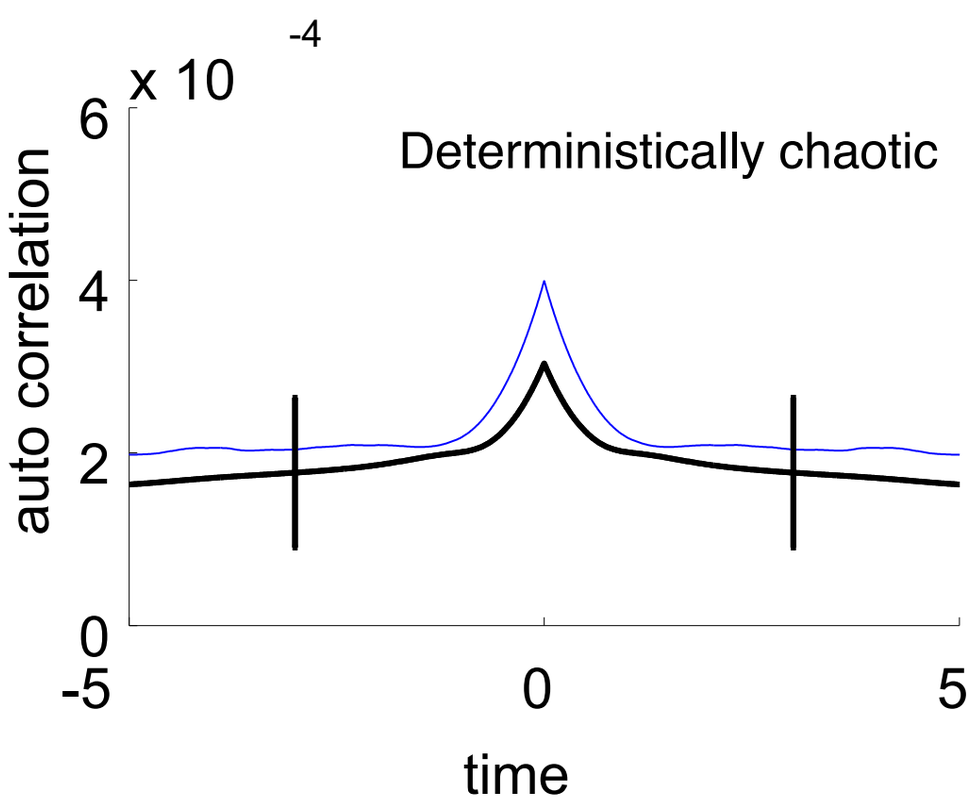
Strongly connected

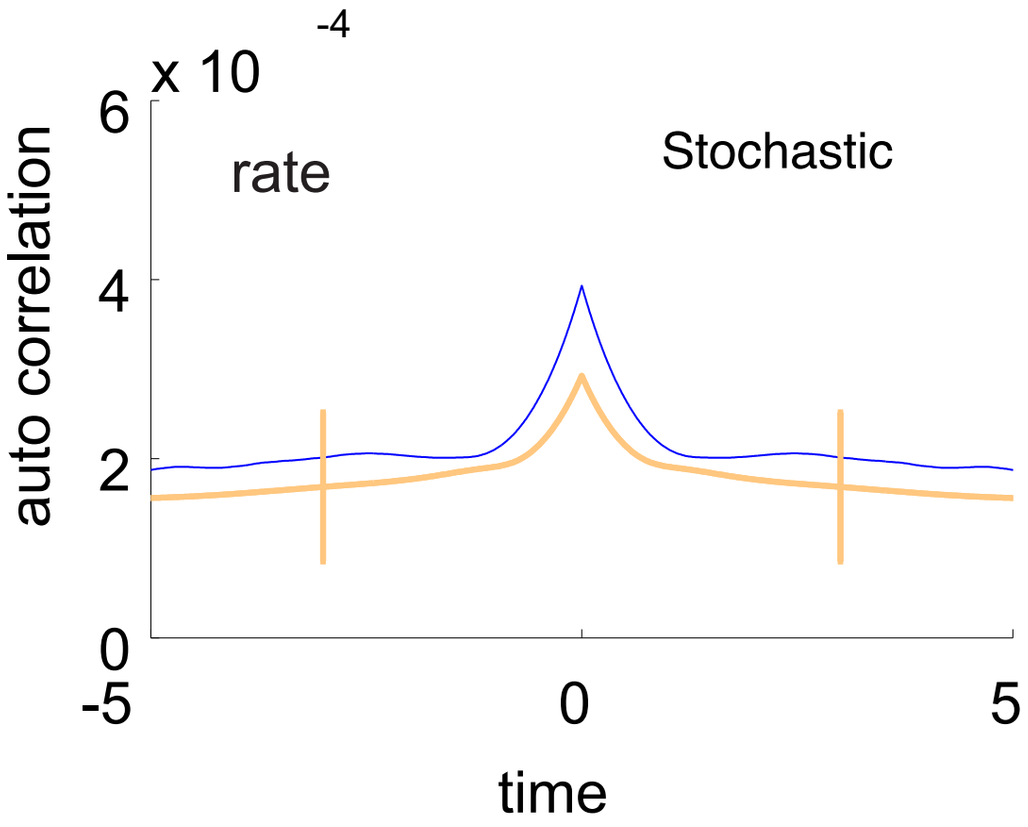


Stochastic

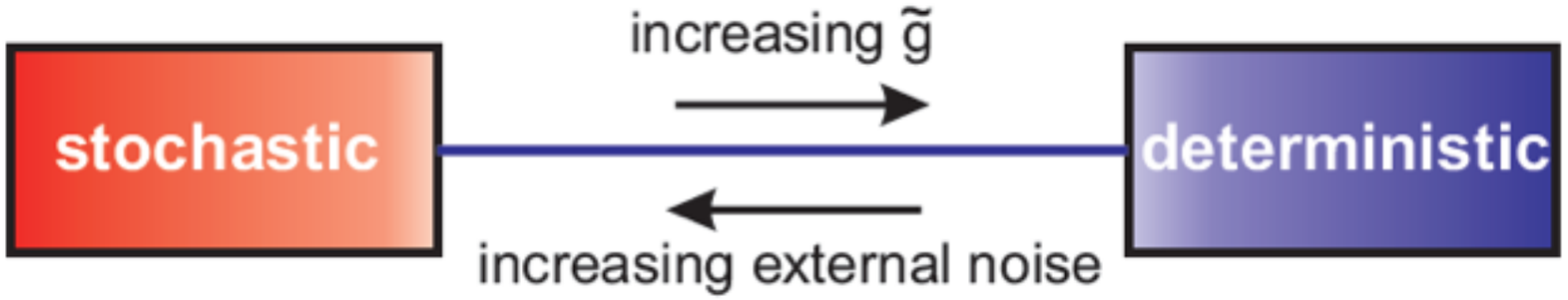
Weakly connected







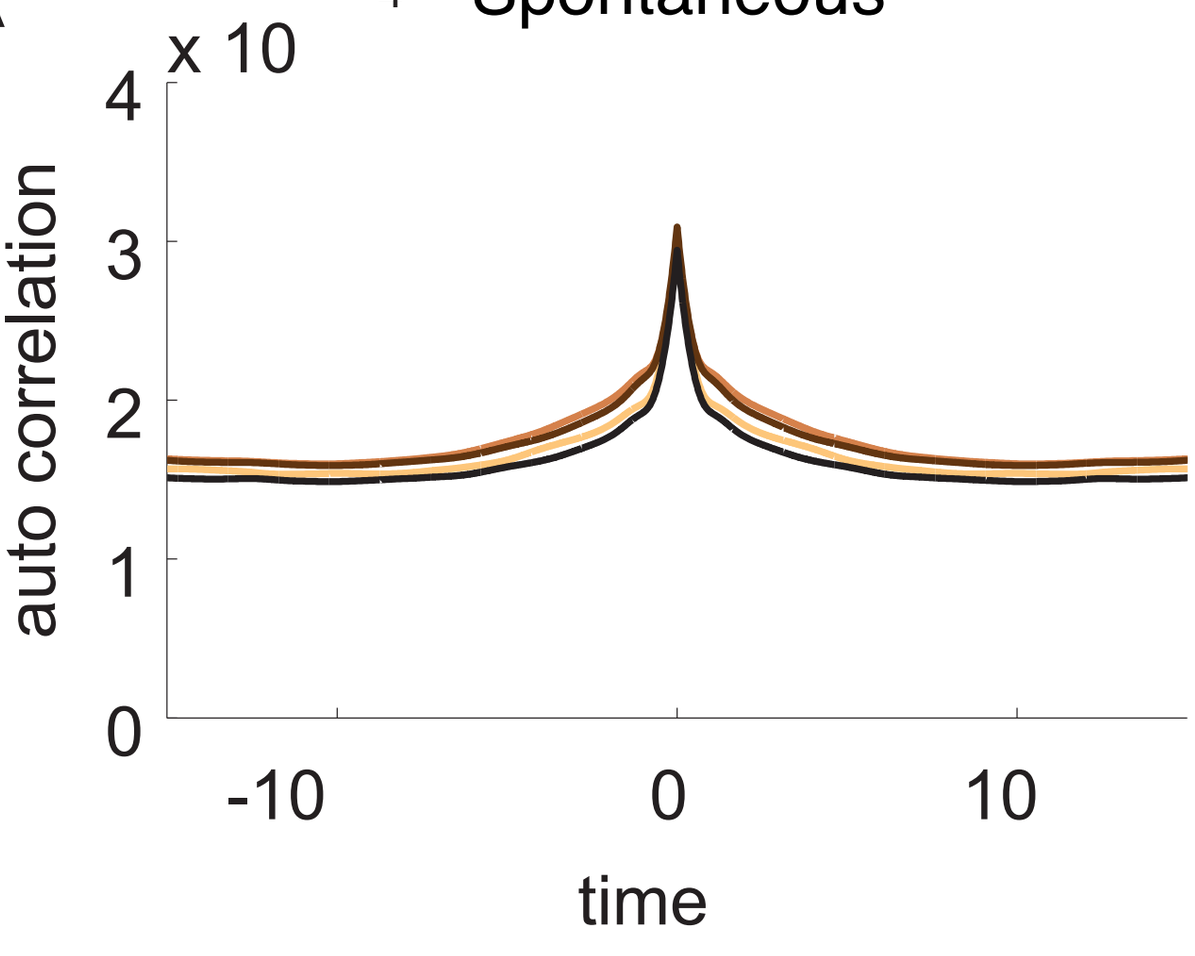
DMFT: a one-parameter family with the same spontaneous activity



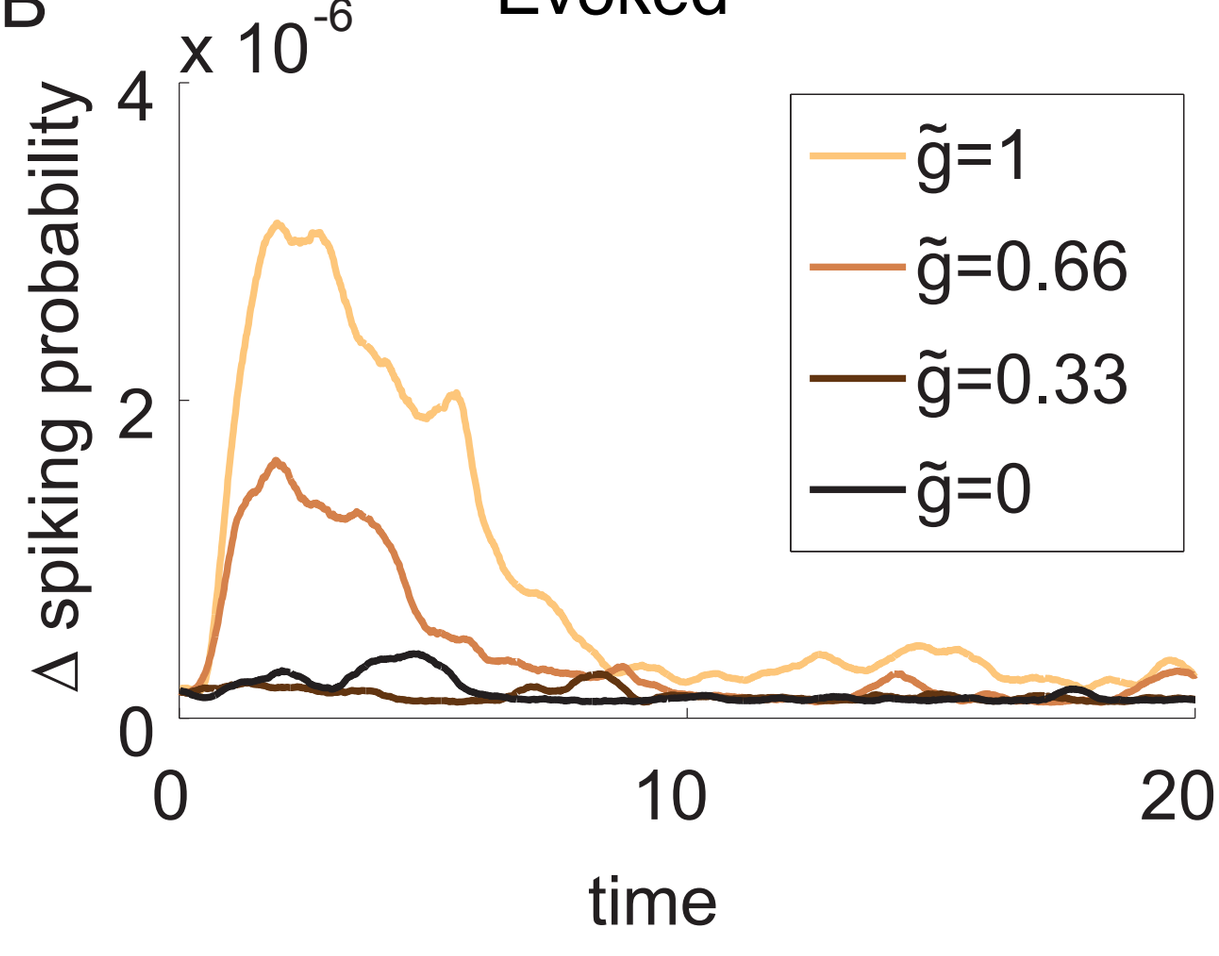
$$\Gamma(\tau) = \left[1 - (\tilde{g})^2\right](c(\tau) - \ddot{c}(\tau))$$

$\tilde{g}$: represents the magnitude of synaptic strength

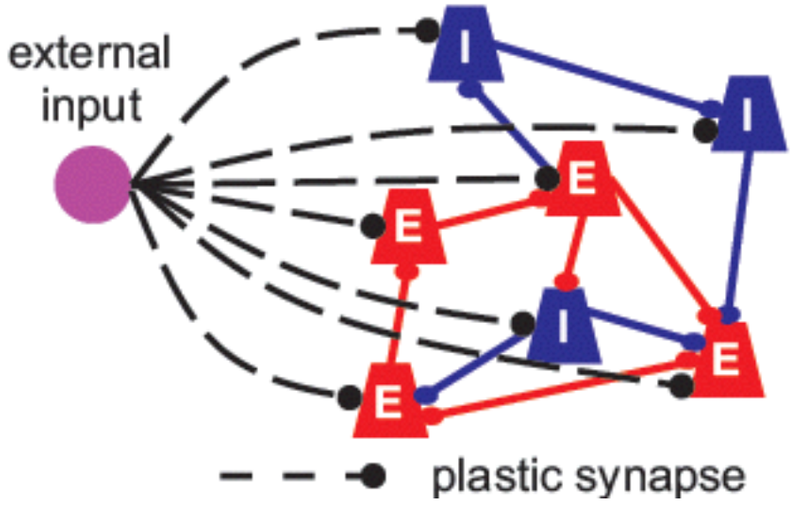
A

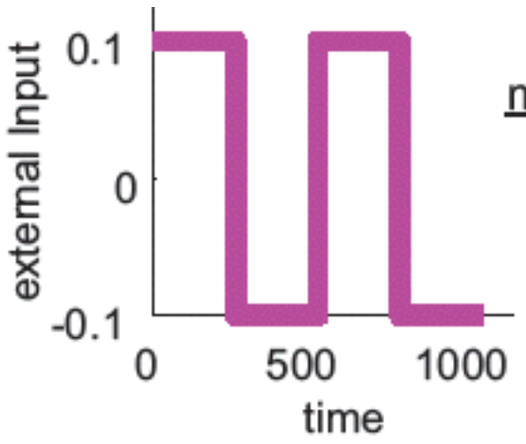


B



The source of variability influences signal processing under activity dependent plasticity



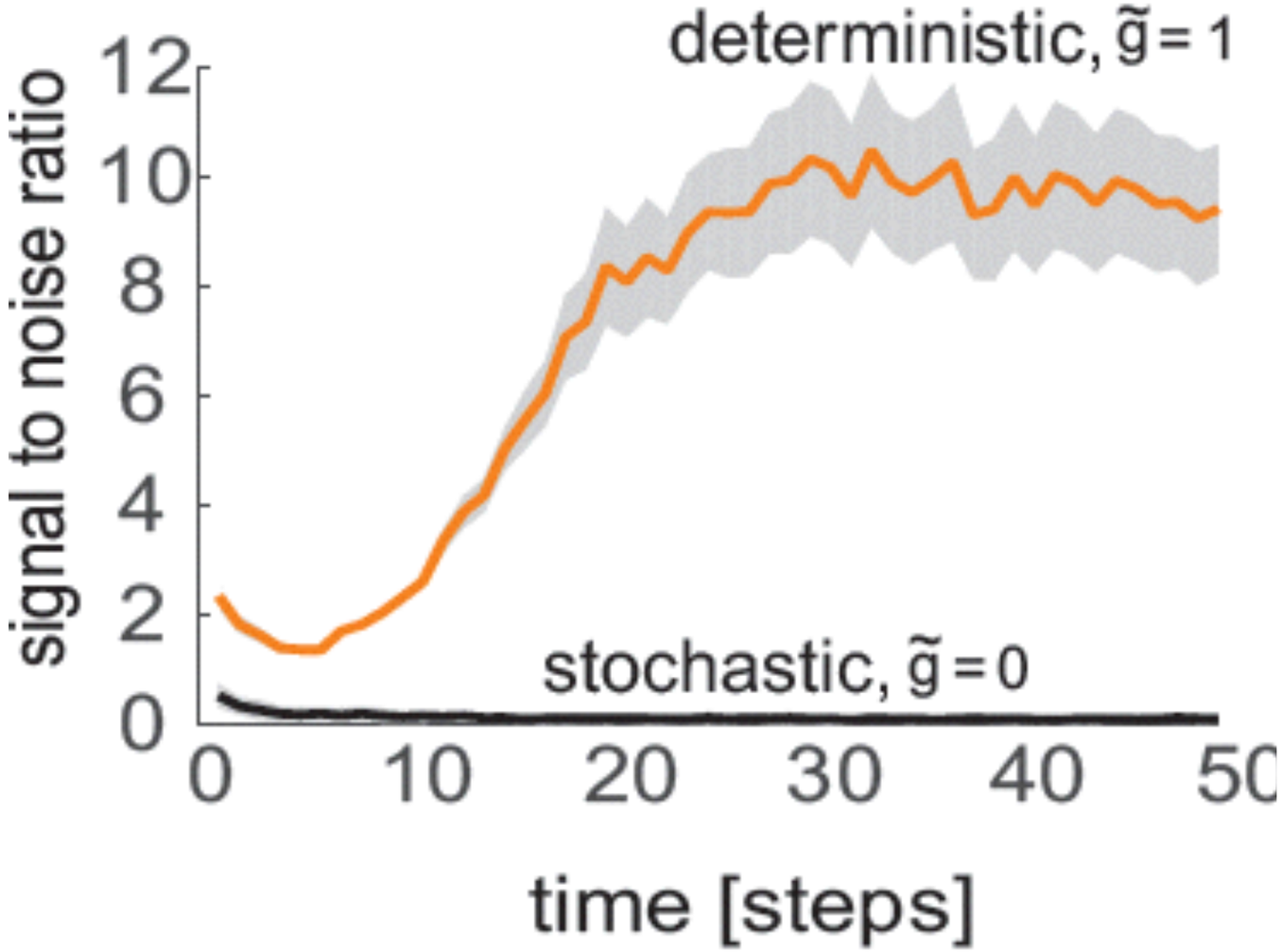


Hebbian plasticity

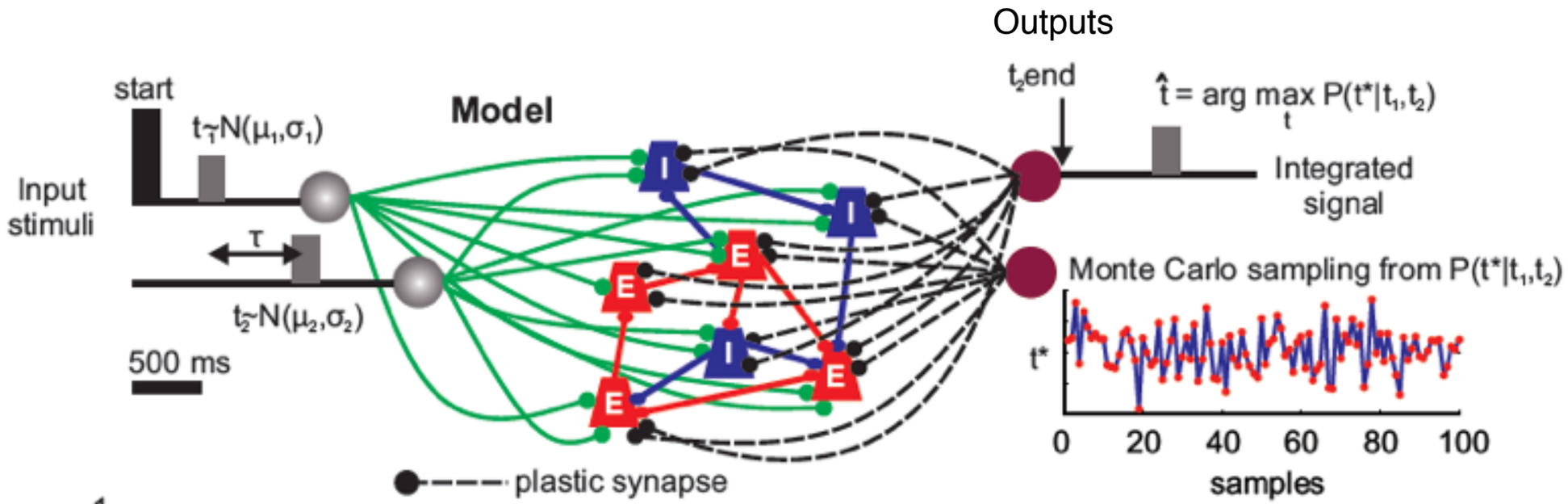
modified Oja's learning rule:

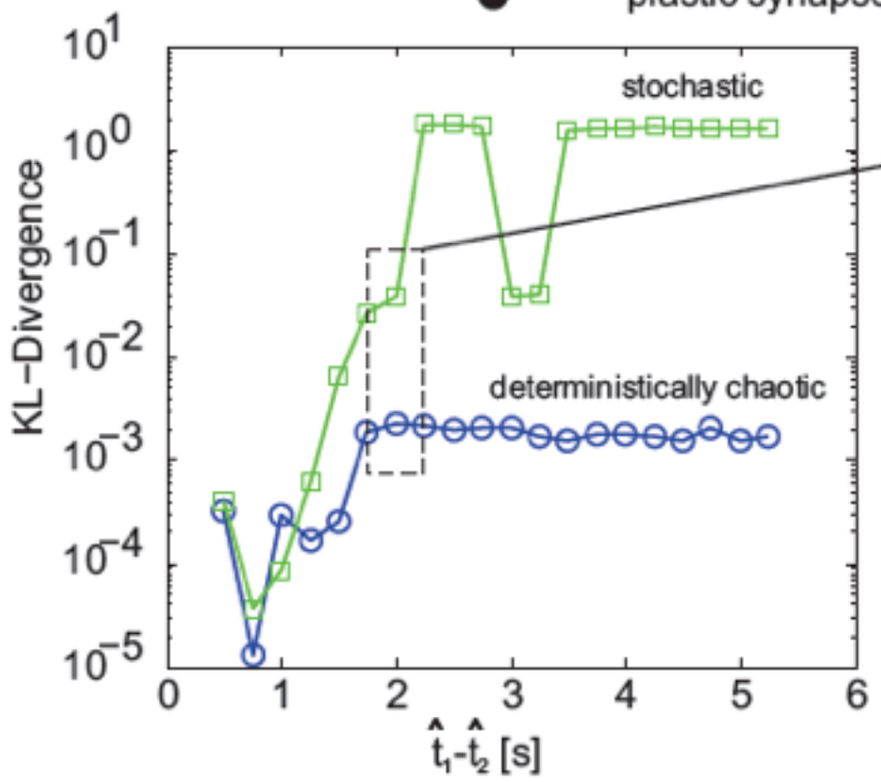
$$\tau\dot{\omega}_i = \mathrm{cov}\,[r_i, x] - \gamma|\vec{\omega}|r_i^2$$

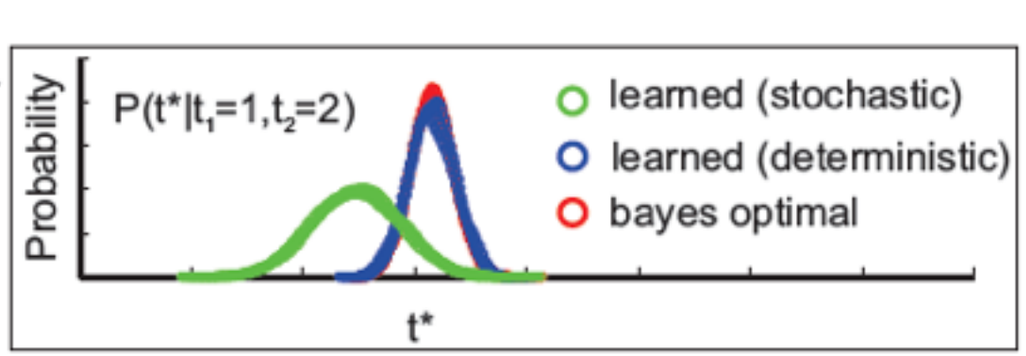
synaptic strength · input · time constant · firing rate



Internally generated variability (deterministic chaos) as substrate for Bayesian integration and sampling







Deterministic chaotic network performs bayes optimal probabilistic computation

<u>Conclusion:</u> Deterministic chaos as a possible substrate for cortical variability and efficient neural computations

→ POSTER