Efficient Signal Processing in Random Networks that Generate Variability: A comparison of internally and externally induced variability

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

resting state is highly irregular

neurons are reliable in isolation.

Fox et al. PNAS 2005

Mainen and Sejnowski Science 1995
Deterministic and stochastic networks exhibit the same spontaneous activity

**MODEL**

Balanced Randomly connected quadratic-integrate-and-fire neurons

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

\[
\tau_r \dot{r}_i = -r_i + \tau_V \delta(V - V_\infty)
\]
DMFT: a one-parameter family with the same spontaneous activity

![Diagram showing the transition from stochastic to deterministic models with increasing $\tilde{g}$ and increasing external noise.](image)

\[ \Gamma(\tau) = [1 - (\tilde{g})^2] (c(\tau) - \bar{c}(\tau)) \]

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

**A** Spontaneous

**B** Evoked

![Graphs showing spontaneous and evoked activity with different $\tilde{g}$ values.](image)
The source of variability influences signal processing under activity dependent plasticity.

Hebbian plasticity

modified Oja’s learning rule:

\[ \tau \dot{\omega}_i = \text{COV} \left[ r_i, x \right] - \gamma |\bar{\omega}| r_i^2 \]

- time constant
- firing rate

Deterministic, \( \tilde{g} = 1 \)

Stochastic, \( \tilde{g} = 0 \)
Internally generated variability (deterministic chaos) as substrate for Bayesian integration and sampling

Conclusion: Deterministic chaos as a possible substrate for cortical variability and efficient neural computations