Response correlation dissects spiking variability and subthreshold variability in a model of V1 neurons

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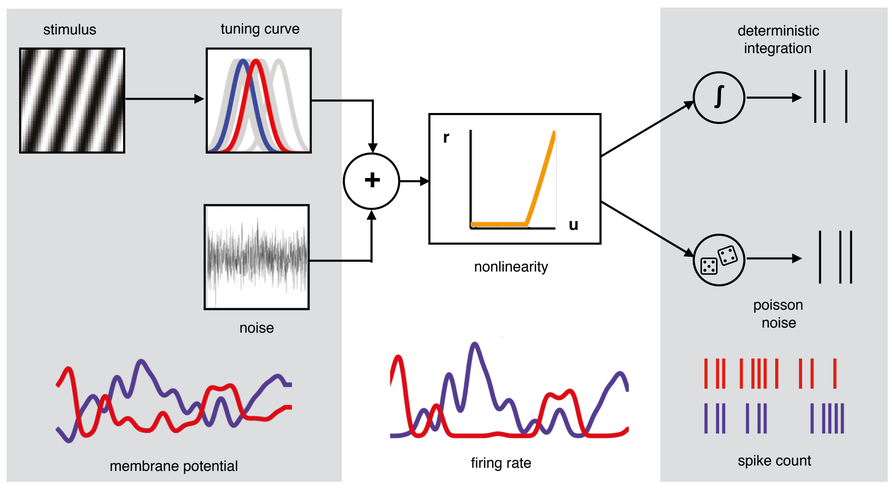
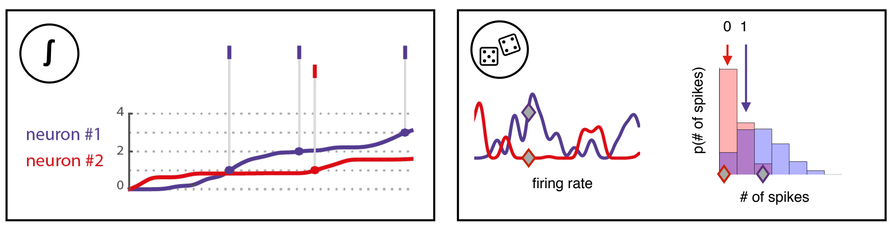
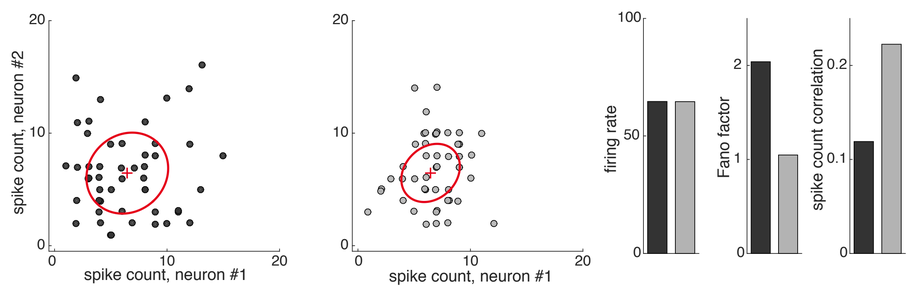
Models of stochastic and deterministic spike generation in simple model neurons

- instantaneous firing rates are produced by a threshold nonlinearity acting on correlated Gaussian membrane potentials
- the Doubly Stochastic Poisson (DSP) model samples spike counts from a Poisson distribution, while the Rectified Gaussian (RG) model produces spike counts deterministically from the firing rate

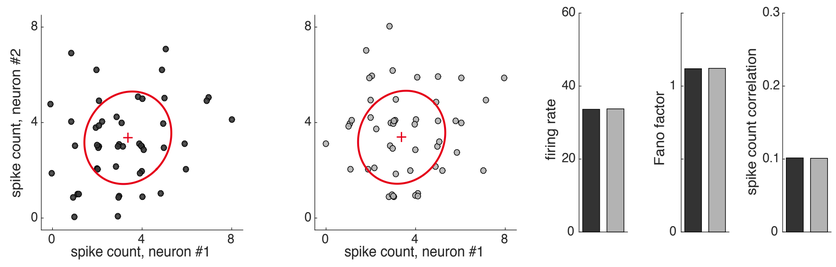




Matching spiking statistics in the two models

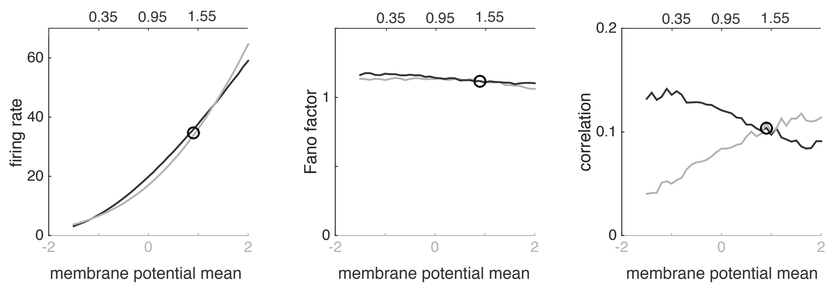


- The two model produce different spiking statistics using similar membrane potentials, but their spiking statistics can be matched using different membrane potential statistics (DSP - black, RG - grey)

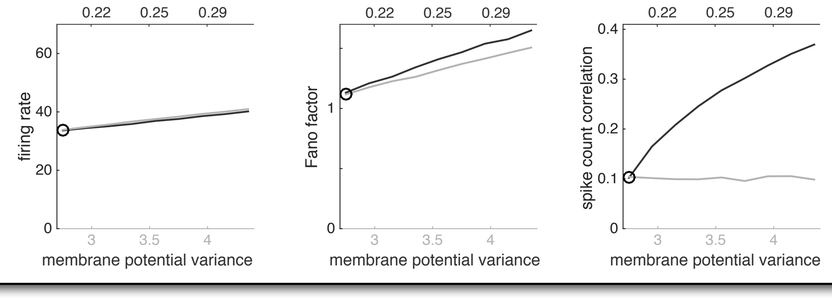


Dependence of spiking statistics on membrane potential mean and variance

- spike count means and variances in the two models depend similarly on membrane potential mean, but spike count correlations dependences differ (DSP - black, RG - grey)

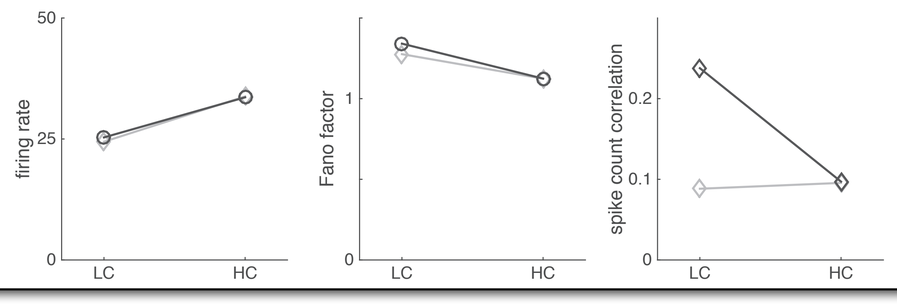


- changing membrane potential variance also introduces different effects in the spike count correlations in the two models



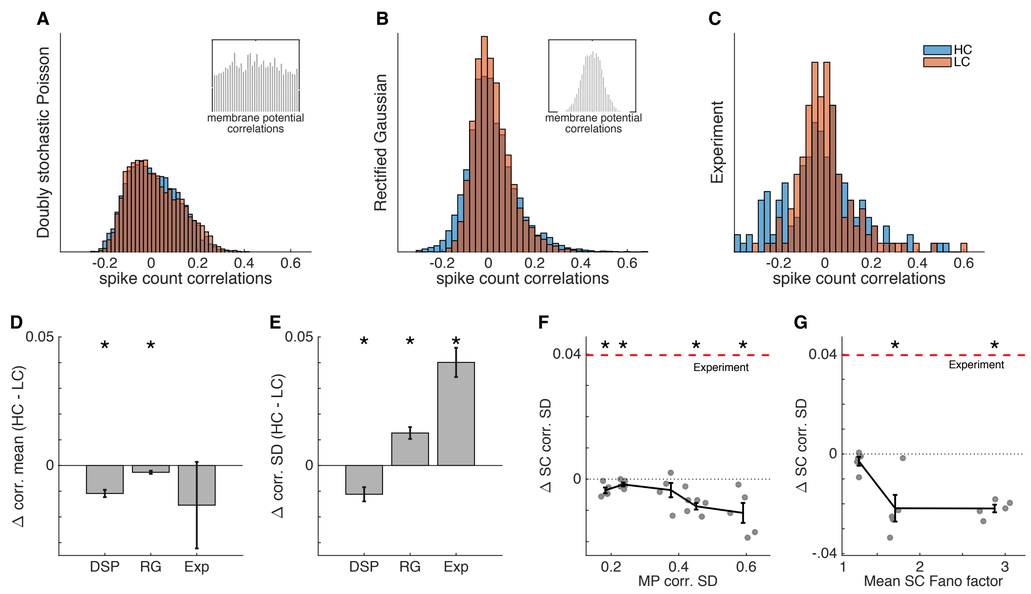
Spiking statistics in response to changing stimulus contrast

- higher contrast elicits a membrane potential response of higher mean and lower variance
- the two models predict different changes in spike count correlations in response to increasing contrast (DSP - black, RG - grey)

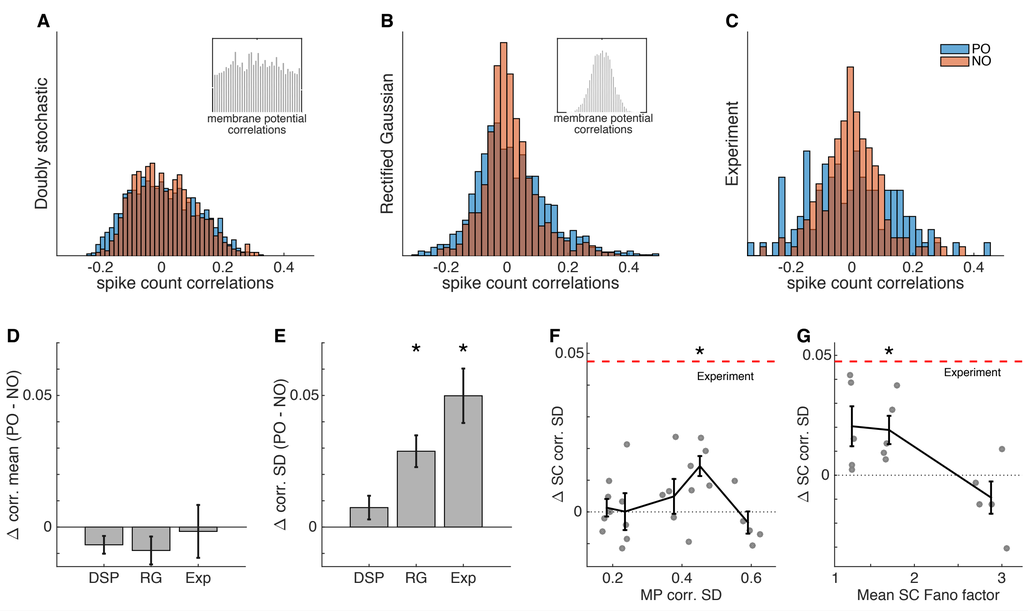


Contrast-dependent modulation of spiking correlations in a population of simple cells

- spike count statistics in simulated populations of DSP and RG neurons are contrasted to experimental results of Ecker et al, 2010.



- spiking responses to changing contrast (HC and LC) and orientation (PO and NO) are better predicted by the RG model



Conclusions

- It is possible to discriminate between spiking models based on only population measures of spiking activity
  - no need to know the membrane potential
  - no need to precisely control receptive field contents
- Experimentally measured dependence of the population distribution of spike count correlations on stimulus properties is compatible with assuming stochasticity in the membrane potential only, but not with Poisson spiking

Acknowledgements

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