3.2 Exploratory analysis of a theoretical model

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Dynamical models with two populations (excitatory (E) and inhibitory (I) neurons) of visual processing have been used to reproduce a host of experimentally documented phenomena in V1. When an inhibition stabilized network (ISN, the I population stabilizes an otherwise unstable E population), these models exhibit the paradoxical effect [1], selective amplification [2], surround suppression [3], and sensory integrative properties [4]. Since almost all I neurons fall into one of three classes (parvalbumin (P)-, somatostatin (S)-, and vasointestinal peptide (V)-expressing neurons) [5, 6], theoretical neuroscientists look to extend these dynamical models to four populations [7]. A current challenge in theoretical neuroscience is understanding the distributed role of inhibition stabilization across these inhibitory subtypes.

These four populations exhibit neuron-type specific connectivity (Fig. 1A) [8], in which some populations do not project to others. Since S and V are the only populations that mutually inhibit each other, a popular conceptualization is that S and V have winner-take-all dynamics. In fact, evidence in mice suggests that V silences S when presented with large stimuli, and S silences V for small stimuli [9]. Here, we use DSNs to understand the possible sources of inhibition stabilization in this V1 model, when either S or V is inactive, selecting the weight matrix parameters as the free parameters of the DSN. The behavior of the DSN sampled models is constrained to produce two things: 1.) a mean-zero distribution of ISN coefficients $\gamma(W) = 1 - f'(f^{-1}(r_E(W)))W_{EE}$ with some variance, and 2.) α-population silencing $r_\alpha(W) = 0$, for $\alpha \in \{S, V\}$. When $\gamma < 0$ the network is ISN, and not ISN otherwise. Constraining the DSN behavior to a zero-mean distribution of ISN coefficients gives us samples of both ISN and non-ISN networks, optimizied to have greatest variety of stabilization motifs.

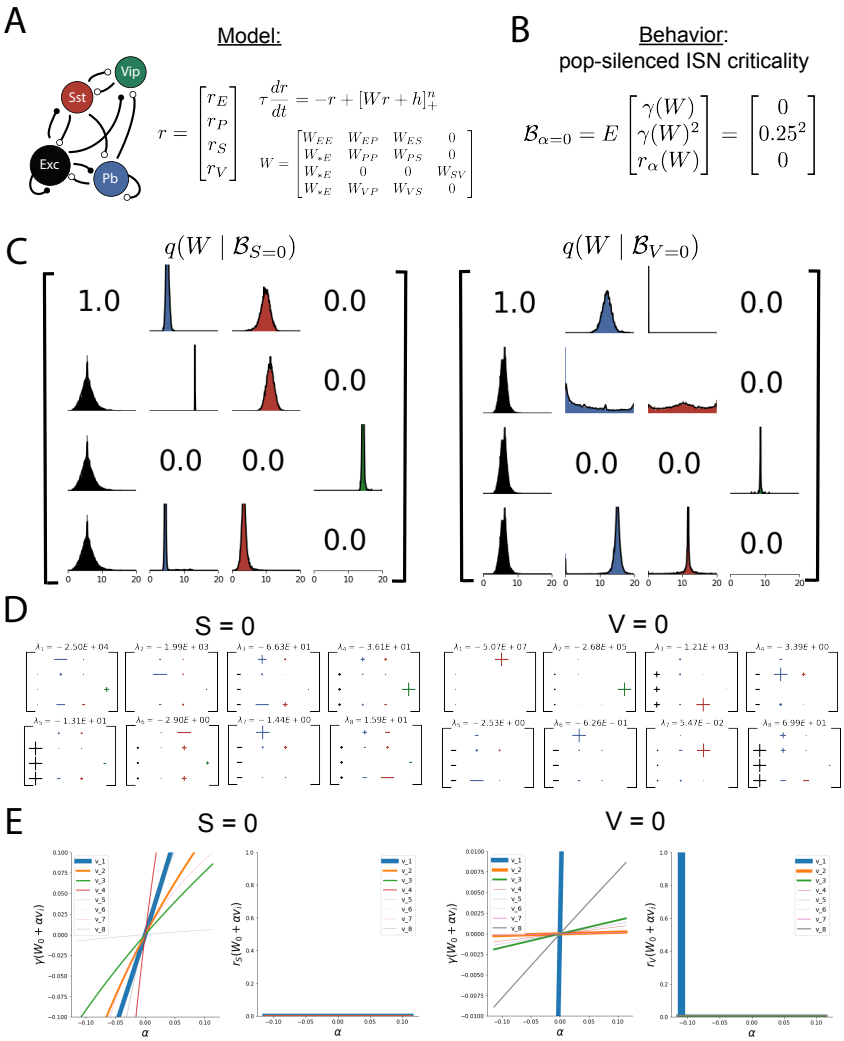

Figure 1: A.) Model of primary visual cortex (V1) Neurons: E - excitatory (black), P - parvalbumin- (blue), S - somatostatin- (red), and V - VIP-expressing (green). Parameters: weights of the dynamics matrix W. B.) The DSNs are conditioned on population-silenced ISN criticality. C.) DSN distribution of the parameters of the V1 model conditioned on population-silened ISN criticality. D.) Eigenmodes of the hessian of each DSN ordered by eigenvalue. E. Behavioral sensitivity of the model along each mode of the hessian.

The DSN posteriors are blah blah blah

References

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