

UP-DOWN cortical dynamics reflect state transitions in a bistable network

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Detecting UP and DOWN states

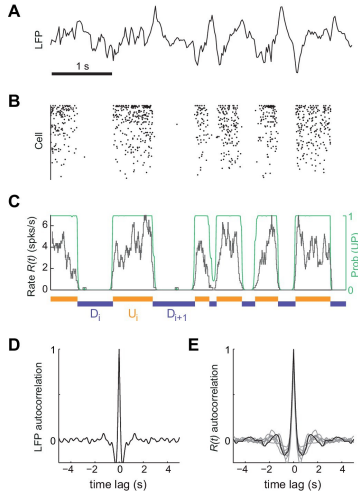


Figure 1. In the synchronised state (urethane anesthesia) the population oscillates between a low-rate UP state and a quiescent DOWN state.

UP and DOWN statistics

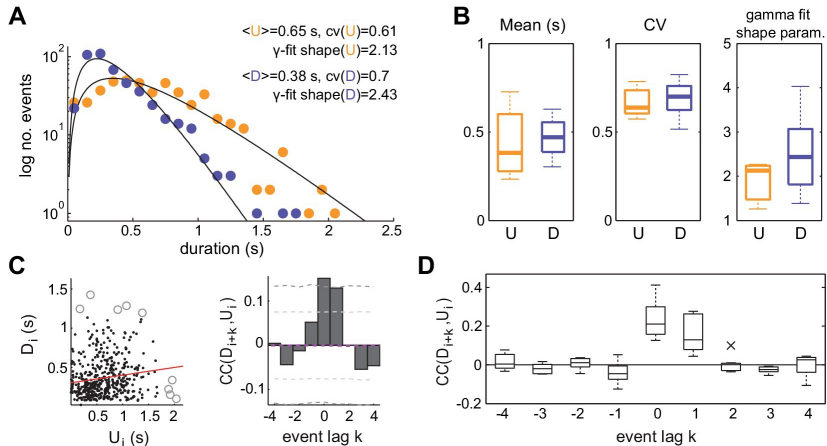


Figure 2. Transitions between UP and DOWN states are irregular but their lengths are temporally correlated.

Dynamics of population rate in UP and DOWN states

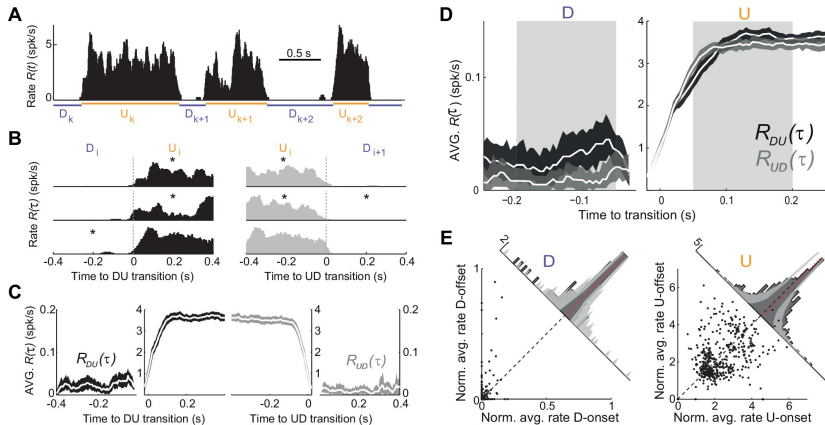


Figure 3 The population firing rate stays stable during the UP state and increases slightly at the end of the DOWN state.

Simplified rate model of UP and DOWN states

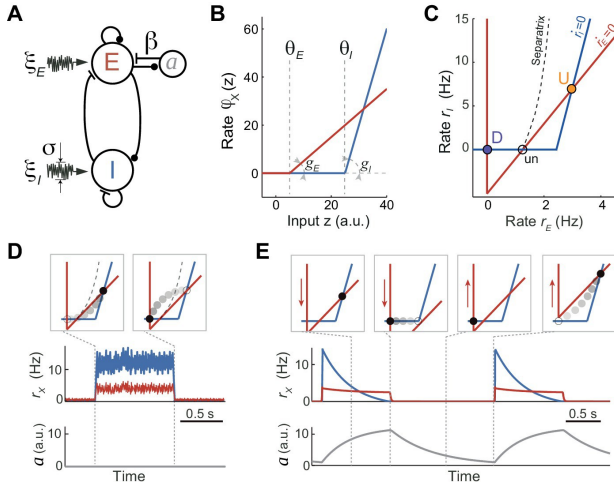


Figure 4. A model with threshold-linear transfer function of inhibitory and excitatory populations manifests the stable DOWN (quiescent) and UP (low non-zero rate) states.

Exploring the parameter space

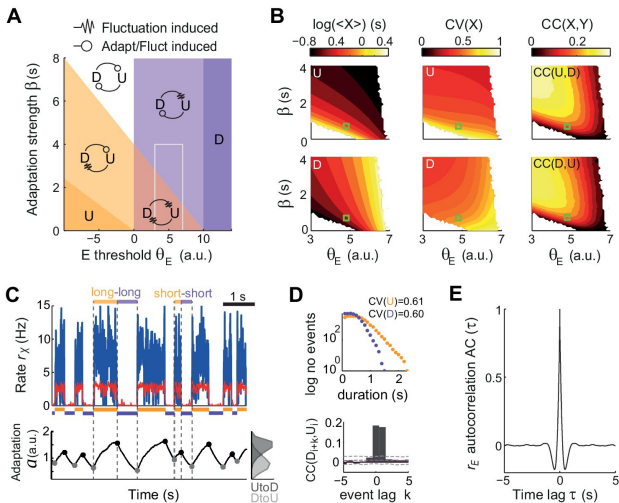


Figure 5. The transitions between UP and DOWN states can be either fluctuation- or adaptation-driven depending on the adaptation strength and firing threshold of the inhibition.

Dynamics of the inhibitory and excitatory firing rate in the model

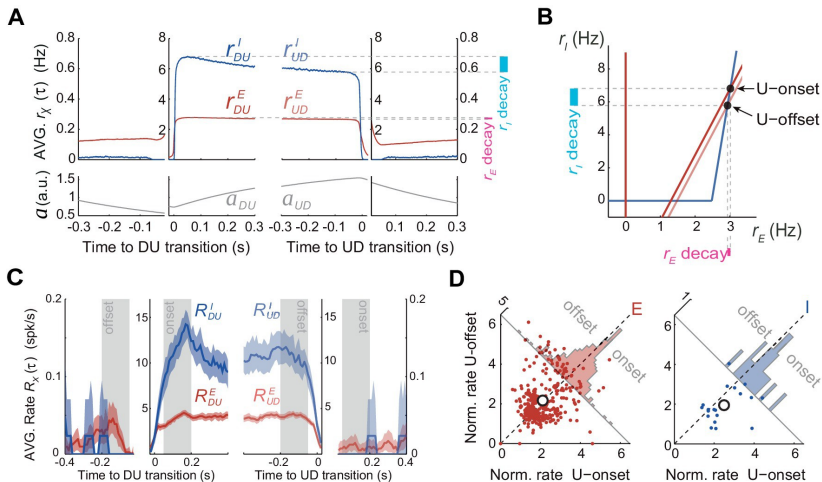


Figure 6. Although the adaptation affects only E population, both in model and data the I rate decays at the end of UP state. Conversely, the E rate increases slightly at the end of DOWN state.

Spiking network model of UP and DOWN state

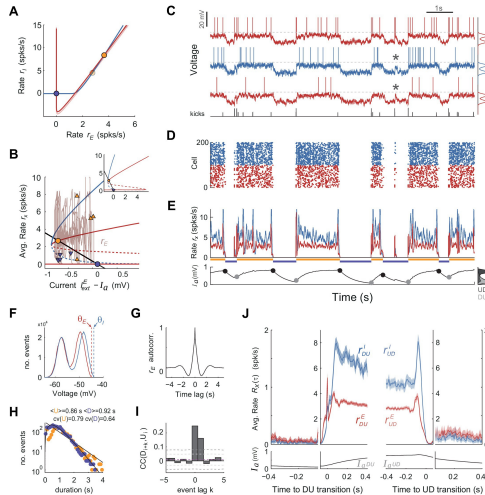


Figure 7. In the spiking network with bi-stable membrane dynamics the UP-to-DOWN transitions are spontaneous but DOWN-to-UP transitions require an external synchronous “kick”.

Key Points

- ▶ irregular up-down transitions
- ▶ serial correlations between UP/DOWN states lengths
- ▶ noise- vs adaptation-driven transitions
- ▶ change of firing rate at the onset vs. offset of UP state in inhibitory and excitatory neurons
- ▶ DOWN to UP transitions in realistic models with moderate noise
- ▶ origins of “kicks” - hand waving arguments (sparse connectivity, synchronous events, thalamocortical inputs)
- ▶ inhibition stabilised vs. shunting inhibition (Kumar 2008, Latham 2000) vs. contractive nonlinearity (Amit & Brunel, 1997)