Spike timing precision: stimulus dependence and predictability

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Neural responses are variable: repeating a stimulus yields spike trains that vary in total spikes and spike timing. Visual cortex likely uses timing of retinal spikes for stereo and motion vision. Therefore, to assess the limits of information transmission from retina through cortex, neural signals must be analyzed with a measure that quantifies spike timing precision. We developed such a measure and asked:

1. how variable is the timing of retinal spikes?
2. is spike timing variability stimulus dependent?
3. can spike timing variability be explained with a model?

1 Spike time deviation measure applied to in vivo cat ganglion cell responses to drifting sine wave gratings

2 Spike timing precision is stimulus dependent

3 Spike timing precision varies with mean firing rate, but more than predicted by a Poisson model

4 Alternative: Noisy Leaky Integrate and Fire (NLI&F) model

Spike time deviations of simulated and recorded responses are similar

5 NLI&F: stimulus dynamics and membrane noise amplitude determine spike timing precision.

6 Conclusions

1. Spike time deviations provide a quantification of response variability that is not captured by measures of spike count variability.
2. Spike timing precision depends on temporal frequency content and is higher than would be predicted by a Poisson model, especially at high mean spike rates.
3. High spike timing precision supports correlations at high temporal resolution.
4. A deterministic leaky-integrate-and-fire model with added noise accurately describes spike timing in retinal ganglion cells.