Visual response properties of neurons in the rat LGN

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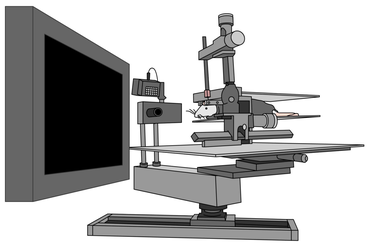
Abstract

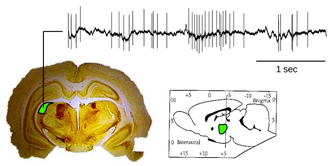
We characterize the response properties of visual neurons in the lateral geniculate nucleus (LGN) of adult Long-Evans rats. Most cells were recorded under isoflurane anesthesia; some cells were recorded in awake, eye-tracked, passively viewing conditions. We characterize the spatial frequency tuning, direction selectivity, and contrast sensitivity of neurons in the rat LGN.

We recorded extracellular spikes in response to drifting sinusoidal gratings with varying direction of motion and spatial frequency. In the anesthetized state, some cells were band pass with a peak response around 36° to 72° per cycle. However, more than half the cells responded strongest to the lowest spatial frequency that was reasonable to display on the monitor (144°/cyc), suggesting that they were low pass. Preliminary data indicate that most cells are band pass in the awake state, with a peak response about 18° to 36° per cycle. Some LGN cells show significant direction selectivity in the anesthetized state. This remains untested in the awake state.

For other cells, we presented a static square-wave grating for 200 msec per trial, varying the grating contrast from trial to trial. This stimulus was designed to match stimuli viewed by other rats in an awake behaving paradigm. Most LGN neurons reduced firing as contrast decreased, and some completely ceased to fire at low contrast suggesting that behavioral performance at these contrasts was probably limited by sensory encoding rather than cognitive confusion.

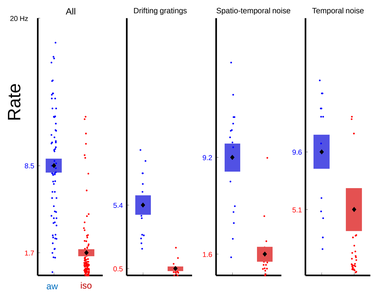
To fit the stimulus-response relationships in these data, we used a generalized linear model (GLM) that separately accounts for the effects of the stimulus parameter of interest, refractoriness (spiking neural history), and the state of the network (LFP).



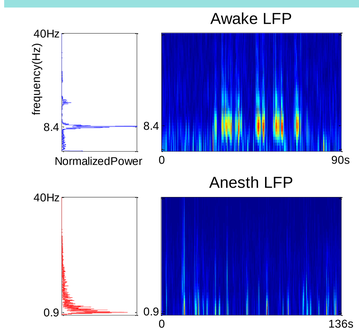


-Rat visual thalamus (putative dLGN)
-Extracellular recording
-Awake and anesthetized
  -Awake: passive viewing (24 cells)
  -Anesthesia: 1-2% isoflurane (34 cells)

Isoflurane reduces evoked firing rate



Isoflurane reduces 6-10Hz LFP power

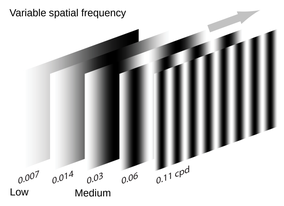


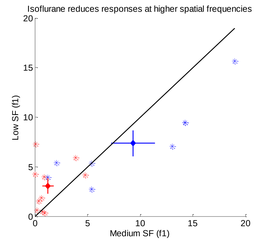
Methods

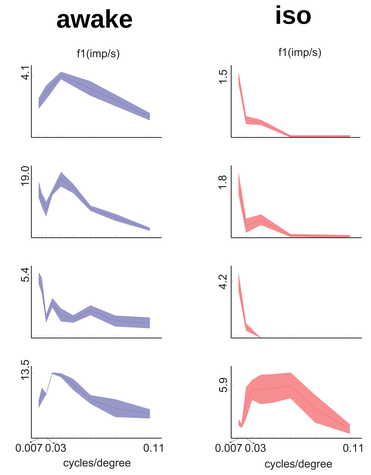
We recorded from the visual responses of single cells from the thalamus of Long Evans rats during awake and anesthetized conditions. Awake rats passively viewed the CRT monitor while head fixed. The same experimental apparatus was used for anesthetized rats. These rats were initially exposed to 3-5% Isoflurane, and then sustained at 0.75-2%.

Extracellular single unit recordings were performed with FHC Tungsten electrodes (2-15 MOhm) or 16 channel NeuroNexus probes(A1X16). Neurons were identified by virtue of visual responsiveness to 2Hz drifting gratings. Isolated cells were recorded responding to drifting gratings, flashed gratings, and flickering noise sequences. Stimuli were generated with PsychToolbox. The right pupil was tracked using an infra-red optical tracking system (EyeLink-1000). All experiments were conducted under the supervision and with the approval of IACUC at UCSD.

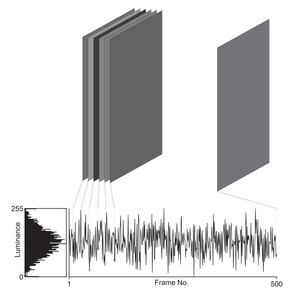
Isoflurane acts as a spatial low pass

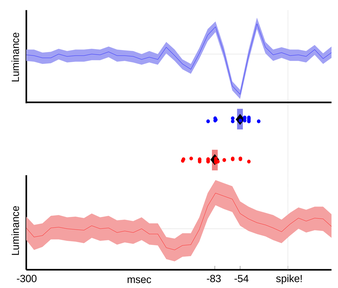




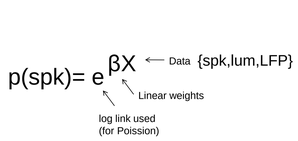


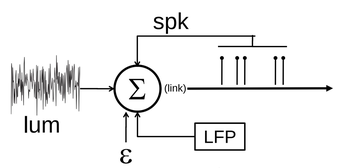
Isoflurane slows temporal STA

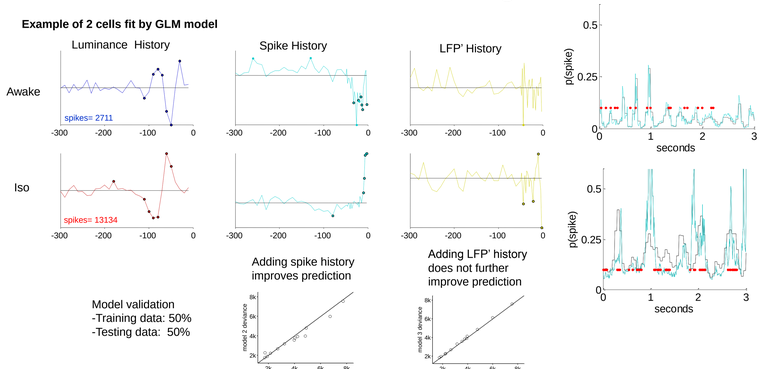




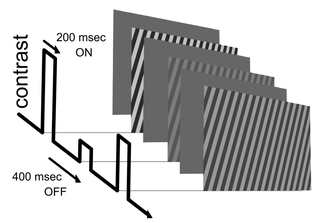
GLM predicts spiking responses

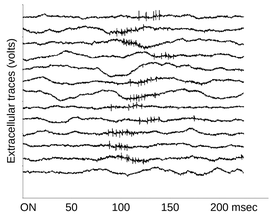




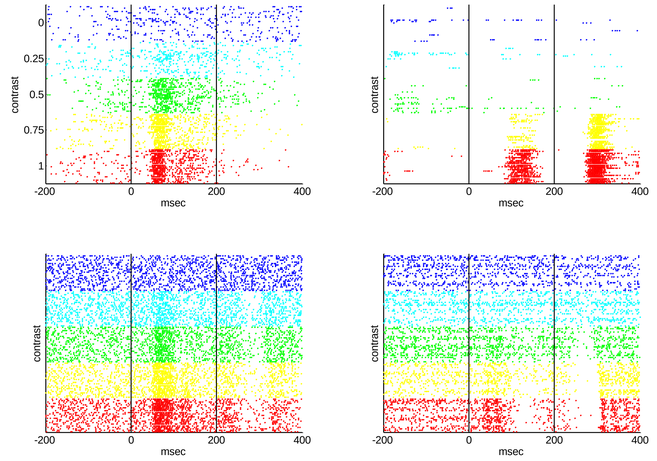


Flashed grating responses





Diverse onset and offset responses



Isoflurane shifts contrast sensitivity