REVERSE CORRELATION ANALYSIS OF THALAMIC RESPONSES TO DYNAMIC WHISKER STIMULATION

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A major function of the whisker thalamus (ventro posterior medial nucleus, VPM) is to transmit signals about surface texture to the barrel cortex. Different textures are known to induce characteristic "kinetic signatures" of whisker vibration, which are transduced as corresponding temporal sequences of precisely timed spikes by mechanoreceptors in the whisker follicle. However, it is not known how dynamic whisker vibrations are encoded by neurons in the thalamus.

In this study, we performed extracellular recordings from single VPM neurons in anaesthetized rats. To study how VPM neurons encode dynamic whisker vibrations, we recorded their response to mechanical stimulation of the contralateral whiskers with Gaussian white noise and analysed stimulus-response relationships using reverse correlation methods.

We found that many VPM neurons responded in a highly reproducible manner, with mean spike timing jitter of 0.4 ms. The most common type (~50% of our sample) had a velocity-sensitive spike-triggered average (STA), and an input-output function where firing rate increased monotonically with velocity. Other neurons had either monophasic position-sensitive STAs or more complex, polyphasic STAs sensitive to higher derivatives of the whisker signal.

To test the completeness of this stimulus-response description, we fit a maximum likelihood "generalised linear model" (GLM) to the data [1]. In this model, the instantaneous firing rate depends not only on an afferent input (convolution of the stimulus with a filter) but also on a spike-feedback term (convolution of spike train with a second filter). In our case, the stimulus filter typically captured velocity-sensitivity, the spike-feedback filter refractoriness. We found a good match between the time-varying firing rate predicted by the model and that recorded experimentally. Thus, stimulus-response relationships of these VPM neurons were well-captured by a single filter model. Consistent with this, the most informative kernel resulting from spike-triggered covariance analysis added at most 20% to the mutual information conveyed by the STA.

Our results indicate that neurons in the whisker thalamus encode surface texture by spike timing that is precise to at least 1ms and that the stimulus-spike relationship can be well-described by a generalised linear model dependent on a single stimulus feature – typically velocity.

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References

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