**Introduction**

High acuity vision in primates only exists in the central 1° of gaze (in the fovea), but nearly 1/2 of primary visual cortex (V1) is devoted to foveal processing [1]. Nevertheless, little is known about the stimulus processing of foveal V1 neurons, primarily due to difficulty measuring [2,3,4] -- as well as controlling [5] -- eye position with sufficient accuracy. While some foveal receptive field properties have been reported [6,7], more detailed functional descriptions of V1 stimulus processing, which have been developed for parafoveal V1 neurons, cannot be directly tested without high resolution eye tracking. Here we extend previous versions of V1 stimulus processing, which have been developed for parafoveal V1 neurons, beyond 0.1° accuracy [2,3,4].

**Methods**

A V1 neuron’s firing rate $r(t)$ depends on the visual stimulus on the retina. Thus, we can use the absence of V1 firing to infer the stimulus’s location (e.g., by staring at a blank screen). To probe detailed functional properties of foveal V1 neurons, even during fixation, the eyes continually undergo small movements -- including drift and microsaccades [9,10].

**Agreement with measured eye position**

For foveal V1 neurons, we evaluated eye position uncertainty by simulating microsaccades, inferring microsaccades, and continuously updating the position. The resulting microsaccades were used to infer the true microsaccades, which were in close agreement with the simulated microsaccades.

**Binocular eye-position inference**

Independently inferred left and right eye positions (using a non-synoptometric stimulus) were in agreement to within a few arc minutes, in order to probe detailed functional properties of foveal V1 neurons.

**Dependence on number of units**

Time lag (ms)

**SUM**

Regression values (cyc/°)

**Conclusions**

- Models of simultaneously recorded neurons’ stimulus processing can be used to infer the animal’s eye position with high precision.
- Using inferred eye positions, stimulus-processing models improved dramatically, revealing much sharper receptive fields (RFs).
- Estimated eye positions are in good agreement with features of the eye position signals measured from eye coils.
- Averaging inferred left and right eye positions are in agreement to within a few arc minutes.
- Eye position inference is robust even when initial estimates are very noisy, suggesting this method can be used with even smaller RFs, as well as in tasks without defined fixation positions.
- Eye positions can be accurately inferred using multunit activity only, even with few tens of units.
- This approach can be directly extended to infer 2-dimensional eye position (not shown).

**References**