Efficient mapping of joint tuning for retinal and eye velocities in macaque area MT

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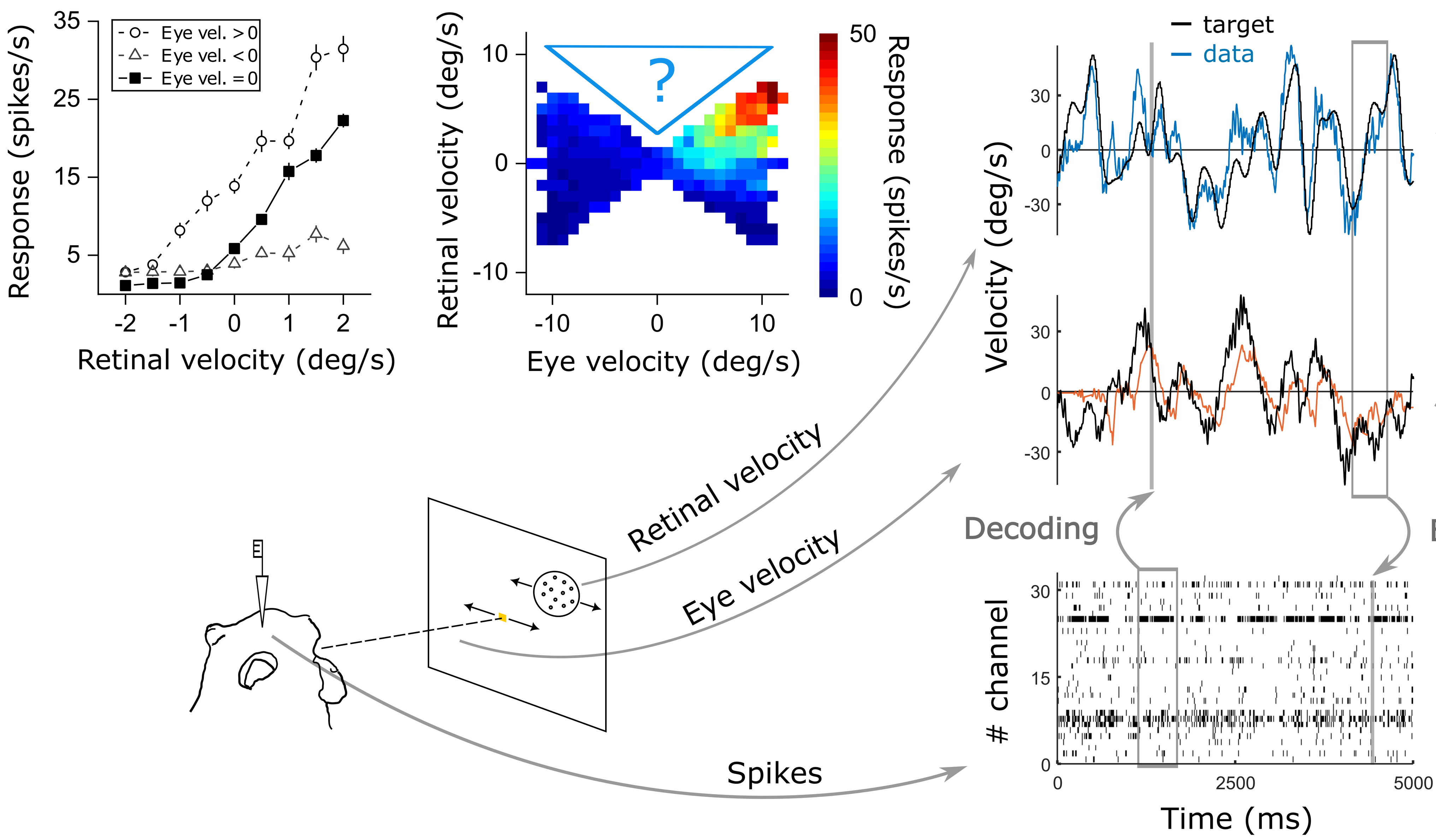
Introduction: extra-retinal modulation in MT neurons

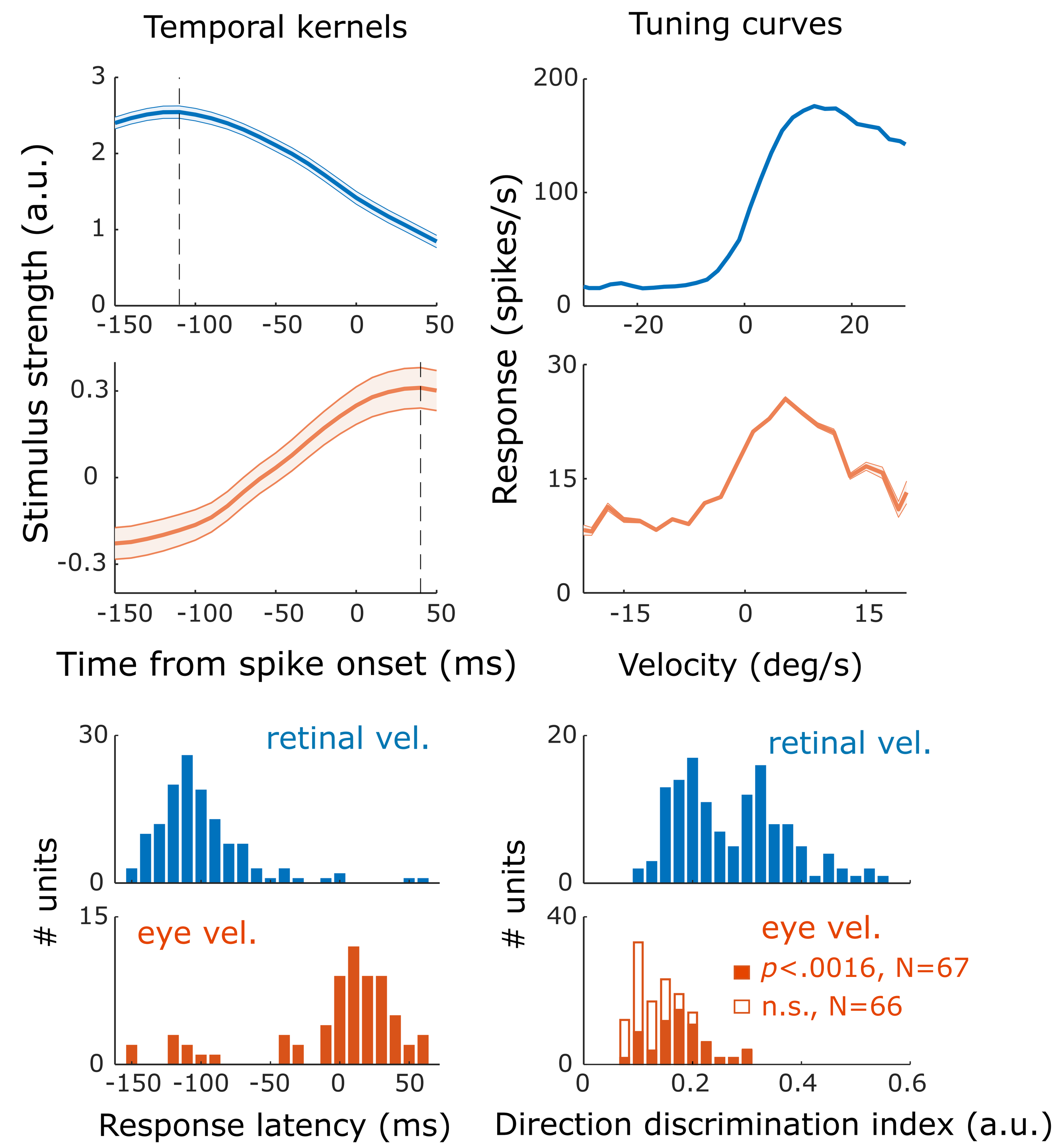
Neurons in macaque middle temporal (MT) area are known to encode 2D local motion on the retina[1]. However, recent studies suggest that neural responses in MT are also modulated by extra-retinal signals including pursuit eye movements[2,3] and global optic flow[4], providing a neural substrate for computing higher-level perceptual variables such as motion in the world and depth from motion parallax. The extact interactions between retinal motion and pursuit eye movements in MT remain unclear[5].



We developed an efficient method for estimating the joint encoding of retinal motion and eye velocity in MT neurons using uncorrelated Gaussian white noise sequences generated from binary m-sequences[6]. Neural responses were recorded from area MT with 32-channel V-probes.

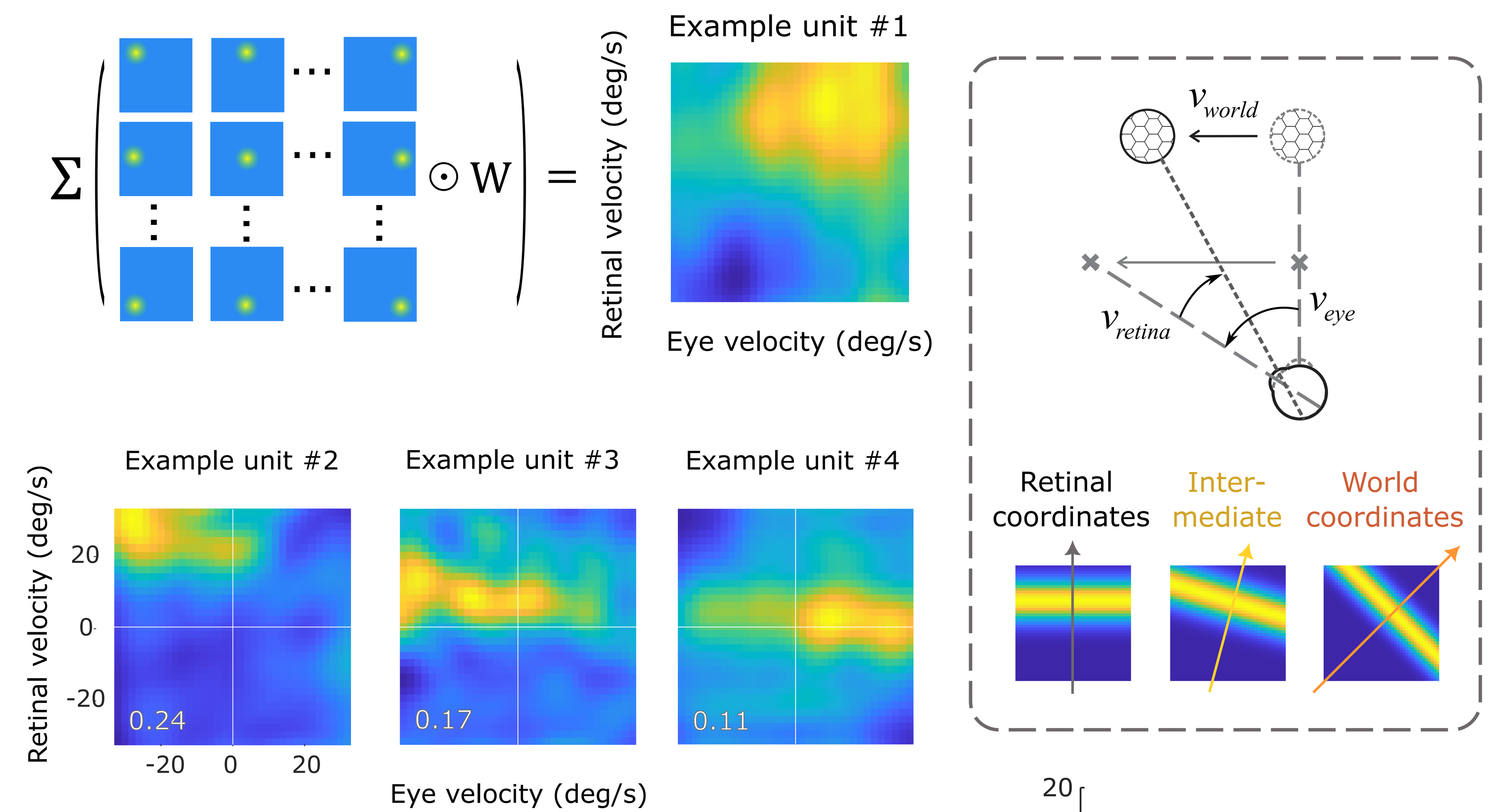
Temporal dynamics and tuning curves

Temporal kernels were extracted by spike-triggered averaging (STA) of retinal and eye velocities separately. Tuning curves were obtained by discretizing velocity signals into 2deg/s bins and performing STA on each bin separately.

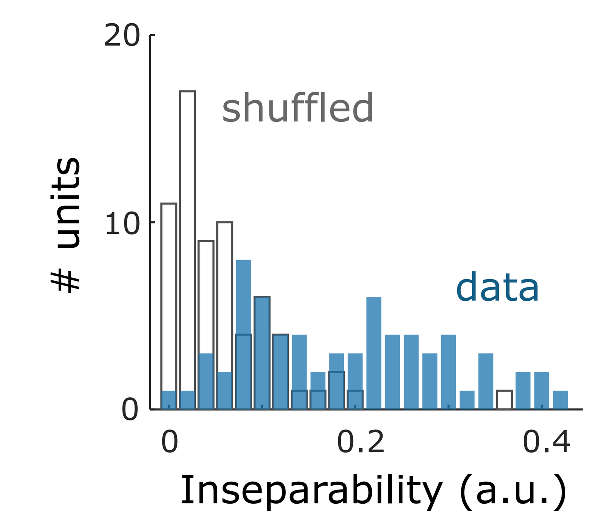


Joint tuning for retinal and eye velocities

The 2D joint tuning profiles were obtained by fitting a set of 2D raised cosine kernels to the neural responses. We first estimated the response latencies and shifted the velocity signals in time accordingly. A set of cosine basis functions (12x12) was then fit to the spike trains using ridge regression.



We found that some MT neurons show a diagnoal structure in their joint tuning profiles, indicating a small shift toward representing velocity in world-centered coordinates.

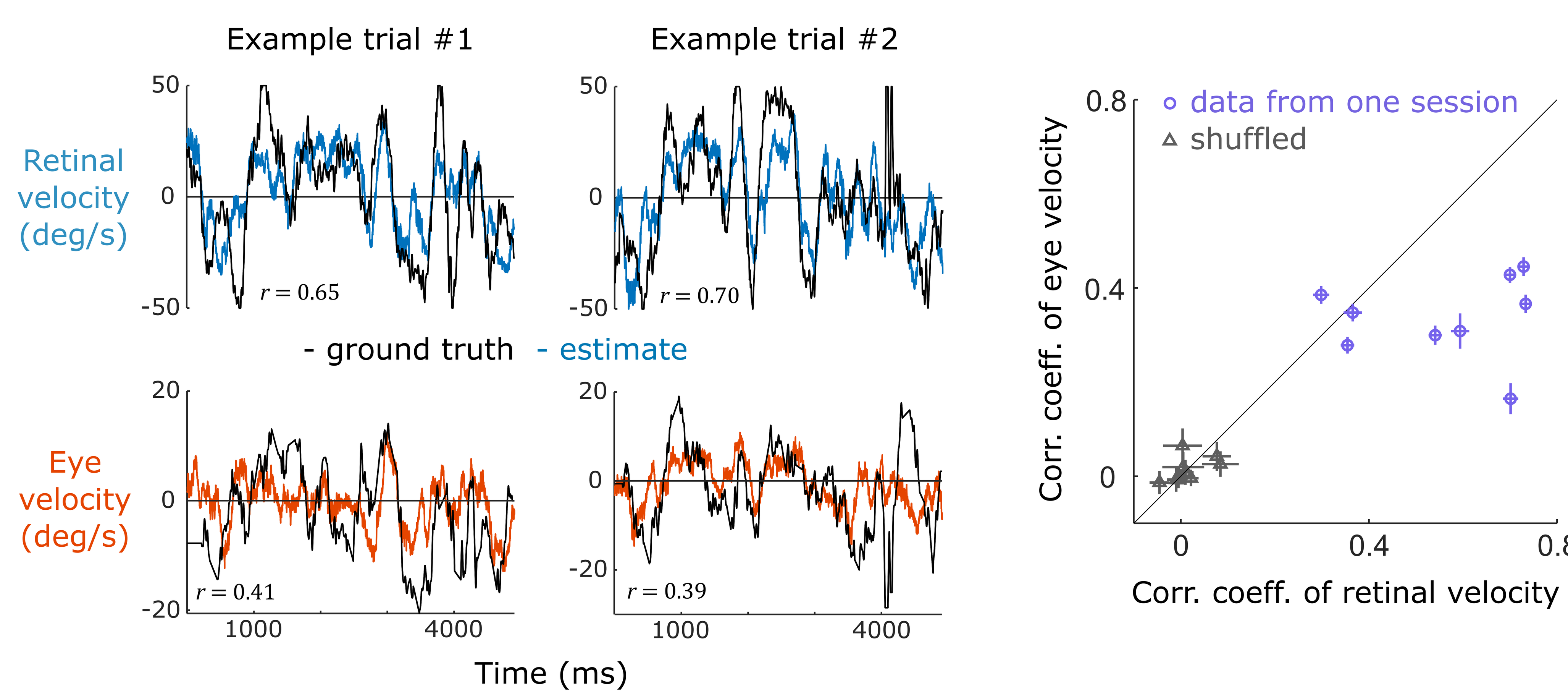


Single-session decoding of velocity signals

A linear decoder was trained on the threshold-crossing multi-unit activities from all 32 channels to recover the velocity signals on 70% of the trials using ridge regression. The decoder was allowed to have separate sets of weights for each velocity signal.

The decoder was then tested on the remaining 30% of the trials. As a control, we shuffled the spike trains across different trials and performed the same training procedure.

We show that a simple linear decoder can reliably decode both retinal and eye velocities from a small population of MT neurons.



Take home messages

1) We provide an efficient method for mapping the joint tuning of MT neurons for retinal and eye velocities using uncorrelated Gaussian white noise

2) Some MT neurons show a diagonal structure in the joint tuning, indicating a representation of velocity shifted toward world coordinates

3) Both retinal and eye velocity signals can be linearly decoded from the responses of a small population of MT neurons

References

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