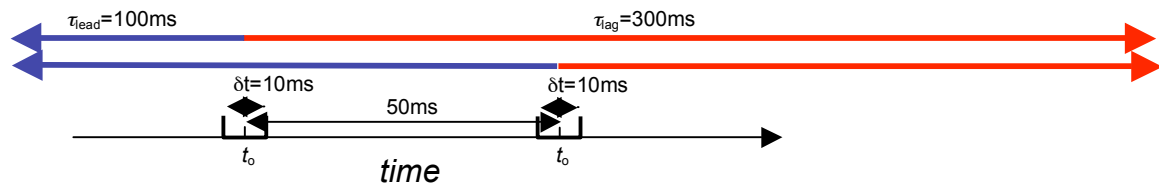


Supplementary Materials

Encoding model

In order to create the training data used to build the encoding model for each neuron, thousands of sample movement segments along with an associated spike or lack of a spike in that neuron were extracted from the monkey's continuous hand motion while it performed the random target pursuit task. This extraction process (shown in Supplementary Figure 1) was accomplished by defining a time, t_o , every 50 ms throughout the continuous data set. For each time, t_o , a movement segment was extracted that extended back in time by τ_{lead} and extended forward in time by τ_{lag} . Also, a spike sampling window (10 ms duration) was assigned to each of time, t_o . If the neuron fired a spike within that window, a one was associated with the extracted movement segment. Otherwise, a zero was associated with that movement segment. The x - and y -trajectories of each sample movement segment were smoothed by replacing each sample point with the time averaged position (± 50 ms about the sample point) and then numerically differentiated (Segments with peak velocities greater than 100 cm/s were excluded from the model.) to generate velocity trajectory vectors of duration $\tau_{lead} + \tau_{lag}$.



Supplementary Figure 1

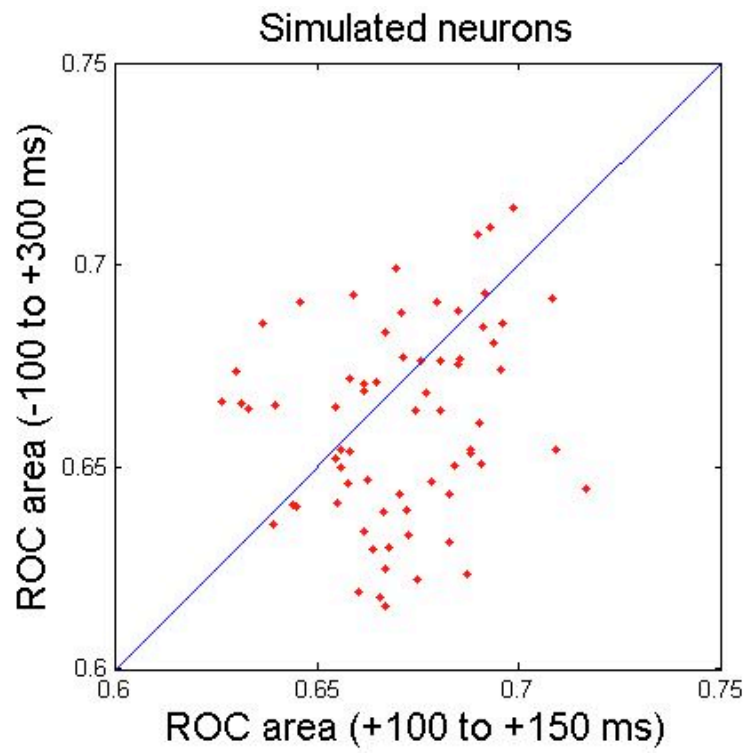
Simulation

We simulated 68 neurons with preferred directional tuning that was identical to 68 actual neurons recorded in one data set. This was accomplished by first determining the preferred directions of the 68 actual neurons using a 100-150 ms delay between the firing of the actual neurons and the instantaneous direction of the monkey's hand. We then simulated the firing probability (in a 10ms bin) of each of the simulated neurons as a Poisson process using the following logistic equation:

$$P(\text{firing}) = \frac{g \times e^{\bar{D} \cdot \bar{\theta}}}{1 + g \times e^{\bar{D} \cdot \bar{\theta}}}$$

where $\bar{D}$ is the preferred direction of the simulated neuron and $\bar{\theta}$ is the instantaneous direction of the monkey's hand in that data set. g is a gain parameter that we adjusted so that the overall firing rates of the simulated neurons were comparable to that of the actual neurons. We then used the encoding model described in the manuscript and estimated a pathlet for each of the simulated neurons.

We also used these simulated neurons to compare the predictive power of a simulated pathlet of length 400ms (i.e. -100ms to +300 ms) with a simulated pathlet of length 50ms (i.e. +100ms to +150ms) (See Supplementary Figure 2). The ROC areas were significantly larger using the 50ms pathlet as compared to the 400ms pathlet ($p < 0.05$, paired t-test). This should be contrasted with the same comparison made with the actual neurons (see Figure 4C).



Supplementary Figure 2