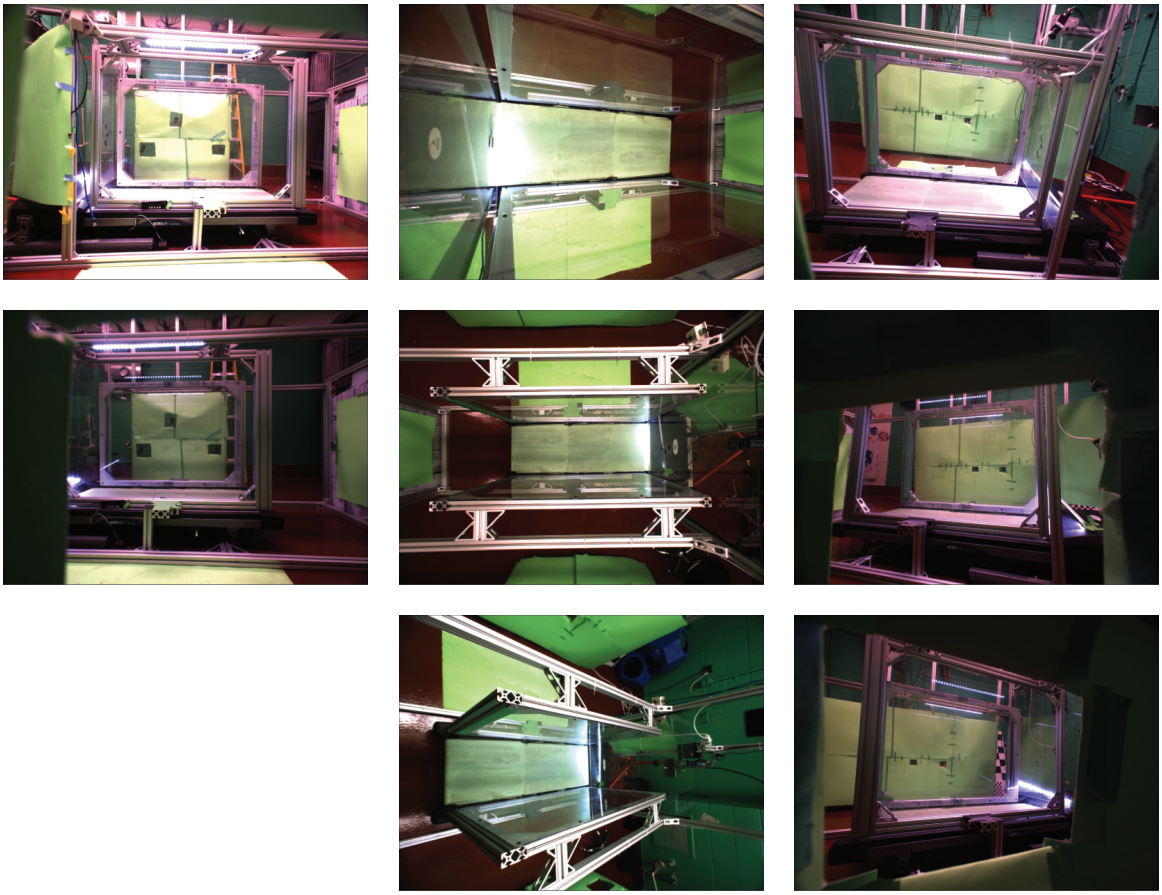
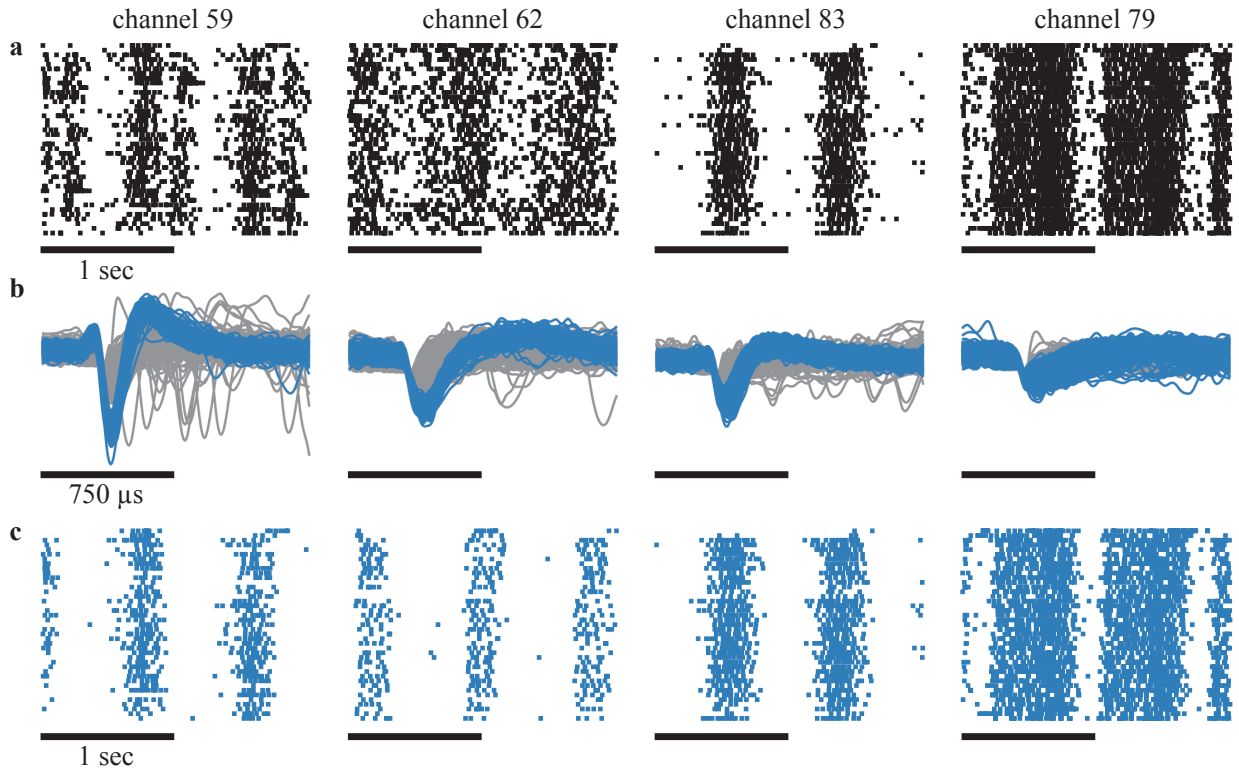
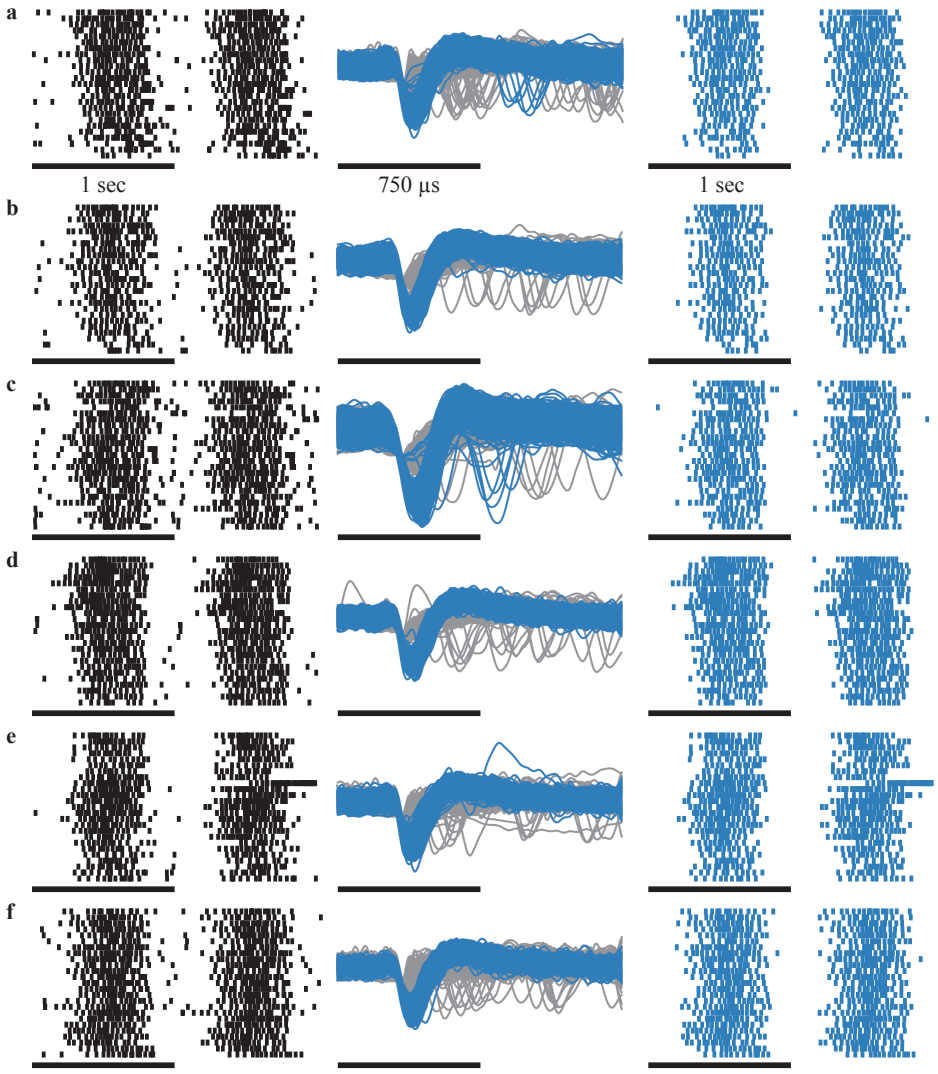
1 Supplementary Figures



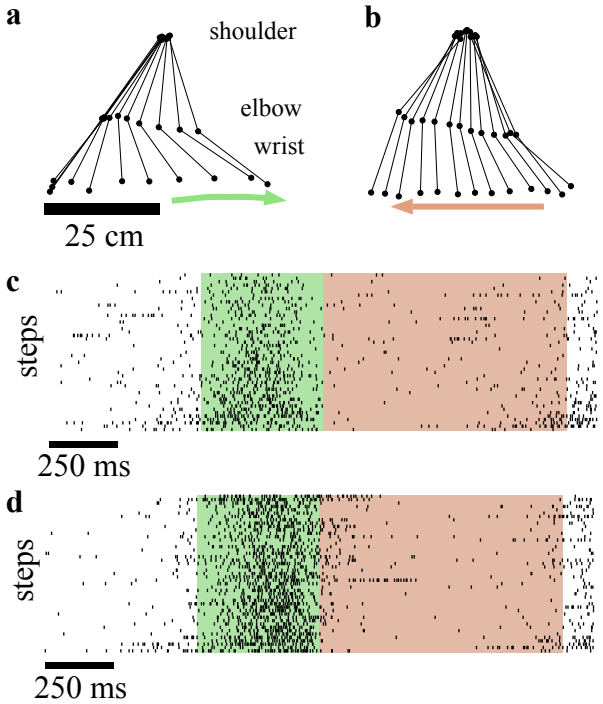
Supplementary Figure 1: **Treadmill environment from** 8 **camera views.** Two cameras were positioned on the left side of the treadmill (first column), three cameras were positioned above the environment (second column), and three cameras were positioned on the right side of the treadmill (third column). To increase the contrast between the environment and the monkeys, the tread of the treadmill and the walls of the room were painted green, and green paper was placed in the background.



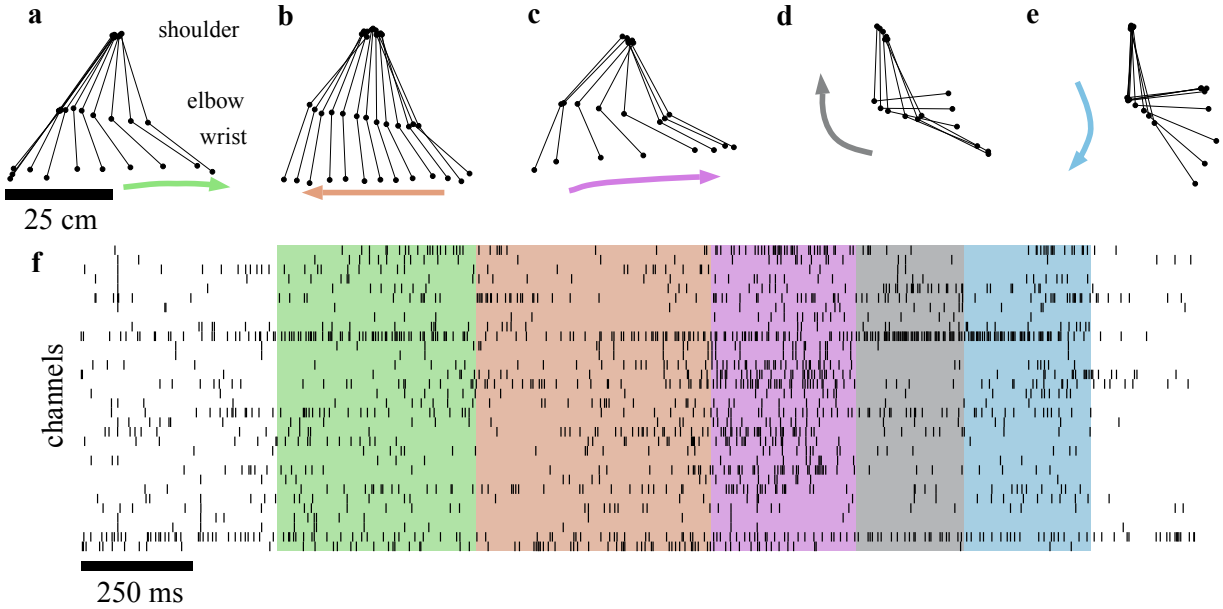
Supplementary Figure 2: **Diversity of single unit response.** (a) Threshold crossings for 41 steps (y-axis) as monkey I walks at 4.0 kph are aligned to the transition between the swing and stance phase (I20121024). Each row depicts 1 second before and after the alignment point. (b) Single units (highlighted in blue) were determined by first performing k-means clustering on spike waveforms and then hand-sorting the clusters. Here we plot four channels with relatively good isolation, but not all channels had single units that could be isolated. (c) The rasters are plot again including only the single units that were isolated by spike sorting. The single units tend to consistently fire for a portion of the step cycle. The phase relationship between the firing of single units and the walking phase varies between individual units.



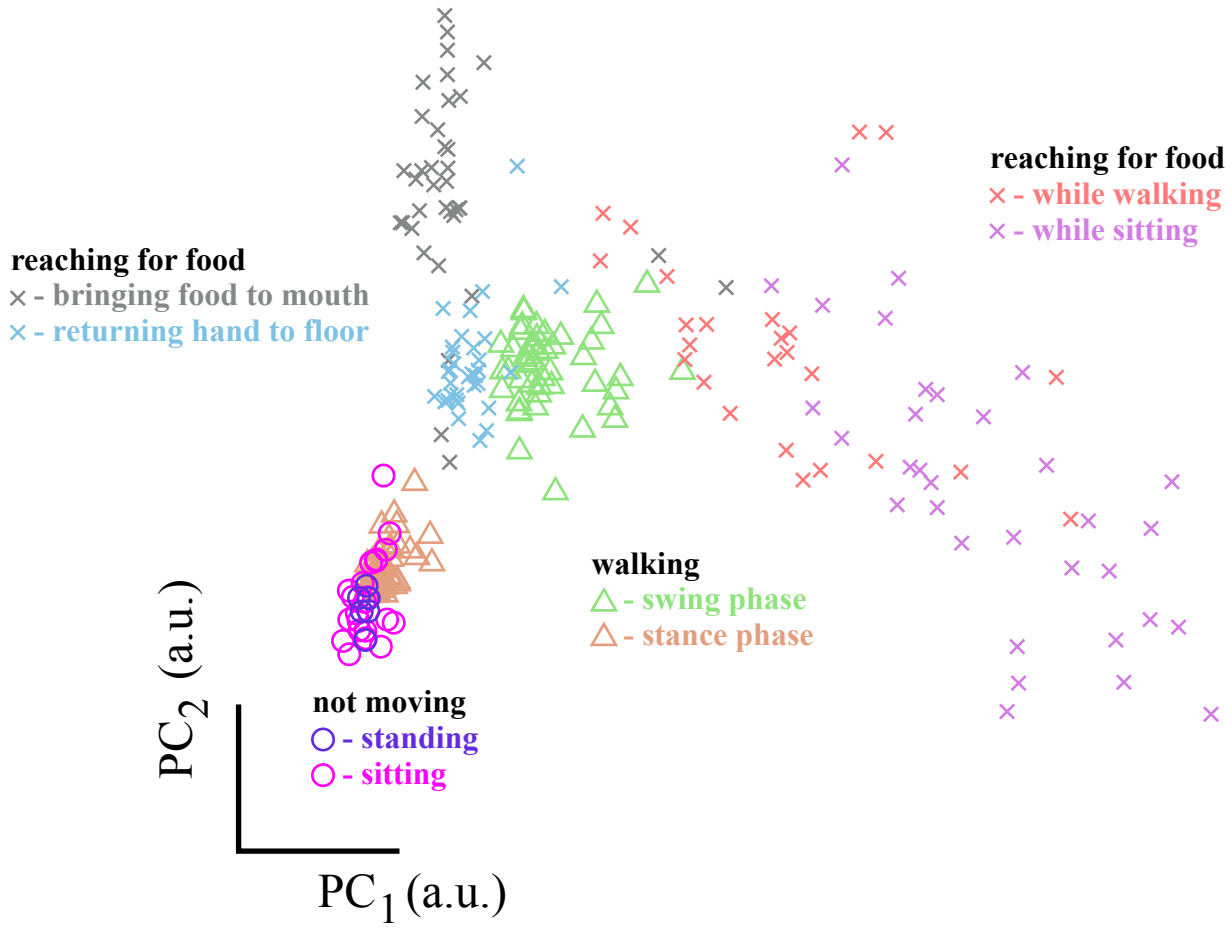
Supplementary Figure 3: **Consistent tuning across days.** Threshold crossings on channel 83 for 25 steps (y-axis) as monkey I walks at 3.0 kph are aligned to the transition between the swing and stance phases of walking (first column). The spike waveforms are sorted (second column), and a raster plot of the single units is shown (third column). This is repeated for three consecutive days (a) I20120919, (b) I20120920, and (c) I20120921, and repeated again a month later for three consecutive days (d) I20121022, (e) I20121023, and (f) I20121024. All data are collected with HermesE except (c) which was collected with HermesD. The relationship between the firing of the single unit and the phase of walking is consistent across days.



Supplementary Figure 4: **Modulation of neural activity during the phases of walking.** Example arm trajectories for (a) the swing phase and (b) the stance phase of walking from monkey I. Spike rasters of approximately 50 steps at a slow speed (2.0 kph) for two example tuned channels during the swing phase (green) and stance phase (orange): (c) channel 7 and (d) channel 32 (I20120130). To determine if a channel was tuned we compared the firing rate of the swing phase to that of the stance phase.



Supplementary Figure 5: **Complex behavior and corresponding spike raster.** Behavior was measured from 8 camera views as the monkey performed complex coordinated movements. Location of the wrist, elbow, and shoulder (contralateral to implant) are triangulated from video frames as the monkey moves through (a) the swing phase and (b) the stance phase of walking, (c) reaches for food, (d) brings food to his mouth, and (e) drops his arm down. Simultaneously, broadband neural activity was recorded from PMd. (f) Neural spiking from 32 channels (HermesD data) is plotted with the behavioral epochs highlighted (I20120130).



Supplementary Figure 6: **PCA plot of average firing rates during complex behaviors.** Behavior was divided into categorical behavioral epochs, and the average neural firing rate was calculated during each epoch. The average firing rate is projected into the top two PCs and plotted above (I20120130). Triangles represent walking epochs (swing phase in green, stance phase in orange), X's represent epochs reaching for food (reaching to food while sitting in pink, reaching to food while walking in red, bringing food to mouth in gray, and returning his hand to the floor in blue), and circles represent idle epochs (sitting idly in pink and standing idly in purple). Similar behaviors cluster together in this space and are decodable using leave-one-out cross-validation with a 96% success rate.