**Figure S1. Training apparatus, task structure and illustrative trials. Related to Figure 1. A)** Head-fixed mice are running for liquid rewards (drops of a sucrose solution) on a free spinning wheel. Rewards are delivered in front of the animals mouth and licks are detected with a photodetector. Movements of the wheel are detected when its spokes cross a photodetector. The distance between 2 successive spoke detections is about 2.4 cm. **B)** Task structure (top) and illustrative trials (real data taken from 3 different sessions of a single animal, bottom). Green squares indicate that the mice was immobile during the last 2 s of the No run period. Red squares indicate that the mice was moving during the last 2 s of the No run period.
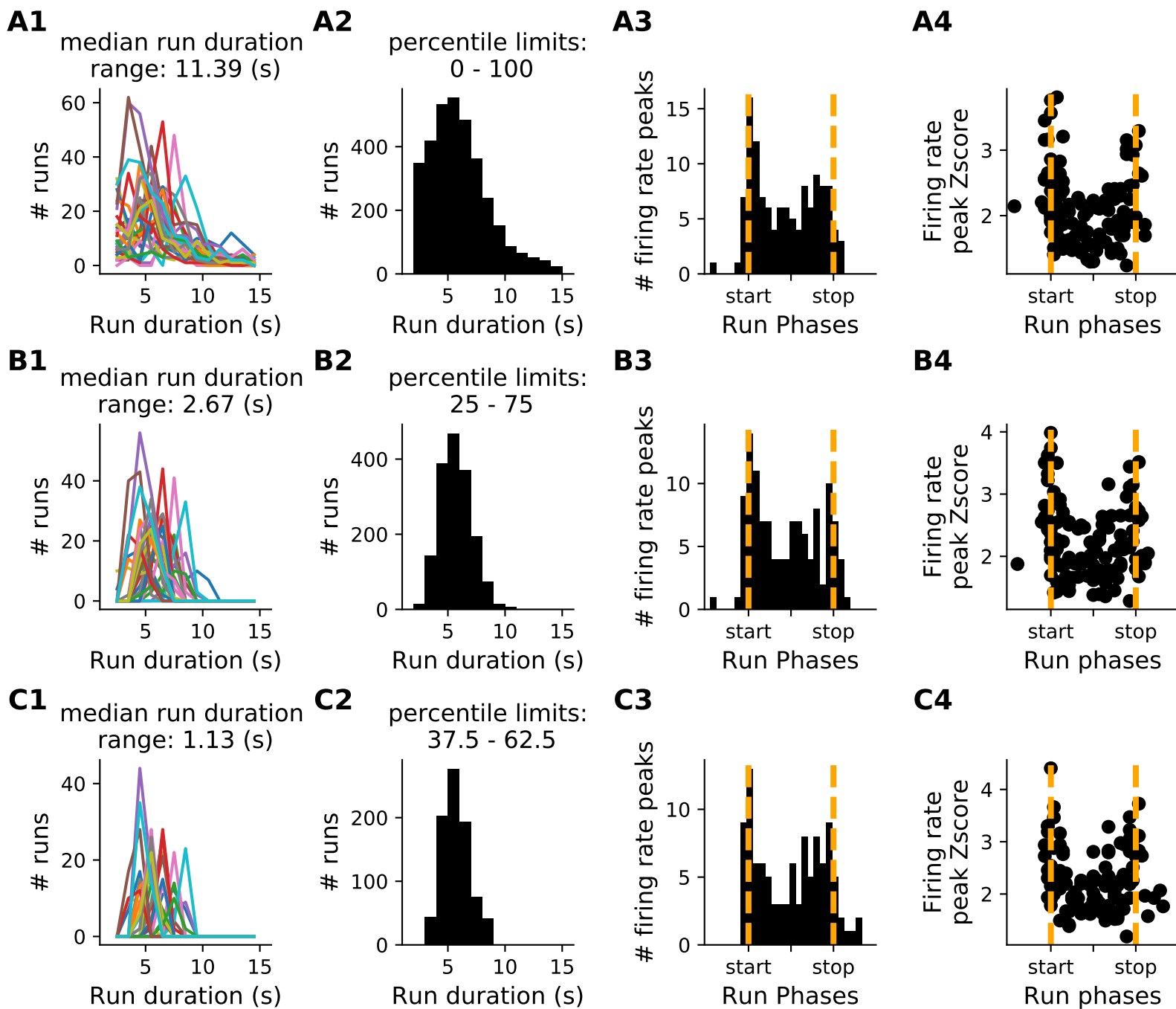
**Figure S2. Run start and stop phases are associated with stronger and more numerous modulations of firing rate than the middle phases of the run. Related to Figures 2H and 2G. A1)** Distribution of the duration of all the runs included in the tuning curve analysis (each colored line represents a single session). **A2)** Same as A1, but all the run duration values were pooled together. **A3)** Distribution of the run phases of the peak firing rates. **A4)** Z-scored peak firing rates versus run phases. A3 and A4 are identical to **Figures 3F and 3G**. **B1-4)** Same as A but in each session we only considered run with durations comprised between the 25th and 75th percentiles of the entire data set (detected runs in A). **C1-4)** Same as A but in each session we only considered run with durations comprised between the 37.5th and 62.5th percentiles of the entire data set (detected runs in A).
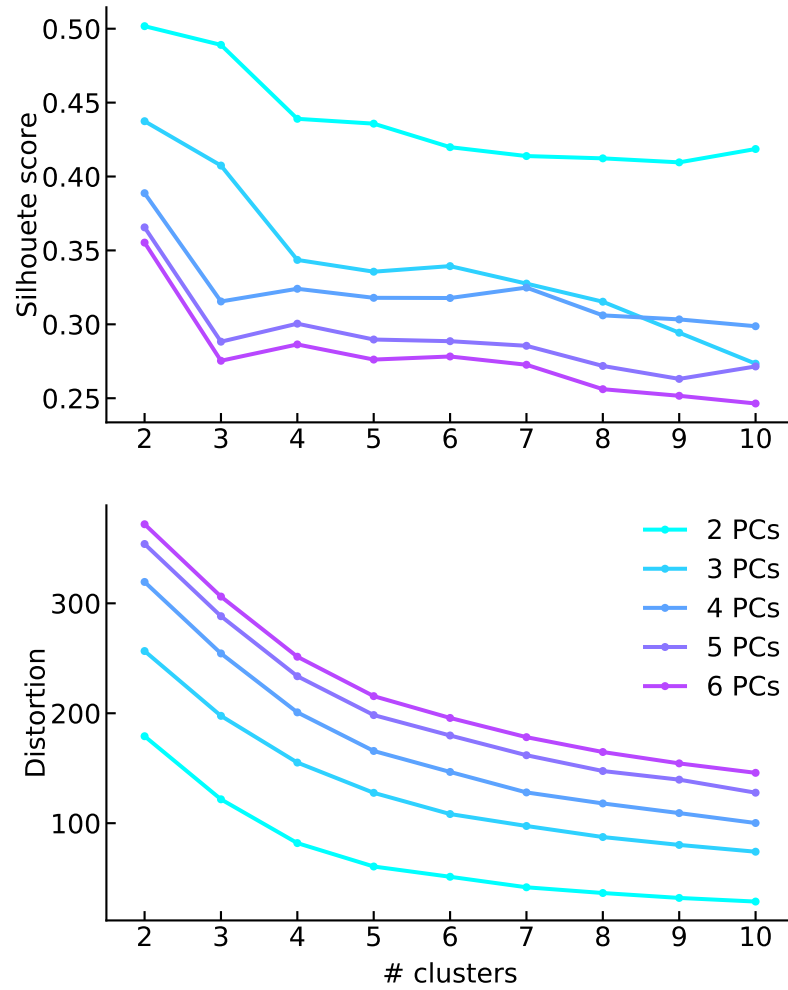
**Figure S3. Similar Silhouette score and distortion profiles with increasing number of principal component. Related to Figure 3G.** Same analysis as **Figure 3G** but repeated with increasing number of principal components.
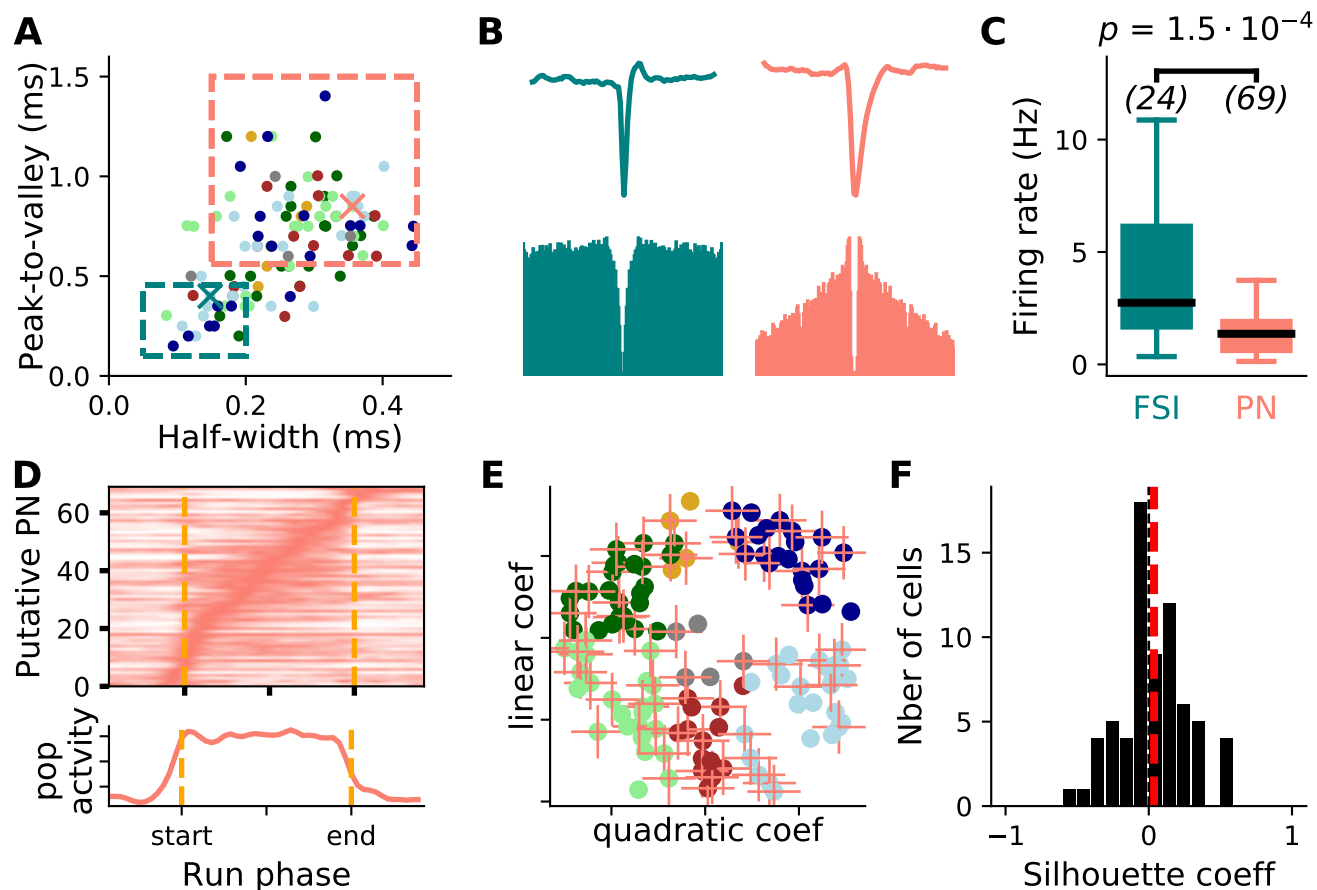
**Figure S4. Population activity of putative projection neurons. Related to Figures 3D and 3E. A)** Scatter plot of two waveform markers. Each dot represents a single neuron (same color code as **Figure 3B**). Dashed squares indicate classical limits used to distinguish putative fast spiking interneurons (FSI, teal) and projection neurons (PN, salmon). **B)** Examples of waveforms (top) and spike auto-correlograms (bottom, 1 ms bin, +- 100 ms) of a putative FSI (teal) and putative PN (salmon). **C)** Boxplots of average firing rates for putative FSI and PN during task performance. Statistical comparison was done using the non-paramatric Wilcoxon test. **D)** Normalized average firing rates during run (sorted according to the peak firing rate phase) for putative PN (top) and averaged population firing rate activity (bottom). **E)** Similar to **Figure 3D** with crosses indicating putative PN. **F)** Distribution of the Silhouette coefficients for data points in E marked by a cross (i.e., putative PN). Red dashed line indicates Silhouette score.