

Figure S1. A, *Left*: wide-field image of a carbon fiber coated in fluorescent Parylene-C, after it had been fire-sharpened. *Middle*: UV filter image for the same fiber. *Right*: Merged images of the wide-field and fluorescence view show that the fire sharpening method exposes an average of 89 ± 17 microns. **B**, Another example fiber. The length of the exposed carbon tip was taken to be the distance from the point to the boundary of the full intensity Parylene edge.

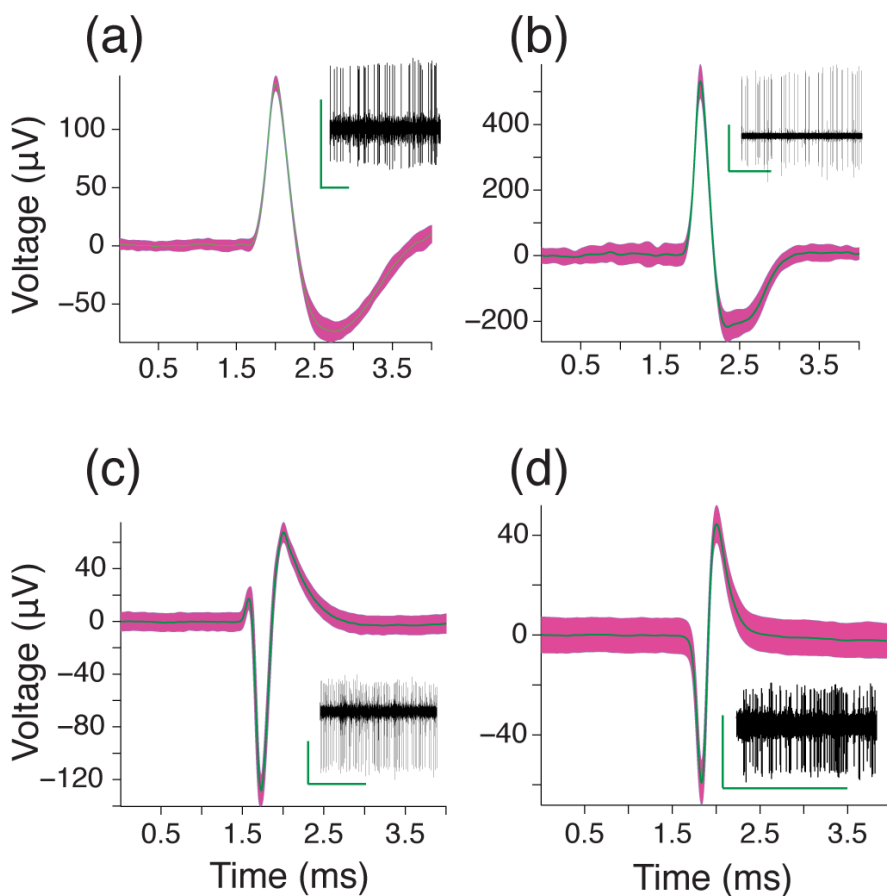


Figure S2. Average waveforms of isolated single units recorded acutely with 16-channel carbon fiber arrays. **A**, A unit recorded in auditory area Field L in an awake head-fixed bird (SNR=9.18). **B**, A unit from the pre-motor nucleus HVC in an anesthetized bird (SNR=21.64). **C**, An isolated unit found in the basal ganglia of an anesthetized bird (SNR=3.50). **D**, A unit recorded in Field L of an awake, head-fixed bird (SNR=3). Insets show corresponding spike trains. Inset scale bars: (A) 200 μV , 50 s; (B) 400 μV , 100 s; (C) 100 μV , 1 s; (D) 100 μV , 5 s. Pink indicates standard deviation.

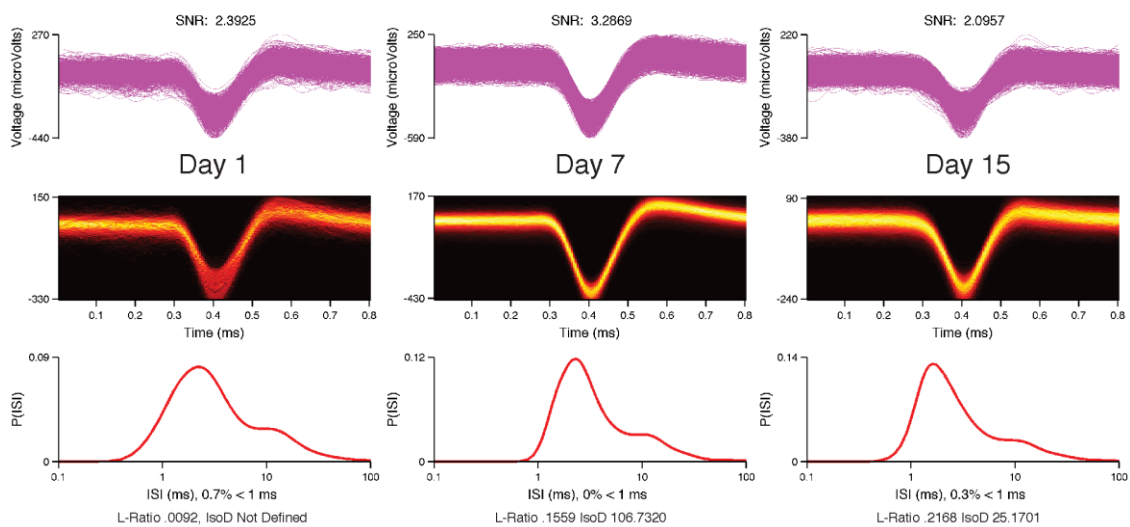


Figure S3. Clusters for the chronic signal shown in Figure 3b. Top row, overlaid spike waveforms. Middle row, spike waveform histograms. Bottom row, spike ISI histograms. The SNR changed from 2.39 on Day 1 of recording (left column) to 3.29 on Day 7 (middle column) and 2.09 on Day 14 (right column).

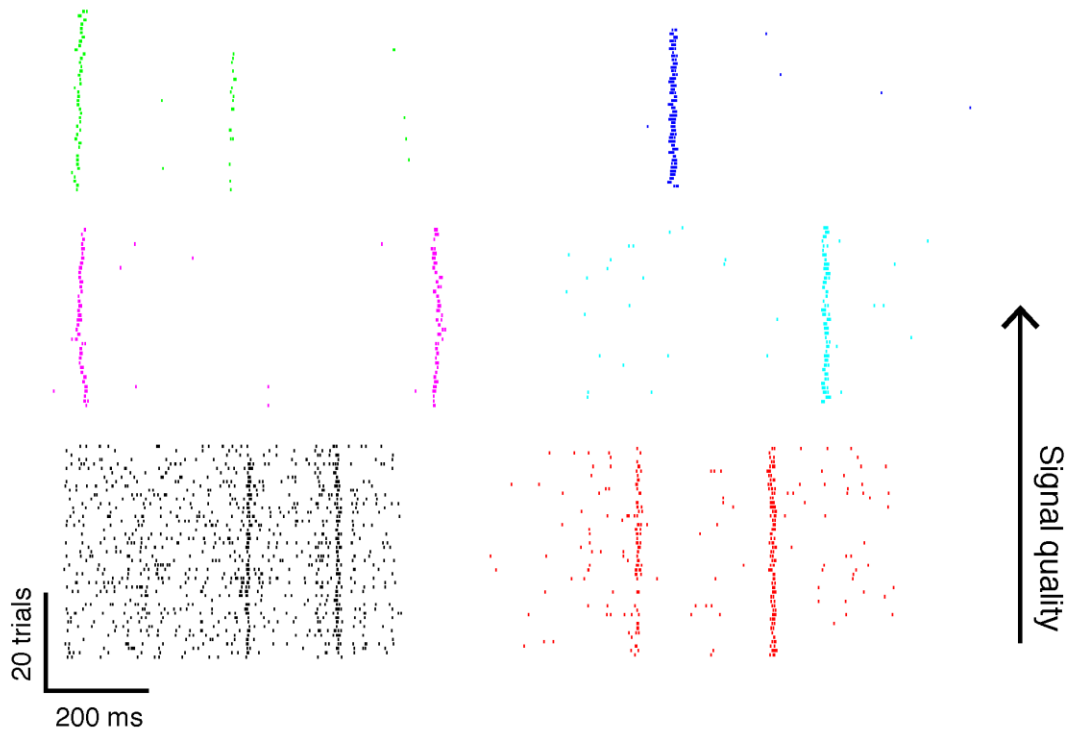


Figure S4. Example projection neuron recordings of various signal qualities. Song-aligned rasters from 6 neurons show the effect of signal quality on unit isolation. As signal quality decreases, the number of contaminating non-burst “error” spikes increases. All units except the one shown in the bottom left raster meet the standard criteria for single units (see Methods). The raster in the top left met the more stringent criterion.

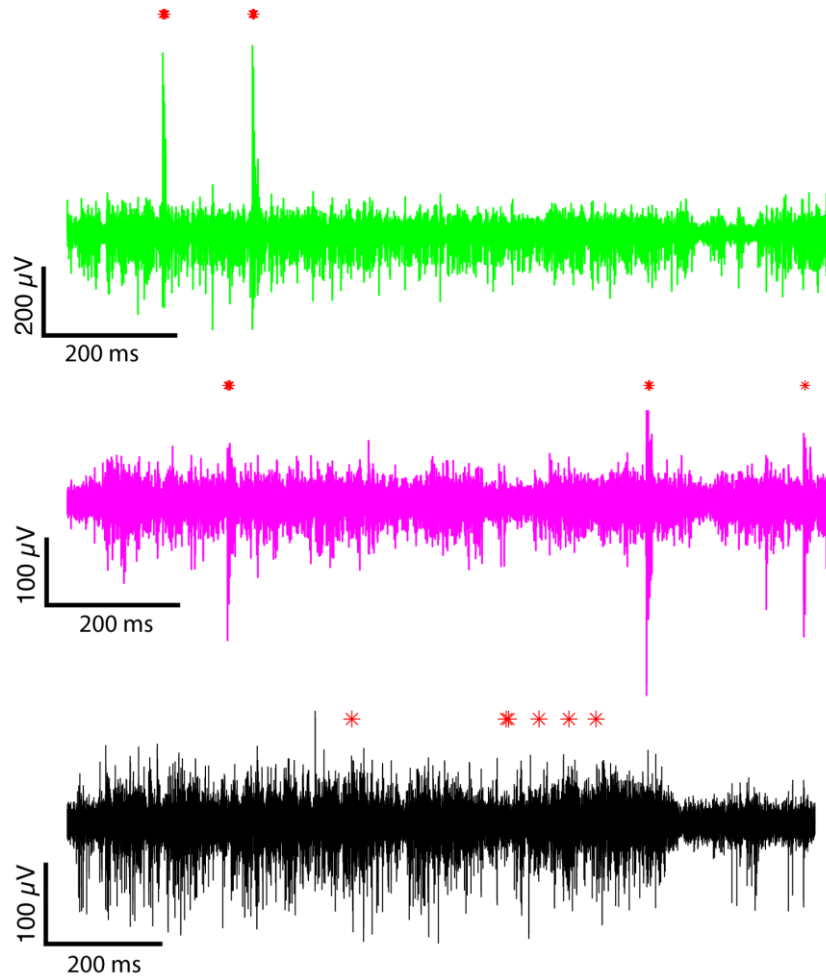
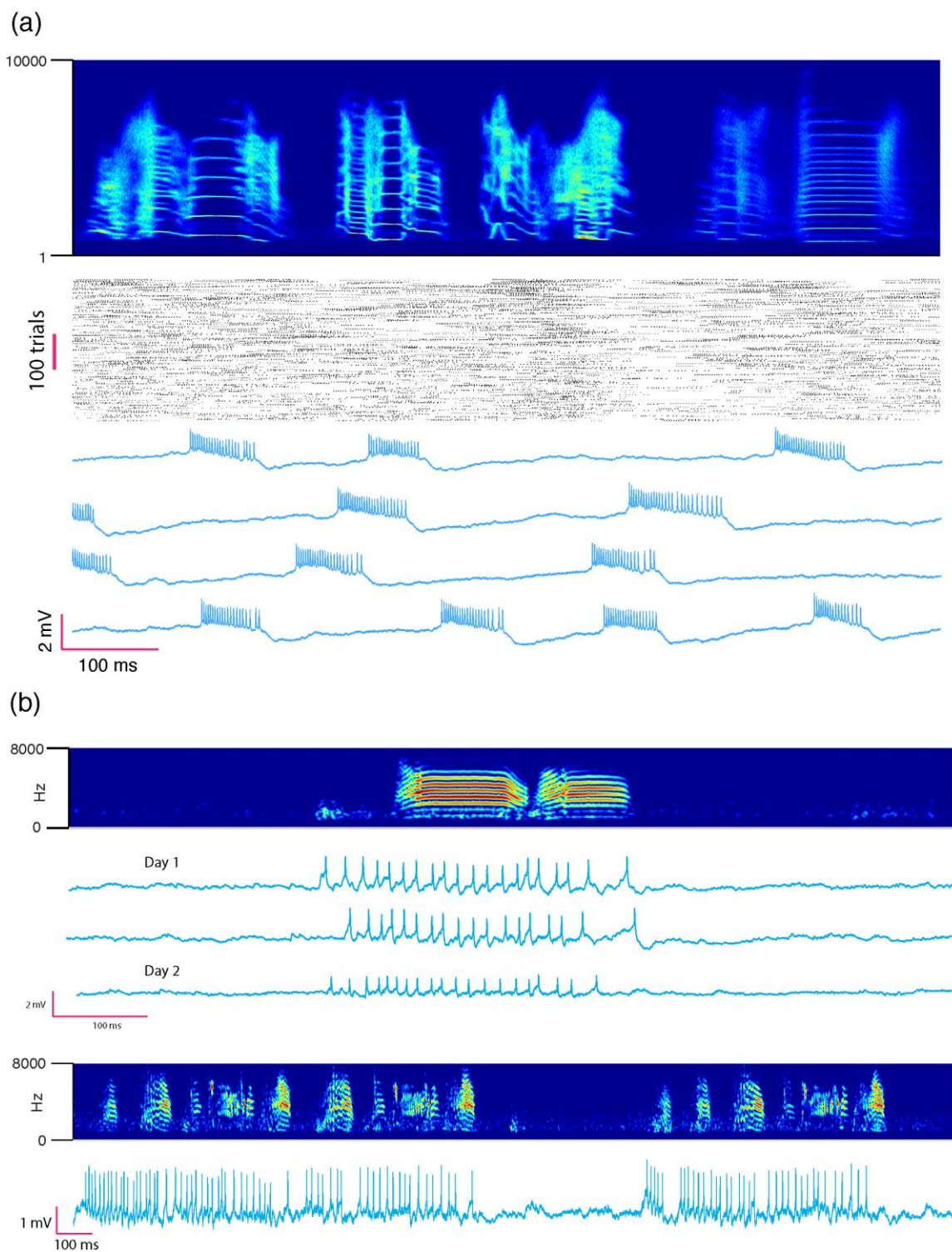


Figure S5. Single trial voltage traces from 3 rasters show in Figure S4. The single trial voltage traces are shown with the identified spikes indicated by a red asterisk. Colors match rasters from Figure S4.



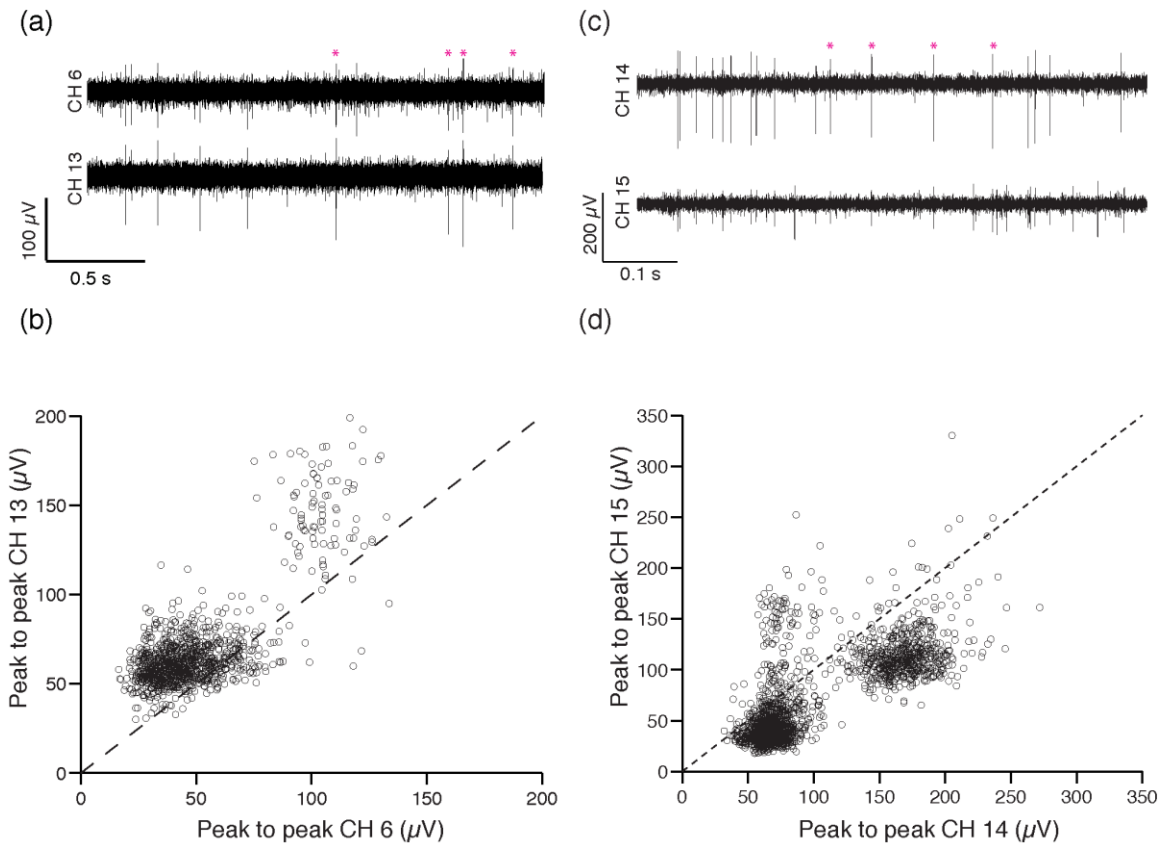


Figure S7. Tetrode Effect. **A and C**, Example traces recorded from a chronically implanted bird showing correlated signal on two channels. Pink stars indicate example times for spikes present on both channels. **B and D**, scatter plots of spikes amplitudes on the two channels showing correlated signal. Events do not fall on the unity line (dotted line), suggesting that the common signal is not explained by cross-talk.

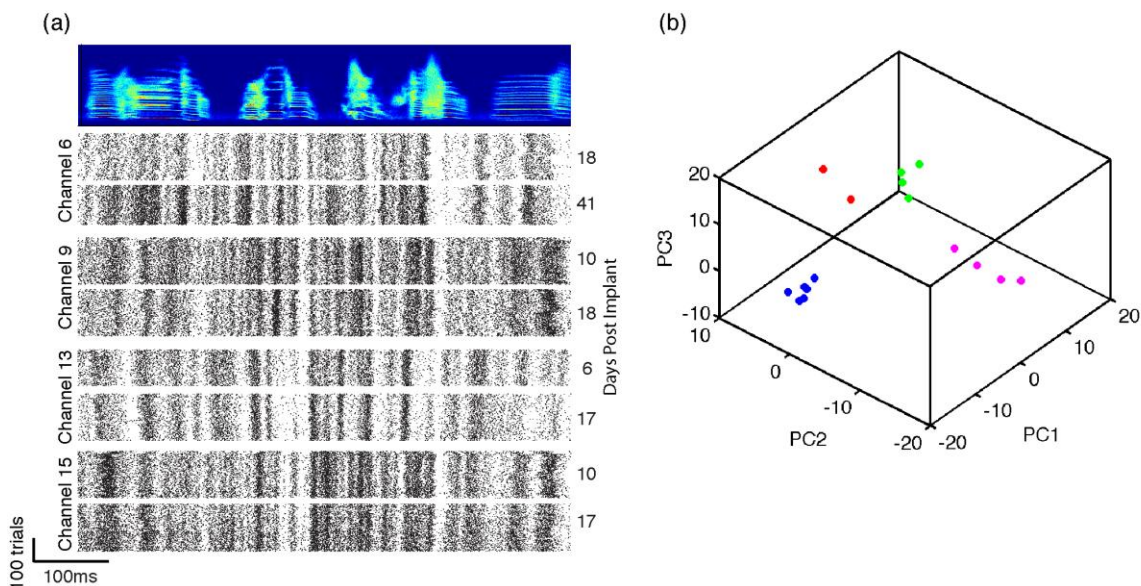


Figure S8. Sorted Multi-unit Stability. A, Four signals recorded in HVC on different channels in one bird. Each site was recorded on two sessions for each neuron. (Units were sortable by the standard criterion). Firing patterns on different electrodes are distinct across the small ensembles, but similar for any given ensemble's two recording sessions. Days post implant of recordings are shown to the right of each raster. **B,** Principal components analysis of the firing rate patterns shown in **A**. Each dot indicates the average projection of the firing patterns for an entire day and colors indicate separate channels.

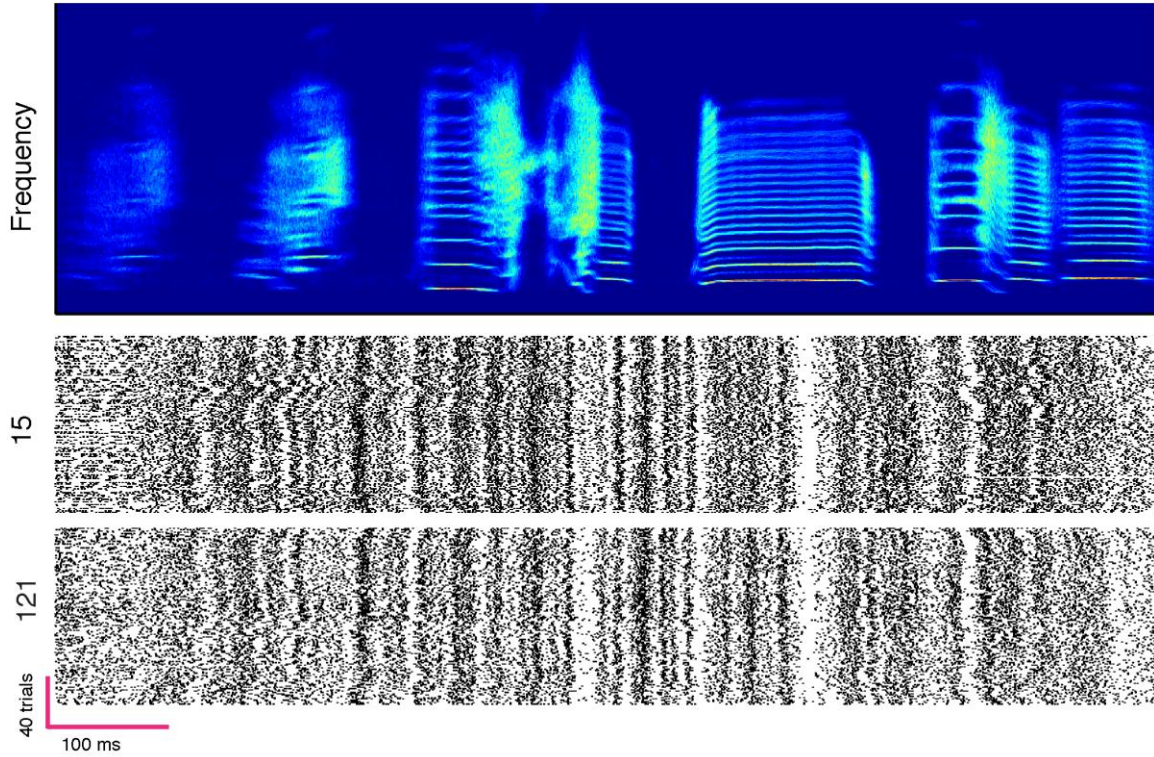


Figure S9. An HVC interneuron recorded on sessions 107 days apart. Analysis on waveform shape, ISI distribution and firing pattern classifies the recordings as the same sorted cell, based on the standard criterion. Dates post implant are shown on the left of each raster.

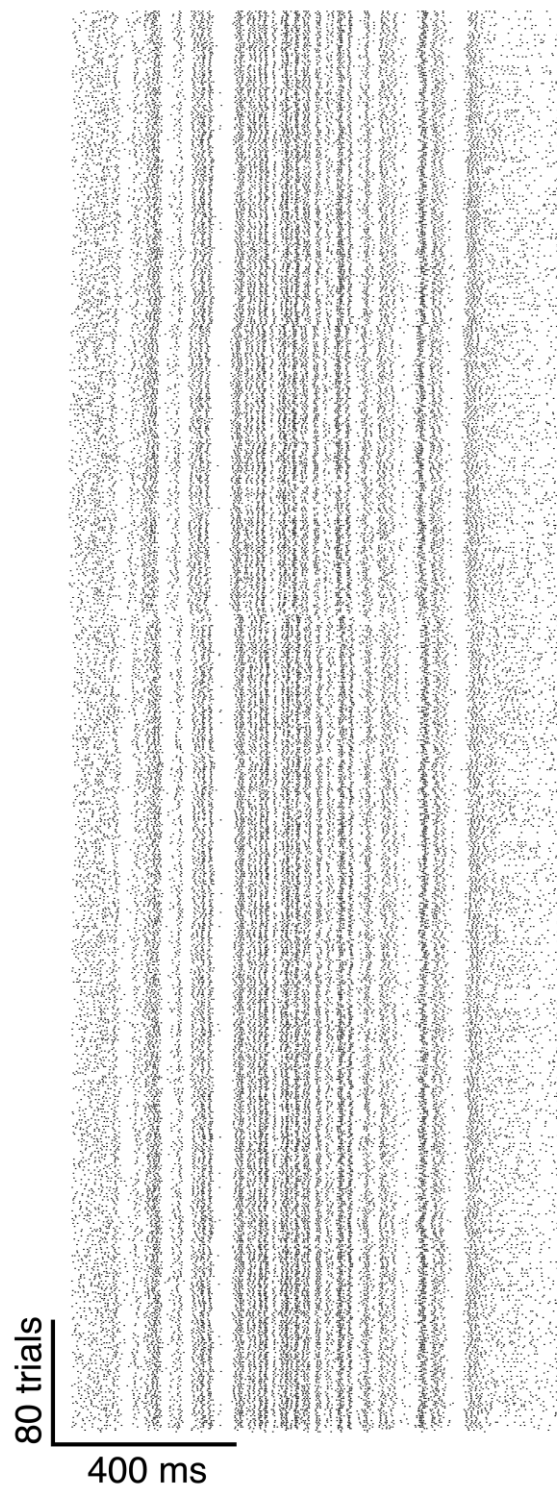


Figure S10. Spike raster for bottom example from Figure 7. All trials included in the analysis for the bottom example from Figure 7 are shown in order from top to bottom.