Supporting Online Material

Figure Legends.

Supplemental Figure 1. Consistent waveforms across stimulus amplitude suggest that the example invariant neuron shown in Figures 1 and 2 is a single neuron. Spike raster, with line separating song intensities, showing the response of the intensity invariant neuron from Figures 1 and 2 to randomly repeated presentations of either A, Song A or B, Song B. C, Waveforms for the invariant neuron separated by song intensity. Red lines indicate mean and plus and minus one standard deviation.

Supplemental Figure 2. Quality of unit isolation, as quantified by the number of 1 ms violations, do not correlate with invariance or other response measures. A, scatter plot of 1 ms violations with invariance B, performance, C, sparseness and D, intrastimulus R_{corr}.

Supplemental Figure 3. Performance as a function of the τ value used in the van Rossum spike distance metric. The optimal timing for discrimination is approximately 10 ms across the stimulus intensities. At a τ value of 1000 ms the discrimination performance is at or near chance level. This corresponds to discrimination based upon a spike count. A, percent correct as a function of τ for the sensitive neuron example from figures 1 and 2 B, percent correct as a function of τ for the invariant neuron example from figures 1 and 2.

Supplemental Figure 4. Examples of 3 intensity discrimination invariant neural recordings. A, Spike raster for the two songs and spike distance matrix for recording with

invariance index of 0.93. ***B***, similarly for another recording with invariance index of 0.92

and ***C***, third recording with invariance index of 0.89.

Supplemental Figure 5. Correlations between invariance and the three response

properties shown in Figure 3 after the arcsine transformation to reduce heteroscedasticity

within the original distribution. ***A***, scatter plot of 1 ms violations with performance, ***B***,

intrastimulus R_{corr} and ***C,*** temporal sparseness. All values are in radians.

Supplemental Figure 6. Example intensity invariant neuron from dataset testing

discrimination using 5 different songs at 5 different intensities. ***A***, spike raster for the 5

songs with lines separating the different intensities. ***B***, MDS for the 5 song categories

across all tested intensities. ***C***, discrimination performance curve for this neuron across

the range of intensities tested.