THE SPARSENESS OF STIMULUS ENCODING BY SINGLE NEURONS AND BY POPULATIONS OF NEURONS IN THE INFERIOR TEMPORAL CORTEX.

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Abstract

Sparseness is a measure of the selectivity of neuronal responses. High sparseness indicates low stimulus selectivity with a sparseness of 1.0 indicating a neuron that is non-selective to the set of stimuli. The sparseness of the encoding of stimuli by single neurons and by populations of neurons is fundamental to understanding the efficiency and capacity of representations in the brain.

The sparseness of the responses of single neurons in the primate inferior temporal visual cortex (the single neuron sparseness a^s) was measured to a set of 20 visual stimuli including objects and faces in macaques performing a visual fixation task. Neurons included for analysis had significant firing rate increases from baseline in response to some of the stimuli. The firing rate distribution of 36% of the neurons was exponential. Twenty-nine percent of the neurons had too few low rates to be fitted by an exponential distribution, and were fitted by a gamma distribution. The sparseness a^s of the representation of the set of 20 stimuli provided by each of these neurons had an average across all neurons of 0.77, indicating a rather distributed representation.

The sparseness of the representation of a given stimulus by the whole population of neurons (the population sparseness a^p) also had an average value of 0.77. Ergodicity is the ability to predict the distribution of the responses of the system at any one time (the population level) from the distribution of the responses of a component of the system across time. Considering this in neuronal terms, for the average sparseness of a population of neurons over multiple stimulus inputs to be ergodic, it must equal the average sparseness to the stimuli of the single neurons within the population, provided that the responses of the neurons are uncorrelated (Foldiak 2003). As there is little or no correlation in the response profiles of inferior temporal cortex neurons (Rolls et al, 2004), the similarity of the average single neuron sparseness a^s and population sparseness for any one stimulus taken at any one time a^p shows that the neural representation of visual stimuli such as objects and faces is essentially ergodic.

References

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