DECODING NEURONAL RESPONSES FROM SINGLE TRIALS MILLISECOND_BY_MILISECOND

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A goal of neurophysiology is to decipher the information represented by the sequence of action potentials recorded from extracellular neuronal recordings. In our case the data come from from awake behaving monkeys. Up to now, information theoretical analyses have been used to great advantage to analyze such data. However, although information assesses the potential separability of data distributions, such analyses have generally not provided the step of decoding the responses trial-by-trial, ms-by-ms.

To understand how the nervous system processes information it would be helpful to learn what the message encoded in a response is -- that is to decode it. Decoding any coded signal requires a lexicon that provides the translation for it. Because of the large number (order of n choose k, or n!/(k!(n-k)!), where n is the number of bins and k is the number of spikes in the train) of neuronal spike patterns, decoding neuronal responses exactly has seemed beyond reach. Recent work has shown (Oram et al, J. Neurophysiol, 1999; Baker and Lemon, J. Neurophysiol, 2000; Oram et al, J. Neurophysiol, in press), however, that spike trains of neurons in many brain areas, both visual and motor, are almost perfectly represented as stochastic samples taken from the overall time varying rate (the peristimulus time histogram) and the spike count distribution. By taking advantage of this result, a simple, exact realtime decoder can be constructed using adaptations of order statistics.

It can easily be shown that: (1) that this stochastic model of spike trains is virtually perfect for single neurons in several brain areas under several different conditions of sensory, motor and cognitive processing (all of the conditions we have yet tested) for both single neurons and pairs (with a small extension) of neurons; and (2) that when the stochastic assumption is met, a simple, closed form, exact neuronal decoder can be derived. Spike trains are decoded millisecond-by-millisecond, whether ore not spikes arrive. Using this decoding tool it is possible to compare the decoding performance possible from spike trains at each point in time to the behavioral performance of the monkey.