An Integration Model for Detection and Quantification of Synchronous Firing within Cell Groups

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Cooperative firing among groups of cells is a reliable and efficient means of communication throughout the cortex. Synchrony may serve to bind relevant information across the visual field by increasing the probability of eliciting postsynaptic action potentials, thus ensuring transmission to other cortical areas. We have developed a biologically representative model of excitatory postsynaptic potential integration that detects and quantifies the degree to which groups of cells are synchronized, thus gauging their effectiveness in transferring salient information. The approach utilizes a progressive clustering algorithm and similarity measures for both identification of cooperative cell groups and descriptions of synchrony within those groups. The method may be applied to multi-cellular array recordings to determine joint correlations among groups of cells. Traditional cross-correlation techniques also identify synchrony, but can only predict pair-wise relationships. We applied this method to multi-cellular array recordings from the visual cortex of cats anesthetized with N₂O and propofol and found that the average synchrony for cell groupings varied predictably over the range of stimuli presented, in that the amount of synchrony increased for stimuli that were collectively more optimal for the group. Optimal stimuli yielded response structure (synchrony, bursting) that embraced over 80% of the total spikes generated by a group. Group membership was dynamic, depending on the spatial configuration of the stimuli. These results support speculations on encoding of structure by neural assemblies and may have important implications regarding the biological substrate underlying contour detection and object recognition.

NIH: RO1 EY014680-02