4th Neural Coding Workshop, Plymouth, UK 10-15 September 2001

WHAT ARE THE NEURONAL MECHANISMS OF SPECIFIC NEURAL CODE OF THE SECOND-ORDER FEATURES IN THE CAT STRIATE CORTEX?

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We studied sensitivity of neurons in the cat area 17 to a cross, a corner and an Y-like figure centered and flashing in the receptive field (RF). About 40% of these neurons (114/289) gave a larger response (by a factor of 3.06±0.32 on average) to a figure than to an optimal light bar (Shevelev 1998, 2000). More than 70% of such cells were found to be selective both to a figure shape (an angle between its lines) and orientation, while about 30% of units revealed all possible types of a tuning invariance to orientation and/or shape of a figure.

The intracortical mechanisms that could underlie the striate sensitivity to a figure might be: an excitatory convergence to a studied neuron of two units with different preferred orientations, an inhibitory formation of sensitivity to a cross due to a specific topography of excitatory, inhibitory and disinhibitory subzones in RF, and an enhancement of the neuron output by recurrent excitation.

Excitatory convergence of two V1 units with different preferred orientations as a reason for tuning to a figure was shown to be involved in about 20% of neurons that have double orientation tuning to a single bar. Sensitivity to a figure may arise in RF also when ends of the bars making up a figure go off the end-stopping inhibitory zone(s) of RF. As it is shown in our simulation study, a net for detection of a figure, if it do not include disinhibition of end-inhibition, must contain a scheme intensifying the response to an optimal figure by recurrent excitation. This may be necessary, if one need to have typical unimodal orientation tuning to a single bar and sensitivity index to a figure (figure/bar response ratio) higher than 2.0.

In about half of the figure-sensitive cells a bar-length function significantly (average of 2.3±0.2 times) increased under stimulation of the side disinhibitory zone of the RF indicating involvement of disinhibition of end-inhibition to figure-sensitivity. The $GABA_A$ergic intracortical inhibition provides for or controls this sensitivity: microiontophoretical application of bicuculline suppressed or diminished it in about 3/4 of cases.

Our simulation supported all these schemes and showed also that variation of location, size and weight of RF zones reproduces different combinations of sensitivity to a central, peripheral and entire cross. The possible mechanisms of selective sensitivity to figures were simulated and are discussed, as well as their functional implication for the second-order feature extraction in the primary visual cortex.

The study was supported by the Russian Foundation for Basic Research.

References

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