BMC Neuroscience

POSTER PRESENTATION Open Access

Context integration in visual processing: a computational model of center-surround suppression in the visual system

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From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

A dysfunction of GABAergic neurotransmission is hypothesized to be an important factor in the pathophysiology of schizophrenia [1], depression and anxiety disorders. Findings of decreased center-surround suppression (CSS, i.e. the mutual inhibition of a focal visual stimulus and its surrounding) have been interpreted in terms of GABAergic dysfunction [2]. Consistently, strongly decreased CSS is reported in schizophrenic patients [3]. However, the underlying mechanisms of this decrease remain unclear.

Methods

We developed a biologically inspired neural network model of the human primary visual system, consisting of two retinas, two layers of dorso-lateral geniculate nucleus and section B and C of layer 4 of the primary visual cortex. The model was built using GENESIS (www.genesis-sim.org) and comprises about 150,000 neurons. Three different kinds of neurons were incorporated, namely thalamic relay neurons, and excitatory and inhibitory cortical neurons. The processing of input in the retina was simply modeled as random-spike units, where the average firing rate corresponds to the input intensity. The neurons consisted of a soma, an axon and two or four dendrites for relay or inhibitory and excitatory neurons, respectively. We used different ionic channels to reproduce the desired firing behaviour. Synaptic transmission was implemented using the built-in excitatory and inhibitory synaptic channels.

Results

We designed a protocol to explore the center-surround suppression capabilities of our model. The retina was stimulated with contrast stimuli similar to those used in [2]. We compared activity in central neurons of layer 4B and 4C in response to two stimuli with a focal circle of 40% Michelson contrast, where the target stimulus had a high-contrast surrounding while the reference had a uniform surrounding. We found a decrease in activity of 27.73% in layer 4B and one of 31.41% layer 4C when comparing responses to the target with responses to the reference.

A plausible neural network model of the human primary visual system which is consistent with psychophysical effects previously reported in humans [2] is a starting point to further investigate the role of GABAergic inhibition in visual context integration. The capabilities of the model to explain both individual variance of CSS strength and CSS in pathological conditions of GABAergic neurotransmission remains to be tested. We plan to do so on the basis of psychophysical CSS data in humans and corresponding *in vivo* measurements of GABA and Glutamate concentrations in primary visual cortex using Proton Magnetic Resonance Spectroscopy (1H-MRS).

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Published: 20 July 2010

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doi:10.1186/1471-2202-11-S1-P100
Cite this article as: Metzner *et al.*: Context integration in visual processing: a computational model of center-surround suppression in the visual system. *BMC Neuroscience* 2010 **11**(Suppl 1):P100.