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Presentation Abstract

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Presentation Title:	The flow and disintegration of sensory information in the spinal circuitry
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Abstract:

Bashor (1998) created a large-scale biological neural network model and used it to study the dynamic interactions in neuron populations. We adapted the model to control a single-joint musculoskeletal model during a postural task (Stienen et al., 2007). The biological neural network controls the motoneuron firing rate by combining the tonic descending excitation and the muscle spindle and Golgi tendon organ proprioceptor signals.

The network with a total of 2298 neurons consists of motoneurons and several types of interneurons in six antagonistic population pairs: the motoneurons (169 neurons per pair-half) directly drive the muscles; the interneurons (five types, 196 neurons per pair-half) are exciting or inhibiting---and possibly recurrent or reciprocal---intermediates for passing the Ia (muscle length and velocity), Ib (muscle force) and II afferent (muscle length) information received from the proprioceptors on to the motoneurons. The model parameters are based on spinal recordings in cats, which are assumed to be functionally comparable with humans.

With this model we showed that the model mimics the findings of human postural experiments using presynaptic inhibition of the Ia-afferents to modulate the feedback gains, with both human and model able to achieve negative feedback gains. In a pathological example, disabling one specific interneural connection simulates the experimental results in complex regional pain syndrome patients.

We have further investigated the flow of sensory information in the spinal circuitry. Two aspects seem to dominate the outcome: the number of synapses the information crosses and the total stimulation effect of all inhibitory and excitatory connections.

The proprioceptive feedback reaches the motoneurons directly or via one or more intermediating interneurons. The number of synaptic connections classifies these paths. For instance, for the monosynaptic stretch reflex the spinal information crosses only one synapse between muscle spindle and motoneuron. Paths that cross two or three synapses

between sensor and motoneurons are called di- and trisynaptic. The influence decreases with the number of synapses due to information dilution. We found that paths that cross more than three synapses can be ignored.
Paths can provide positive or negative stimulation to the motoneurons. Crossing one reciprocal or one inhibitory synapse will make the stimulus negative; crossing another makes the stimulus positive again. The total stimulation effect of the path on the motoneuron can be calculated. Note that positive stimulation results in a negative feedback path with positive gain components in feedback control diagrams.

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MODEL

SENSORY

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