

## How to switch from standing to walking

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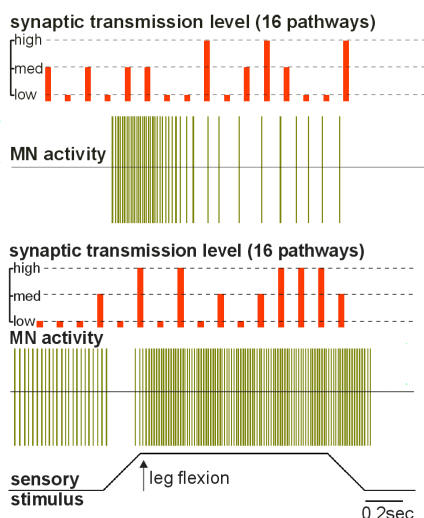
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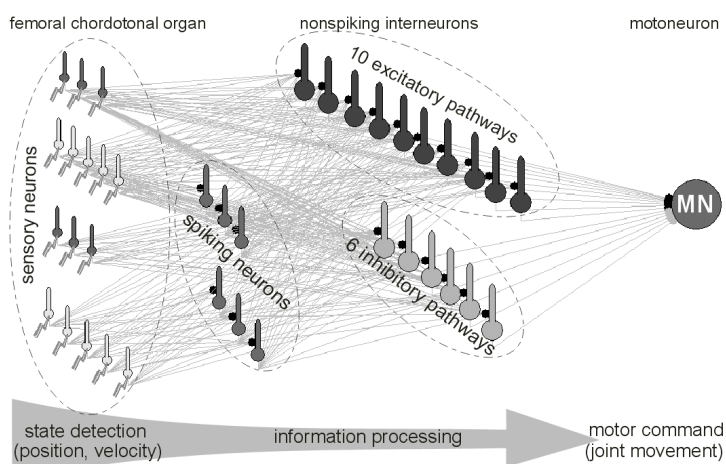
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All animal behavior is characterized by the movement of the body and by its response to sensory stimuli. The nervous system shows a great plasticity in the processing of sensory information and thus also in its response to such information. Here, we tried to combine the physical structure of the nervous system with the activity of nerve cells and the required computation within the nervous system. We used an insect model system, the femur-tibia joint control system of the stick insect, for the investigation of how the nervous system can switch between two different motor outputs, walking and standing. For this task, the nervous system has to toggle from a static joint control during standing (resistance reflex, Fig. 1 top) to movement control of the limbs (reflex reversal, Fig. 1 bottom) when the animal starts to walk although it receives the same sensory input.



**Fig. 1:** Different motor outputs. MN: Motoneuron. Red bars indicate synaptic transmission levels of interneuron pathways.



**Fig. 2:** Simulated femur-tibia joint control system with information flow. Small arrows: Current injections.

We used a computer simulation based on the known network structure (Fig. 2, an extension of Sauer, Driesang, Büschges, Bässler, *J comput Neurosci* 3, 1996) to permute the strength of specific identified nonspiking interneuronal pathways (Büschges, *J exp Biol* 151, 1990; Stein, Sauer, *J comp Physiol A* 183, 1998) which process velocity and position information from leg proprioceptors. Two independent analysis of the resulting database of more than 43 million network outputs showed that the same neural network can produce the two different behaviors by specifically altering the weighting of interneuronal pathways. We obtained specific combinations of pathway transmission levels for each behavior (Fig. 1, red bars on top of motoneuron activity). This means, that solely changing the pathway transmission strengths is sufficient to switch between different behaviors, like from standing to walking. In our model this was achieved by activating or deactivating additional network parts. During walking, the transition between stance and swing phase of the leg is likely to be produced by these components, for example by a relaxation oscillator (Driesang, Büschges, *J comp Physiol A* 179, 1996). In a reduced model in which the femur-tibia control system was provided with such an oscillator circuit, the network only generated the appropriate output when position, but not velocity information was fed into this circuit. This was achieved by either applying a negative velocity signal to the oscillator (Bässler, Koch, *Biol Cybern* 62, 1989) or by providing the oscillator with a strong position dependent switch that rapidly attenuated velocity information. The latter circuit predicted a dependence of the transition between stance and swing phase on the velocity of the leg movement. We are currently testing this prediction with measurements of the leg movement in a walking animal.

In conclusion, our results show that the same neuronal network can produce two different behaviors (standing and walking in the stick insect) despite having the same sensory information. The transition between both behaviors can be produced by specific changes in the weighting of parallel information pathways to the motoneuron. Those changes seem to be implemented by a relaxation oscillator circuit that resides presynaptically to the known interneuronal pathways.