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Functional gain modulation in spinal motoneurons by sub-threshold Vm-fluctuations due to balanced synaptic inhibition and excitation.

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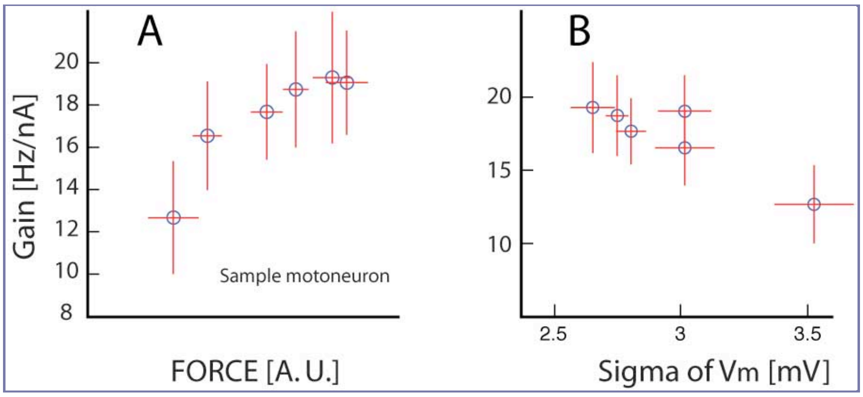
Abstract: The mechanisms underlying the large dynamic range in motor systems are poorly understood. We have previously shown that the intensity of synaptic inhibition and excitation co-vary in phase (rather than out of phase) during rhythmic limb movements (Berg et al. Science 2007). This could provide a mechanism for gain modulation in motoneurons.
Fluctuations in membrane potential due to balanced synaptic input is a possible candidate for gain modulation in neurons, as suggested for sensory processing (Chance et al. Neuron 2002), but issues still remain: 1) is gain modulation by balanced synaptic fluctuations in fact used by the nervous system to adjust the dynamical range? 2) does this mechanism also adjust dynamical range and improve precision in motor systems? Scratch spinal network activity in the turtle is an ideal model for addressing both issues. Here we quantify the motor output during scratching and relate it to the intensity of the synaptic fluctuations and the gain recorded in individual motoneurons.
We find that: 1) the FI-gain of individual motoneurons is modulated during motor behavior. 2) the motor output (quantified as the integrated electroneurogram (ENG) of hip flexor nerves) correlates with this gain (figure A). Interestingly, this relation represents a functionally meaningful gain modulation because it scales the force precision with the absolute force in analogy to Weber law for sensory perception, i.e. ΔForce/Force ≈ constant. Gain is equivalent to ΔForce and the ENG is equivalent to Force. 3) the gain is reversely related to the magnitude of the fluctuations in membrane potential (i.e. sigma of V_m, figure B), as previously predicted from theory (see e. g. Tuckwell 1988).



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