

# MODELLING PROPRIOCEPTIVE SENSORY CONTROL OF THE MAMMALIAN LOCOMOTOR CPG.

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## INTRODUCTION

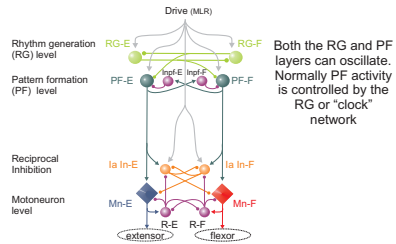
We have constructed a model of the mammalian locomotor CPG that reproduces realistic cycle and phase durations as well as deletions of motoneuron activity during fictive locomotion.

Can this model also reproduce afferent-evoked perturbations of the fictive locomotor pattern?

### Approach:

- incorporate sensory feedback into the Rybak et al CPG model
- simulate and reproduce the effects of trains of peripheral nerve stimulation on patterns of motoneuron activation and the step cycle.
- offer plausible mechanisms for the sensory control of locomotion

## The Model



## METHODS

### Modeling afferent input:

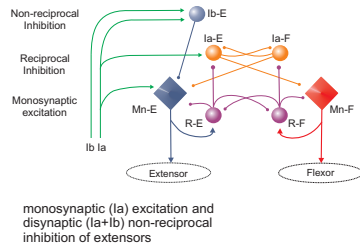
- synaptic connections were weighted
- group I fibres: a rectangular pulse with fixed amplitude
- group II fibres: activation required to exceed a set threshold and group II afferent activation always included group I recruitment like increasing stimulus intensity in animal experiments
- add sensory input adjusting synaptic input weighting until the stimulation corresponds to ENG records obtained with cycle-triggered nerve stimulation during MLR-evoked fictive locomotion in decerebrate cats

## ABBREVIATIONS

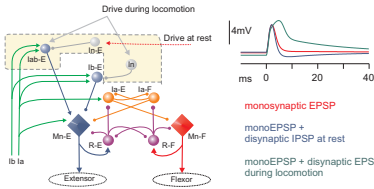
AB - anterior biceps	PF-E/F - pattern formation- extensor / flexor
EDL - extensor digitorum longus	R-E/F - renshaw - extensor / flexor
Ia In-E/F - Ia interneuron-extensor / flexor	RG-E/F - rhythm generation-extensor / flexor
Ib-E/F - Ib-extensor / flexor	Pi - plantaris
In-E - interneuron-extensor	Psoas - hip flexor muscle
InF-E/F - pattern formation extensor / flexor interneurons	Sart - sartorius
LGS - lateral gastrocnemius + sartorius	Sm - semimembranosus
MG - medial gastrocnemius	TA - tibialis anterior
MLR - mesencephalic locomotor region	TIB - tibialis
Mn-E/F - motoneuron-extensor / flexor	

## 1. Model of a locomotor-dependent reflex reversal

### Model 1: No locomotion

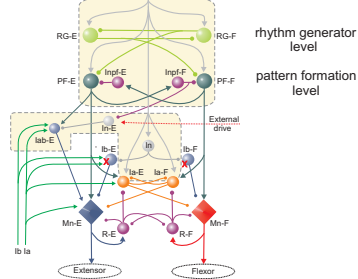


### Transition to locomotion: reflex reversal



- locomotor drive (tonic excitation) inhibits Ib-E (via In) and removes non-reciprocal inhibition.
- Ia-E is disinhibited and can produce disynaptic excitation during locomotion

### CPG Added:



## 2. Model of extensor group I and cutaneous actions during locomotion

### CPG model for afferent stimulation during locomotion

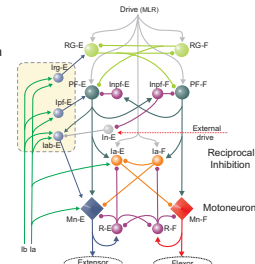
#### Added afferent input:

-at the rhythm generation level

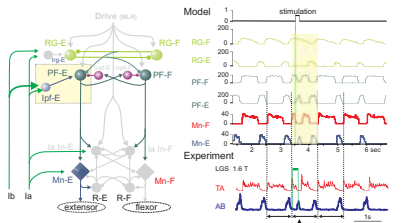
-at the pattern formation level

#### Removed:

non-reciprocal inhibitory INs

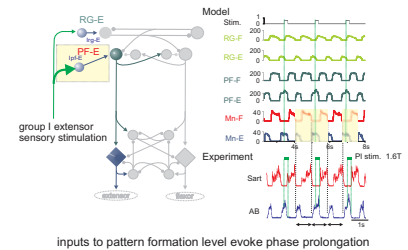


### Extensor group I afferents during flexion: PF level resetting



inputs to pattern formation level generate a quick "step" at the PF level without changing the rhythm (no RG effect)

### Extensor group I afferents during extension: PF level phase prolongation



### Extensor group I afferents during extension: PF level phase prolongation and RG rhythm resetting

Increased group I afferent input to the rhythm generation level

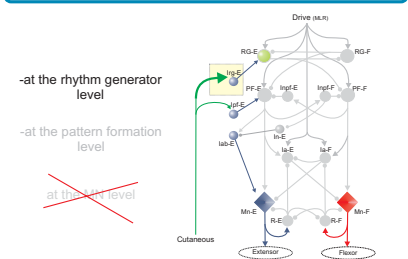
-at the rhythm generator level

-at the pattern formation level

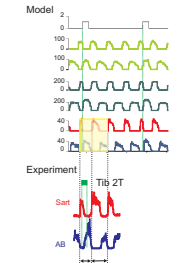
at the ~~PF~~ level



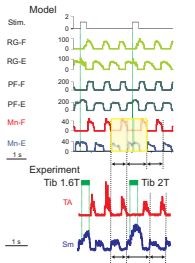
### Cutaneous nerves could change the step cycle: strong RG action, no direct actions at the motoneuron level



### stimulation during flexion resets to extension

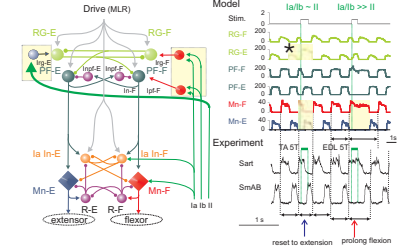


### stimulation during extension prolongs/enhances extension

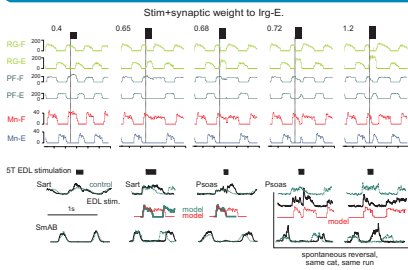


## 3. Model of flexor group I and group II actions during locomotion

### Hypothesis: Flexor afferents have competing effects on the flexor and the extensor half centers



### Reflex reversal evoked by increased synaptic strength of group II afferent input to the RG level



## CONCLUSIONS

- The 2-level CPG reproduces realistic cycle durations, deletions and sensory reflex perturbations
- extensor group I actions can be evoked at the RG and PF levels
- Flexor group II excite the extensor half-centre rhythm generator and flexor group I excite the flexor half-centre pattern formation network. The balance of the number of afferents and synaptic strength of these actions accounts for the differential effects of 5T nerve in the cat.
- Changes in the synaptic strength of group II input by spontaneous or controlled changes in presynaptic transmitter release result in variable reflex actions.