MODELLING THE VARIETY OF ACTIVATION PATTERNS OF BIFUNCTIONAL HINDLIMB MOTONEURONS DURING FICTIVE LOCOMOTION.

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INTRODUCTION

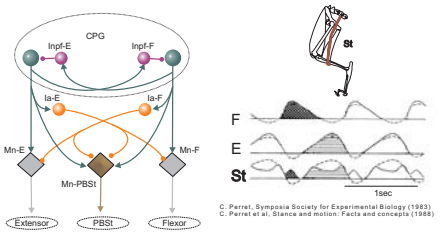
During real and fictive locomotion, the activity of bifunctional motoneurons such as PBSt differs from that of both the pure flexors and extensors acting at single joints.

The peculiar activity of PBSt has been used as an argument against the classical, half-center bipartite organization of the locomotor CPG (e.g., see Edgerton et al. 1976; Grillner and Zangger 1984; Stein 1985).

Can our new, two-layer, CPG model reproduce the activities of bifunctional motoneurons while retaining the essential features of a bipartite CPG organization?

Approach: using PBSt as the bifunctional motoneuron pool,
1. determine the variety of PBST activities encountered during MLR-evoked fictive locomotion
2. modify the Rybak et al CPG model to replicate these activity profiles.

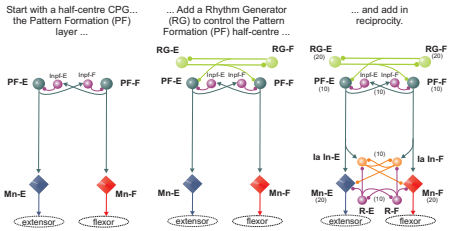
Perret et. al model for biphasic PBSt activity



Activity in bifunctional muscles like PBSt, during locomotion, has been previously ascribed to the summation of the excitatory and inhibitory inputs from both the flexor and extensor halves of the CPG.

Construction of the 2 level CPG

Separate rhythm generator and pattern formation layers



ABBREVIATIONS

CPG	- central pattern generator
Ia-E/F	- Ia extensor / flexor
Inpf-E/F	- interneuron pattern formation- extensor / flexor
LGS	- lateral gastrocnemius + soleus
MG	- medial gastrocnemius
MLR	- mesencephalic locomotor region
PBSt	- posterior biceps + semitendinosus
Mn-E/F	- motoneuron-extensor / flexor
Mn-PBSt	- motoneuron-PBSt
PF-PBSt	- pattern formation- PBSt
PF-E/F	- pattern formation- extensor / flexor
R-E/F	- Renshaw-extensor / flexor
R-PBSt	- Renshaw - PBSt
RG-E/F	- rhythm generation-extensor / flexor
Sart	- sartorius
SmAB	- semimembranosus + anterior biceps
TA	- tibialis anterior

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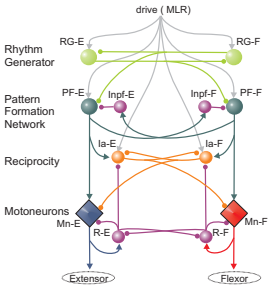
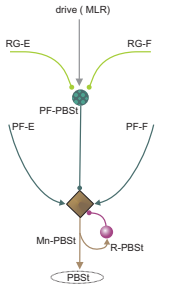
Basic 2 level CPG model



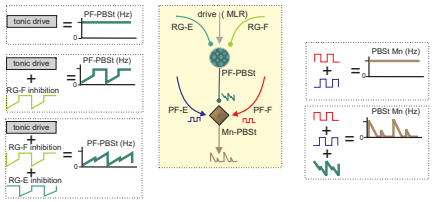
To which we add:



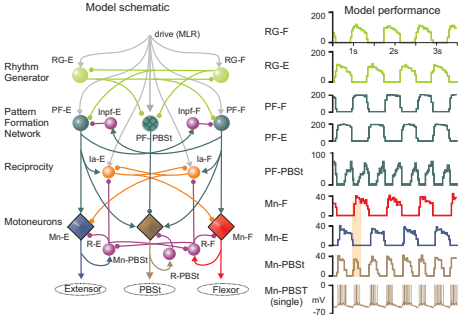
Mechanism of PBSt activation during fictive locomotion

inhibitory Pf-PBSt Ins receive:
tonic locomotor excitation
rhythmic RG-E inhibition
rhythmic RG-F inhibition

PBSt Mns receive:
rhythmic PF-E excitation
rhythmic PF-Fexcitation
sculpted PF-PBSt inhibition

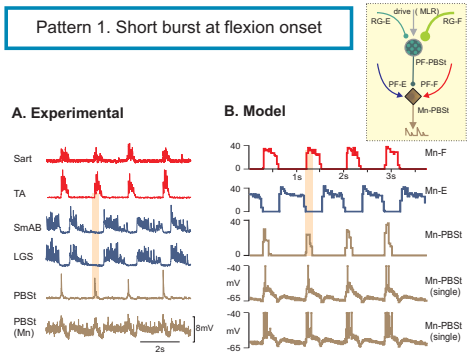


Control of PBSt activity by the two-layer CPG

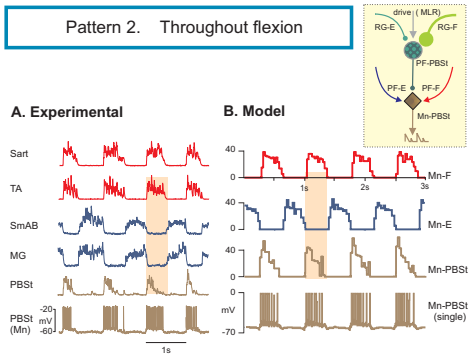


Four Patterns of PBSt Activity

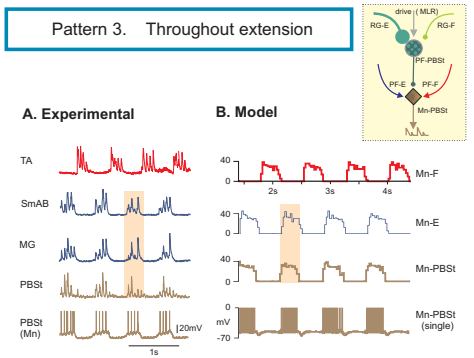
Pattern 1. Short burst at flexion onset



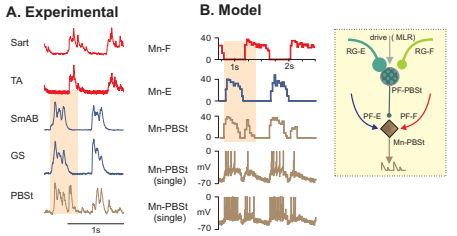
Pattern 2. Throughout flexion



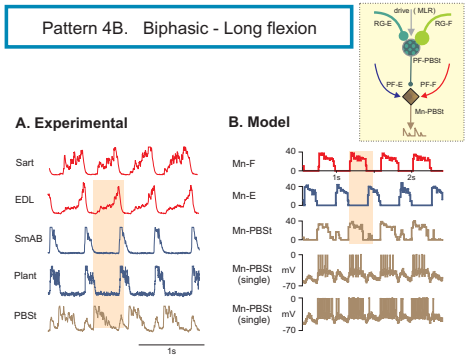
Pattern 3. Throughout extension



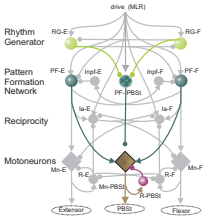
Pattern 4A. Biphasic - Long extension



Pattern 4B. Biphasic - Long flexion



CONCLUSIONS



The 2 layer CPG model can reproduce several profiles of PBSt actvity including double bursts per cycle while retaining a bipartite CPG organization by adding..

one inhibitory neuron (PF-PBSt) with input from both halves of the Rhythm Generator network.

PBSt activity depends upon:
- PF-PBSt inhibition
- excitation from PF-E and PF-F

Since PBSt activity depends on the activity of RG and PF populations, sensory afferents affecting rhythm generation (RG) and/or pattern formation (PF) levels of the CPG (1) could change PBSt activity patterns.

This would allow for gait-dependent (e.g. upslope vs. downslope) bifunctional activity (2).

1. McCrea et al. Modelling proprioceptive sensory control of the mammalian locomotor CPG. SFN #883.4

2. Stein & Smith "Neural and Biomechanical control strategies for different forms of hindlimb motor tasks, Neurons Networks & Motor Behavior p. 61-72, 1997