Lecture 8

Last lecture: Reflex System: How its wired

α - motor neurons receive Ia & Ib

γ " " do not

Stretch reflex helps

- prevent injury
- avoid instability
- fatigue compensation

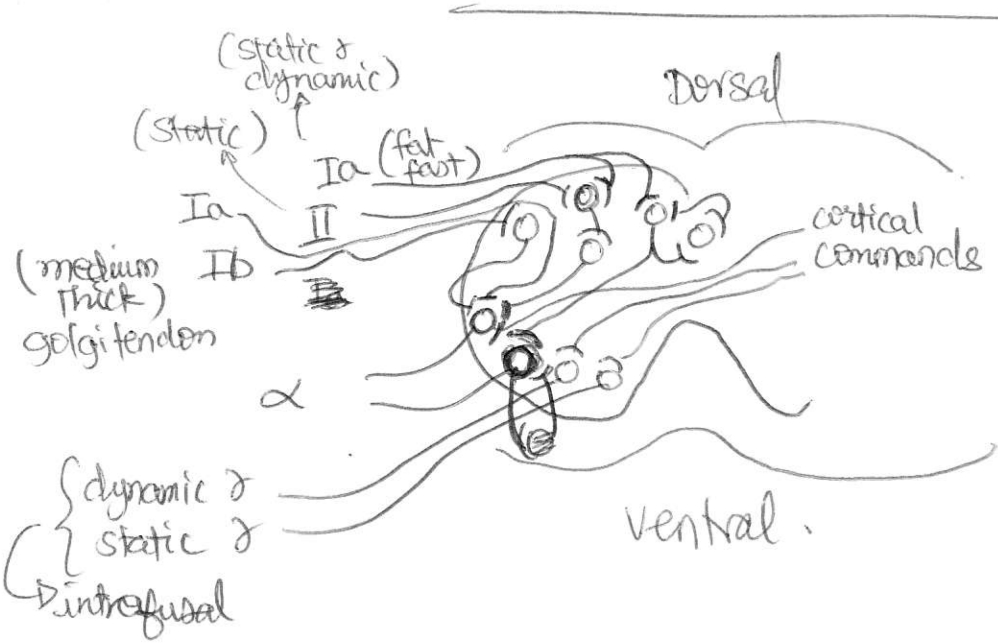
- Model of muscle spindle

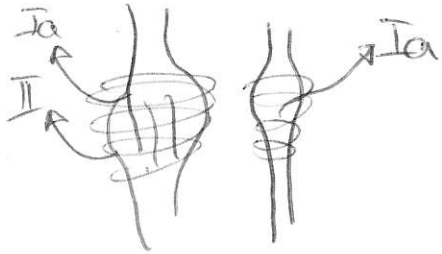
Impt ance of vel. } will talk more
Delay

Todays lecture: More on reflex

↳ concentrate on feedback loop

Spinal Cord Cross-section

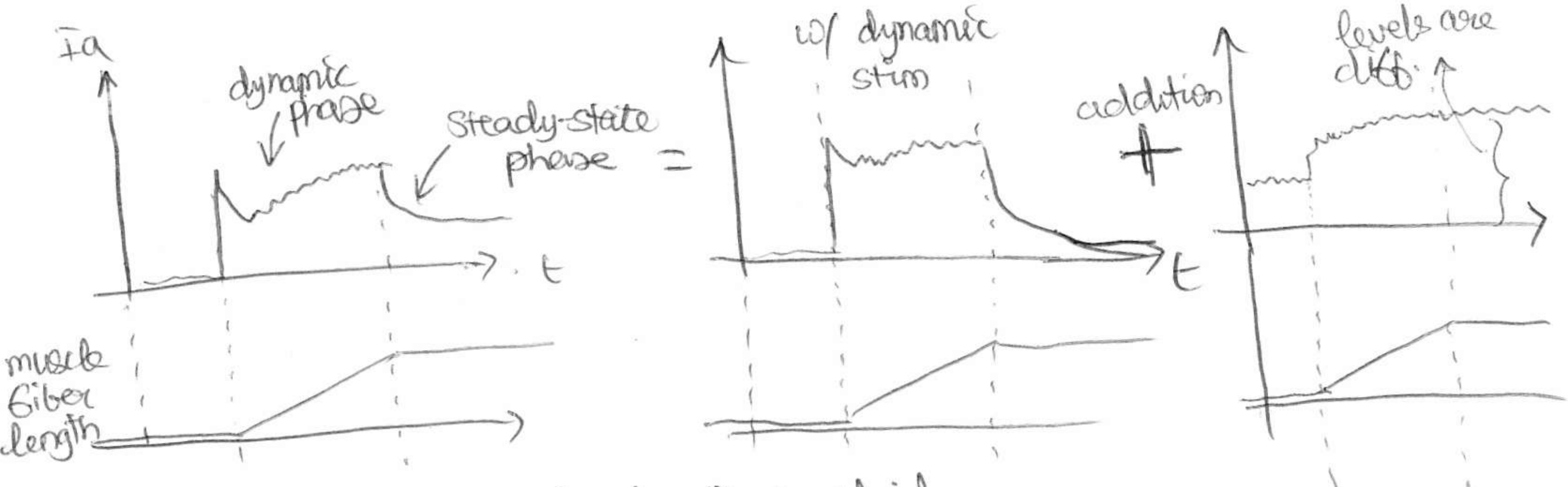




will add more features to the diagram!

2 types of γ motor neurons.
- dynamic γ motor neurons
- static γ motorneuron

} connected to dynamic & static nuclear bag fiber separately



Ia measures both muscle length & velocity

Dynamic γ motor neuron stimulation

↳ enhances the velocity component.

Static γ motor-neuron stim → enhances steady state (position) component.

Add their responses.

Last time we mentioned that α & γ are co-activated to have reflex interfere w/ voluntary mvts: when α is stimulated, γ must be ″ .

BUT γ can carry additional information

↳ when the task is difficult requiring more & faster feedback, γ motor neurons are activated more.

In addition: static & dynamic γ motorneuron activation is varied depending on the task.

P3

For cats

	S	D
sleep	off	off
slow walking	medium	almost off
scratching (paw striking)	low	high
beam walking	high	high

Feedback pathways from γ activation

Ia → carries both dynamic & static info } → mono synaptic connxns to motor neurons

↖ fattest fastest feedback nerve.

II → carries only positional info. } polysynaptic → a lot more connxns w/ interneurons

↖ slower

Why 2 different connxns?

Ia (fastest) needs to carry both vel & pos info for faster & better feedback sys. (remember PD control)

→ Having II allows separation of pos & vel. info

II → pos

Ia - II = velocity

Why not two lines? (one for pos & one for velocity?)

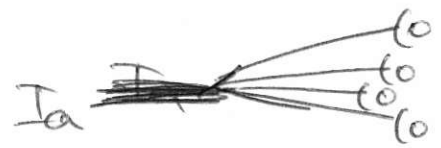
→ Combining it ~~one~~ to one line (Ia) guarantees no time shift. If two separate lines, no guarantee why is there a time lag betwn Ia & II?

- Not clear
- May be used for higher level feedback?

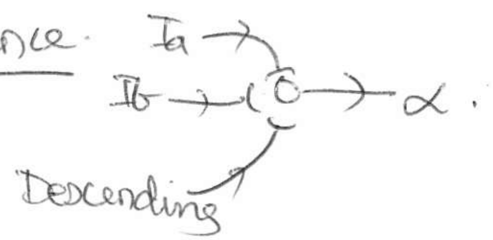
Many of Ia make monosynaptic connxns.
But most reflex pathways are polysynaptic
↳ interneurons are an impt part of reflex

Connxn types - impt for neural computation

Divergence

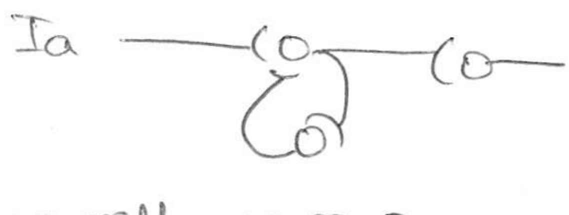


Convergence



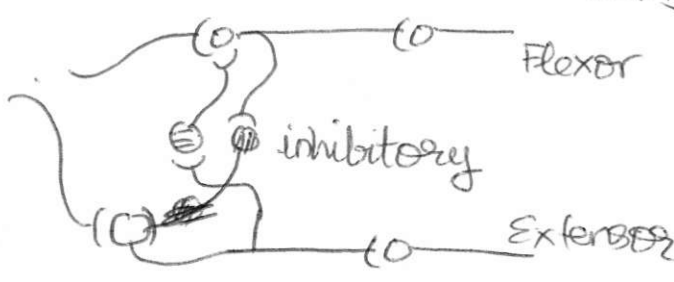
Spatial info

Reverberating Ckt



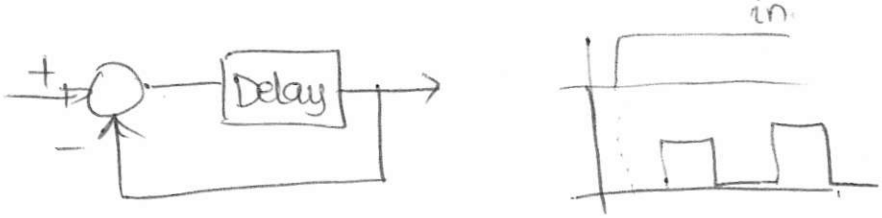
prolong reflex response
add reverberating ckt.

Central Pattern Generator - running etc.



Frequency limited by intrinsic nature
(depends on # of interneurons)

Remember neural delay we talked about last time

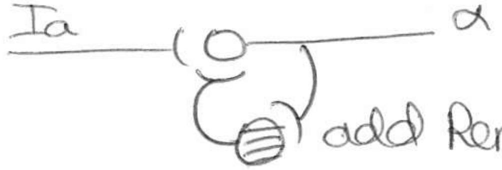


Drastically different output.

- caused by conduction times, synaptic delays & excitation to contraction time
- Out of these, synaptic delays are controllable ~~to~~ by adding more interneurons
- Used to get the desired response: i.e. CPG.
- possibly used for spinal adaptation
    - ↳ keeping memory
      changing synaptic threshold level.
    - if stimulated a lot or related to some other response, threshold drops

Renshaw Cells : plays a big role in feedback system (negative)

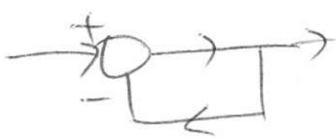
- inhibitory neurons that reverberate motor neurons.



→ adds negative feedback for ~~at~~ motor output

- produces short lived inhibitory effect.

- causes transient depression of the reflex sensitivity for immediate future
- important for error correction
- conditioning.

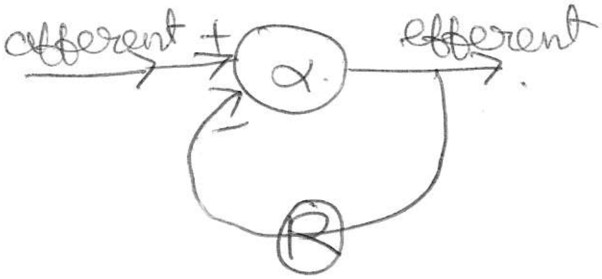


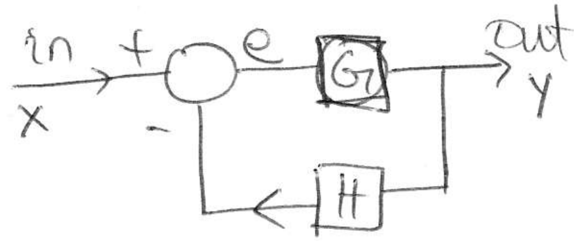
add delays

It's unstable → impt. to talk about the gain in a feedback system

Feedback gain can be caused by -

- adjusting motor neuron activity level
- modulate effectiveness of synaptic inputs
- etc.





G = motor neuron gain (typically < 1.0)

H = Renshaw cell gain

~~e = (in) - H(out)~~

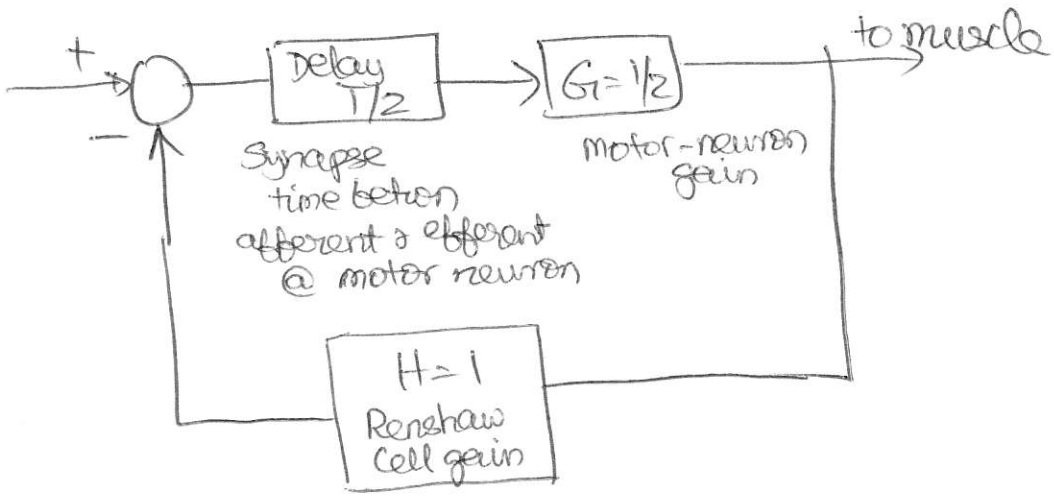
$e = x - HY$

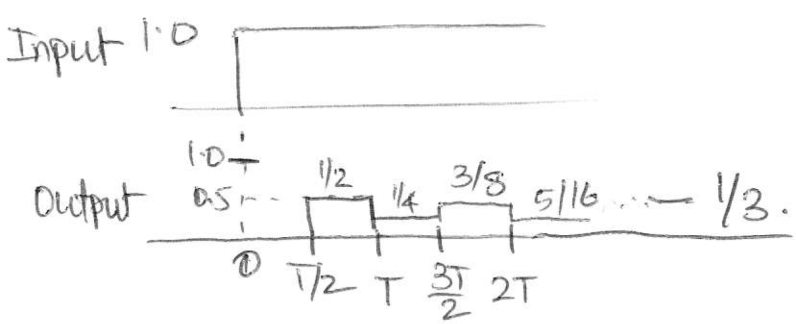
$Y = Ge = G(x - HY)$

$$Y = \boxed{\frac{G}{1+GH}} x$$

↳ C.L. Transfer function

Back to the delayed negative feedback sys.



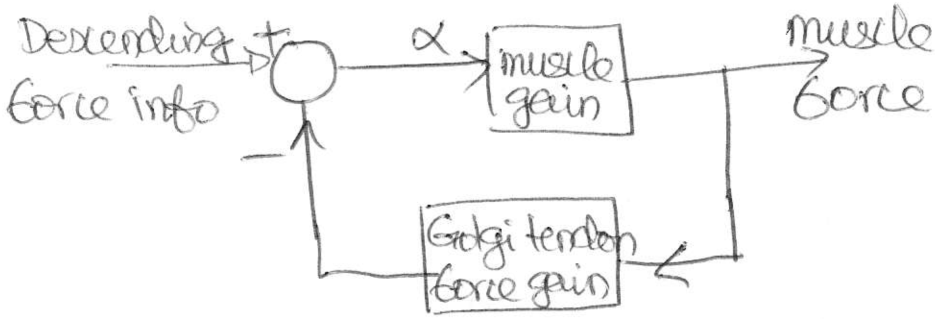


1/3 because $\frac{G}{1+GH} = \frac{1/2}{1+1/2} = 1/3$

Note that there could be delay due to the Renshaw cell also.

Another negative feedback sys.

↳ Golgi Tendon organs.



will play w/ this system in PS2