KEY

VA, ventral anterior nucleus
VL, ventral lateral 
IL, intra laminar

Glutamate
GABA
dopamine
Direct Pathway

Cortex

Striatum

Pallidum

modulator (READ)

Thalamus

$\leq 1/s$

rebound firing
globus pallidus

unilateral injury
hypokinesia
rigidity (co-contraction of agonist/antagonist muscle pairs)

bilateral injury
locked in abnormal postures

injury to GPi/SNr alone
carbon monoxide poisoning resemble injury to GP

idea without inhibitory (GABA) output, excess contractions of skeletal and ocular muscles
aside

GPI output is to MEA
SNr output is to SC

MEA, midbrain extrapyramidal area
SC, superior colliculus

limb, trunk movements
eye movements
SEQUENTIAL CONTROL OF BEHAVIOR

- direct
- indirect

(Boolan) guards/gates
RIGIDITY
STN, subthalamic nucleus

input from executive-motor areas
excitatory output to GPe

80% pallidal input from striatum
20% " " " " STN

injuries to STN cause
hemi ballismus
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Action Tremor</th>
<th>Rest Tremor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>Hands shake when passing cup/saucer</td>
<td>Pill-rolling finger movements of cupped hands</td>
</tr>
<tr>
<td>Onset</td>
<td>6-9 Hz</td>
<td>4-6 Hz</td>
</tr>
<tr>
<td>Cause</td>
<td>Young adult + autosomal dominant Essential Tremor</td>
<td>Stress voluntary action, concentration, sleep</td>
</tr>
<tr>
<td>Treatment</td>
<td>$\beta$-adrenergic blockers</td>
<td>Parkinson Disease dopamine agonists</td>
</tr>
</tbody>
</table>
feedback oscillation in rest tremor
<table>
<thead>
<tr>
<th></th>
<th>Projection</th>
<th>Interneuron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium spiny</td>
<td>GABA</td>
<td></td>
</tr>
<tr>
<td>Large aspiny</td>
<td>ACh</td>
<td></td>
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<tr>
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</table>

- est. 100,000,000 neostriatal neurons
- 540,000 GPe
- 170,000 GPi
- 500,000 SNc
<table>
<thead>
<tr>
<th>STRIATAL NEURONS</th>
<th>class</th>
<th>NT</th>
<th>other</th>
<th>%</th>
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</thead>
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<tr>
<td>projection</td>
<td>medium spiny</td>
<td>GABA</td>
<td>DIR D2R sub P ENK A2AR</td>
<td>49</td>
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<tr>
<td>interneuron</td>
<td>large aspiny</td>
<td>ACh</td>
<td>parvalbumen</td>
<td>1-2</td>
</tr>
<tr>
<td></td>
<td>medium aspiny</td>
<td>GABA</td>
<td>SOM NPY NOS</td>
<td>1-2</td>
</tr>
</tbody>
</table>
SOM, somatostatin
NPY, neuropeptide Y
NOS, nitric oxide synthetase
1. shell nucleus accumbens
2. core
3. caudate
4. putamen

OT, olfactory tubercle

section of frontal lobes
lateral ventricles
septum
striatum

temporal lobe
sensory hierarchy

trans-thalamic (non-reciprocal)

motor hierarchy

goals