COGS 107B

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Logistics

• Section is not mandatory, but recommended
• I’ll cover material from the previous week
  • Slides posted under ‘Resources’ tab
• 3 non-cumulative exams:
  • Week 4, Thursday 1/31
  • Week 7, Thursday 2/21
  • Week 10, Thursday 3/14
• Go to class, pay attention to what Dr. Nitz draws on the board, and know how to do the example problems!
• Questions?
## Lec 1 – Systems neuroscience & Levels of analysis

**systems neuroscience = structure dynamics**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synapses</td>
<td>Synaptic Potentials</td>
</tr>
<tr>
<td>Neurons</td>
<td>Action Potentials</td>
</tr>
<tr>
<td>Nuclei</td>
<td>EEG/Field Potentials</td>
</tr>
<tr>
<td>Regions</td>
<td>fMRI</td>
</tr>
</tbody>
</table>

**Micro** to **Macro**
Santiago Ramon y Cajal

- **neuron doctrine**: neuron is the basic structural and functional unit of the brain

- **law of dynamic polarization**: neural/electrical transmission proceeds in one direction
  - (mostly true)

  dendrite/soma $\rightarrow$ axon $\rightarrow$ axon terminal
Properties of ion channels

1. **Ion selectivity:** what types of ions pass thru
   
   \(Na^+, Ca^{++}, K^+, Cl^-\)

2. **Gating:** what opens/closes it
   
   voltage, ligand

3. **Kinetics:** how long it remains open
   
   some open for 1ms, others 100s of ms – it varies

4. **State:** current activation state
   
   activated, inactivated, deinactivated, persistent

5. **Distribution:** where it is located
   
   in dendrites, at axon hillock
Brain potentials (107A review)

Membrane potential = voltage difference between intracellular space and surrounding extracellular space

Equilibrium potential = membrane potential at which net flux of ions across the membrane is zero

Synaptic potentials = excitatory and inhibitory inputs from one neuron onto another (EPSPs and IPSPs)

Action potentials = all-or-none electrical events in a neuron which reflect the spatial and temporal integration of synaptic potentials and the neuron’s intrinsic excitability
Continuous vs. Discrete

**Continuous**
- Synaptic potentials
  - different amplitudes & durations

**Discrete**
- Action potentials
  - all-or-none
Lec 2 – Somatosensory System

• Transient (rapidly adapting) vs. persistent (slowly adapting)
• Topographic representation
• Response fields
• Cortical column: segregation/integration response types

exam q’s to expect: analogies on these topics
Topographic representation

• Neurons in the brain are **spatially arranged**
• Neurons responding to similar features are **grouped into the same space**
• Groups are **interconnected**
• May reflect actual space
  • retina, skin surface
• May reflect stimulus space
  • type of odor, sound frequency

*homunculus*

1 barrel = 1 whisker

*Bonus: scientists Penfield and Jasper*
Dorsal root ganglion cell

**Dendritic region:**
Unmyelinated; has special mechano-gated ion channels triggered by physical bending

Distortion results in: **generator potential**, which is graded according to intensity

If appropriate threshold is reached, an **action potential** is triggered
Continuous vs. Discrete

**Continuous**
- Synaptic potentials
  - different amplitudes and durations
- Generator potentials

**Discrete**
- Action potentials
  - all-or-none
# Touch receptors in the skin

<table>
<thead>
<tr>
<th>Type</th>
<th>Looks like</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair receptor</td>
<td>wrapped around hair follicle</td>
</tr>
<tr>
<td>Pacinian corpuscle</td>
<td>onion</td>
</tr>
<tr>
<td>Meissner’s corpuscle</td>
<td>pancakes</td>
</tr>
<tr>
<td>Merkel disk</td>
<td>flowers</td>
</tr>
</tbody>
</table>

(Ruffini: stretch)
## Touch receptors in the skin

<table>
<thead>
<tr>
<th>Type</th>
<th>Transient (RA) vs. Persistent (SA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair receptor</td>
<td>transient (RA)</td>
</tr>
<tr>
<td>Pacinian corpuscle</td>
<td>transient (RA)</td>
</tr>
<tr>
<td>Meissner’s corpuscle</td>
<td>transient (RA)</td>
</tr>
<tr>
<td>Merkel disk</td>
<td>persistent (SA)</td>
</tr>
</tbody>
</table>

**Legend:**
- *RA*: Rapidly adapting
- *SA*: Slowly adapting

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*persistent/sustained = slowly adapting (SA) transient = rapidly adapting (RA)*
## Touch receptors in the skin

<table>
<thead>
<tr>
<th>Type</th>
<th>Transient (RA) vs. Persistent (SA)</th>
<th>Depth</th>
<th>Response Field</th>
<th>Info Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair receptor</td>
<td>transient (RA)</td>
<td>deep</td>
<td>10 mm</td>
<td>hair displacement</td>
</tr>
<tr>
<td>Pacinian corpuscle</td>
<td>transient (RA)</td>
<td>deep</td>
<td>very large (hand)</td>
<td>high frequency vibration</td>
</tr>
<tr>
<td>Meissner’s corpuscle</td>
<td>transient (RA)</td>
<td>shallow</td>
<td>3 – 5 mm</td>
<td>low frequency vibration; grip control</td>
</tr>
<tr>
<td>Merkel disk</td>
<td>persistent (SA)</td>
<td>shallow</td>
<td>spotty 2 – 3 mm (0.5 mm)</td>
<td>form, fine texture, points, edges</td>
</tr>
</tbody>
</table>

Pacinian: more sensitive to vibrations at higher freq’s

Merkel: two-point discrimination
Merkel disks have patchy response fields.

Pacinian corpuscles have large response fields.

- Excitatory response = more AP’s
- Inhibitory response = fewer AP’s
- No response = no change in AP rate

Small versus large response fields

Inhibitory surround complete vs. incomplete

Whole versus patchy response fields
Dorsal root ganglion pathways to the brain

Segregation of mechanoreceptor responses until S1

S1 (primary somatosensory cortex)
• Integration
• within-region (column) processing
• direction-selective surround inhibition

S2: response fields expand across digits, but maintain directional selectivity
S1: Within-region (column) processing

Persistent info (Merkel) $\rightarrow$ layers 2/3
- what’s consistently there

Transient info (Pacinian, Meissner’s) $\rightarrow$ layer 4
- what’s changed

Layers 2/3 = **integration** zone
- what is consistently there + what’s changed

General pathway
- layer 4 $\rightarrow$ layer 2/3 $\rightarrow$ layer 5 and 6 (and output)
S1: Direction-selective surround inhibition

partial inhibitory surround:

box = location on skin
black = more action potentials
white = fewer action potentials
grey = no change
Practice Q’s!

Found under the “Resources” tab
When the temporal and spatial integration of synaptic potentials on a neuron exceeds a certain threshold, it generates a(n) _____ potential.
When the temporal and spatial integration of synaptic potentials on a neuron exceeds a certain threshold, it generates an action potential.
True / False:
The action potential and synaptic potential are actually special cases of the membrane potential.
True / False:
The action potential and synaptic potential are actually special cases of the membrane potential.

True

Which one is continuous and which one is discrete?
Name 3 properties of ion channels
Name 3 properties of ion channels

- ion selectivity
- gating
- kinetics
- state
- distribution
Choose the appropriate word:
Generator potentials are analogous to ( synaptic / action ) potentials.
Choose the appropriate word:
Generator potentials are analogous to (synaptic / action) potentials.

*synaptic*

*Continuous or Discrete?*
‘Microslip’ events are best detected by the _____ of touch receptor.
‘Microslip’ events are best detected by what kind of touch receptor?

Meissner’s corpuscles

*Transient (rapidly adapting) or Persistent (slowly adapting)*?
Pacinian corpuscles are sensitive to _______ vibration, whereas Meissner’s corpuscles are sensitive to _______ vibration.
Pacinian corpuscles are sensitive to _______ vibration, whereas Meissner’s corpuscles are sensitive to _______ vibration.

Pacinian – high frequency
Meissner’s – low frequency
Which layer of the cortex does the info from each of these mechanoreceptors arrive at?

Merkel
Pacinian
Meissner’s
Which layer of the cortex does the info from each of these mechanoreceptors arrive at?

- Merkel → layers 2/3 (persistent)
- Pacinian → layer 4 (transient)
- Meissner’s → layer 4 (transient)

*Where is the information integrated?*
Thanks!

tactile sensation

transient

persistent