Cogs 107b – Systems Neuroscience
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Lecture 2: 01/07 – tactile sensation (a.k.a., touch sense or mechanoreception)

the weekly principle: ‘topographic representation’
proprioception and touch sense: the ‘all-axon’ ganglion cell

**Ganglion cell types: breakdown by conduction speed**

- **Aα** – proprioception – myelinated, very fast (70-120 m/s)
- **Aβ** – mechanoreception – myelinated, pretty fast (40-70 m/s)
- **Aδ** – thermoreception, nociception, hair cell – myelinated, fast (12-36 m/s)
- **C** – nociception – unmyelinated, slow (0.5-2 m/s)
Touch receptors in skin
Forms of Response Fields

- **excitatory response** = more AP’s
- **inhibitory response** = fewer AP’s
- **baseline response** = no change in AP rate

- Small versus large response fields
- Inhibitory surround complete vs. incomplete
- Whole versus patchy
Transient versus Sustained Adaptation of Mechanoreceptors

- Slowly-adapting (≈ sustained)
- Rapidly-adapting (≈ transient)

**Merkel disks, Meissner corpuscles, Pacinian corpuscles**

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Forms of Mechanoreceptors

Meissner’s corpuscle:
- Unmyelinated end of DRG cell winds through a stack of flattened skin cells that are positioned in the skin below the epidermis.
- Shallow placement
- Small response field (3-5 mm)
- Responsive to light touch
- Rapidly-adapting
- Highly sensitive to low-frequency vibrations between 10-50 Hz
Meissner’s corpuscles = low-frequency vibration sensitivity
sensitivity to slip = grip control
Forms of Mechanoreceptors

Pacinian corpuscle:
- Unmyelinated portion of the DRG cell is wrapped with multiple layers of skin cells
- Deep-placement
- Large response field
- Sensitive to vibration and pressure
- Rapidly-adapting
- Sensitive to pressure and high-frequency vibration (~250Hz)
- May help to detect texture
Pacinian corpuscles = frequency-dependent sensitivity to vibration
Forms of Mechanoreceptors

**Merkel Disk:**
- Single DRG cell contacts multiple Merkel cells embedded in the skin
- Shallow-placement
- Small, spotty response field (0.5 mm)
- Slowly-adapting (sustained)
- Sensitive to form, texture, points, edges
two-point discrimination = Merkl disk density

- lowest tactile acuity: on back and legs
small Merkl disk receptive field = fine texture discrimination (e.g., Braille)
<table>
<thead>
<tr>
<th>Type</th>
<th>RA / SA</th>
<th>Depth</th>
<th>Response Field</th>
<th>Sensitivity</th>
<th>Info. Processed/Best Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacinian</td>
<td>RA</td>
<td>Deep</td>
<td>Very large (hand)</td>
<td>Very high (10 nm)</td>
<td>High-freq. vibration</td>
</tr>
<tr>
<td>Meissner</td>
<td>RA</td>
<td>Shallow</td>
<td>3-5 mm</td>
<td></td>
<td>Slip / Low-freq. vibration</td>
</tr>
<tr>
<td>Merkl</td>
<td>SA</td>
<td>Shallow</td>
<td>Spotty 2-3 mm</td>
<td>Broad depth range</td>
<td>Form, texture / points, edges</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.5 mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair</td>
<td>RA</td>
<td>Deep</td>
<td>10 mm</td>
<td>1 micron</td>
<td>Hair displacement</td>
</tr>
</tbody>
</table>
dorsal root ganglion pathways to the brain

Ventral Posterolateral Nucleus (VPN) of the Thalamus

Somatosensory ctx. (S1)

medulla

Decussation of the medial lemniscus
Somatosensory cortex

- primary somatosensory cortex (SI): postcentral gyrus + posterior bank of central sulcus
- contains 4 sub-regions: 3a, 3b, 1, 2
In many cases, neurons in the brain are anatomically (i.e., spatially) arranged in a systematic fashion such that those responding to (or ‘representing’) similar features of a single sensory modality (e.g., vision or audition) are grouped into the same space in the brain. An important feature of such groupings is the interconnectivity of its members. Multiple such groups are, in turn, organized in a systematic fashion.

Sensory inputs that are topographically represented in the space of the brain may reflect actual space, as in the space of the retina or skin surface, or may reflect stimulus space as, for example, type of odor or sound frequency.

related concepts: surround inhibition, the cortical columns, the homunculus
1 barrel = 1 whisker
primary somatosensory cortex: within-region (column) processing

merging RA info. into SA info.?
dynamical into static?
Pacinian’s/Meissner’s into Merkl’s?
low-resolution into high-resolution?
S1: direction-selective surround inhibition
S1: direction-selective surround inhibition

- **incomplete**
- **discriminated**
- **not discriminated**

**Baseline**

**Excitation**

**Inhibition**
Convergence: multiple neurons in one region synapse on a *single* neuron in another region.