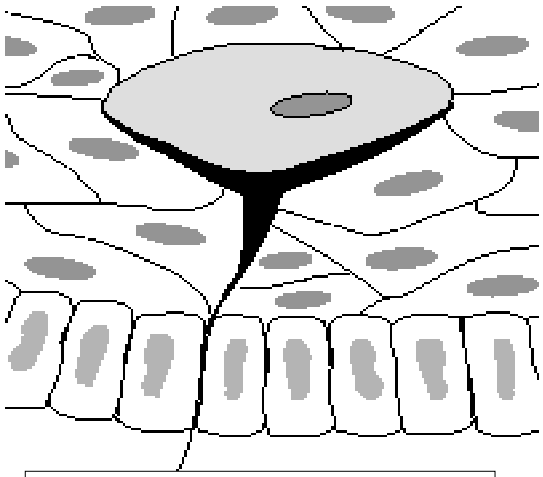
Touch -- Cutaneous Senses

- Subjective Experiences
- Peripheral Physiology
- CNS Physiology

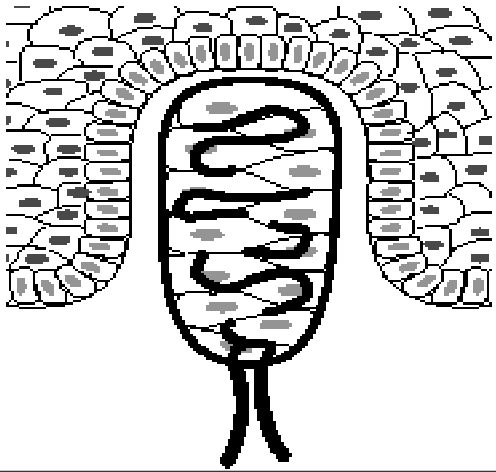
Subjective experiences

- Location
- Sensitivity
- Acuity
  - Two-point thresholds
  - Result of smaller receptive fields in areas of greater acuity
- Temperature
- Texture

Types of Mechanoreceptors

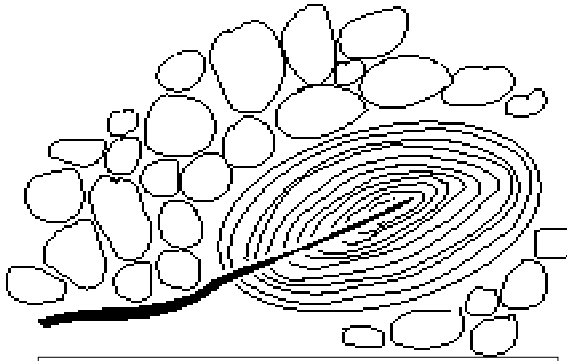


Merkel Receptor



Meissner corpuscle

Ruffini cylinder



Pacinian corpuscle

Meissner Corpuscles

- Near surface, vertical axis, rapid adaptation
- Rapid, small touch stimuli
- 3-40 hz vibrations, feels like flutter

Pacinian Corpuscles

- Deepest, largest, fewest
- Pacinian fiber: One rapid/diffuse fiber
- Most sensitive to slight touch over wide area
- 10 > 500 Hz vibrations, feels like vibration

Merkel Disks

- 2nd deepest, in groups of 5-10, SA-punctate innervation
- steady pressure of small objects
- detail perception
- .3-3 Hz vibrations, feels like pressure

Ruffini Endings

- 3rd deepest, parallel to skin's surface
- one or shared afferent fiber – SA-diffuse
- steady pressure across larger areas, motion of the skin itself
- 15-400 Hz vibrations, feels like buzzing

- **Free nerve endings**
  - In hairy skin, wound around follicles

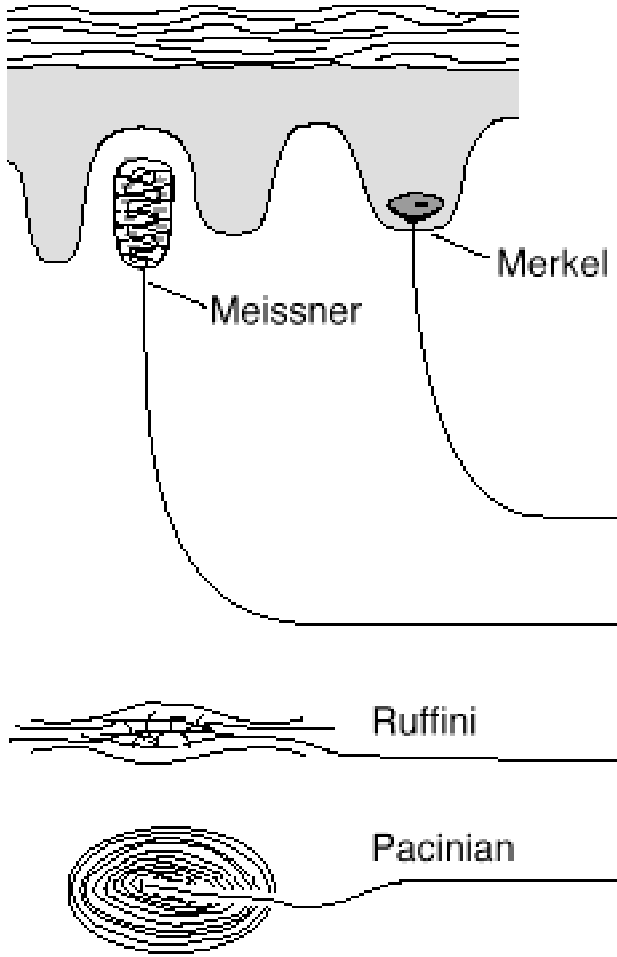
Physiology - Fibers

- Rapidly Adapting – useful for detecting rapid changes in skin pressure
- Slowly Adapting – useful for keeping track of constant skin pressure
- Diffuse/punctate
  - Diffuse – large receptive fields, ill-defined boundaries
  - Punctate – small receptive fields, sharp boundaries (4-10 finger ridges)

Fiber Summary

Fiber	Receptive Field	Receptor	Best Stimulus
SA 1	Punctate	Merkel	Pressure
RA 1	Punctate	Meissner	Tapping
SA 2	Diffuse	Ruffini	Skin movement; stretching
PC (RA 2)	Diffuse	Pacinian	Vibration

Mechanoreceptors & Touch Channels



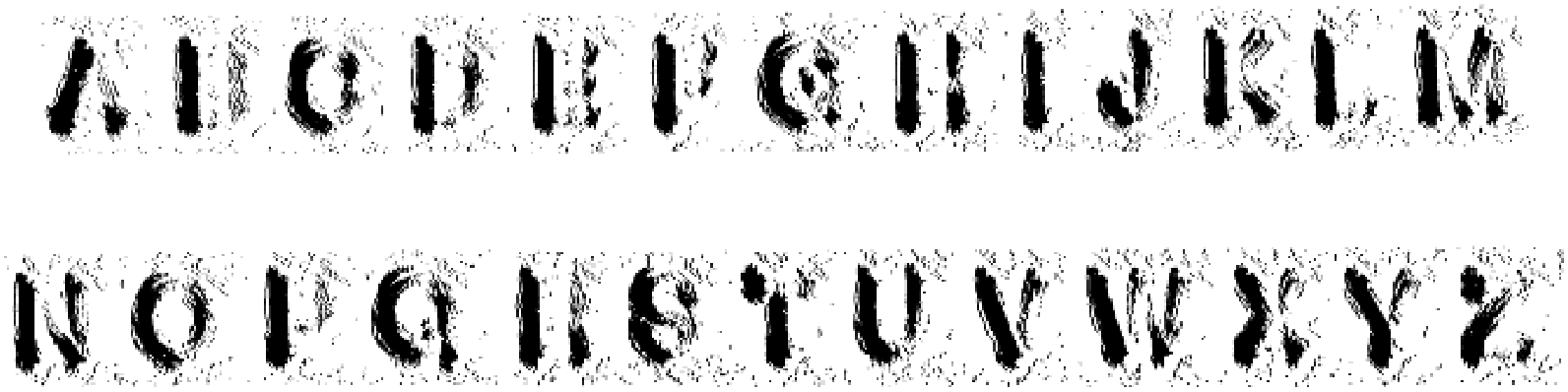
Fiber	Stimulus	Psychophysical channel	Perception
SA I	Pressure	NP III	Pressure
RA I	Light tapping	NP I	Flutter
SA II	Stretching of skin	NP II	Stretch
PC	Rapid vibration	P	Vibration

Spatial Event Plots

- Drums with bumps are rolled over the skin
- Recordings are made of neural activity in receptors
- Results:
  - **Merkel (SA1): very similar to stimulus**
  - Ruffini (SA2): almost no response
  - Meissner (RA1): much more diffuse response
  - Pacinian (PC): much more diffuse response

More Spatial Events

- Spatial event plot from SA1 in chimps below
- Letter confusions in humans are predicted by these plots:
  - C & O; B -> D



Thermoreceptors

- Cold fibers – fire more as skin temperature decreases
  - Respond best around 30˚ C
- Warm Fibers – fire more as skin temp. increases
  - Respond best around 44˚ C

Nociceptors – Pain

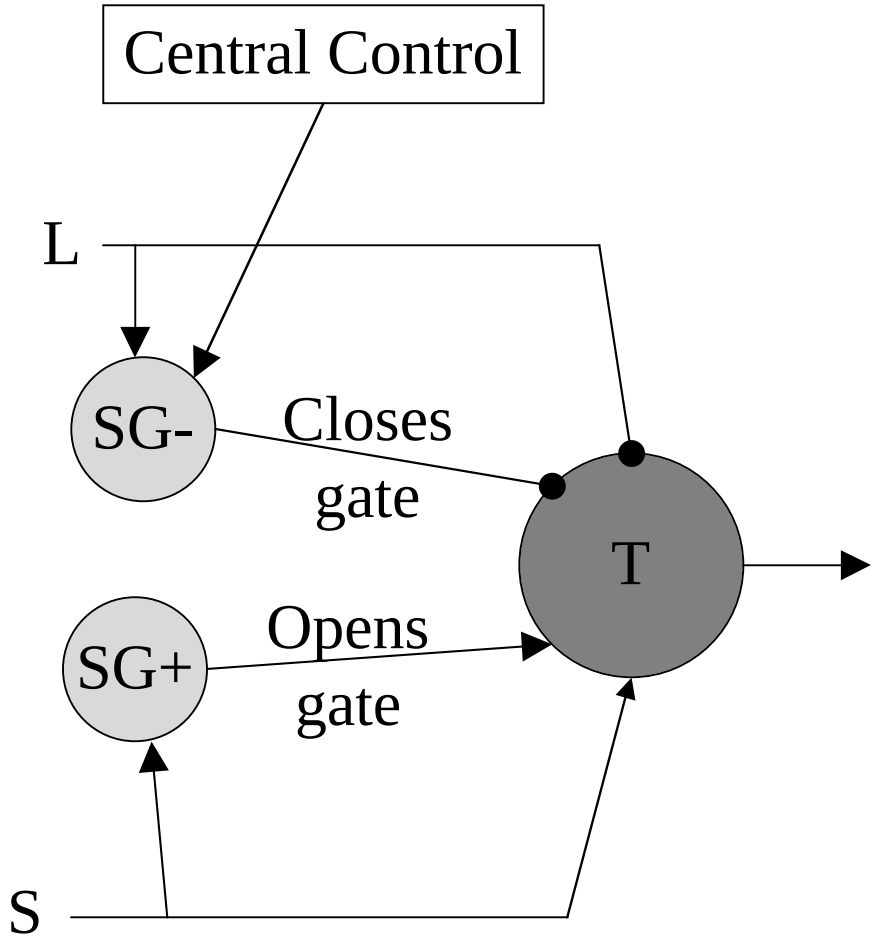
- Special cells that respond to temperatures above 45˚ C, where pain generally begins
- Also respond to impact, piercing of skin, etc.
- Cognitive & Cultural determinants of pain
  - Morphine works best on pain associated with anxiety
  - Religious rituals

Gate Control Theory

- Cells in the dorsal horn of the spinal cord
  - Substantia Gelatinosa
- T-cell firing determines pain perception
  - More firing, more pain
  - SG+ cells open the gate (pain increases)
  - SG- cells close the gate (pain decreases)

More Gate Control Theory

- Small diameter fibers (S) activate SG+, open gate
  - Attached to nociceptors
  - Respond to extreme heat, abrasion, etc.
- Large fibers (L) activate SG-, close the gate
  - Respond to massage, gentle heat, vibration

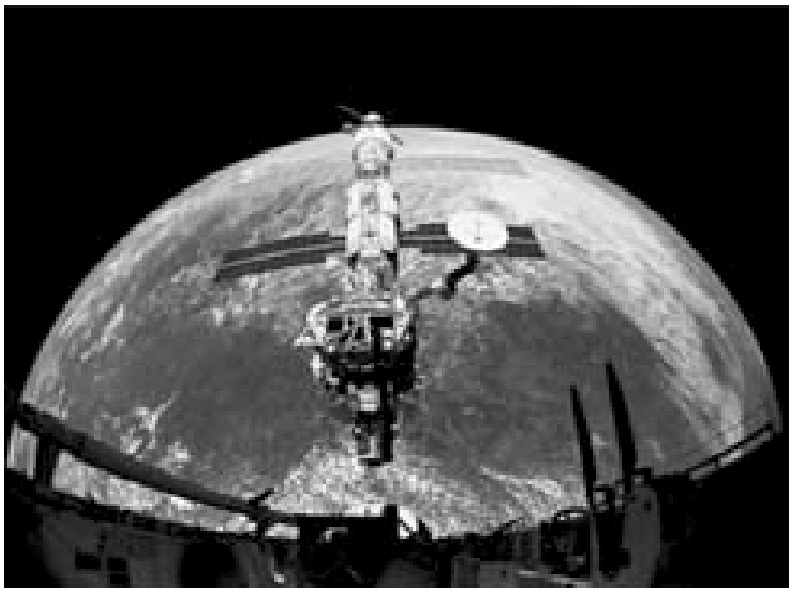


Review Session

- Thursday 5/9
- Room 1415A Belfer
- 6:45 - 8pm
- **Come prepared with questions!!**

3D IMAX Field Trip

- Space Station 3D
  - A movie about the real space station, filmed in space
  - Uses the latest 3d movie technology
- **Loews Lincoln Square**
- **Wednesday 5/8, 9pm**
- Cost: $10
- RSVP by Wednesday via e-mail



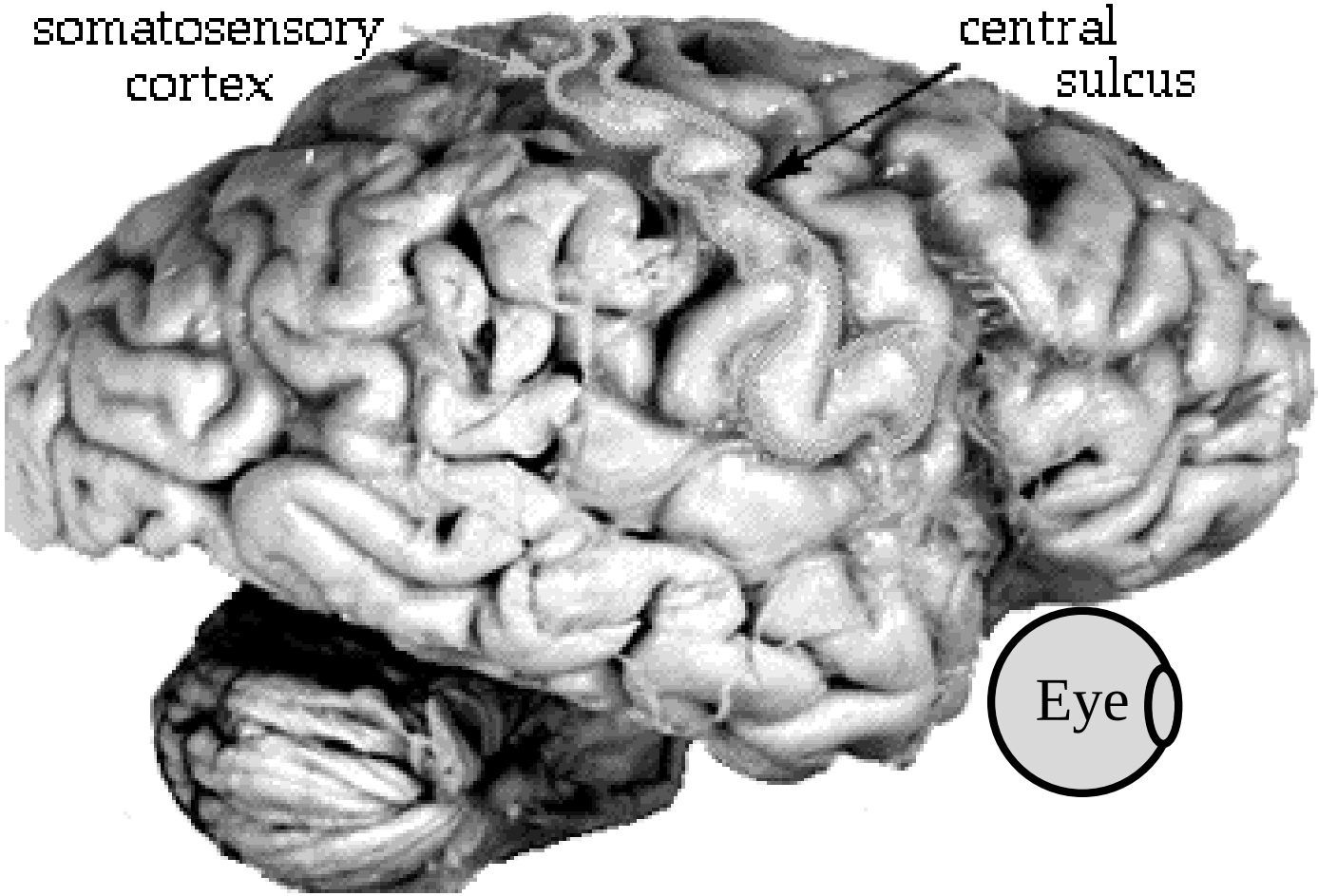
Top-Down Effects on Pain

- **Motivation -** if prepare self you can activate L and that will activate SG-
- **Attitude -** positive or negative
- **Expectations -** do you expect to feel pain or not (childbirth labor) - this has big influence on pain felt
- **Masking -** distraction - mind over matter (glass chewing)
- **Hormones -** fight or flight - aware of damage to body but don't feel pain until you look at the damaged area
- **Analgesics -** closes spinal gate in emergencies allowing you to cope as necessary until you get to safety
- **Endogeneous Opiates -** naturally occurring opiates (chemicals) that are in the body -these are released during fight or flight - Endorphins - Enkephalin

Beyond the skin

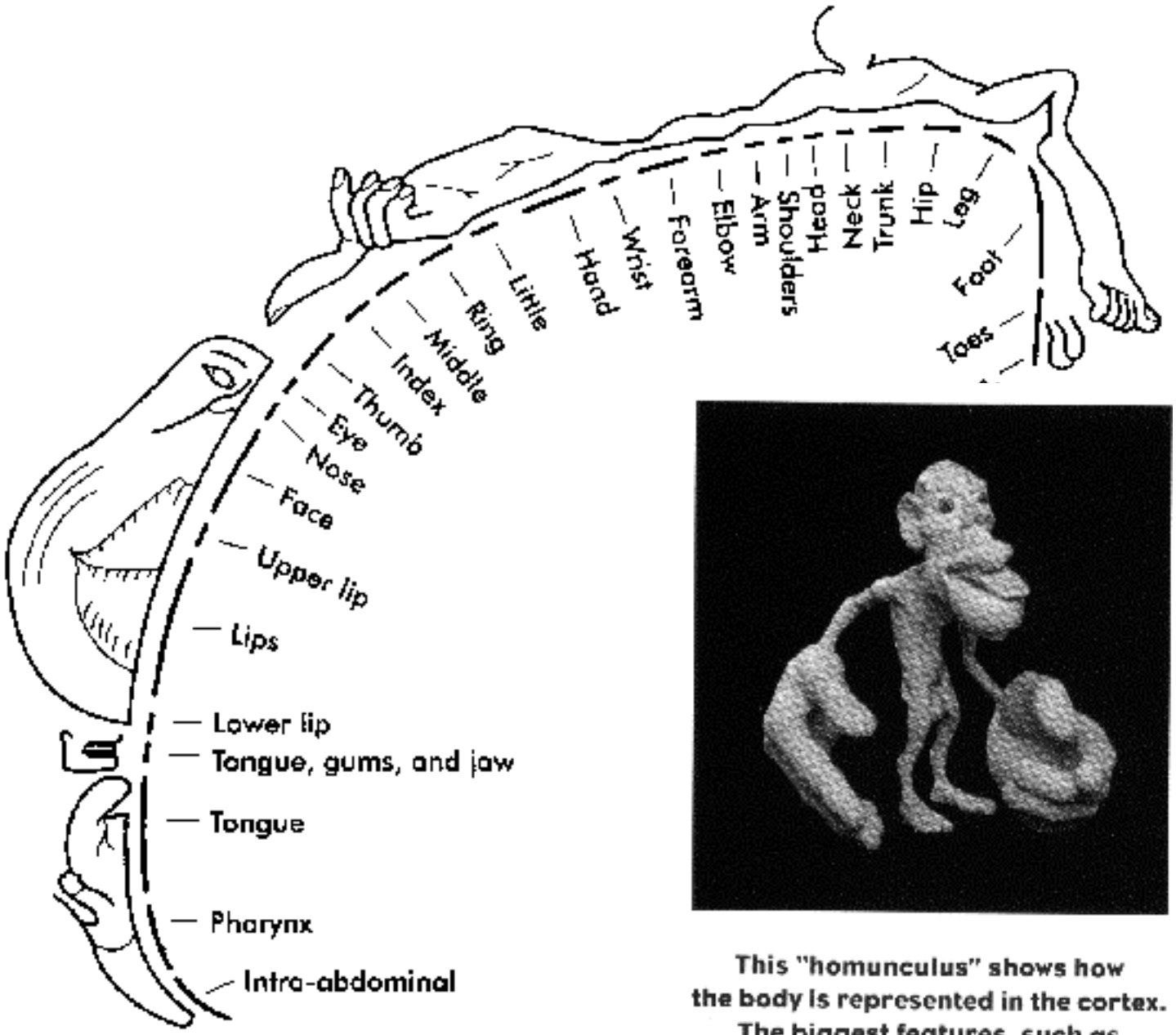
- Spinal cord
  - Medial lemniscal pathway
  - Proprioception & touch
  - Reflexes
  - Spinothalamic pathway
  - Temperature and pain
- Thalamus
  - Ventral posterior nucleus

Somatosensory Cortex



Cortex (S1)

- Somatosensory areas (in front of central sulcus)
- Homonculus isn’t strictly correct
- Four somatosensory layers in S1
- Including discontinuities
- Outer areas most sensitive to joint motion
- Inner areas are skin sensitive (light touches)



This "homunculus" shows how the body is represented in the cortex. The biggest features, such as the hands, have the most neurons.

More Cortex (SII)

- Gets information from S1 (mostly)
- Larger receptive fields
- More equal distribution of neural area to physical areas
- Orientation tuning

Phantom Limb

- After losing a limb, still feeling it (including pain)
  - 30-75% of amputees report some pain
- Why? Not just wishful thinking or nerve activation at the stump
  - Continuing activity of motor and sensory cortex
- Stimulation of cheek causes experience on phantom limb, too
  - Maybe nerves from face are taking over cortex used by arm
  - Maybe there are built in (but unused) connections

Movement of Phantom Limbs

- Most people with phantom limbs have the sensation that they can move them
  - Motor cortex sends out signals to move arm; commands are monitored by adjacent somatosensory cortex and ‘felt’ as movements
- If limb is paralyzed before amputation, people do not have the sense of being able to move the phantom; the phantom feels ‘paralyzed’
  - Ramachandran suggests that body sense is revised to reflect the fact that signals go out but the eyes can see the paralyzed limb is not moving
- ‘Mirror in box’ cure of phantom limb paralysis and pain: mirror gives impression of two limbs
  - Patient ‘claps hands’ - seeing this led to loss of limb
  - Speculates that discordance between vision and proprioception forces the brain to realize something is wrong

Haptics – movement and touch

- Exploratory hand motions
  - Enclosure (most common first move)
  - Lateral motion (texture)
  - Pressure (hardness)
  - Unsupported holding (weight)
  - Contour Following (shape)
  - Part motion/function tests (specific functions and relationships)

Unilateral Neglect

- Ignoring information about one side of your body
  - Usually the left
- Result of damage to right posterior parietal cortex

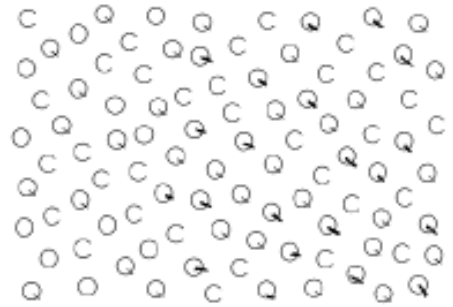


Figure 1: In this task, one of my patients was shown a field cluttered with the letters O, Q and C. She was asked to mark every letter O so that it would appear to be a Q. Notice that she accurately marked all of the O's on the right side, but consistently missed objects on the left side.

Figure 2: In this test, the patient was asked to draw a house and tree. Notice that the patient neglected the left side of the tree and the fence. This drawing is from the same patient as the first diagram.

Courtesy of Chris Rorden at the MRC