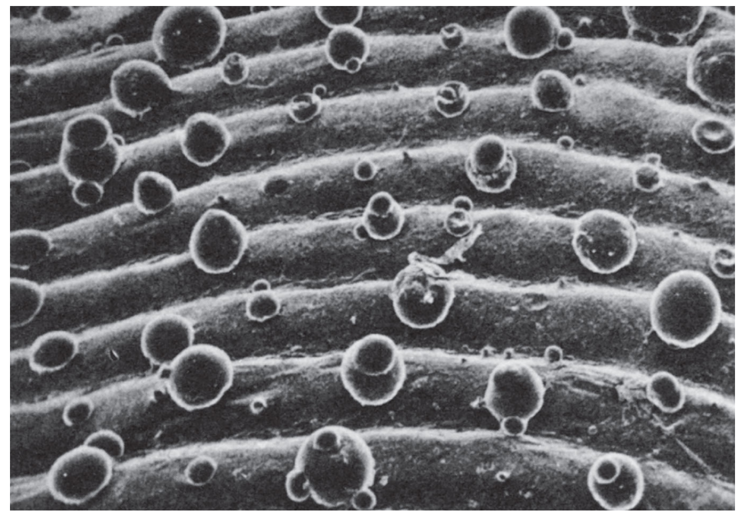
Touch / Somatosensation
(Chap 13)

Lecture 20



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Sensation & Perception (PSY 345 / NEU 325)
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“Touch” is really a collection of many different senses relating to the surface (and internal states) of the body.

Somatosensation - collective term for sensory signals from the body

Cutaneous senses

- tactile sense
- temperature
- pain
- others: itch, tickle, “pleasant touch”

- **Kinesthesis** - perception of the position and movement of our limbs in space
- **Proprioception** - perception of the body in space (kinesthesia + vestibular senses)

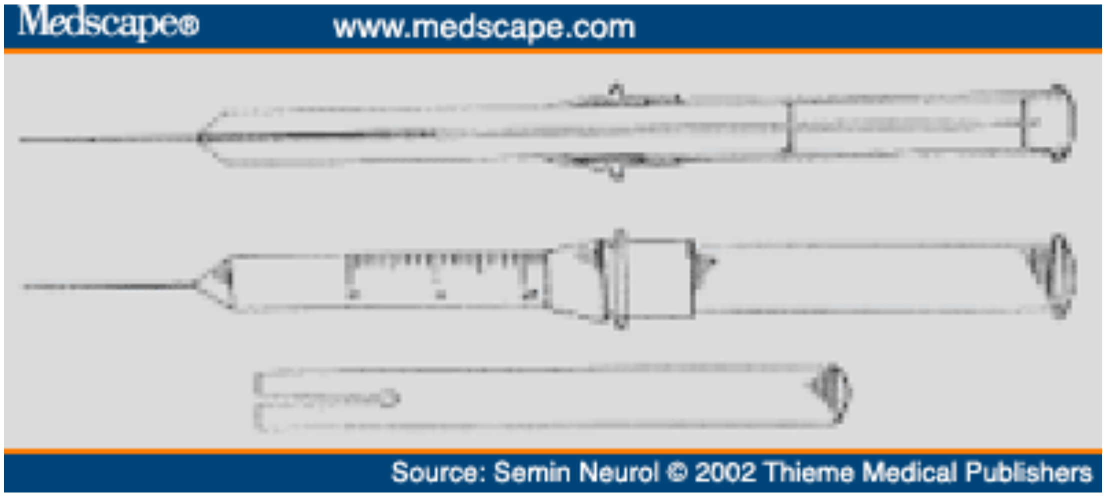
Measuring tactile abilities

1. sensitivity

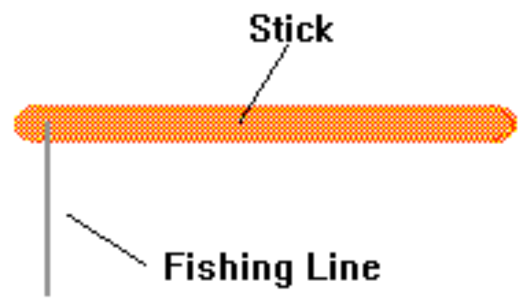
2. acuity

How sensitive are we to mechanical presssure?

Traditionally measured with **Von Frey Hairs**
- Max von Frey (1852-1932)



- Camel hair inside a tube
- various levels of pressure are applied
- calculations made based on how much the hair is bent during the examination
- sensitivity varies over the body
(face most sensitive, then hands and arms)

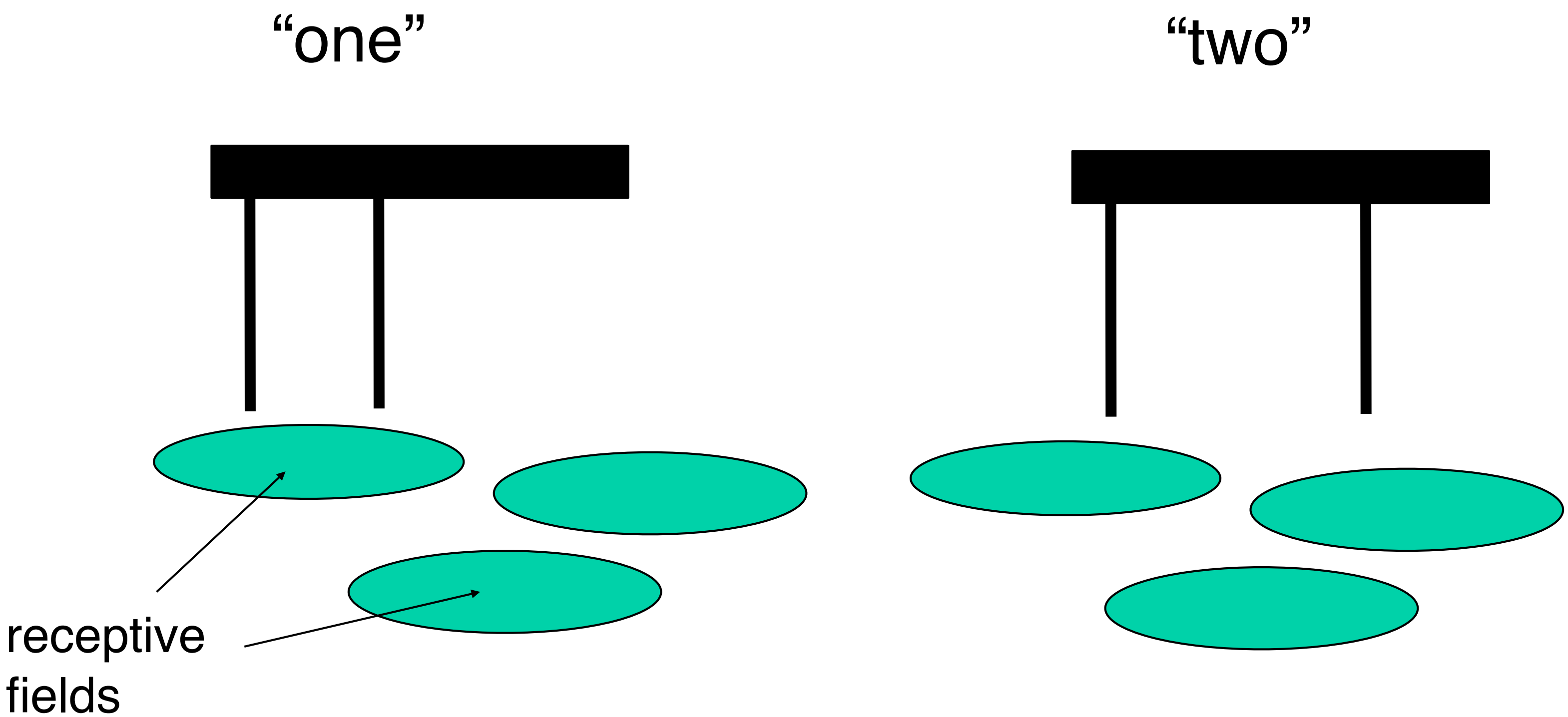


Or make your own with fishing line (various thicknesses) glued to a popsicle stick


DFNS

2. Touch Acuity

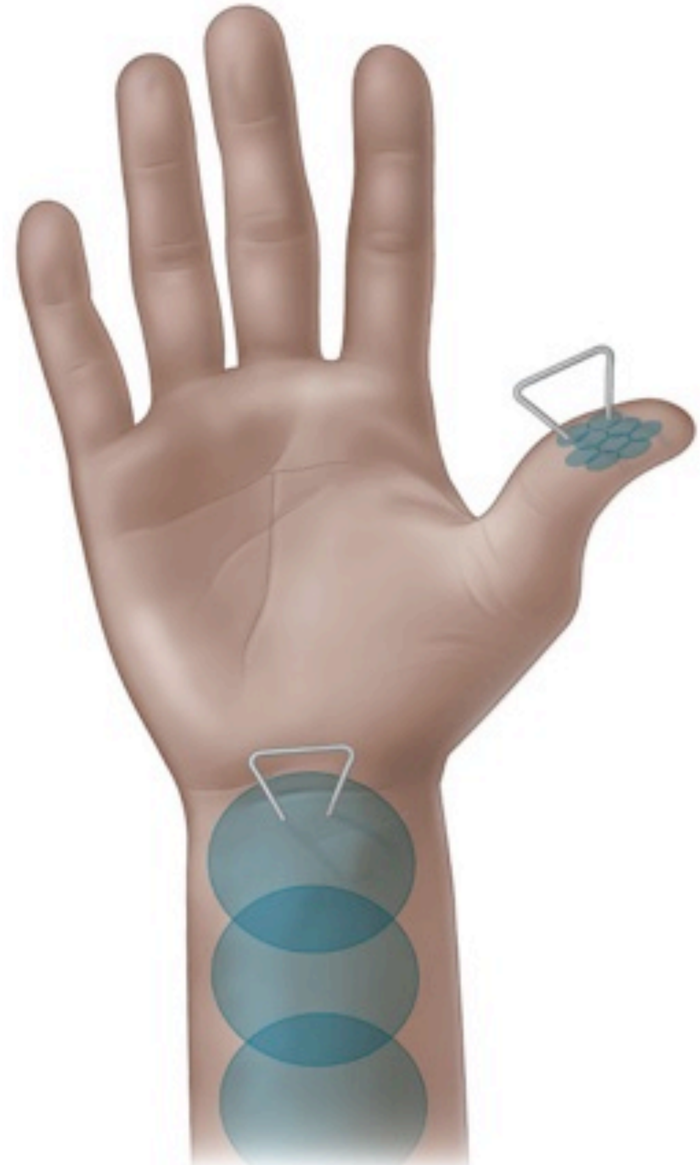
Obvious Experiment: Touch Acuity
(or Two-Point Threshold)



How finely can we resolve spatial details?

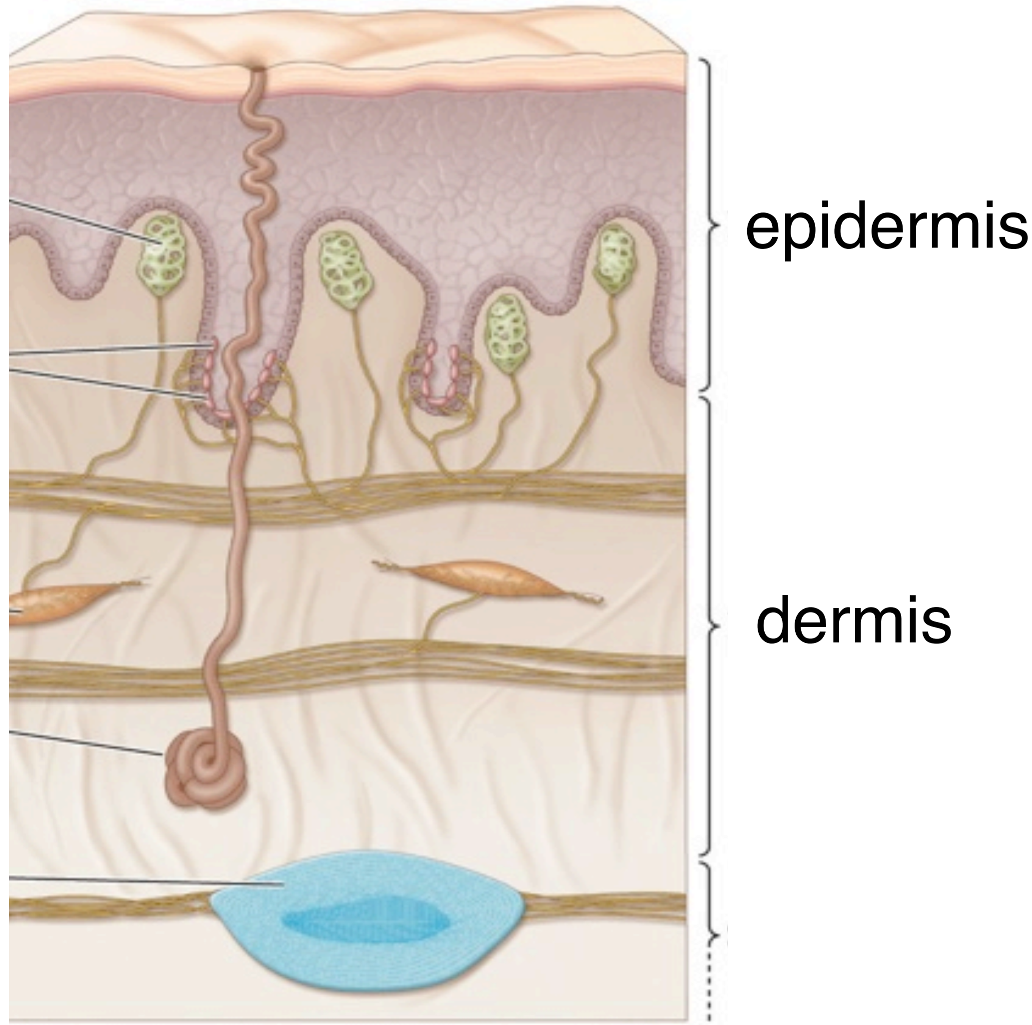
- **Two-point threshold**: minimum distance at which two stimuli are just perceptible as separate

- Like sensitivity to pressure, spatial acuity varies across the body
  - Extremities (fingertips, face, and toes) show the highest acuity



Physiology of the Somatosensory System

Touch receptors:
embedded on outer layer (epidermis)
and underlying layer (dermis) of skin

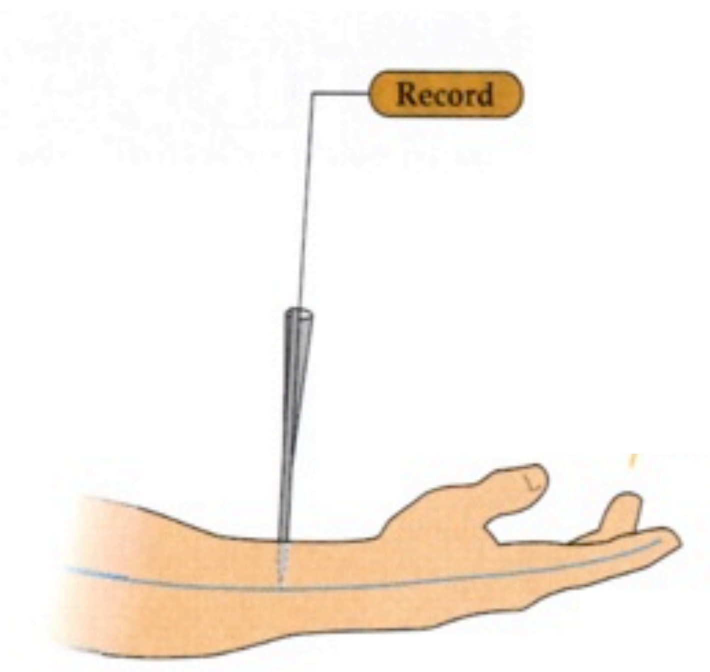


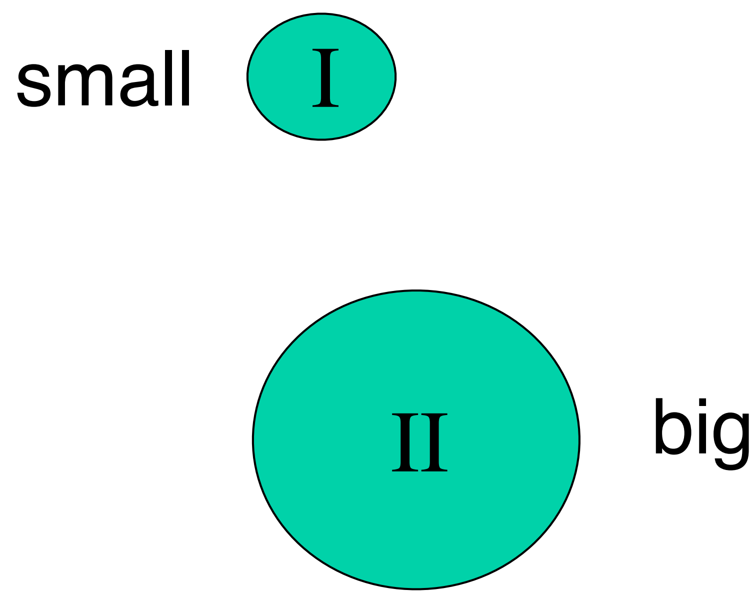
Tactile receptors

Called "**mechanoreceptors**" because they respond to mechanical stimulation: pressure, vibration, or movement

4 types, defined by:

1. Receptive field size (type I vs. II)



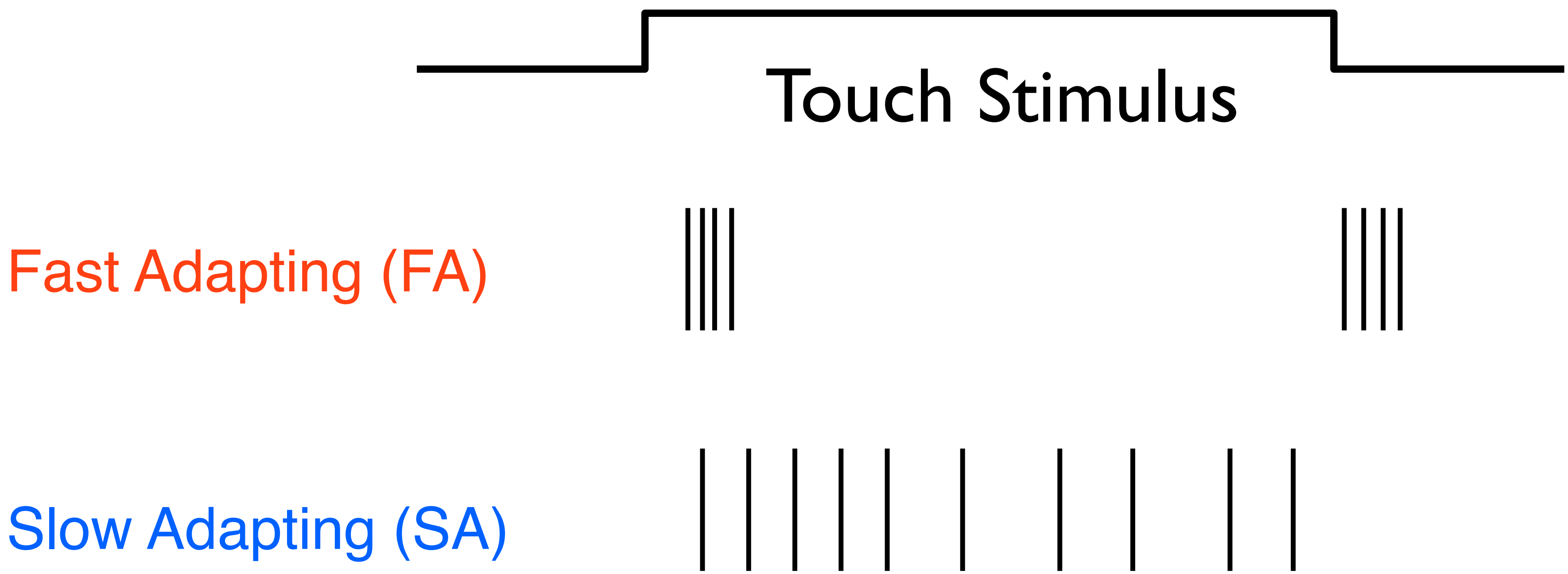


Tactile receptors

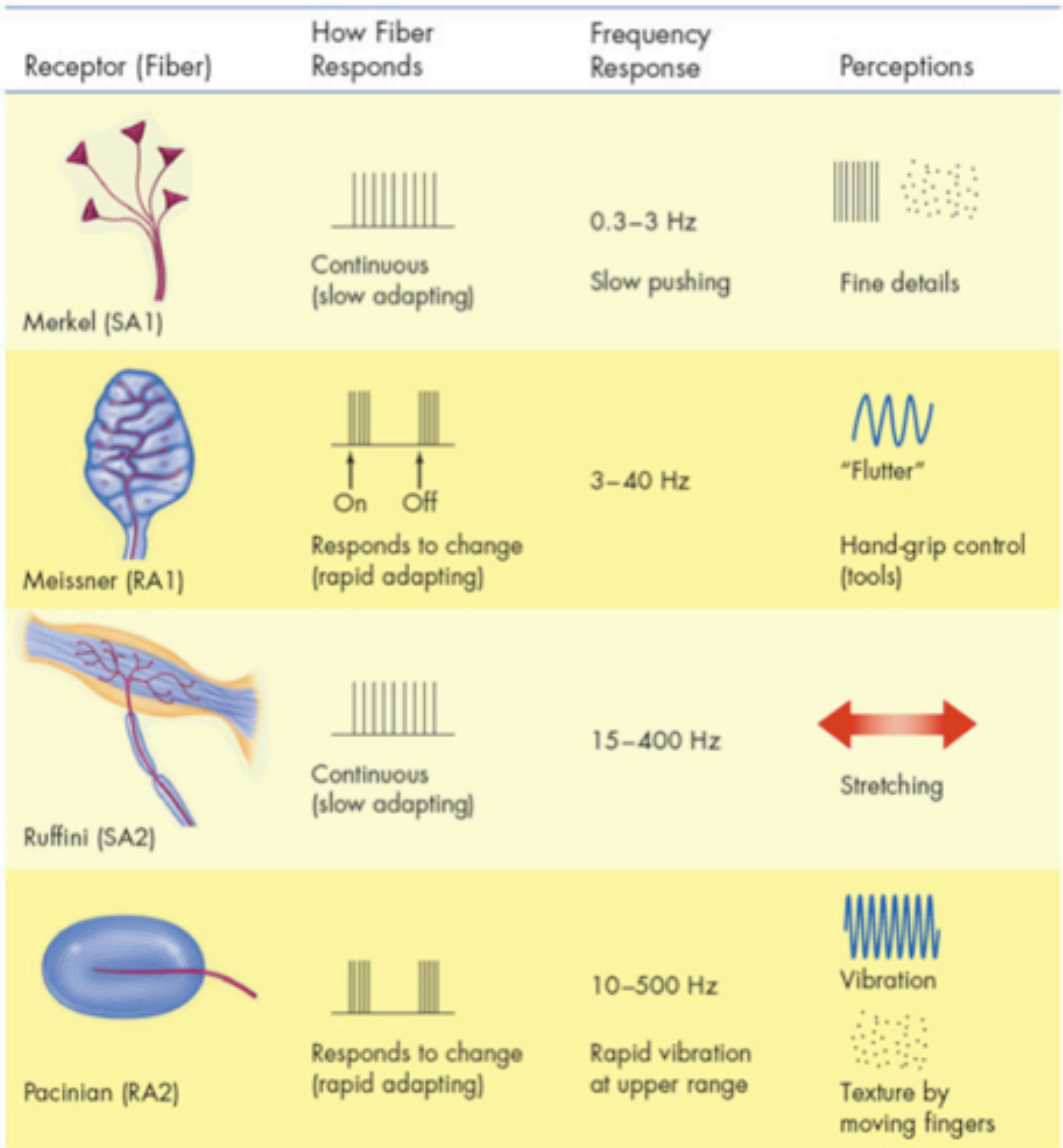
Called "**mechanoreceptors**" because they respond to mechanical stimulation: pressure, vibration, or movement

4 types, defined by:

2. Response properties (FA vs. SA)

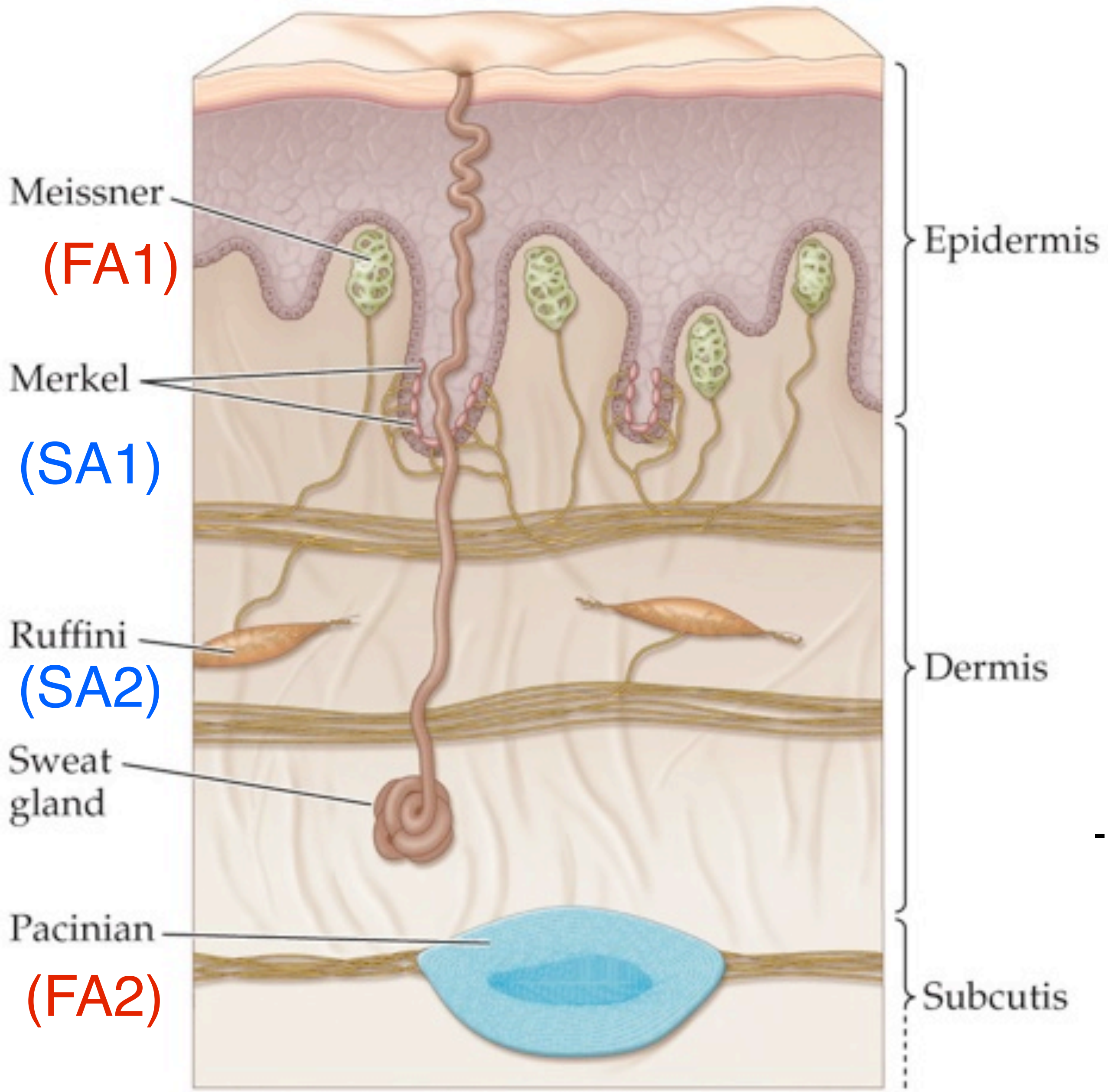


4 kinds of mechanoreceptors



	Receptor (Fiber)	How Fiber Responds	Frequency Response	Perceptions	
SA1	Merkel (SA1)	Continuous (slow adapting)	0.3–3 Hz Slow pushing	Fine details	small
FAI	Meissner (RA1)	On Off Responds to change (rapid adapting)	3–40 Hz	"Flutter" Hand-grip control (tools)	small
SAII	Ruffini (SA2)	Continuous (slow adapting)	15–400 Hz	Stretching	large
FA II	Pacinian (RA2)	Responds to change (rapid adapting)	10–500 Hz Rapid vibration at upper range	Vibration Texture by moving fingers	large

Cross section of the human hand illustrating locations of the four types of mechanoreceptors and the two major layers of skin



→

A-beta fibers

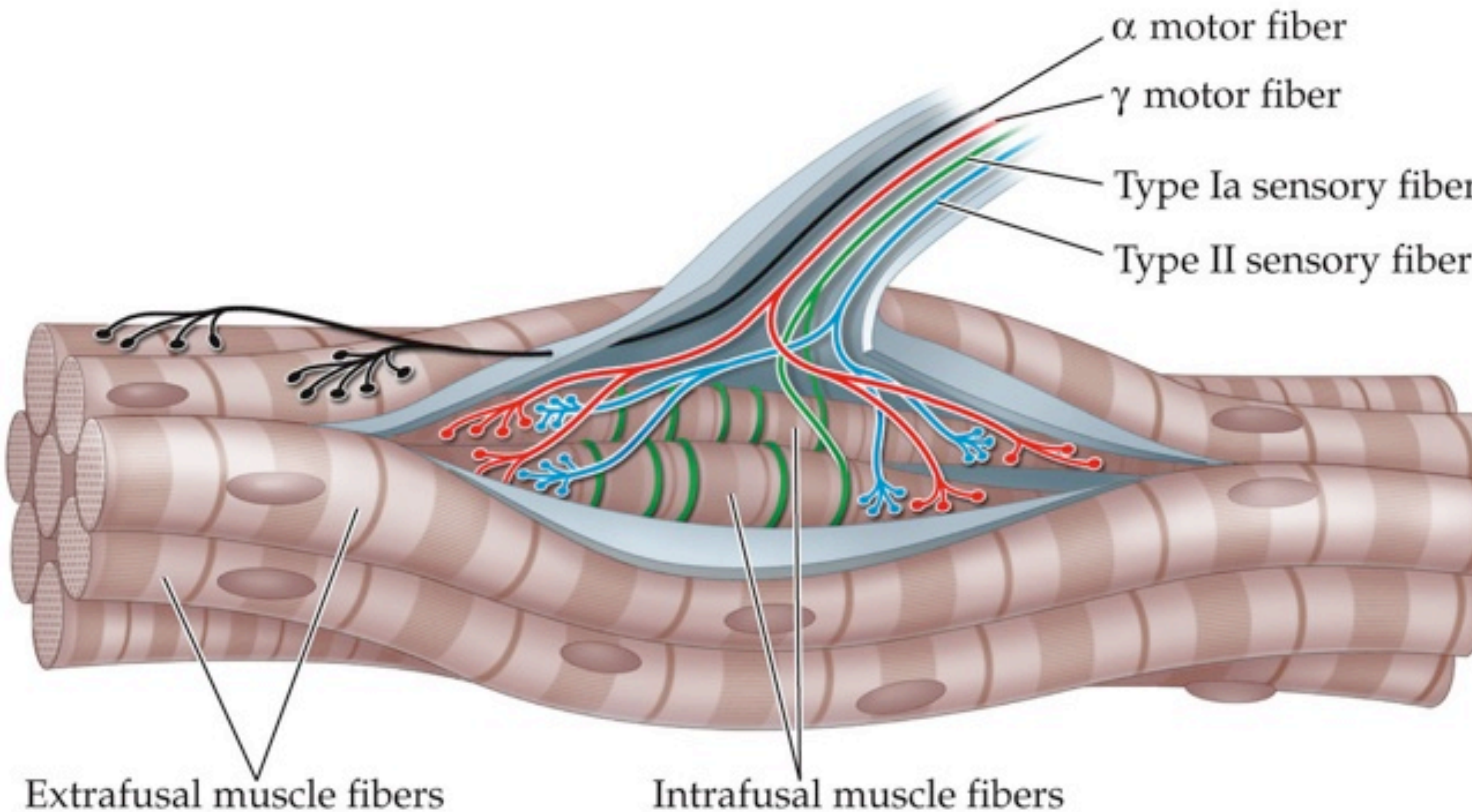
- wide fibers with fast conduction velocities
(all tactile receptors)

Other type of mechanoreceptors:

- **Kinesthetic receptors**: sense of where limbs are, what kinds of movements are made,
  - found within muscles, tendons, and joints

  Types:
  - **Muscle spindle**: located in a muscle, senses its tension (also known as a “stretch receptor”)
  - Receptors in tendons signal tension in muscles
  - Receptors in joints signal when joint is bent

A muscle spindle



Importance of kinesthetic receptors:

Strange case of neurological patient Ian Waterman:

- Cutaneous nerves connecting kinesthetic mechanoreceptors to brain destroyed by viral infection
- Lacks kinesthetic senses, dependent on vision to tell limb positions

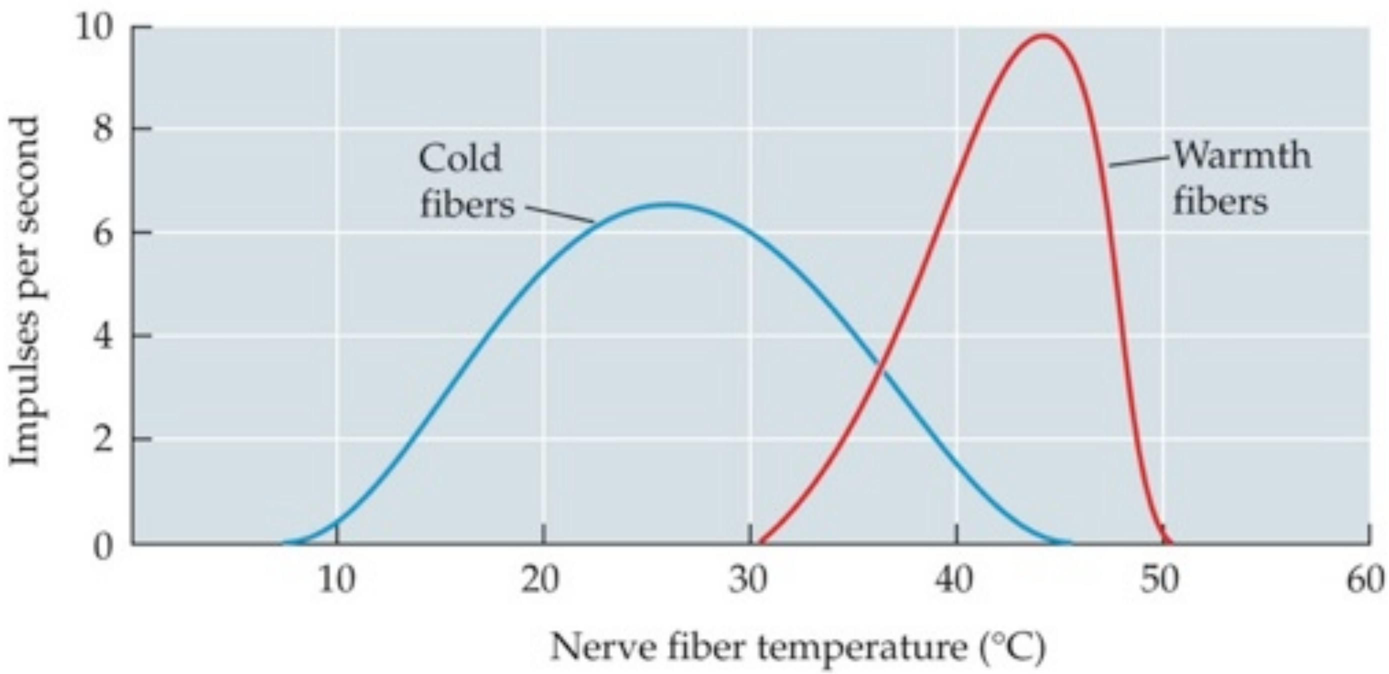
"Lacking kinesthetic senses, Waterman is now completely dependent on vision to tell him about the positions of his limbs in space. If the lights are turned off, Waterman cannot tie his shoes, walk up or down stairs, or even clap his hands, because he has no idea where his hands and feet are! Caught in an elevator when the lights went out, he was unable to remain standing and could not rise again until the illumination returned."

http://www.youtube.com/watch?v=FKxyJfE831Q


BBC PRIME

Temperature:

- **thermoreceptors**: signal changes in skin temperature
- Two distinct populations of thermoreceptors: **warmth fibers**, **cold fibers**
- Respond when you make contact with an object warmer or colder than your skin

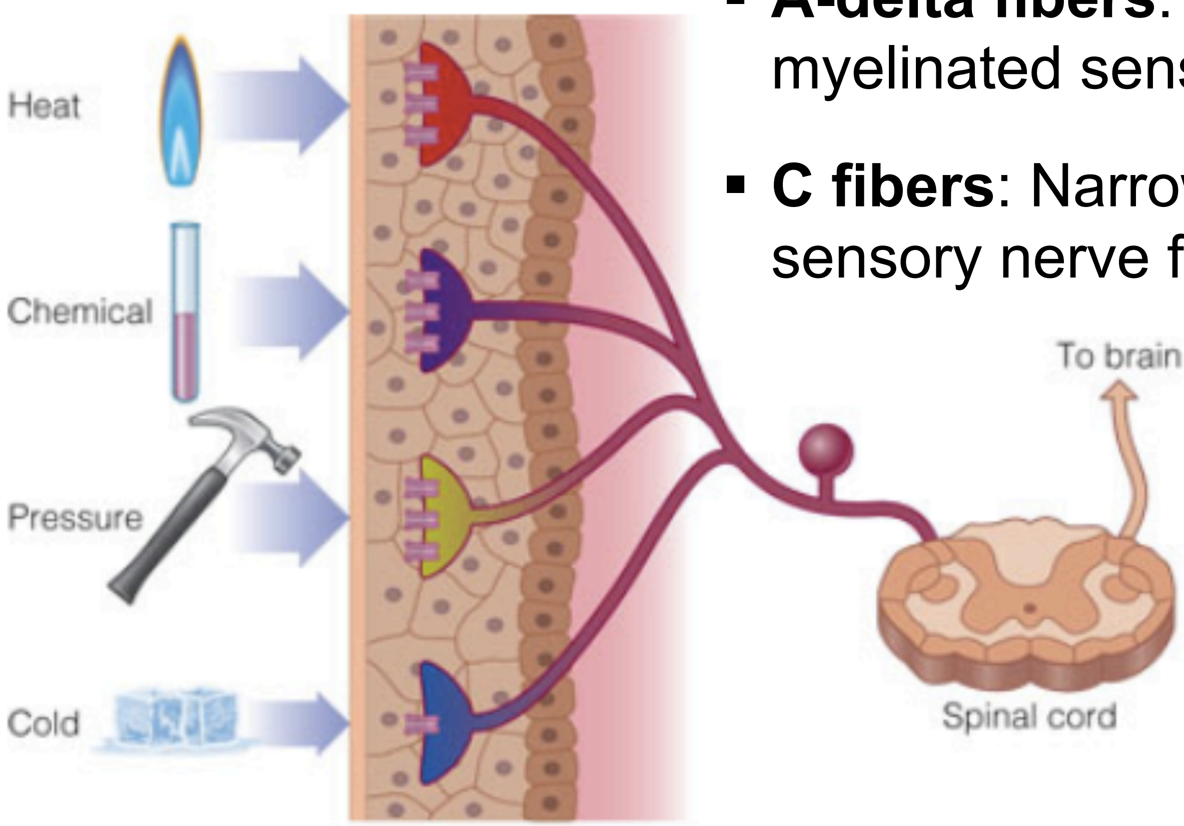


Pain

- signaled by **nociceptors**
- transmit information about noxious stimulation that causes damage or potential damage to skin
- no specialized endings (“bare nerve endings”)

<u>two types</u>

- **A-delta fibers**: Intermediate-sized, myelinated sensory nerve fibers. (Faster)
- **C fibers**: Narrow-diameter, unmyelinated sensory nerve fibers (Slower)



Pain Perception

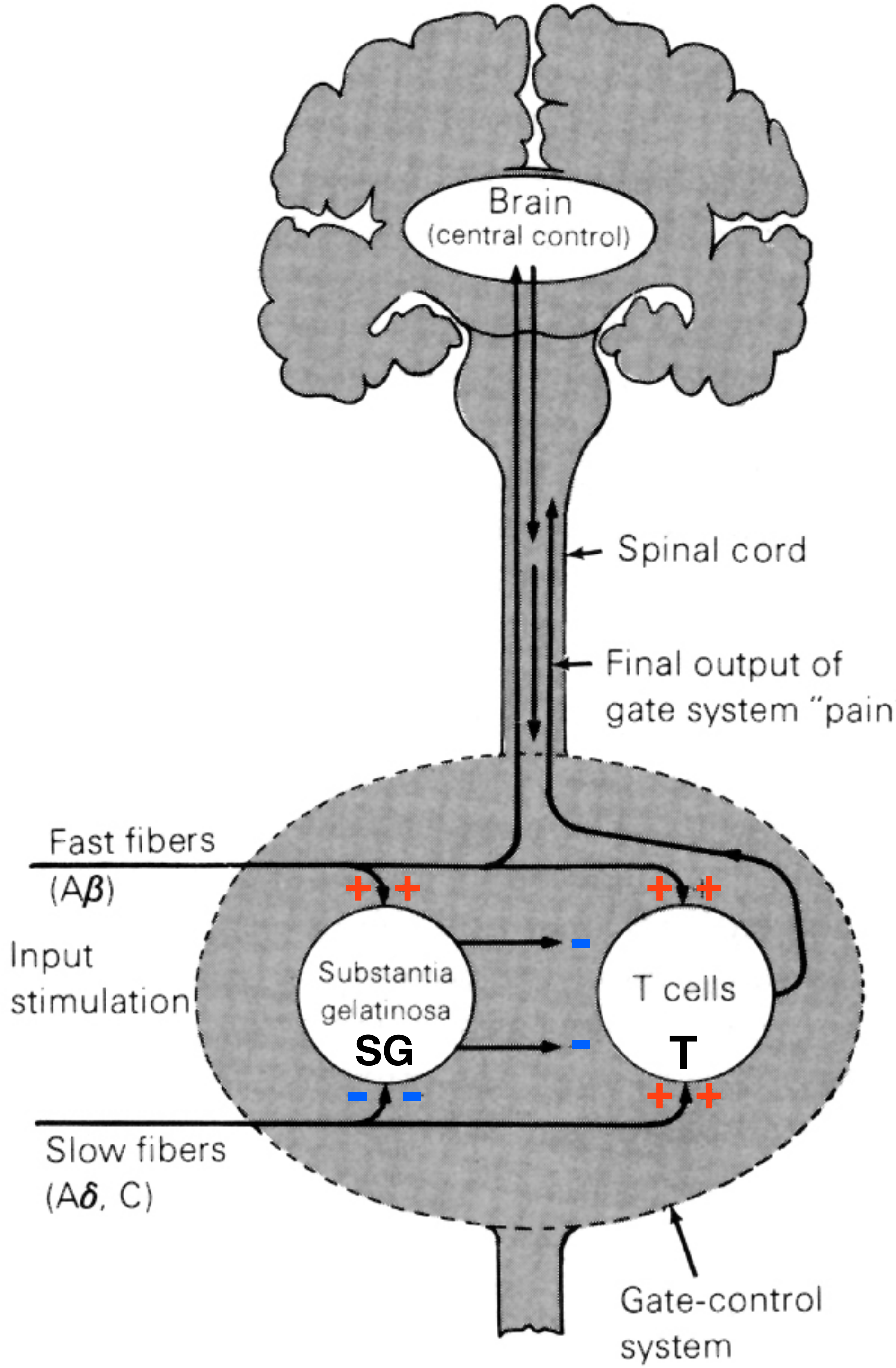
Pain can be moderated by anticipation, religious belief, prior experience, watching others respond, and excitement

Pain Perception

Gate control model

(Melzack and Wall, 1988)

- extreme pressure, cold, or other noxious stimuli can stimulate "gate" neurons in SG that prevent the T cells from transmitting pain signals
- signals from central NS (eg. brain) can also stimulate gate neurons



<u>Benefit of pain perception</u>: Sensing dangerous objects

Case of “Miss C” (Melzack & Wall 1973):

- Born with insensitivity to pain

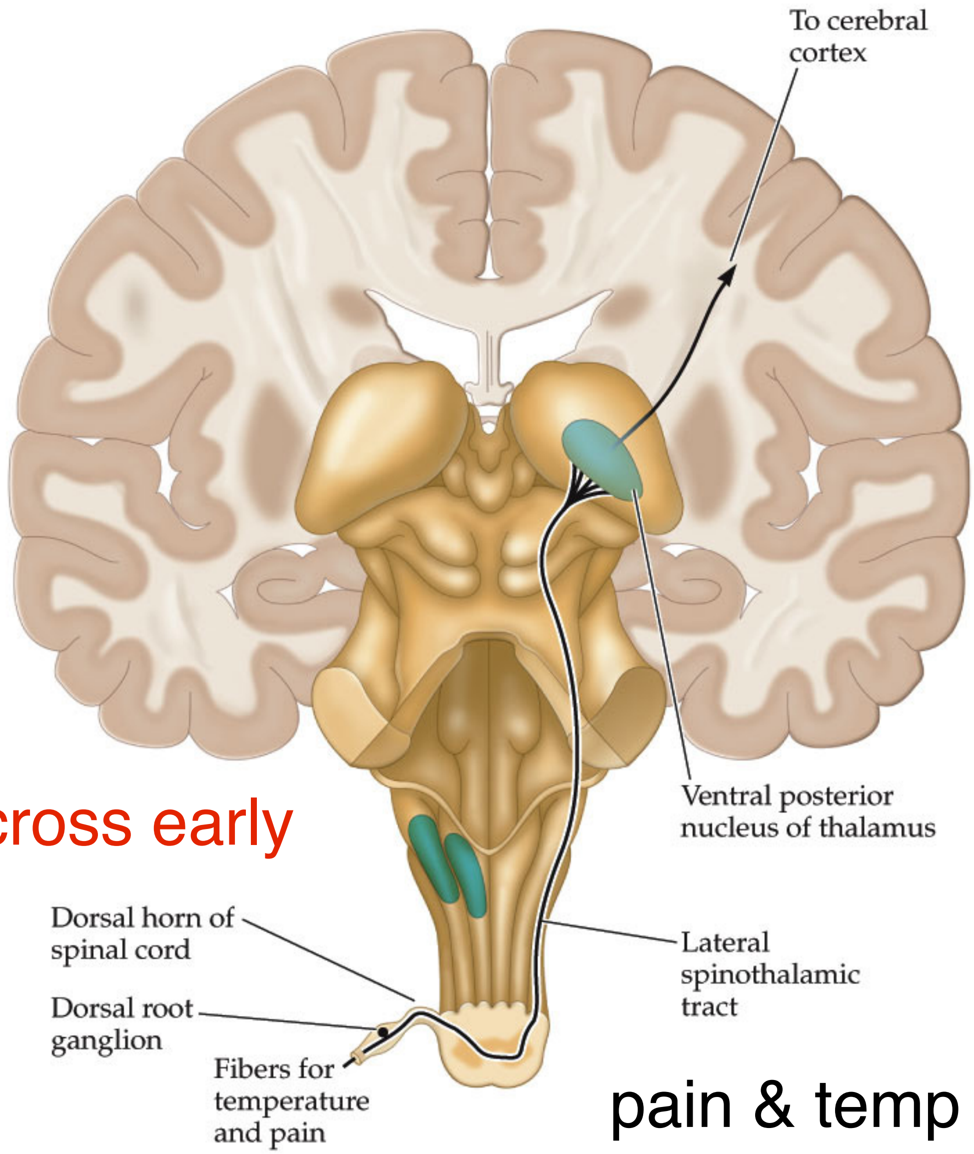
“Not only did Miss C lack pain sensation, but she did not sneeze, cough, gag, or protect her eyes reflexively. She suffered childhood injuries from burning herself on a radiator and biting her tongue while chewing food. As an adult, she developed problems in her joints that were attributed to lack of discomfort, for example, from standing too long in the same position. She died at age 29 from infections that could probably have been prevented in someone who was alerted to injury by painful sensations.”

The Hazards of Growing Up Painlessly

http://www.nytimes.com/2012/11/18/magazine/ashlyn-blocker-feels-no-pain.html?pagewanted=all

Two Pathways from skin to cortex

1. Spinothalamic pathway

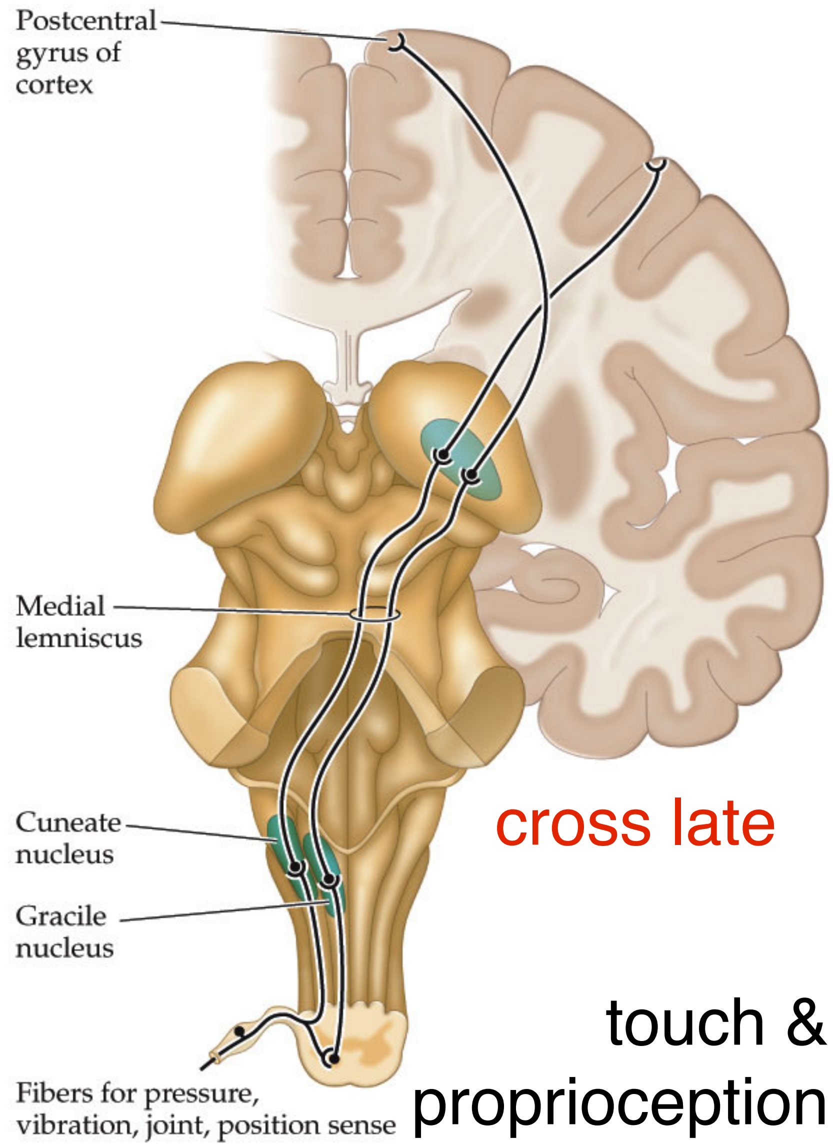


cross early

pain & temp

2. DCML pathway

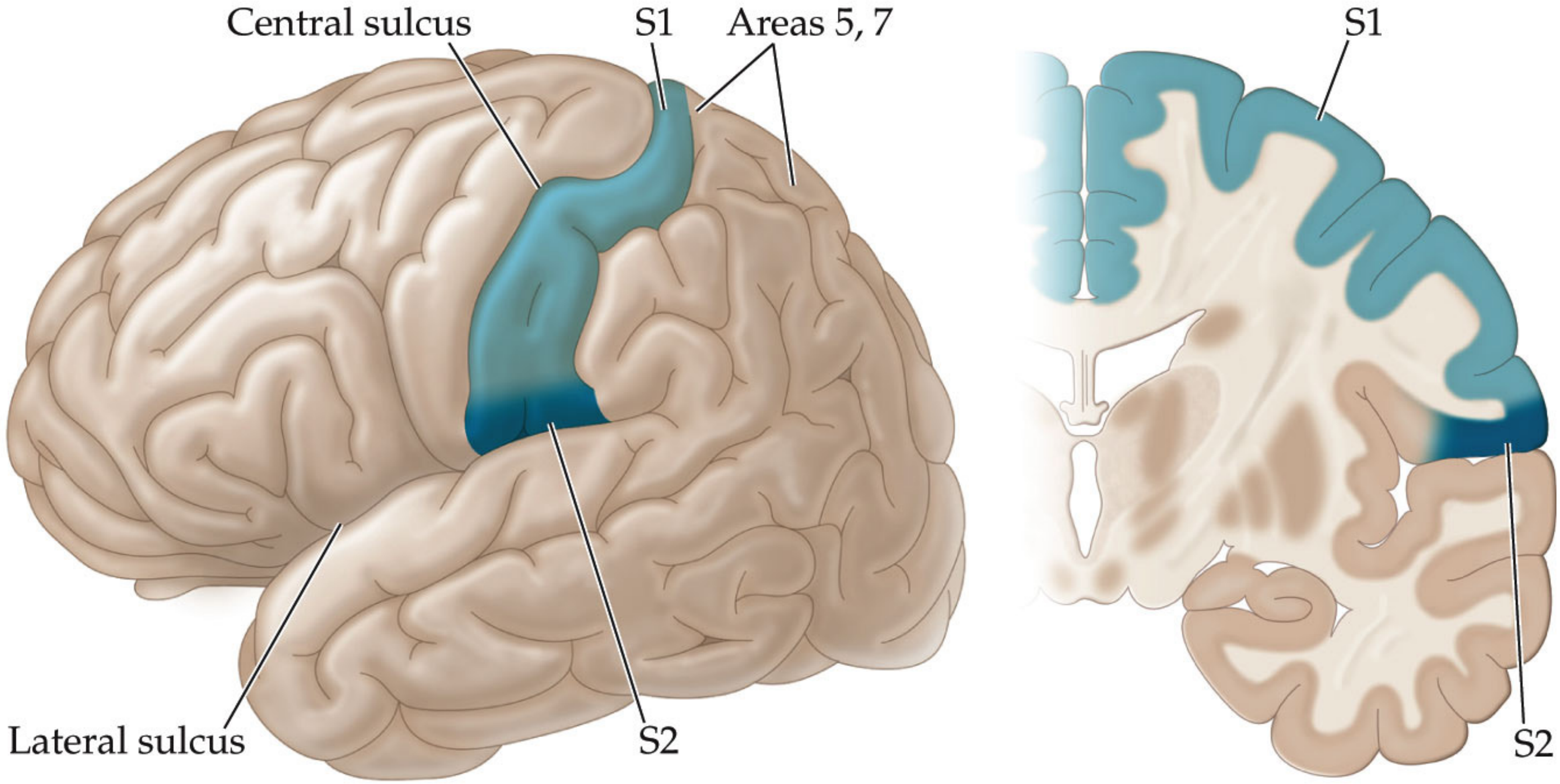
(Dorsal Column Medial Lemniscal)



cross late

touch & proprioception

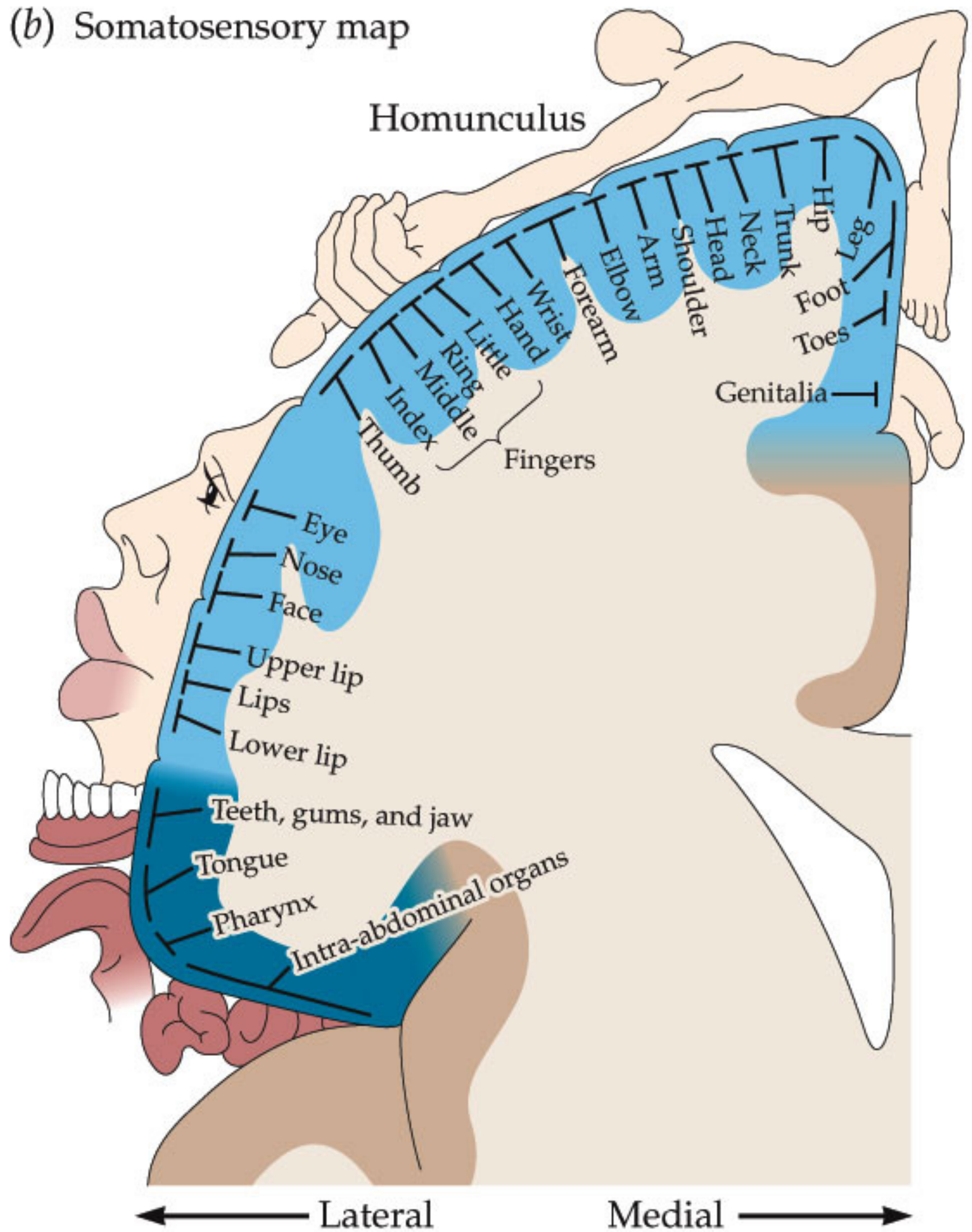
Primary somatosensory receiving areas in the brain



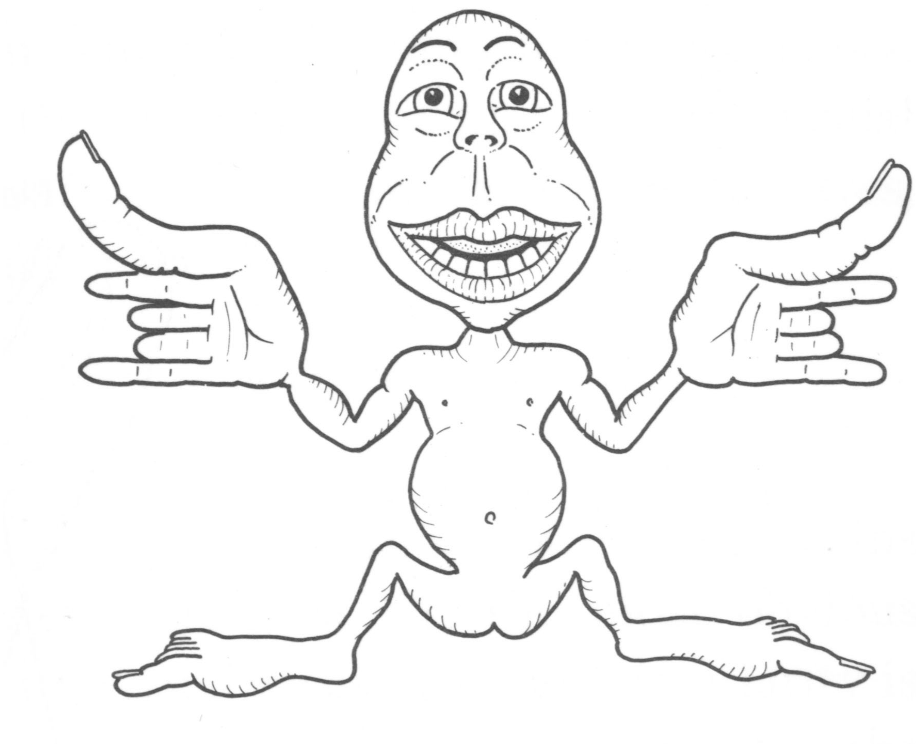
- **S1**: primary somatosensory cortex
  (located on postcentral gyrus)
- **S2**: secondary somatosensory cortex

Somatotopic organization - topographic map of body surface (compare with “retinotopic” and “tonotopic”)

Homunculus: Maplike representation of regions of the body in the brain



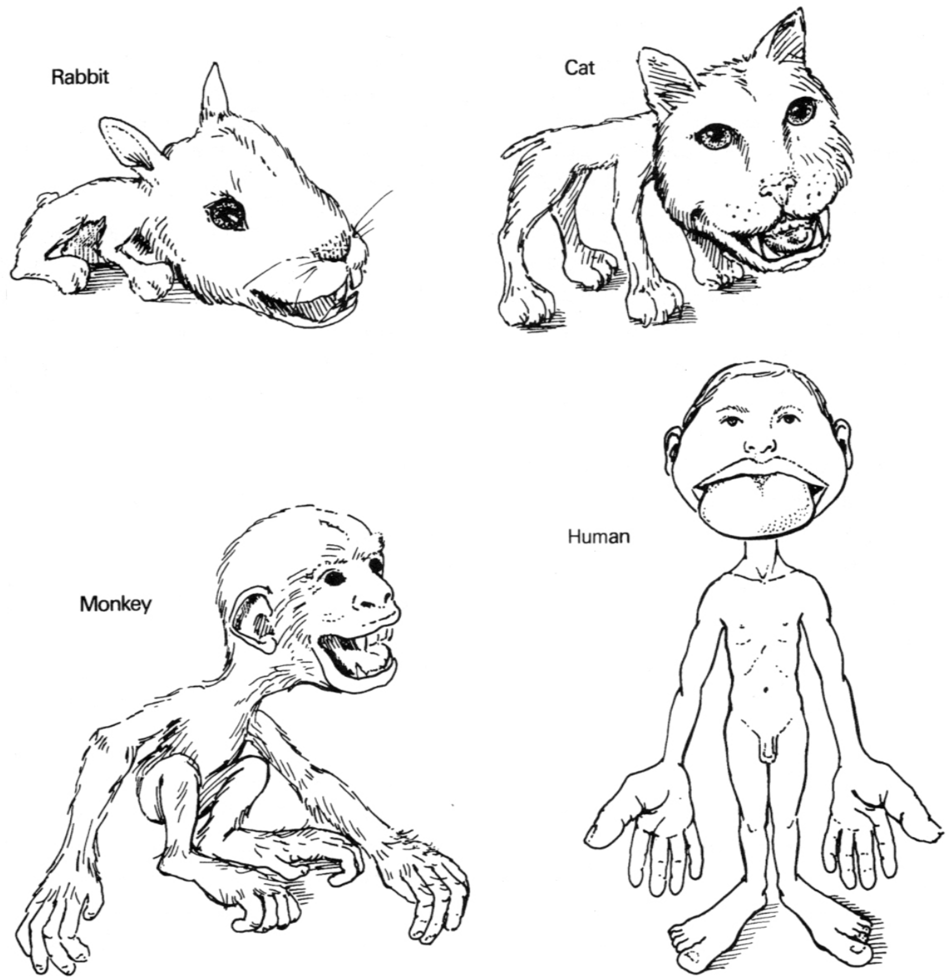
If our bodies reflected S1...



S1 maps across species:

rabbitunculus

catunculus



primatunculus

homunculus

Pleasant Touch

Newly uncovered fifth component of touch: **Pleasant touch**

(contrast with: “Discriminative touch” - classic touch sensations of tactile, thermal, pain, and itch experiences)

- Mediated by unmyelinated peripheral C fibers known as “C tactile afferents” (CT afferents)
- Respond best to slowly moving, lightly applied forces (e.g., stroking)
- Processed in orbitofrontal cortex rather than S1 or S2

Somatosensory Illusions

Although less common than visual illusions, still possible to fool the somatosensory system!

Aristotle Illusion

- brain fails to account for crossing of body parts

1. Cross fingers and touch nose

⇒ two noses?

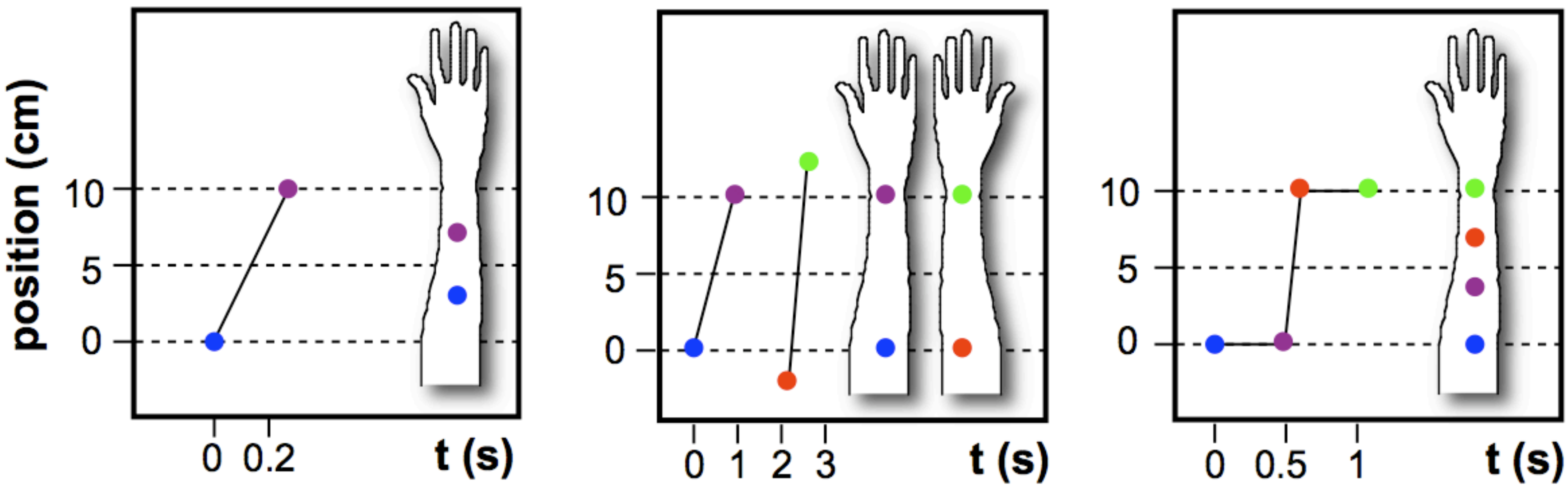
Aristotle Illusion

- brain fails to account for crossing of body parts

2. Close eyes, have a partner tap backs of hands in rapid succession

- easy if hands are uncrossed
- with crossed hands, significant error rate

Rabbit Illusion



- points appear closer together if presented rapidly in time
- like “rabbit hopping up the arm.” (Geldard & Sherrick, 1972)

Body image is malleable: body-swapping illusion

- subjects report viewing their own body from behind

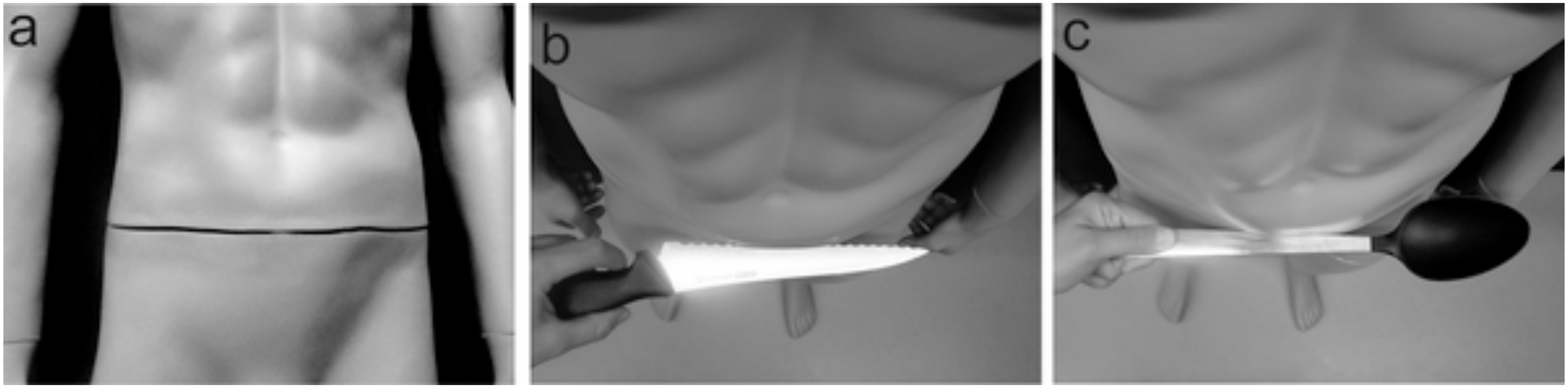
body-swapping illusion

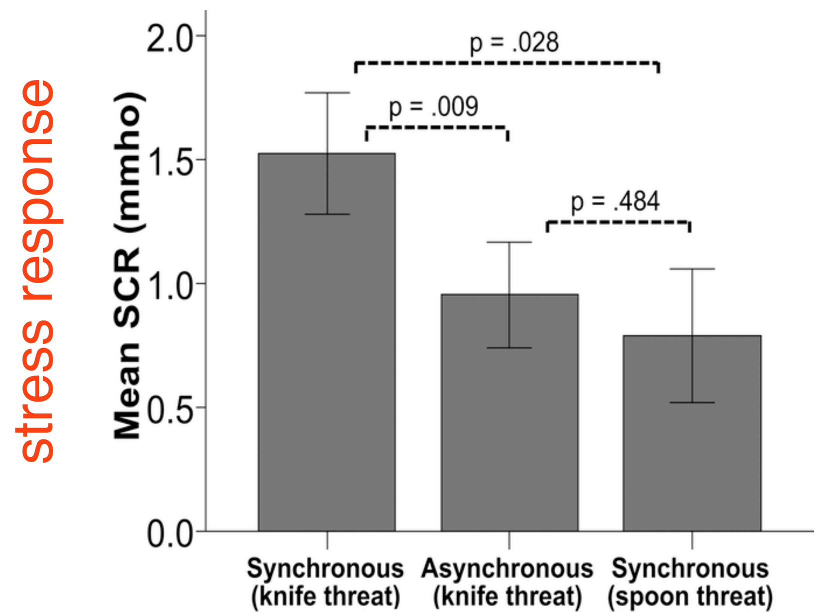
Petkova & Ehrsson, PloSOne 2008

body-swapping illusion

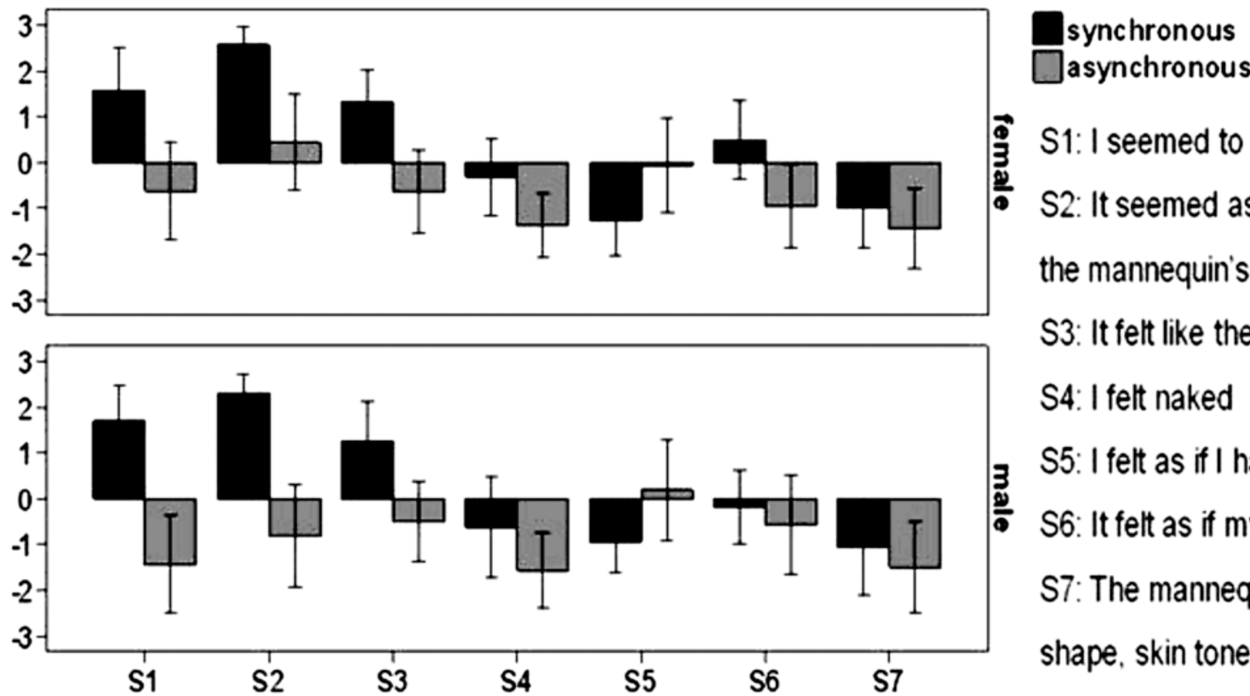
Petkova & Ehrsson, PloSOne 2008

body-swapping illusion





body-swapping illusion



S1: I seemed to feel the touch given to the mannequin

S2: It seemed as though the touch I felt was caused by the stick touching the mannequin's body

S3: It felt like the mannequin's body was my body

S4: I felt naked

S5: I felt as if I had two bodies

S6: It felt as if my body had turned into a plastic body

S7: The mannequin's body began to resemble my own body in terms of shape, skin tone, or some other visual feature

Rubber hand illusion

http://www.youtube.com/watch?v=TCQbygjG0RU

Tactile agnosia

- The inability to identify objects by touch
- Caused by lesions to the parietal lobe

Tactile agnosia

- Patient documented by Reed and Caselli (1994):
  - Tactile agnosia w/ right hand but not left. (Could not recognize objects such as a key chain in right hand, but could with left hand or visually.)
  - Rules out a general loss of knowledge about objects.
  - Other sensory abilities were normal in both hands.

Summary

- proprioception / kinesthesis
- cutaneous senses: tactile sense, temperature, pain
- other cutaneous senses: itch, tickle, pleasant touch
- touch sensitivity (Von Frey Hairs) vs. acuity (two-point test)
- somatosensory homunculus
- mechanoreceptors (FA vs. SA, I vs II),
- A-beta fibers (fast)
- kinesthetic receptors, muscle spindles
- spinothalamic vs DCML pathway
- gate control model for pain perception
- pleasant touch
- illusions: Aristotle, rabbit, body-swapping
- tactile agnosia, haptics, exploratory movements (read in book!)