TOUCH

Psychology 215
Spring 2002
Jody Culham

Why study touch?

Our skin is our largest sensory system

Touch allows us to explore and manipulate the world

- tactile exploration
- assessment of textures
- feedback from object manipulation



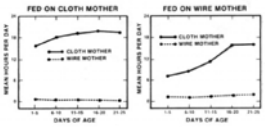

Touch is more "trustworthy" than other senses.

Why study touch?

Touch is critical to our social and emotional lives

- Harlow's monkeys
- premature babies
- social contact

Harlow's Monkeys



- Harlow raised motherless monkeys with two surrogate mothers, one wire and one cloth
- Even monkeys who were fed by the wire mother went to the cloth mother for comfort and affection

Premature babies


- licking of newborn pups by mother rat (or stroking with a paintbrush) stimulates growth hormone
- premature babies who are massaged gain weight 47% faster than those who aren't

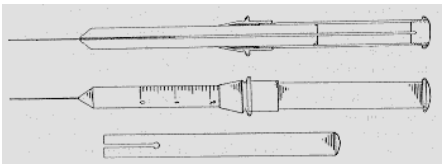
Adults



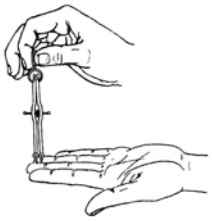
- touch is fundamental to human interactions
- even subliminal touch affects behaviour
  - subliminal touch by librarian → patrons report greater satisfaction with library and with life
  - subliminal touch by waitress → higher tips

Touch threshold

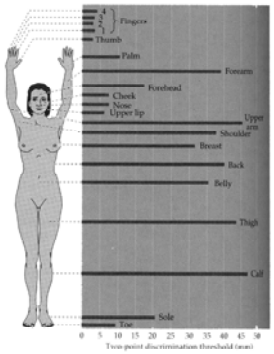
Von Frey
- hairs of various diameters and lengths
- determined weakest pressure that could be felt = threshold
- sensitivity (1/threshold) varied across parts of body
  - fingertips and lips: highly sensitive
  - back and stomach: poor sensitivity



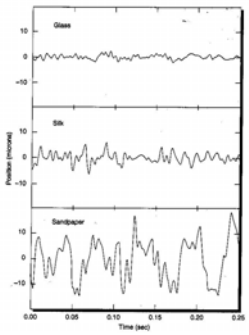
Two-point threshold



Touch acuity
- minimum separation that can be detected between two points

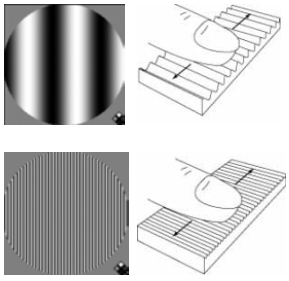


Perceiving Surface Texture



Measure vibrations on skin's surface while stroking various textures
- glass, silk: minor fluctuations
- sandpaper: abrupt displacements

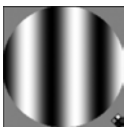
Tactile Spatial Frequency



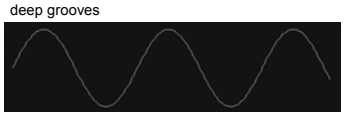
- visual spatial frequency (cycles/degree)
- tactile spatial frequency (cycles/mm)

Tactile Contrast

What would be the tactile equivalent of contrast?



deep grooves

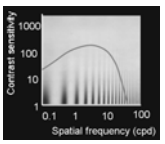


shallow grooves

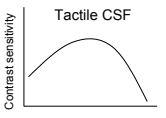
Grating discrimination

Tactile sensitivity
- best at medium spatial frequencies
- can't resolve spatial frequencies > 1 cycle/mm
- do poorly at low spatial frequencies
- varies from one body part to another (just like visual CSF varies from one part of the retina – the fovea – to another – the periphery)

Visual CSF



Tactile CSF

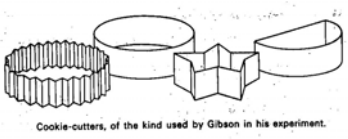


Gratings vs. Two-point discrimination

Two-point threshold at fingertips:
~2 mm
Grating acuity at fingertips:
0.95 mm

Why do people do better with gratings than two-point discrimination?

Active vs. Passive Touch

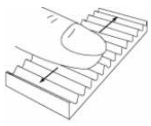


Cookie-cutters, of the kind used by Gibson in his experiment.

J. J. Gibson's cookie cutter experiment
- active touch
  - subject actively feels cookie cutter
  - 95% correct
- passive touch
  - experimenter pushes cookie cutter onto subject's palm
  - 49% correct
- passive touch with movement (Schwartz et al., 1995)
  - experimenter moves cookie cutter over subject's fingers
  - 93% correct

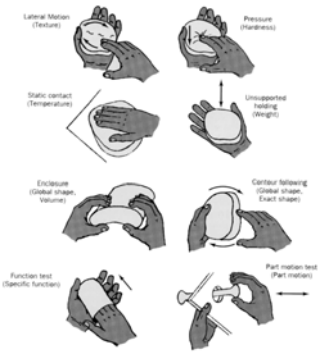
Haptics

- People and animals are active explorers
- haptics: the active process of exploring the world through touch and kinesthesis
- kinesthesis (proprioception): information about ones own body position and movement



The perceived frequency of the grating depends on both the physical frequency of stimulation and information about how fast the finger is being moved across the surface.

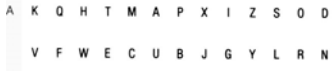
Haptic Exploration



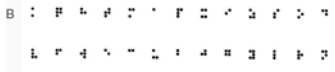
Subjects use different exploratory procedures depending on the goal of exploration

Applied Haptics: Braille

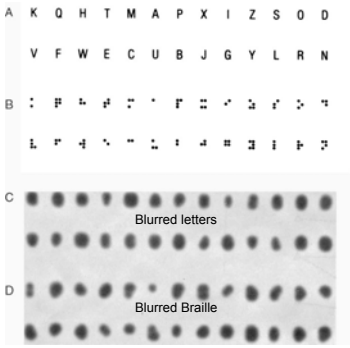
Why not just use embossed letters…



…instead of the Braille characters?



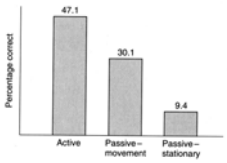
Applied Haptics: Braille



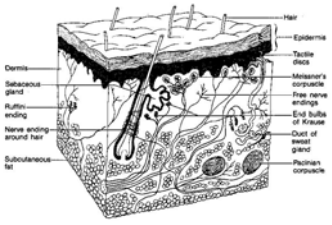
- Pushing on one point deforms the skin around it
- This is effectively like blurring the image
- Like optical blurring, mechanical blurring eliminates high spatial frequency information (fine details)
- Braille characters are less impaired by blurring

Applied Haptics: Braille

Reading Braille requires active interaction



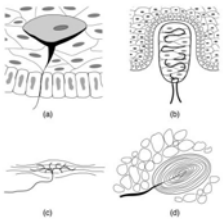
Skin



Two types of skin
- hairless (glaborous)
- hairy

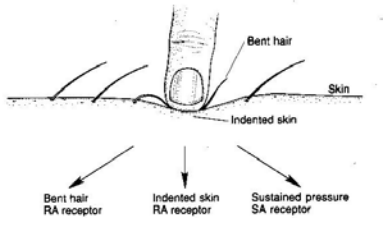
Two main layers of skin
- epidermis: outermost layer, dead skin cells
- dermis: beneath epidermis, soft flexible tissue, sits on fat

Touch receptors



- Several types of receptor are found within the dermis
- receptors transduce mechanical, thermal, chemical or electrical energy into neural signals
- number and type of receptor varies with location on skin

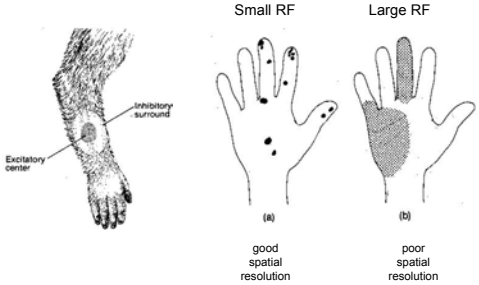
Mechanoreceptors



Mechanoreceptors
- sensitive to mechanical pressure or deformation of the skin
- four types
  - differ in size, shape, complexity, location within the layers, and physiological properties

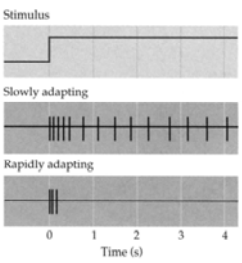
Receptive Field Size

Receptors differ along two main dimensions:
1. Small vs. large receptive fields

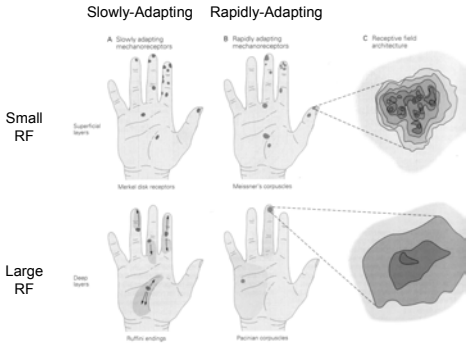


Adaptation

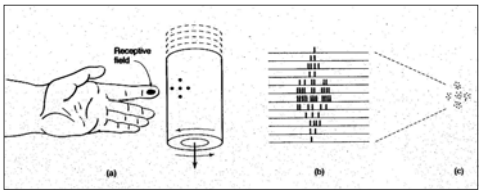
Receptors differ along two main dimensions:
1. Small vs. large receptive fields
2. Rapidly-adapting (RA) vs. slowly-adapting (SA)

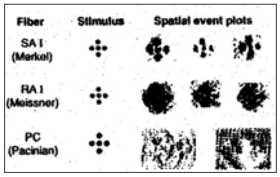


Four Receptor Types

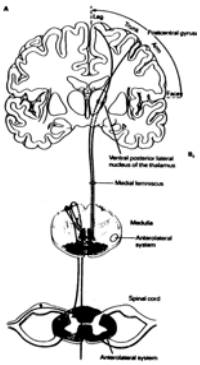


Spatial Event Plot





Somatosensory Pathway



SII and posterior parietal cortex

↑

somatosensory cortex
= SI = postcentral gyrus

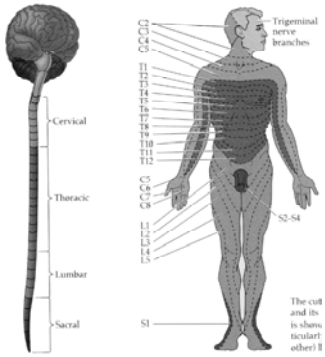
↑

thalamus

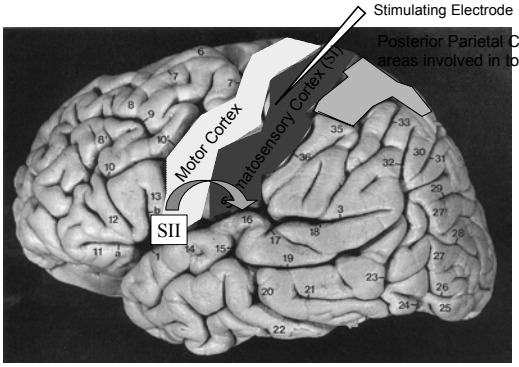
Cross-over
- right body → left brain
- left body → right brain

receptors in skin → spinal cord

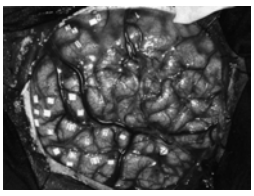
Spinal Cord



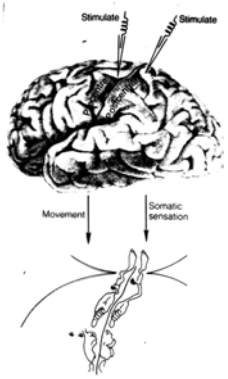
Primary Somatosensory Cortex



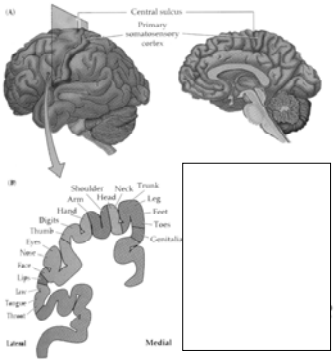
Wilder Penfield maps the brain



Motor and Somatosensory Maps



Somatotopic Organization

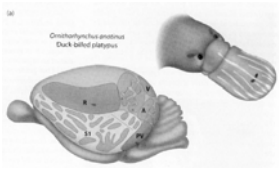


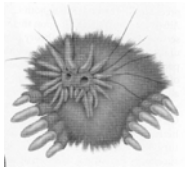
Somatosensory Homunculus

Homunculus (little man)

- shows the relative size of the somatosensory representation devoted to various body parts
- the fovea highest the highest resolution in vision
- Which body area is like the "somatosensory fovea"?
- Do you notice a relationship between the size of the representation and the sensitivity (e.g., two-point touch threshold)?

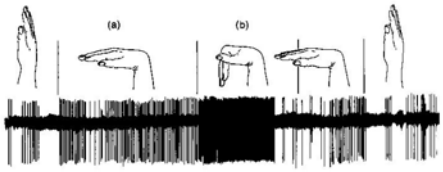
Thought experiment





- platypus homunculus (platypunculus?)
  - platypus has tactile and electrosensory recpetprs
  - bill = 75% of S1
- The star-nosed mole uses its nose for exploration, prey capture and feeding. What would you expect its homunculus to look like?

Kinesthesis

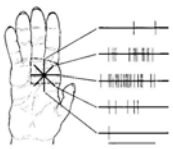


How can we tell where our body parts are?

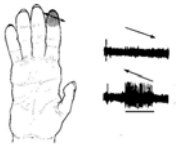
- Some parietal neurons receive kinesthetic (proprioceptive) input from joint receptors
- Some of these neurons respond best to flexion of a number of joints

Complex Tactile RFs in PPC

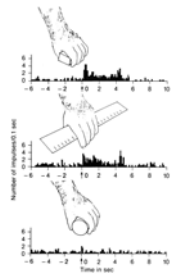
Orientation-selective



Direction-selective



Grasp-selective



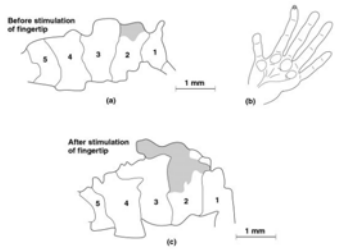
Are brain maps fixed or plastic?

Prior to the 1980s, scientists assumed that brain maps were hard-wired and unchangeable.

Do the maps actually depend on experience?

- What happens to the somatosensory cortex of amputees?
- What happens to the visual cortex of the blind?
- What happens to people who become highly practiced with haptic stimuli (e.g., Braille readers)?

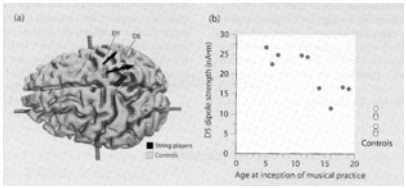
More Experience → Larger representation



- Merzenich & colleagues had monkey use index finger to obtain food
- Representation of that fingertip grew with experience

Jenkins et al., 1990

More Experience → Larger representation

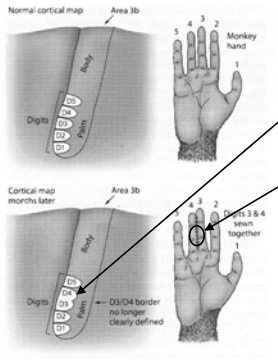


Musicians who play string instruments

- show larger responses to stimulation of the digits and and a larger cortical representation for the thumb and pinky finger
- show stronger responses if they learned the instrument at an early age

Elbert et al., 1995

Altered Experience → Altered Representation

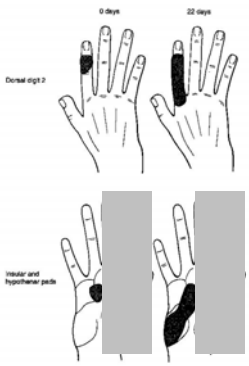


Digits of monkey hand sewn together

- boundary between representations of fingers becomes blurred
- receptive fields come to encompass both fingers

Clark et al., 1988

Deprivation → Cortex Overtaken



Sever median nerve so that palm and underside of digits 1,2&3 (shaded area) are disconnected from somatosensory cortex

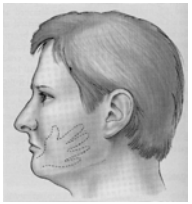
Examine cortical representation of remaining areas before and after

The cortex formerly devoted to the disconnected regions gets taken over by adjacent areas

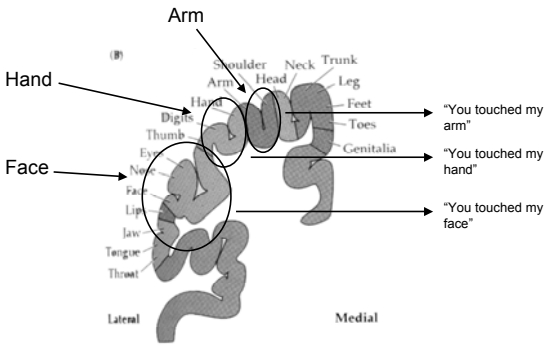
Merzenich et al., 1993

Phantom Limb

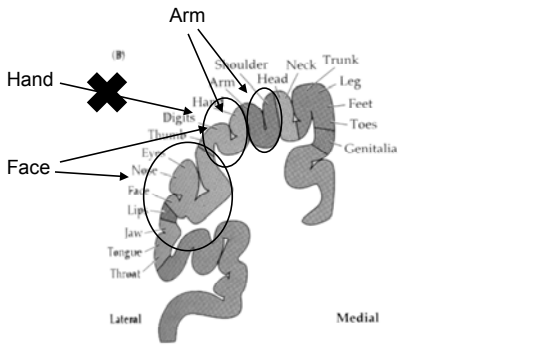
- amputees report rich and vivid perceptions of touch to the amputated limb
- stimulation to remaining parts of the body can be perceived in the missing limb



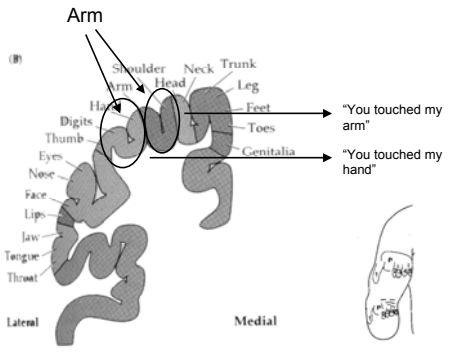
Normal Subject



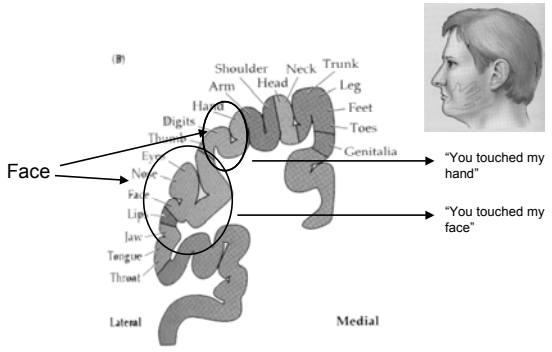
Phantom Limb Subject



Phantom Limb Subject



Phantom Limb Subject

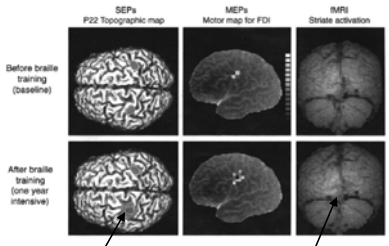


Rama's theory

"An engineer in Florida reported a heightening of sensation in his phantom (left) lower limb during orgasm and that his experience actually spread all the way down into the [phantom] foot instead of remaining confined to the genitals: so that the orgasm was much bigger than it used to be."

-- Ramachandran, 1993

Braille-reading in Visual Cortex???

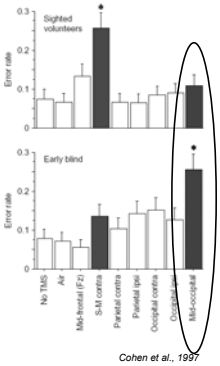


As blind people become experienced in reading Braille

- the somatosensory cortex opposite to the hand used becomes more active
- Braille-reading begins to activate visual cortex

Pascual-Leone & Torres, 1993

Braille-reading in Visual Cortex???



"Zap" visual cortex using transcranial magnetic stimulation (TMS) while subjects are using touch to read

- sighted volunteers reading embossed text
  - TMS to visual cortex has no effect
- blind volunteers read Braille
  - TMS to visual cortex disrupts reading
  - Braille dote felt 'different', 'flatter', 'less sharp and well-defined'

Cohen et al., 1997

Review

Why is touch important?
- tactile exploration and interaction
- social value

How good is our sense of touch?
- touch thresholds
- two-point thresholds
- grating sensitivity (how is it like vision?)

What is haptics?
- exploratory touch
- kinesthetics
- example: Braille

Review

What are the stages of tactile perception?
- receptors
  - tactile receptive fields
  - rapidly vs. slowly adapting receptors
- spinal cord
- thalamus
- somatosensory cortex
  - somatotopy, homunculus
- posterior parietal cortex
  - complex receptive fields and properties

Review

Are brain maps fixed or plastic?
- more experience → bigger representation
  - monkey trained to use index finger
  - practiced musicians
  - Braille readers enhance finger activity in S1
- altered experience → altered representation
  - monkey with fingers sewn together
- deprivation → cortex overtaken by other areas
  - monkey with severed median nerve
  - phantom limb patients
  - visual cortex activated in blind Braille readers