Touch

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May 13, 2004
9.35

The different sensory modalities register different kinds of energy from the environment.

The sense of touch registers mechanical energy.

Basic idea: we bump into things, our skin gets depressed, and receptors in the skin transduce this this mechanical deformation into a voltage.

We can also sense temperature, with receptors that detect heat gradients.

The skin is thus the receptor organ for touch.

Like the retina in vision, the receptors in our skin are laid out such that they provide a spatial map of stimulation over the body.

Unlike vision, though, usually only part of the skin is stimulated at any one time.

And despite this spatial map provided by the receptors, people are not very good at localizing stimulation on the skin.

Our sense of touch is usually best when we move our skin over whatever it is that we want to feel.

(Image removed due to copyright considerations.)

Touch & the somatic senses

Imagine not having it. What would you lose?

Provides information that allows you to:

Identify objects
Sense texture
Detect mechanical properties
-rough, smooth, hard, fuzzy, sharp….
Feel pleasure and pain

Also:
Touch needed for normal development (growth hormone)
Social communication

Sensitivity to touch is measured via the minimum pressure needed to detect a sensation.

Touch sensitivity varies drastically over the skin. The lips are the most sensitive. Maybe this is why we kiss with our lips?

Females are more sensitive than males.

Acuity of touch

Image removed due to copyright considerations. Please see: Sekuler, Robert and Blake, Randolph. Perception (Fourth edition). New York: McGraw-Hill, 2001.

Figure 11.1, p. 382.

(Image removed due to copyright considerations.)

Acuity is measured with 2 point thresholds.

Note that this is not the same as sensitivity, although they are correlated. ed due to copyright considerations.

Why might acuity vary over different parts of the body?

Somatosensory receptors fall into four functional classes:

Mechanoreceptors - signal mechanical stimulation

Proprioceptors - signal muscle tension and joint position

Nociceptors - signal pain

Thermoreceptors - signal temperature

Schematic of skin

There are four kinds of mechanoreceptors.

Each has unique properties.

(Image removed due to copyright considerations.)

Mechanoreceptors are differentiated in two ways:

They can be rapidly adapting or slowly adapting.

And their receptive fields can be punctate or diffuse.

Rapidly adapting (info about change or dynamic quality of stimuli)

Found just beneath the epidermis of fingers, palms, and soles.
Receptive fields are puntate.
Most common receptors of glabrous skin (smooth and hairless).
Account for ~40% innervation of the human hand.
Responds best to low frequency vibration (30-50 Hz).

(Images removed due to copyright considerations.)

Found in subcutaneous tissue (and gut).
Respond best to high-frequency disturbances (250-350 Hz) to active the nerve endings.
Stimulation introduces a sense of vibration and/or tickle.
10-15% of cutaneous receptors in the hand.

(Image removed due to copyright considerations.)

Slowly adapting (static info about shape, edges, rough texture)

Located in the epidermis, precisely aligned with dermal ridges.
Punctate receptive fields.
~25% of the receptors in hand, and are particularly dense in the fingertips, lips, and external genitalia.
Stimulation introduces a sense of light pressure.

(Images removed due to copyright considerations.)

Located deep in the skin, as well as in the ligaments and tendons.
Diffuse receptive fields.
Particularly responsive to stretching.
They account for ~20% of the receptors in the hand.

Two kinds of adapatation: Rapid and slow.

What would they represent effectively?

(Image removed due to copyright considerations.)

To summarize the mechanoreceptors:

	Rapidly Adapting	**Slowly Adapting**
Punctate	Meissner Corpuscle	Merkel Disk
Diffuse	Pacinian Corpuscle	Ruffini Ending

Proprioceptors: "receptors for self." Primary purpose is to give info about position of limbs and body parts

Include (low-threshold): muscle spindles, golgi tendon organs, and joint receptors

Muscle spindles: Provide info about muscle length

(Image removed due to copyright considerations.)

Muscle Spindles & Golgi Tendon Organs

• Muscle spindles: tightly wound coils around a muscle fiber. Sensitive to muscle stretch / elongation

(Image removed due to copyright considerations.)

* Golgi-tendon organs: located in tendons, axons in collagen fibers, so that if tendon is stretched, they are compressed and fire

Nociceptors: from the latin *noci*, "hurt"

Nociceptors are just nerve fibers of various sorts.

Only lightly myelinated, or unmyelinated.

Conduct slowly compared to mechanoreceptors.

(Image removed due to copyright considerations.)

A∂ family (myelinated) and C fibers (unmyelinated)
Both typically have large receptive fields

A∂ mechanosensitive nociceptors
A∂ mechanothermal nociceptors

(Image removed due to copyright considerations.)

First and second pain:

Myelinated and unmyelinated pain fibers convey signals at different speeds.

(Image removed due to copyright considerations.)

Why do some objects feel cold (steel), whereas others feel warm (plastic)?

Why do cold objects feel heavier than warm objects (coin experiment)?

On to the Cortex…

Two main systems:

1) subsystem for detecting mechanical stimuli (touch, vibration, pressure)

2) subsystem for detecting painful stimuli and temperture

(Image removed due to copyright considerations.)

Two paths to cortex:

Dorsal column-medial lemniscus pathway:

info from mechanoreceptors that mediate tactile discrimination and proprioception

Spinothalamic (anterolateral pathway):

pain and temperture sensation

Both pathways project to the ventral posterior nucleus of the thalamus.

Image removed due to copyright consideration.
Please see: Sekuler, Robert and Blake, Randolph. Perception (Fourth edition). New York: McGraw-Hill, 2001.

Figure 11.9, p. 398.

Note that motor cortex and somatosensory cortex are right next to each other in the brain. This is probably because much of touch involves bodily motion, and motor and somatosensory info need to be integrated.

There is a map of the body laid out in somatosensory cortex.

Some body parts get more area than others. The area devoted to a particular body part is determined by the receptor density there.

This map is often known as the homunculus.

(Image removed due to copyright considerations.)

(Image removed due to copyright considerations.)

Somatosensory Cortex: 6 Principles of Sensory Cortical Organization / Function

1. Cortical Maps
2. Multiple Cortical Areas
3. Cortical Columns
4. Cortical Magnification
5. Mirror Maps between Cortical Areas
6. Adult Cortical Plasticity

Somatosensory Cortex: 2. Multiple Cortical Areas

* Penfield in humans and Woolsey and colleagues using recordings in animals defined area SII

* Large, sometimes bi-lateral receptive fields

* Robust attentional modulation of activity level & firing synchrony across neurons

Somatosensory Cortex: 3. Cortical Magnification

* Cortical Magnification Rule: Space devoted to a skin surface is inversely proportional to the size of the receptive field in that area (**Sur et al., 1980**)

(Image removed due to copyright considerations.)

Somatosensory Cortex: 4. Cortical Columns

* Also discovered & explicated by Mountcastle, cells in a vertical dimension across the layers of the neocortex tend to have the same rf

(Image removed due to copyright considerations.)

Somatosensory Cortex: 5. Mirror Maps

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Somatosensory Cortex: 6. Adult Cortical Plasticity

(Image removed due to copyright considerations.)

Somatosensory Cortex: 6. Adult Cortical Plasticity

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Perceptual Consequences

* Phantom Limbs, reference zones

(Image removed due to copyright considerations.)

Perceptual Consequences Beyond Phantom Limb?

* Increased spatial tactile resolution in 'reference' zones. First discovered By **Teuber** (founder of the Department)

* Possible cause?

(Image removed due to copyright considerations.)

Cortical Plasticity: Adaptive Effects

Trained skin regions develop expanded cortical representations

String instrument players have expanded representations of the 'picking' hand

(Image removed due to copyright considerations.)

Cortical Plasticity: Adaptive Effects

Blind individuals activate visual cortex when they read braille.

Zapping occipital cortex in the blind impairs tactile discriminations.

Normal people can get tactile-induced occipital activation if they walk around with a blindfold for a week.

Haptics - interaction between touch and movement/proprioception.

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Figure 11.3, p. 384.

Spatial frequency & amplitude of textures

Why doesn't the texture change as you change the rate that you move your finger?

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