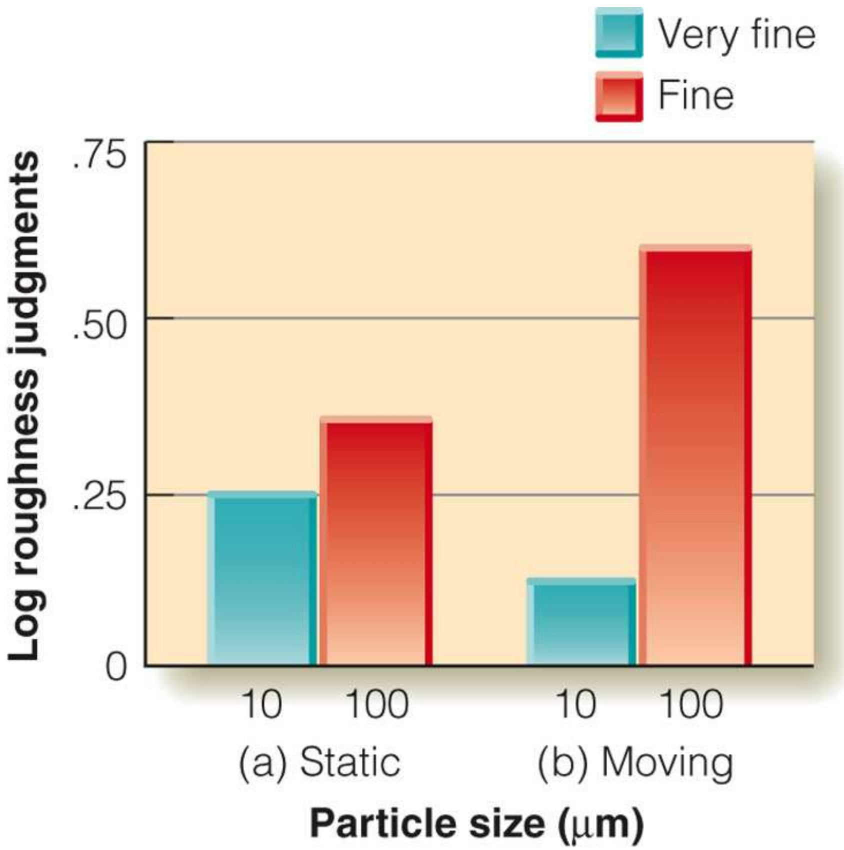
‘Duplex Theory’ of Texture Perception

- Katz (1925) proposed that perception of texture depends on two cues:
  - Spatial cues are determined by the size, shape, and distribution of surface elements
  - Temporal cues are determined by the rate of vibration as skin is moved across finely textured surfaces
- Two receptors may be responsible for this process - called the *duplex theory of texture perception*

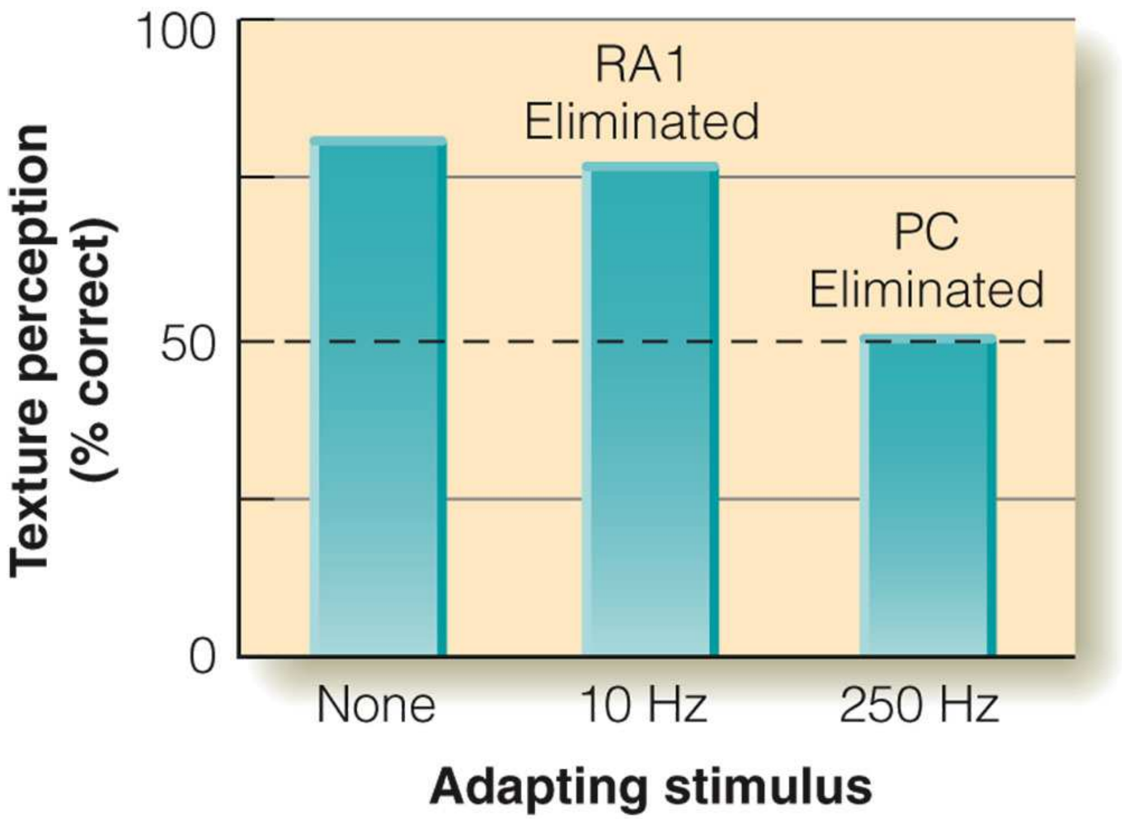
Perceiving Texture

- Past research showed support for the role of spatial cues
- Recent research by Hollins and Reisner shows support for the role of temporal cues
  - In order to detect differences between fine textures, participants needed to move their fingers across the surface

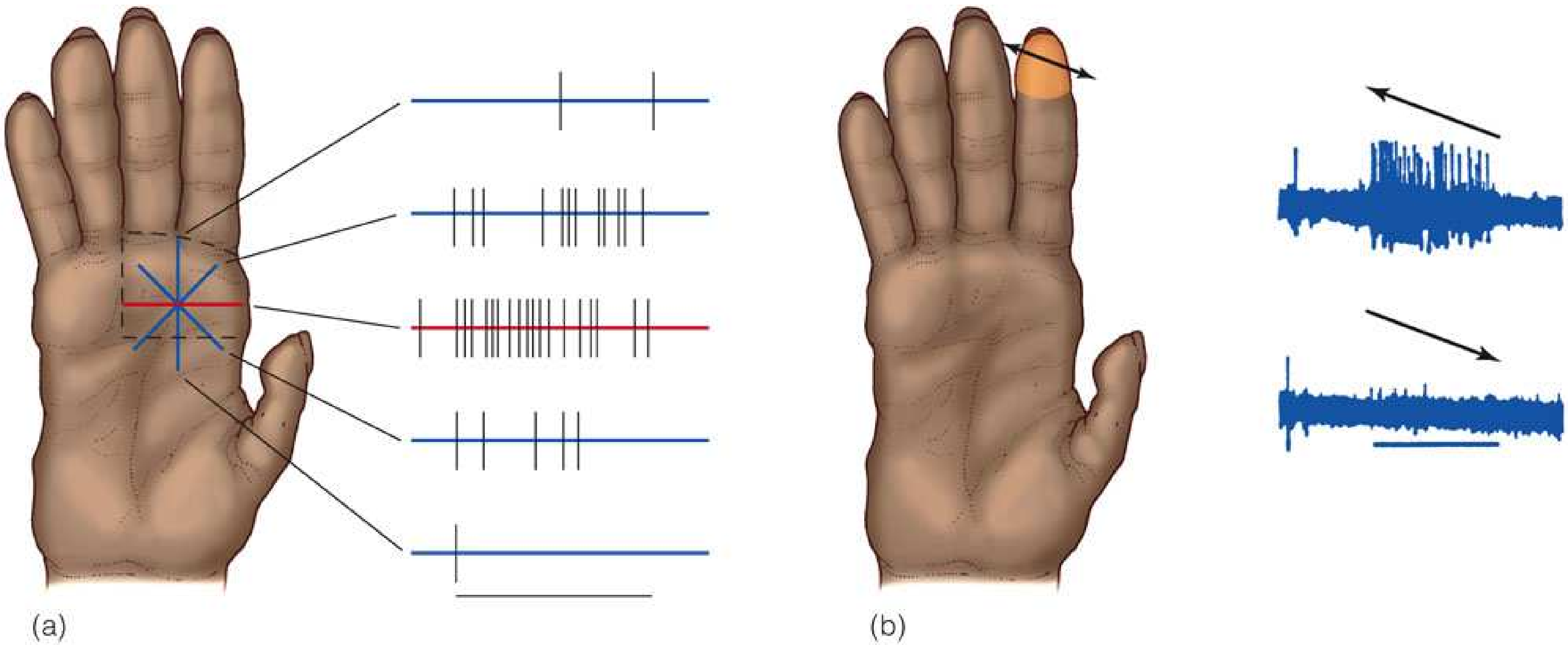


Adaptation Experiment by Hollins et al.

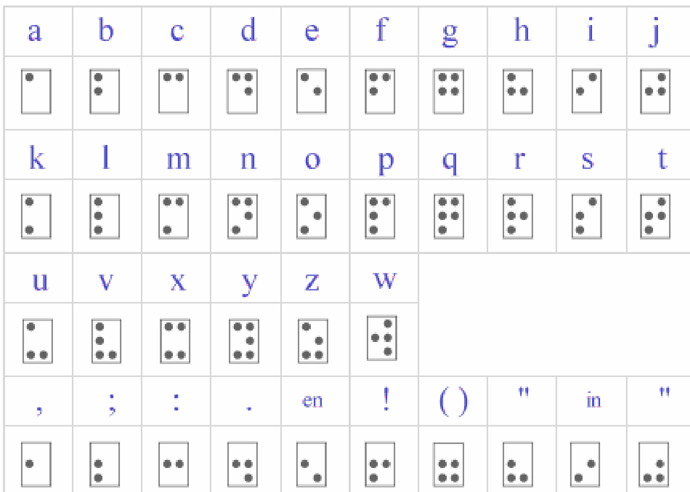
- Participants' skin was adapted with either:
  - 10-Hz stimulus for 6 minutes to adapt the RA1/Meissner corpuscle
  - 250-Hz stimulus for 6 minutes to adapt the RA2/Pacinian corpuscle
- Results showed that only the adaptation to the 250-Hz stimulus affected the discrimination of fine textures.

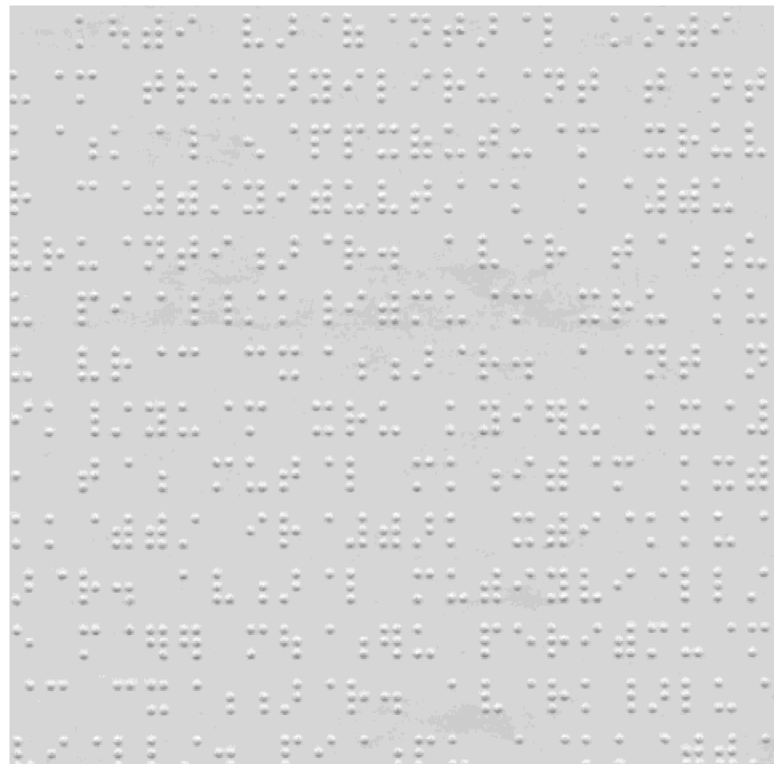


Somatosensory cortex shows cells that respond maximally to orientations and direction of movement



English Braille

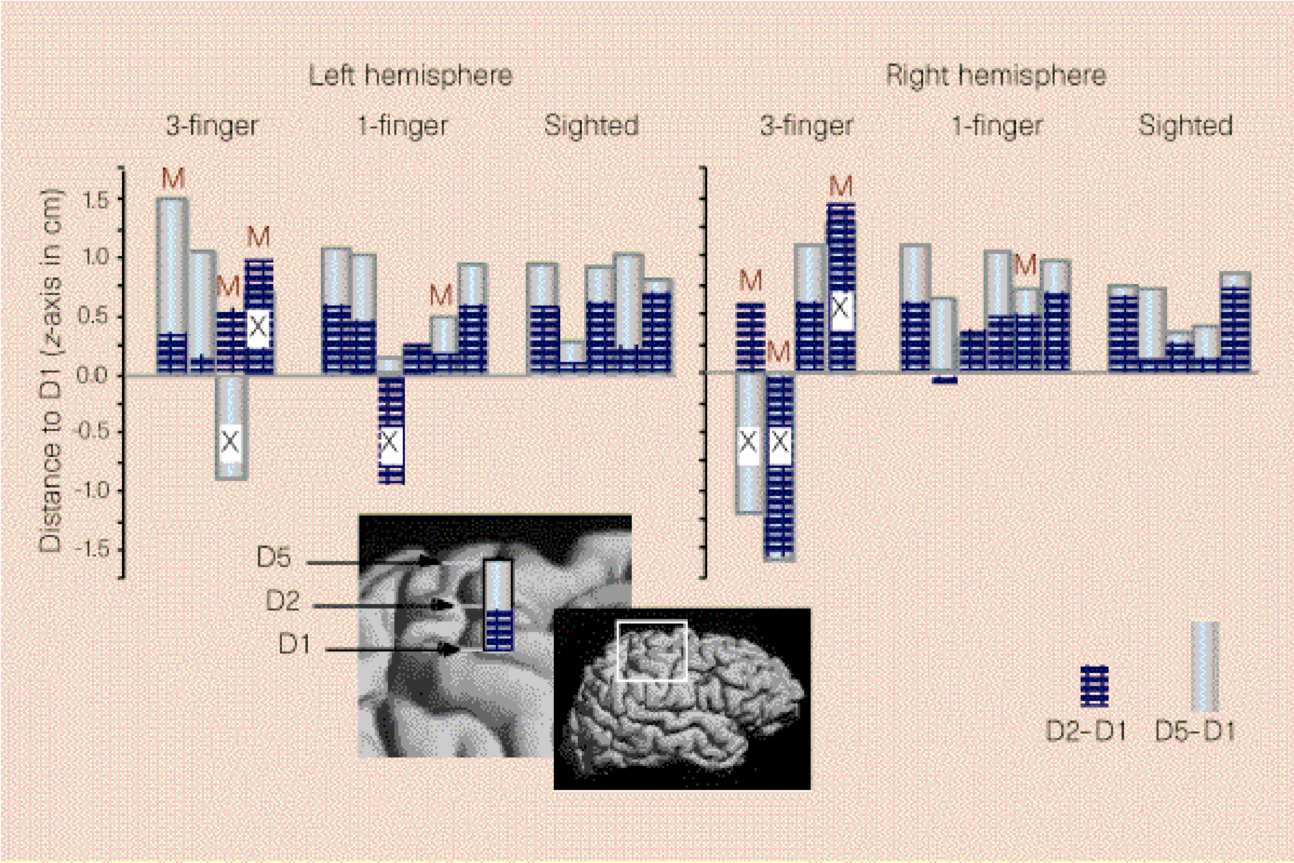




Experienced Braille readers can read about 100 words per minute (as opposed to 250-300 for visual reading)

A blind user can read the screen of his computer with a Braille display or with a speech synthesizer (or both together). He/she moves on the screen in using moving keys either on a specific keyboard or in using the standard keyboard.

Three-finger Braille readers have distorted map for the finger representations in SA1 compared to 1-finger Braille readers and sighted control subjects.



Sterr et al., Nature **391**, 134-135

In addition to the expected responses in somatosensory cortex, experienced Braille readers show large fMRI responses in the occipital cortex while reading Braille compared to control subjects.

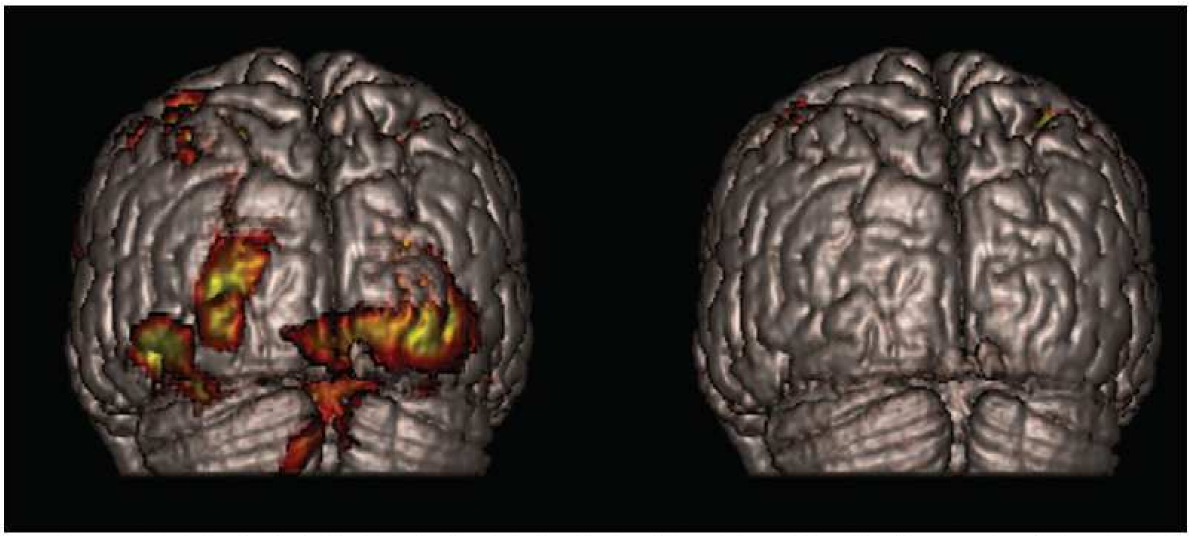
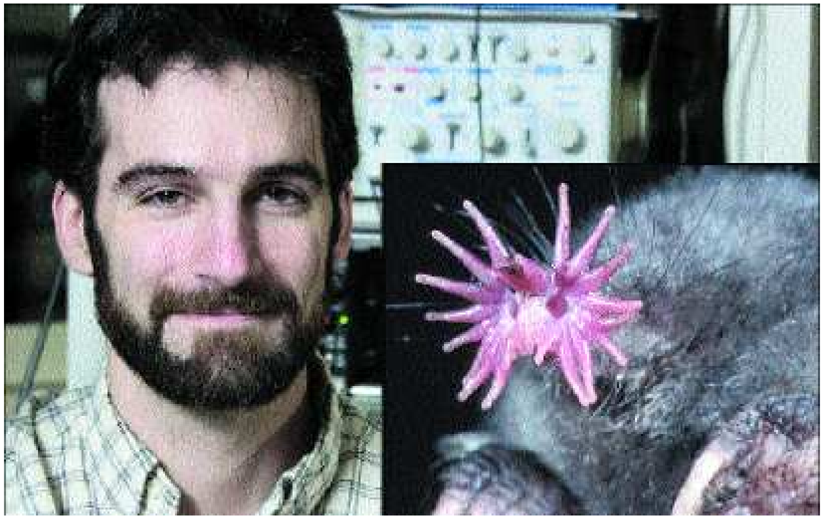


Fig. 2. Areas activated by Braille tactile discrimination tasks in a blind participant who lost his sight at 3 years of age (*left*) and a sighted control (*right*). The brain areas are superimposed on a surface-rendered high-resolution magnetic resonance image viewed from behind. In the blind subject, activity was seen in the occipital lobe, which includes the V1. By contrast, no activation of the occipital lobe was seen in the sighted subject.

Sadato, N. *Neuroscientist*. 2005;11(6):577-82.

The champion of somatosensory perception: the ***Star Nosed Mole***



Ken Catania at Vanderbilt has made a career studying this animal.

During normal foraging activity, the tentacles are constantly being used to feel the mole's surroundings, moving so rapidly that they appear as a blur of motion, touching as many as 12 objects per second. Using these supersensitive organs, identification of prey can be made in under half a second.

Pain Perception

Copied from comments by Ronald Melzack:

Descartes' specifity theory proposed that injury activates specific pain receptors and fibers which, in turn, project pain impulses through a spinal pain pathway to a pain center in the brain.

The psychological experience of pain, therefore, was virtually equated with peripheral injury.

In the 1950's, there was no room for psychological contributions to pain, such as attention, past experience and the meaning of the situation. Instead, pain experience was held to be proportional to peripheral injury or pathology.

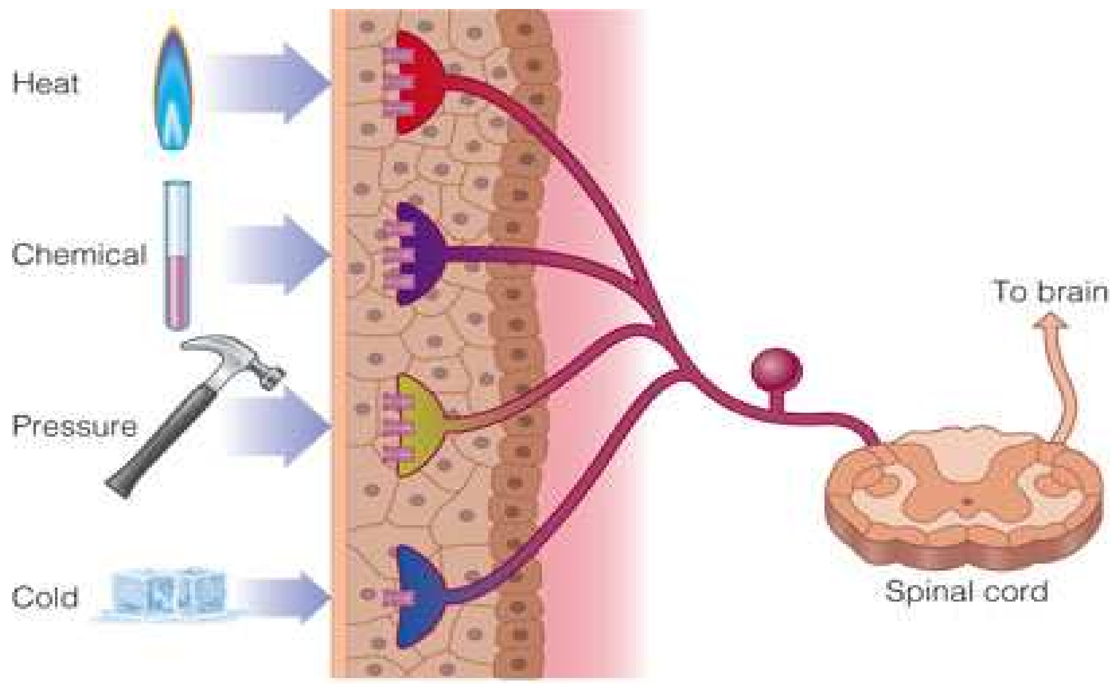
Patients who suffered back pain without presenting signs of organic disease were labelled as "crocks" and sent to psychiatrists. The picture, in short, was simple, and not surprisingly, erroneous.

To thoughtful clinical observers, however, the theory was clearly wrong.

Pain Perception: three kinds

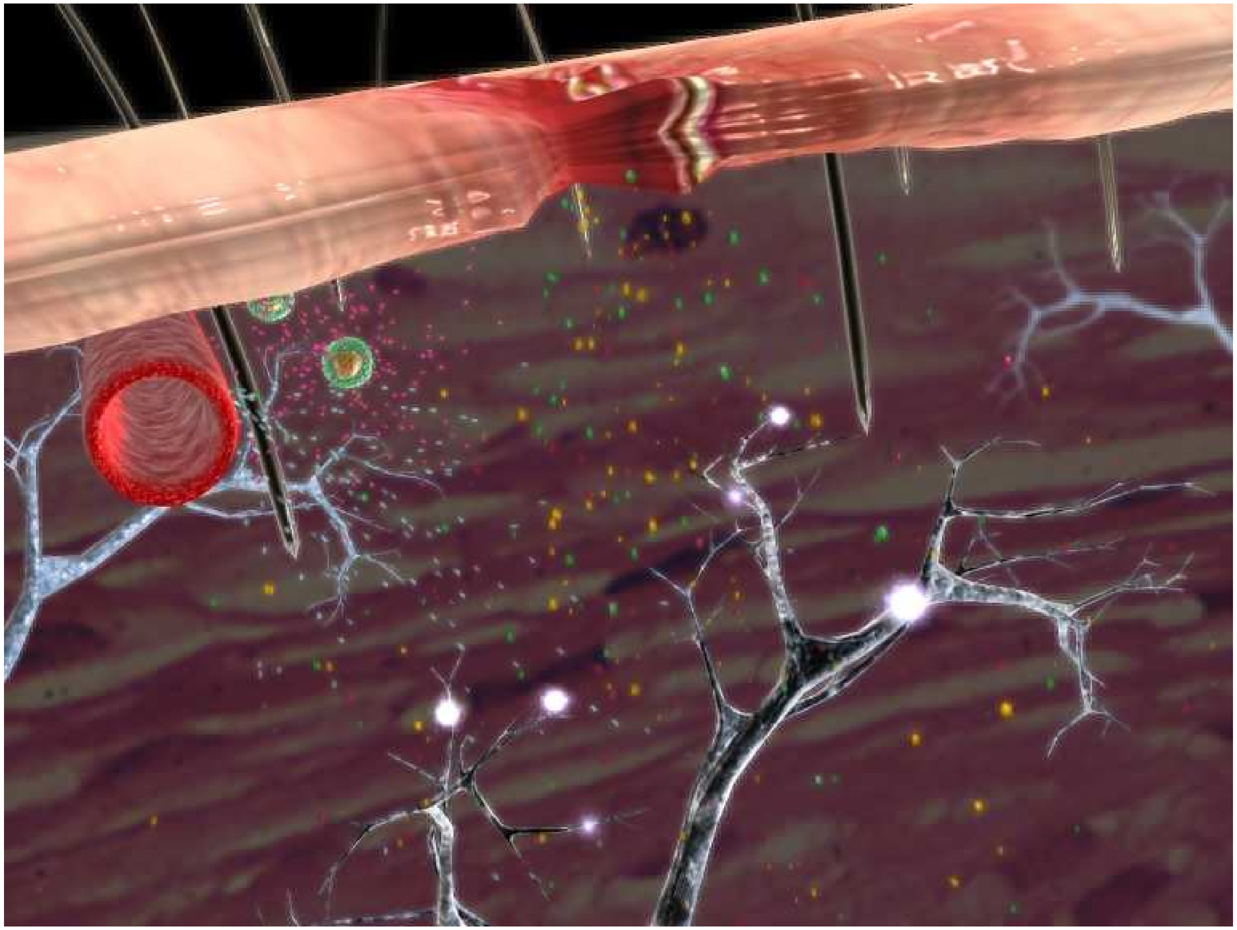
(a) Nociceptive - signals impending damage to the skin

- Types of nociceptors respond to heat, chemicals, severe pressure, and cold
- Threshold of eliciting receptor response must be balanced to warn of damage but not be affected by normal activity

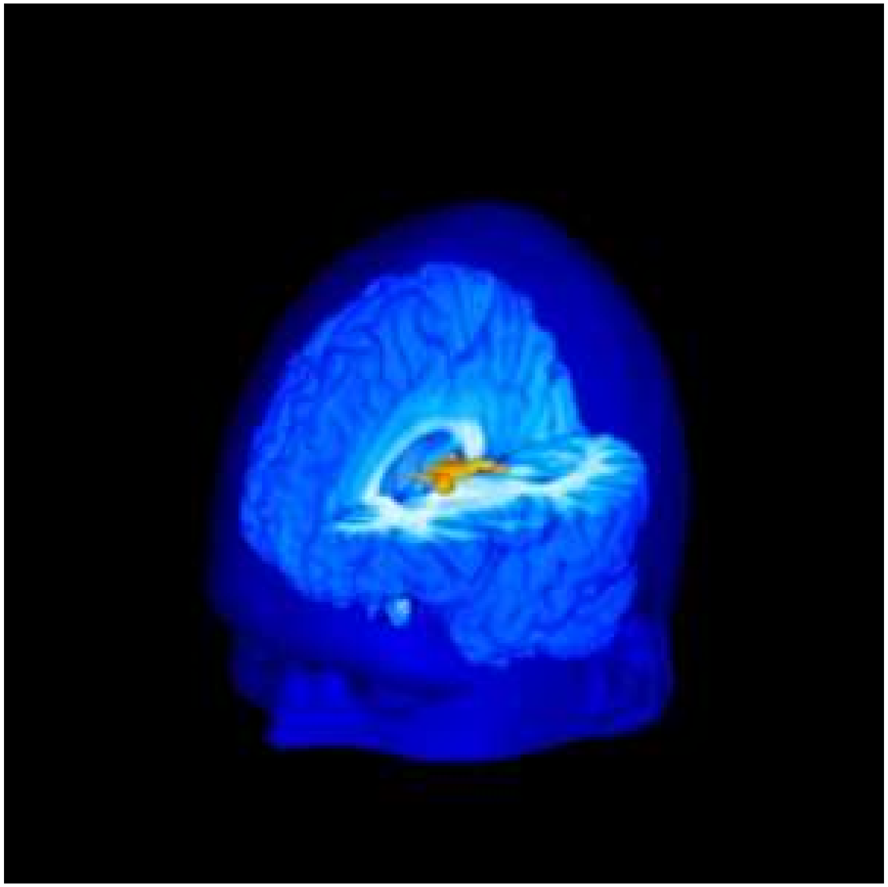


Types of Pain

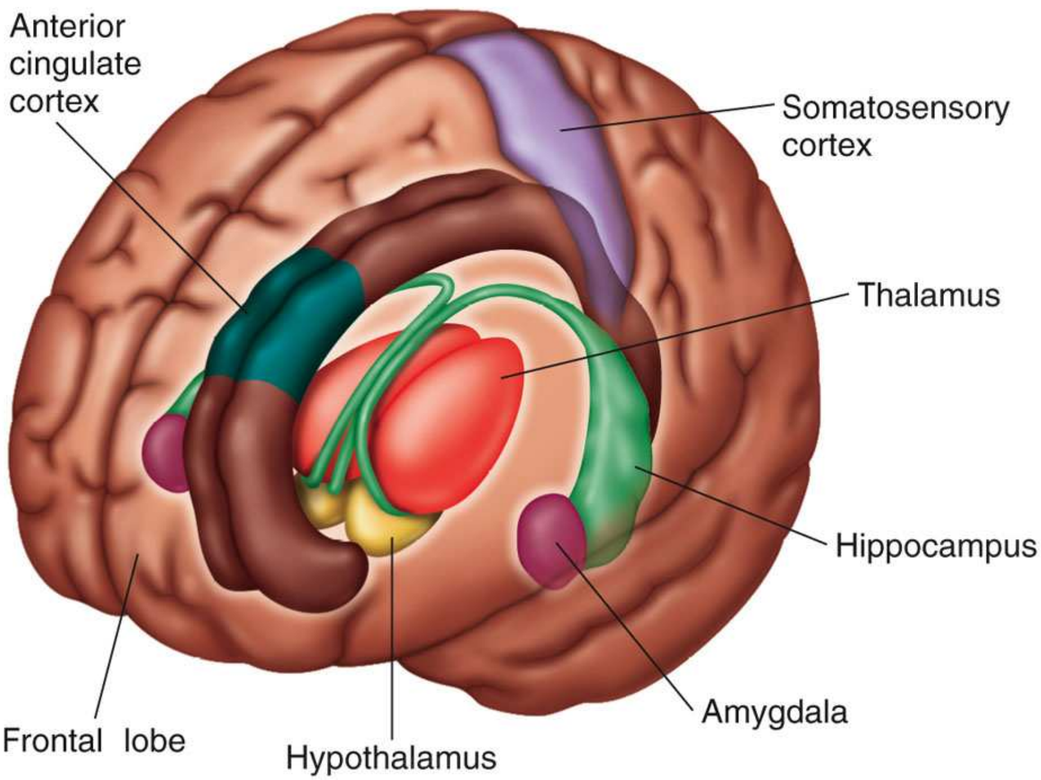
(b) Inflammatory pain - caused by damage to tissues and joints that releases chemicals that activate nociceptors



(c) Neuropathic pain - caused by damage to the central nervous system, such as brain damage caused by stroke, and repetitive movements which cause conditions like carpal tunnel syndrome.



- Signals from nociceptors travel up the spinothalamic pathway and activate:
  - (1) Subcortical areas including the hypothalamus, limbic system, and the thalamus
  - (2) Cortical areas including S1 and S2 in the somatosensory cortex, the insula, and the anterior cingulate cortex
  - – These cortical areas taken together are called the *pain matrix*



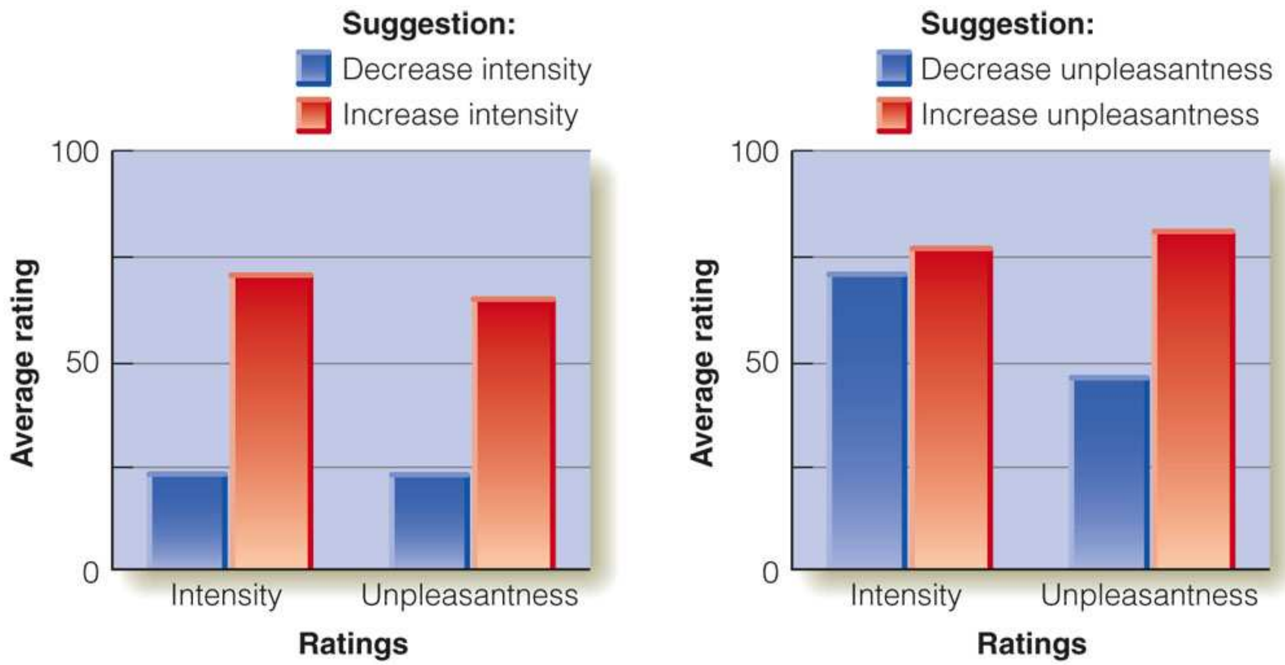
Sensation vs. Perception of pain

Experiment by Hoffauer et al.

- Participants were presented with potentially painful stimuli and asked:
  - To rate subjective pain intensity (sensation)
  - To rate the unpleasantness of the pain (perception)
- Brain activity was measured using PET scanning while they placed their hands into hot water
- Hypnosis was used to increase or decrease the sensory and affective components

Sensation vs. Perception of pain

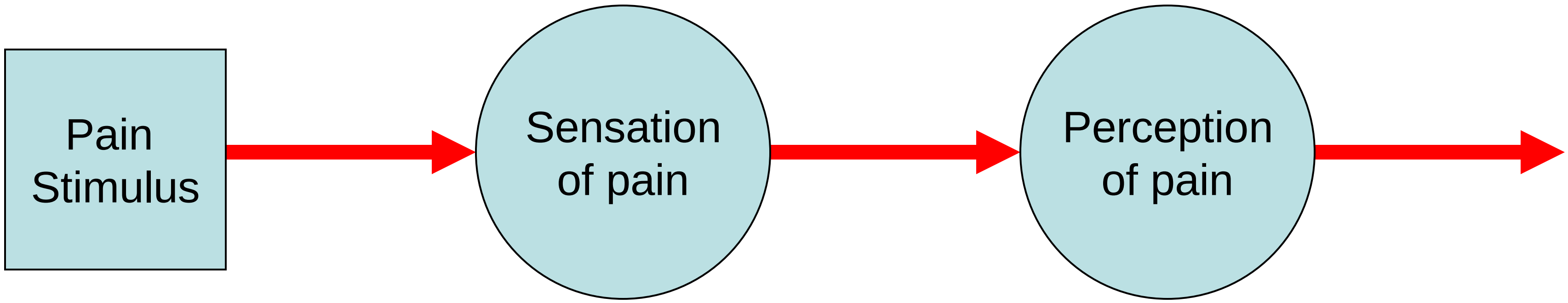
- Results showed that:
  - Suggestions to change the subjective intensity (sensation) led to changes in those ratings and in S1
  - Suggestions to change the unpleasantness of pain (perception) did not affect the subjective ratings (sensation) but did change:
    - Ratings of unpleasantness
    - Activation in the anterior cingulate cortex



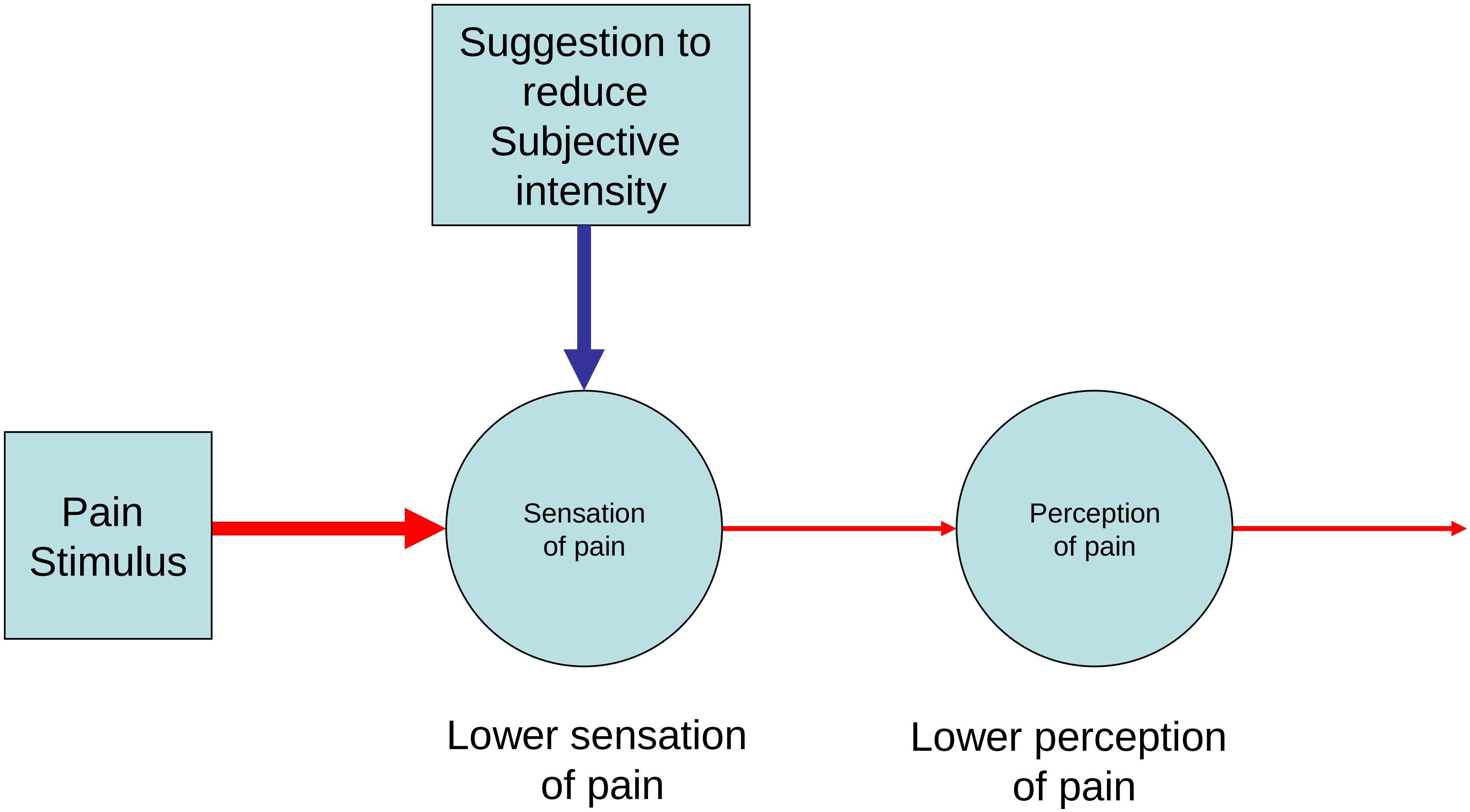
(a) Hypnotic suggestion: change *intensity* of pain

(b) Hypnotic suggestion: change *unpleasantness* of pain

Sensation vs. Perception of pain

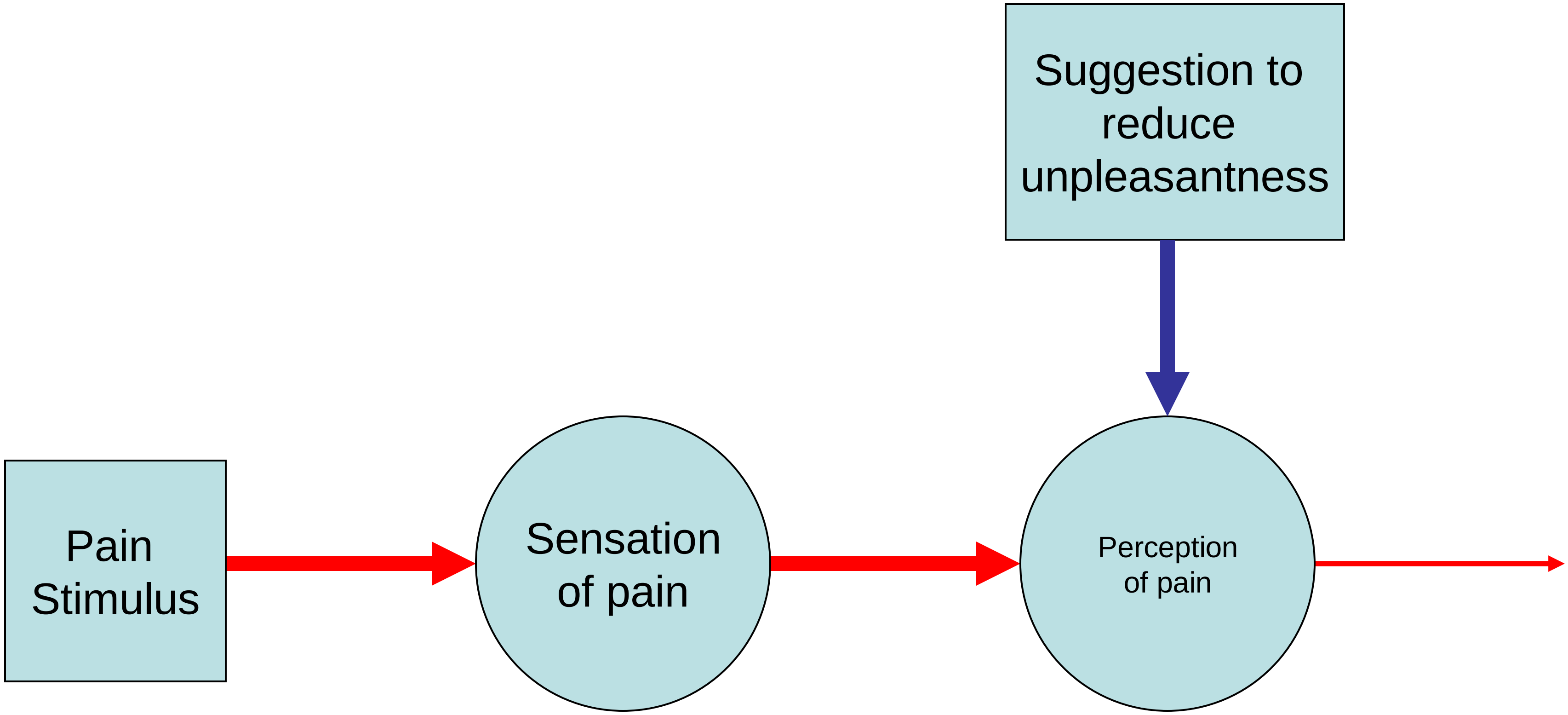


Sensation vs. Perception of pain



Reduced response in S1

Sensation vs. Perception of pain

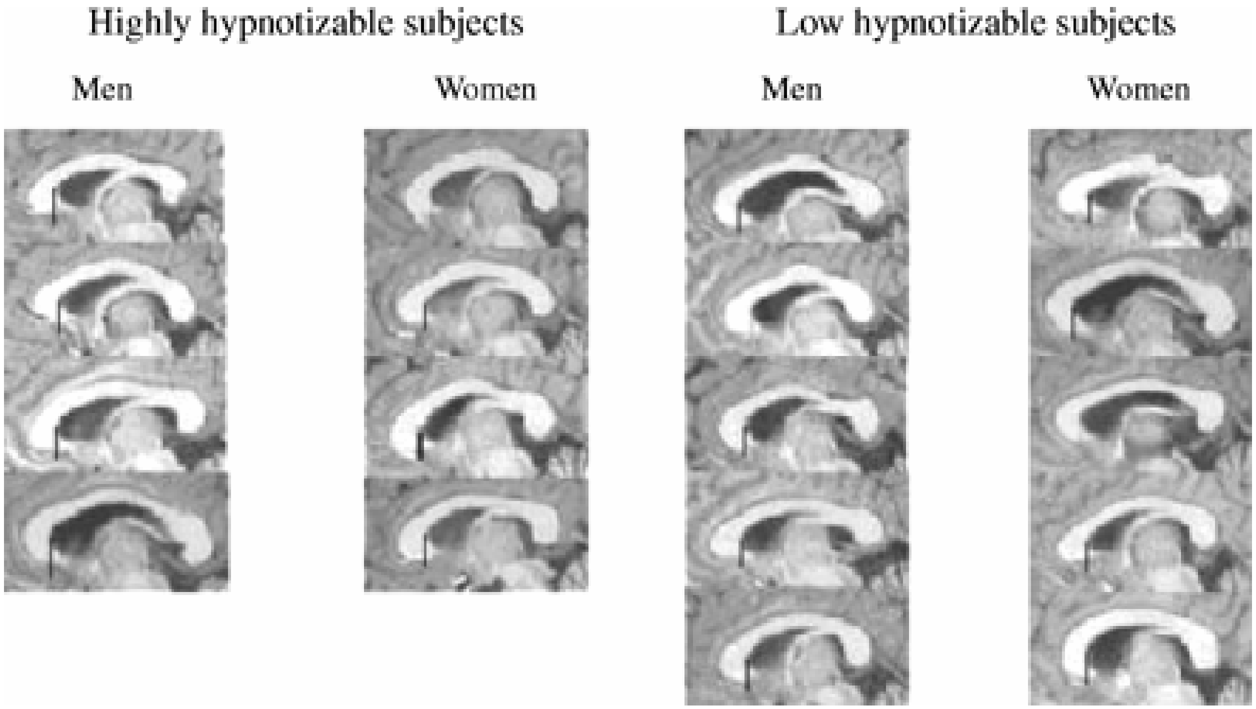


Lower perception of pain

Reduced response in anterior cingulate

Pain and Hypnosis

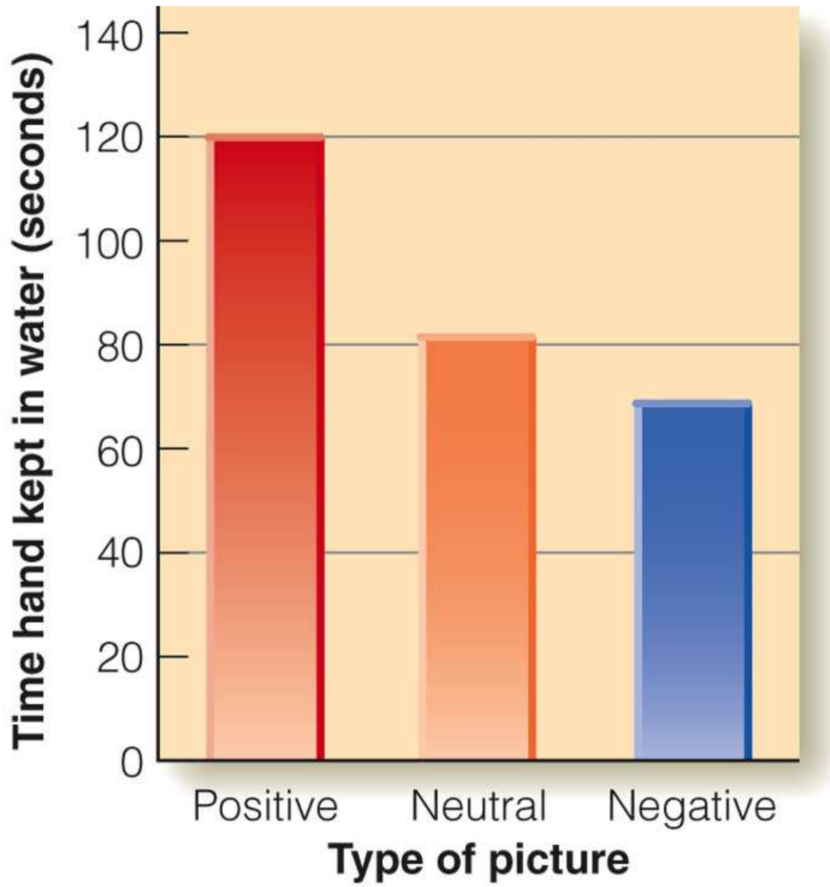
Increased anterior corpus callosum size is associated positively with hypnotizability and the ability to control pain



These results suggest that highly hypnotizable subjects have more effective frontal attentional systems implementing control, monitoring performance and inhibiting unwanted stimuli from conscious awareness than low hypnotizable subjects.

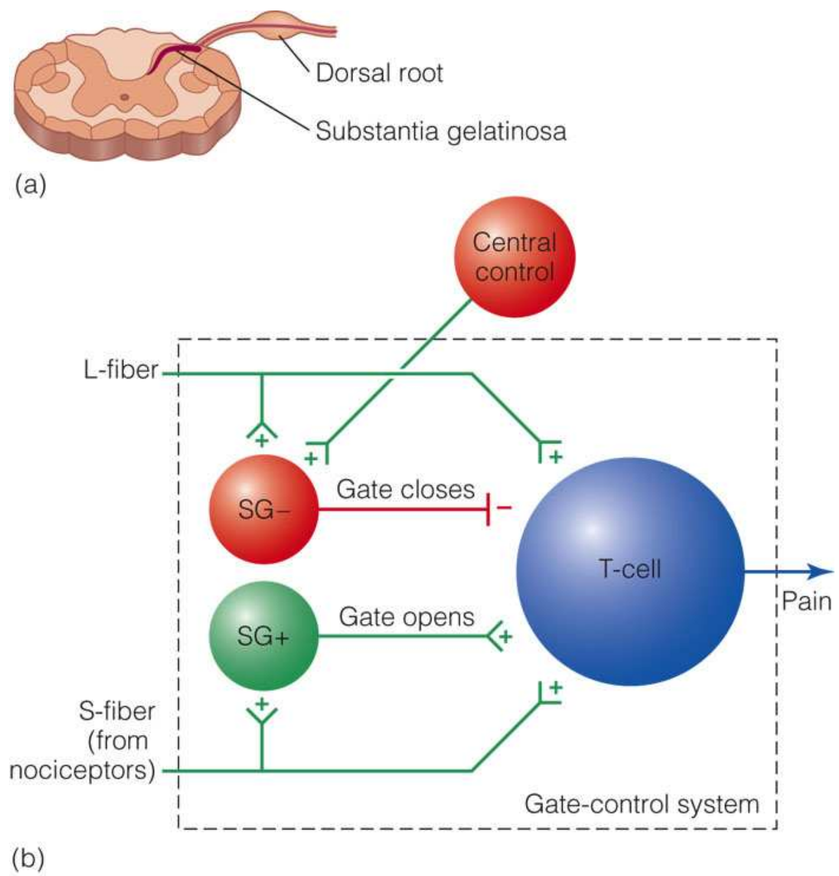
Sensation vs. Perception of pain

- Expectation - when surgical patients are told what to expect, they request less pain medication and leave the hospital earlier
- Content of emotional distraction - participants could keep their hands in cold water longer when pictures they were shown were positive



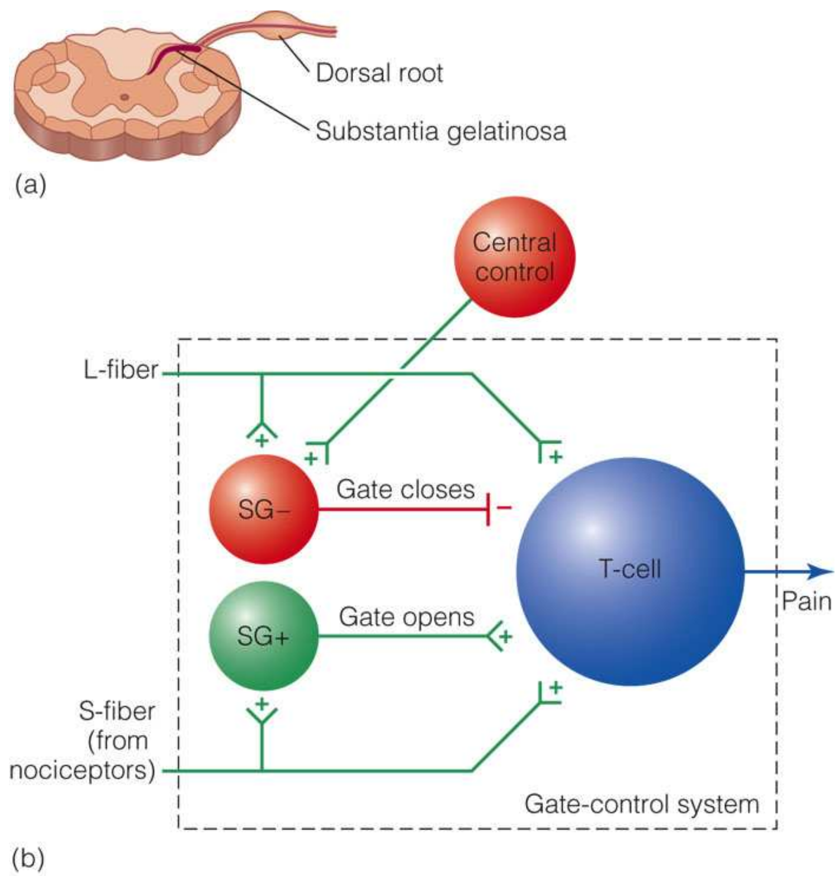
Gate Control Model of Pain Perception

- The “gate” consists of substantia gelatinosa cells in the spinal cord (SG- and SG+)
- Input into the gate comes from:
  - Large diameter (L) fibers - information from tactile stimuli
  - Small diameter (S) fibers - information from nociceptors
  - Central control - information from cognitive factors from the cortex



Gate Control Model of Pain Perception

- Pain does not occur when the gate is closed by stimulation into the SG- from central control or L-fibers into the T-cell
- Pain does occur from stimulation from the S-fibers into the SG+ into the T-cell
- Actual mechanism is more complex than this model suggests



Pain Perception

"Give Me Novocain"

Take away the sensation inside
Bitter sweet migraine in my head
Its like a throbbing tooth ache of the mind
I can't take this feeling anymore

Drain the pressure from the swelling,
This sensations overwhelming,
Give me a long kiss goodnight
and everything will be alright
Tell me that I won't feel a thing

So give me Novocain

Men in a war
If they've lost a limb
Still feel that limb
As they did before

He lay on a cot
He was drenched in a sweat
He was mute and staring
But feeling the thing
He had not

I know how it is
When something is gone
A piece of your eyesight
Or maybe your vision

A corner of sense
Goes blank on the screen
A piece of the scan
Gets filled in by hand

-Susanne Vega