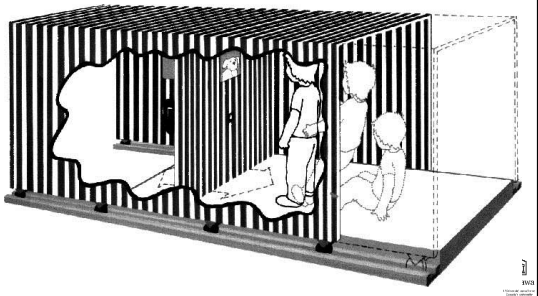
# APA 2120

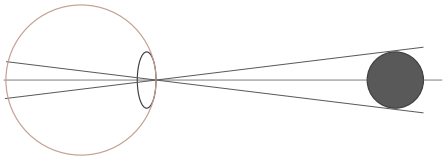
Lecture 6: Sensory Systems
Sept 26, 2012

uOttawa

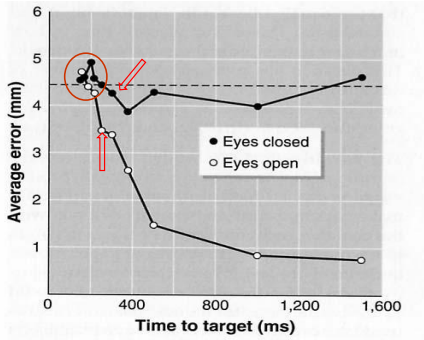
## Vision: Moving Room



## Vision: Time to contact



## Vision: Time to process




## How is Vision used in Control?

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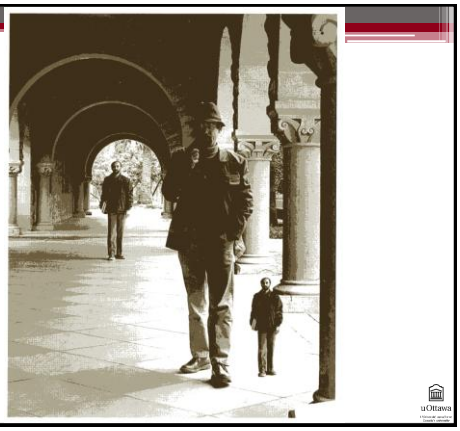
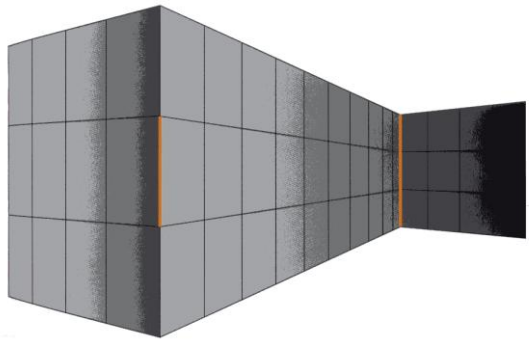
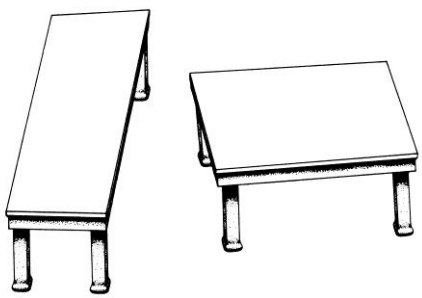
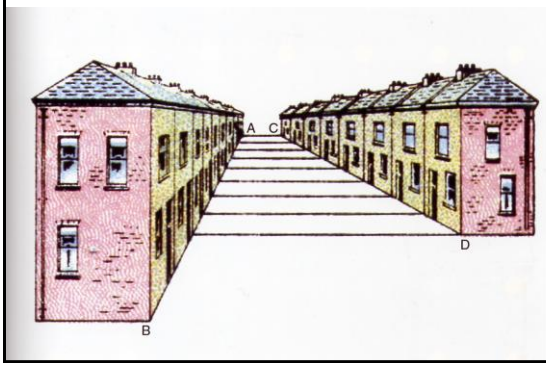
## Visual Illusions

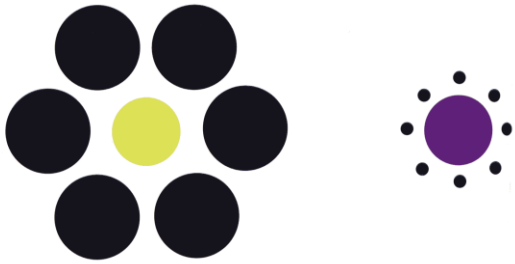
- How perception and action interact
- Illusions





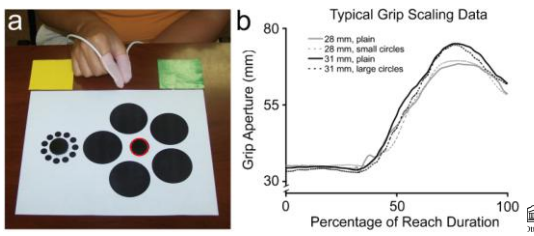




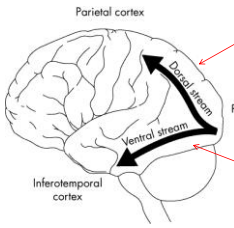



## Interacting with Illusions

- Some studies show that, while our perceptions are affected by illusions, sometimes our actions are not



## Two Cortical Visual Systems




**Dorsal route:** "Where?" ***ACTION***

Possibly immune to the effects of visual illusions

- It is thought to 'ignore' context, and process only the action target

**Ventral route:** "What?" ***PERCEPTION***

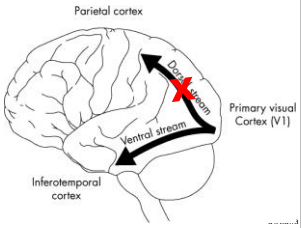
Thought to be responsible for many illusion effects

- Processes the target and its context

- Dorsal: unconscious action towards objects (how to interact with object)
- Ventral: conscious perception of object identification (shape, size, color, lightness, relative location)

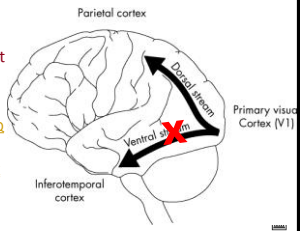
## What Happens if a System is Damaged?

- Damage occurring to the parietal lobe / Dorsal System
- Optic Ataxia:
  - Patients can describe the object but reaching movements are inaccurate



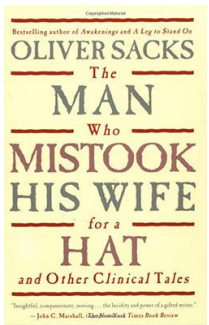

## What Happens if a System is Damaged?

- Brain damage occurring to the temporal lobe / Ventral system
- Visual Agnosia :
  - Patients can pick up the object but cannot recognize or describe it
- http://www.youtube.com/watch?v=rwQpaHQ0hYw#t=0m20s
- http://www.youtube.com/watch?v=kuKqi93FMgQ#t=1m16s




## The Man who Mistook His Wife for a Hat

-Oliver Sacks



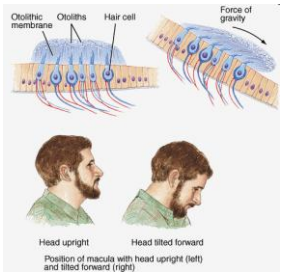

## Vestibular system

## Vestibular system

Vestibular System

- Located in inner ear
- Provide information about movement of head
- Includes:
  - 1. Otolith organs
  - 2. Semicircular canals

## The Vestibular System – Otolith Organs



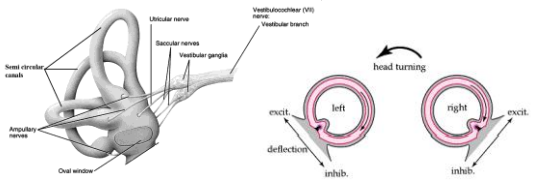

Utricle and Saccule

- Detect Linear acceleration
- Utricle lies horizontally, detects motion in the horizontal plane (forward, back, side to side).
- Saccule is oriented vertically, detects motion in the sagittal plane (up and down, forward and back).
- Hair cells are polarized
  - i.e. deflection in 1 direction increases firing rate and deflection in the other decreases firing rate

## 1. The Vestibular System

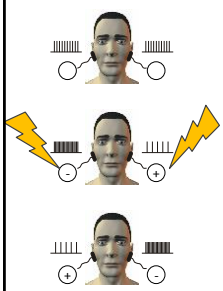
The Semicircular Canals

- Detect angular acceleration (e.g. rotation)
- These hair cells are also polarized




## The Vestibular code

## Galvanic Vestibular Stimulation (GVS)



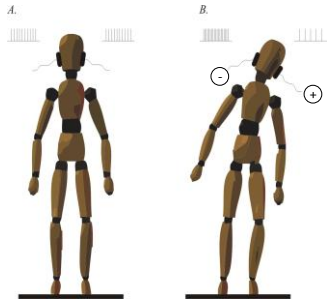
- Surface electrodes placed over the mastoid processes
- Current is delivered bilaterally via the mastoid processes to the vestibular nerve
- **Alters the discharge activity of the vestibular nerve**
- Decreases discharge at site of Anode (+)
- Increases firing at site of Cathode (-)


- Results in a perception of "falling" towards the Cathode,

- feels like he's falling to the negative direction, therefore he conpensates towards the positive direction

- Results in a perception of "falling" towards the Cathode, and produces compensatory sway in the direction of the Anode.


## Galvanic Vestibular Stimulation (GVS)



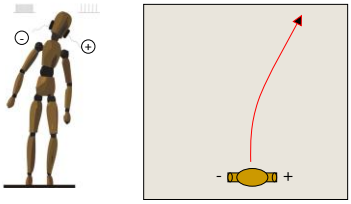

Postural sway in the direction of the anode electrode

As stimulus intensity increases, so does the movement magnitude (Bent et al, 2002)

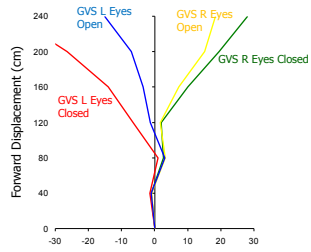
- vision and balance help coordinate movements

## GVS during locomotion

- Walking trajectory deviations are observed opposite the direction of perceived falling (i.e. the direction of compensation, towards the +Anode+)
- **The magnitude of the deviation is moderated by the availability of vision (Bent et al., 2002; Kennedy et al. 2003)**

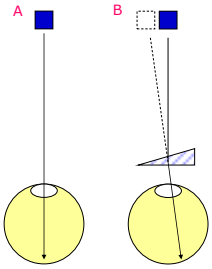



## Effect of Galvanic Stimulation on Walking



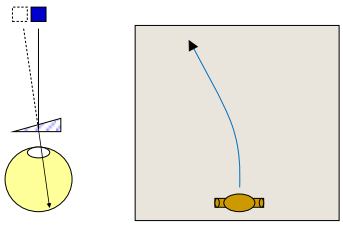

## Prisms

- Displacing prisms cause image on the retina to shift
- Causes a shift in perceptual location of object (or world)

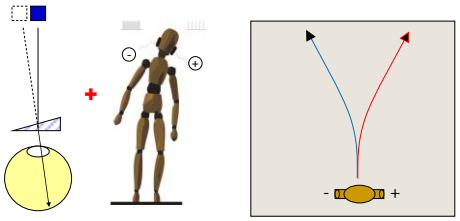



## Prisms during locomotion

- Trajectory deviations are observed towards the direction of perceived optic flow

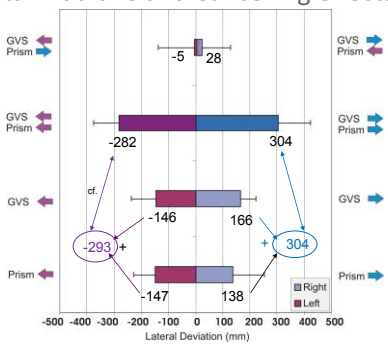


## Combined Visual and Vestibular perturbation?




## GVS-R, Prisms-L (opposing)

## Results: Additive and Cancelling effects




## Anticipatory postural adjustments

- Maintaining posture is very important for movement control.
- How about stepping?

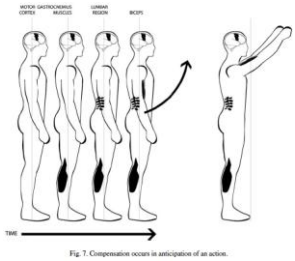


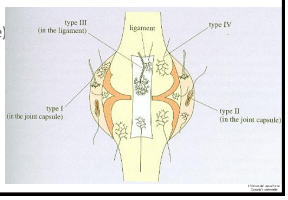

Fig. 7. Compensation occurs in anticipation of an action.

## Proprioceptors

## Joint Receptors

Joint Receptors

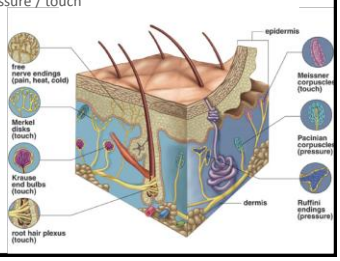
- Located within the joint capsule
- Signal extreme ranges of motion and protect the joint from injury
- Include:
  - Ruffini Endings (position)
  - Pacinian Corpuscles (pressure)



## Cutaneous receptors

Cutaneous Receptors

- Located in the skin
- Provide information about:
  - Light or heavy pressure / touch
  - Vibration
  - Pain




e.g. detect slipping wine glass

## Muscle receptors

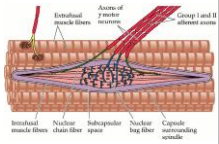
Muscle Receptors

- Located in muscles
- Provide information about length & tension of muscle
- Involved in voluntary & reflexive control
- Protect muscle from damage

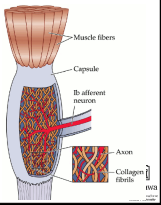
- Include:
  - Muscle Spindles
  - Golgi Tendon Organs (GTO's)

Muscle spindles and Golgi tendon organs are encpasulated structures found in skeletal muscle.

- Spindles
  - are fusiform (football) shaped
  - arranged in parallel with extrafusal muscle fibres
  - Innervated by both afferent and efferent nerves



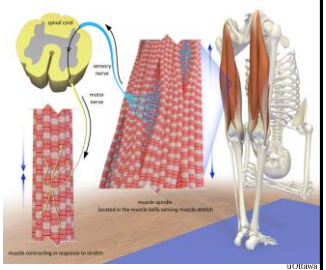

- GTOs
  - found at the junction between a group of muscle fibres and the tendon (e.g. in series with extrafusal fibres).
  - Innervated by a single afferent axon




- afferent nerves: carry the nerve impulses toward CNS
- efferent nerves: carry the nerve impulse from CNS to organ/muscle

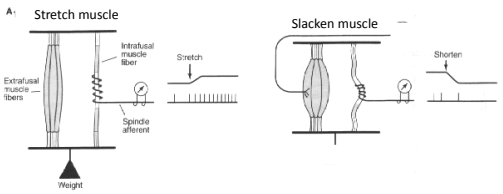
## Muscle Spindles

- Spindle (Football) shaped receptors oriented in parallel with muscle fibers
- Sensitive to changes in length of muscle fiber (i.e. they are stretched along with muscle)
- Also sensitive to Velocity of stretch
- When stretched, the sensory neuron sends information to spinal cord to excite motor-neurons
  - Leads to muscle contraction (stretch reflex)




## Muscle Spindles

- Basic Function
  - stretch of spindle fibers deform the sensory endings
    - increased activity of sensory neuron
  - slackening of spindle fibers
    - decreased activity of sensory neuron



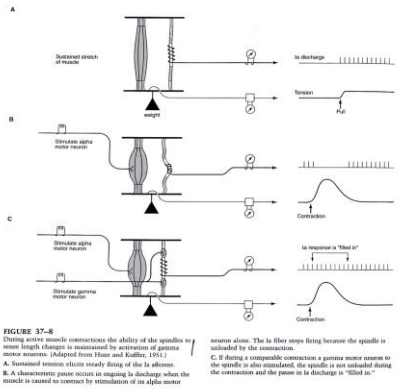
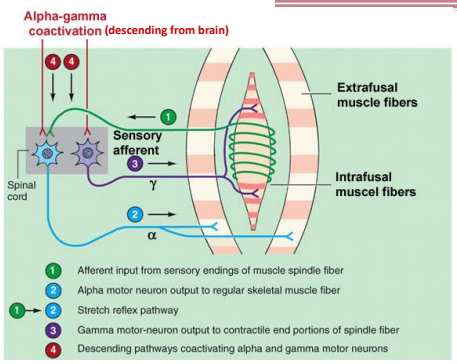
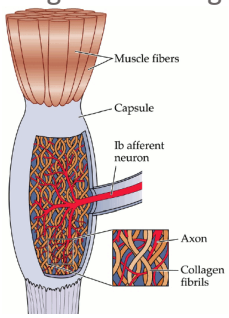




FIGURE 37–8
During active muscle contractions the ability of the spindles to sense length changes is maintained by activation of gamma motor neurons. (Adapted from Hunt and Kuffler, 1951.)
A. Sustained tension elicits steady firing of the Ia afferent.
B. A characteristic pause occurs in ongoing Ia discharge when the muscle is caused to contract by stimulation of its alpha motor neuron alone. The Ia fiber stops firing because the spindle is unloaded by the contraction.
C. If during a comparable contraction a gamma motor neuron to the spindle is also stimulated, the spindle is not unloaded during the contraction and the pause in Ia discharge is "filled in."



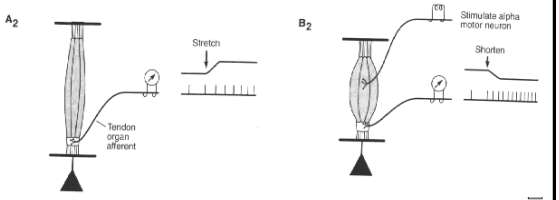

## Golgi Tendon Organs (GTOs)




- Receptors found at muscle-tendon junction
- Sensitive to Active tension in muscle
- When activated, sensory neuron sends information to spinal cord to inhibit motor-neurons
  - Leads to muscle relaxation & decrease in muscle tension

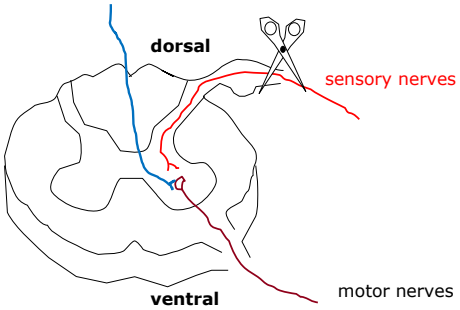
## GTOs

- Basic Function
  - Active tension on the tendon organ deforms capsule and sensory nerve endings → increased activity of sensory neuron



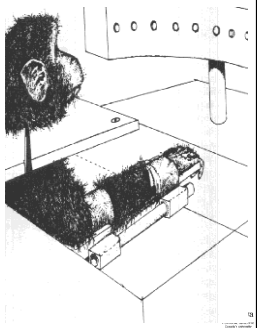

## What happens if you lose proprioception?

## Deafferentation



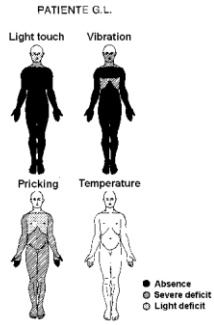

## Deafferentation Studies in Monkeys

- After deafferentation, monkeys were still able to make limb positioning movements but movements were not as accurate
- Proprioceptive feedback is not essential for movement but is important for precise guidance of movement



## GL – deafferented patient

## GL – deafferented patient




The patient GL, was 27 years old when suffering in 1975 from a first episode of acute polyneuropathy with a complete paralysis including the respiratory muscles.

A second episode of extensive sensory polyneuropathy occurred suddenly four years later (April 1979) which a**ffected selectively the large myelinated sensory fibers**;

A severe sensory impairment affecting her whole body below the nose remained totally unchanged over the years.

Clinically she has a total loss of touch, vibration, pressure and kinesthetic senses and no tendon reflexes in the four limbs, the trunk being more moderately affected.

Jacques Paillard

## Deafferentation Studies in Human

- Movements could be produced but were impaired when vision was removed

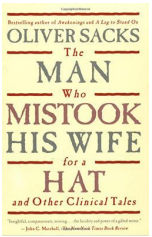
Reprinted by permission from Rothwell et al. 1982

Reprinted by permission from Rothwell et al. 1982

## The Man who Mistook His Wife for a Hat

-Oliver Sacks

- Ch. 3 – The Disembodied Lady




## Tendon Vibration

- http://www.youtube.com/watch?v=NtKWCfWzmtc