

# Spatial Perception In Persons with TBI

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I have no financial  
interest in anything I am  
talking about today.



How does the world  
appear to a person  
with TBI?

What can we do to help?



Mild to severe  
headache

Loss of coordination

Sleeping disorders

Mood Swings

Dizziness or fatigue

Blurred/Double  
Vision

Dysgraphia

Ringing sound in ears

Sensitivity to light or  
sound

Memory problems

Hormone Disorders

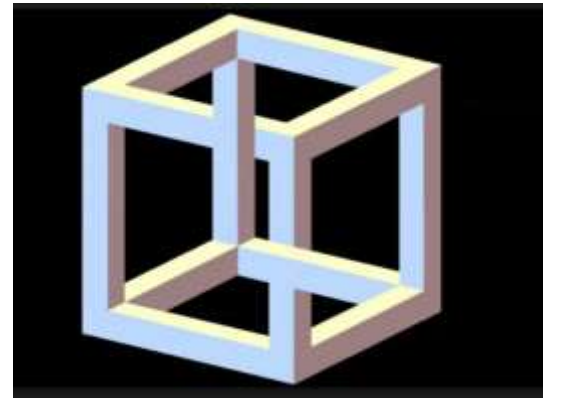
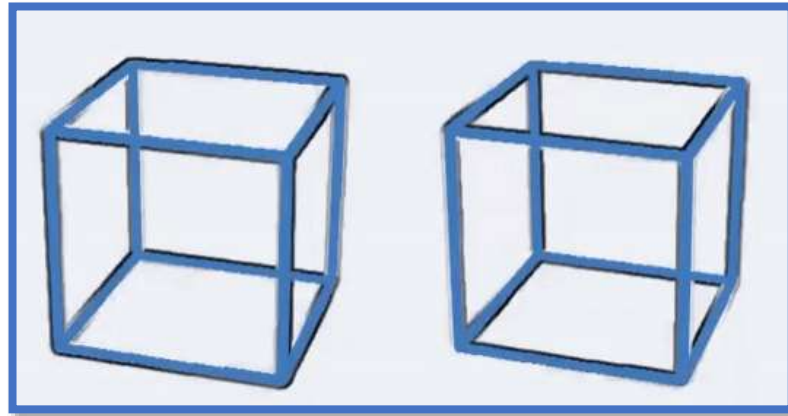
Speaking disorder

Depression or Anxiety

Digestive Issues



**My vision is...just different,  
and I can't really explain it.**



Their descriptions  
sound more  
illusory.

# Vision Therapy / Vision Rehabilitation



BF

Hip pain

Trigeminal pain in her front teeth – has no nerves in her front teeth

headaches and tension in the neck

Poor thinking and information processing

# Vision Therapy / Vision Rehabilitation

Difficulty with gait and  
balance

Dizziness

Unable to work



SD



Spatial Mapping

Visual Midline Shift  
Syndrome

Size/Shape Constancy

Relative Size





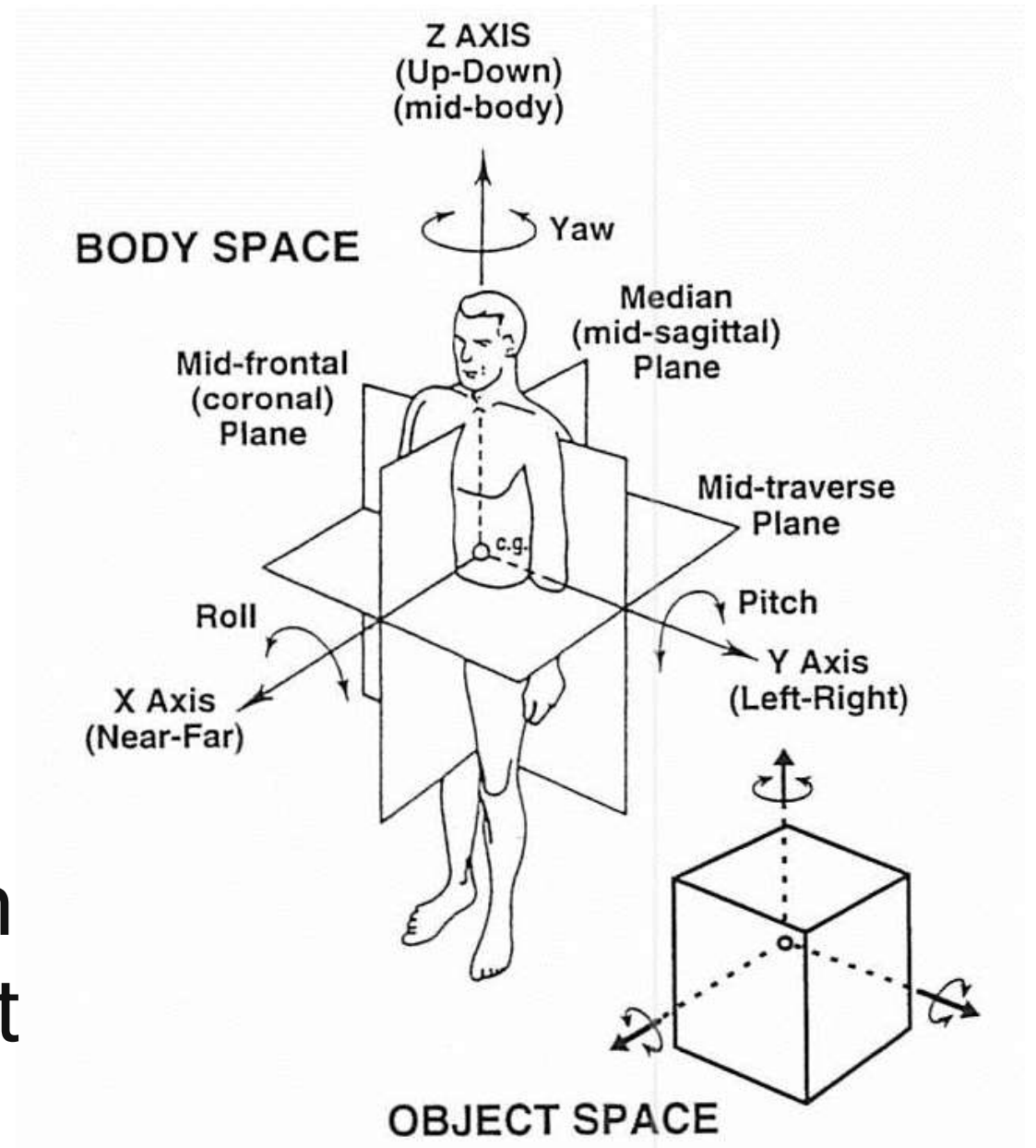
# Spatial Mapping

The Euclidean coordinate system is used to describe spatial maps:

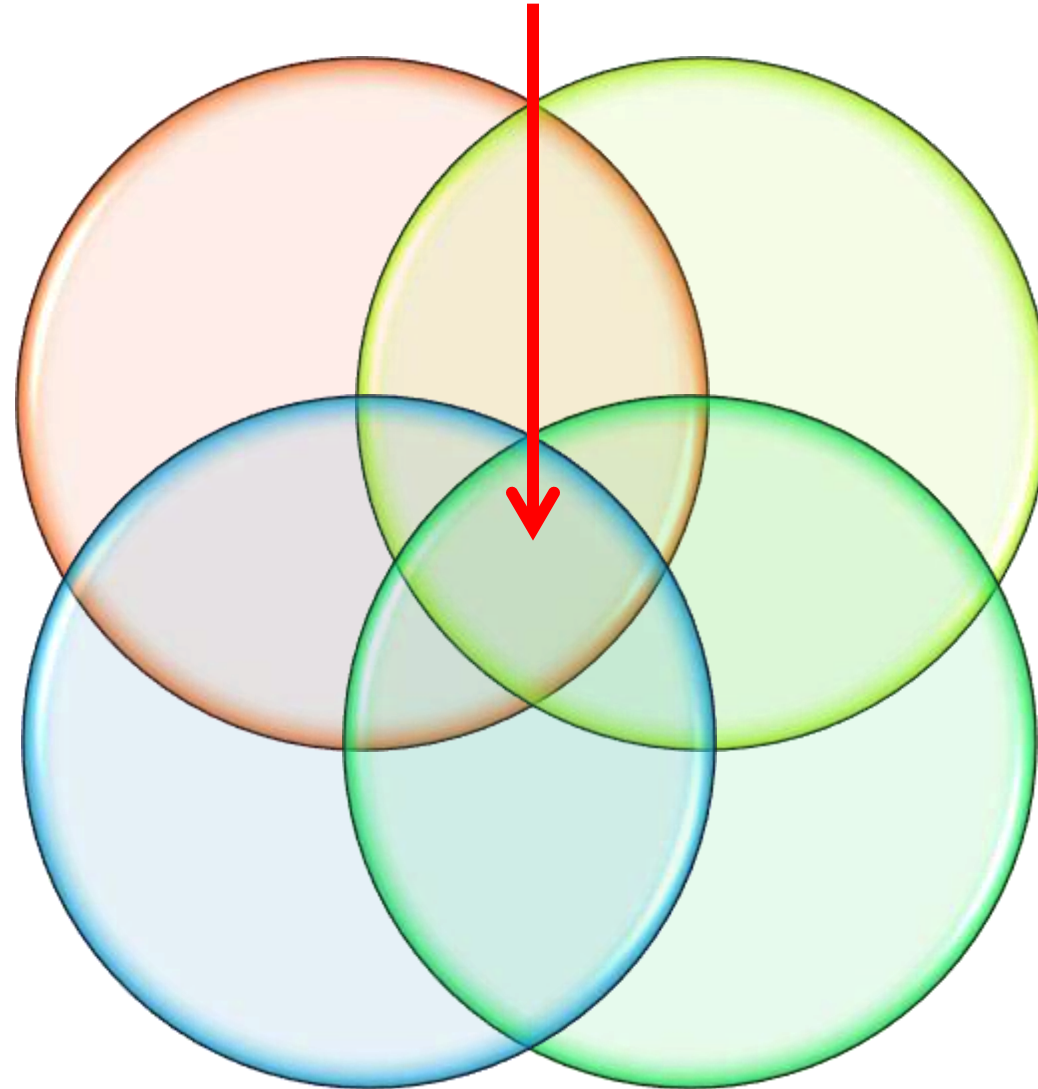
Egocentric or body centered (internal) spatial map.

Allocentric or object (external) spatial map.

We use this coordinate system to map body space onto object space to navigate our world.



# Vision



Centering  
“Where is it?”

Identification  
“What is it?”

Anti Gravity  
“Where am I?”

Speech / Auditory  
“Communication”

# Spatial Mapping



**Exteroceptors:** The information from receptors that reach out into the environment-outside the skin.

Detects stimuli from the external environment, such as touch, temperature, smell, eyesight, or hearing.

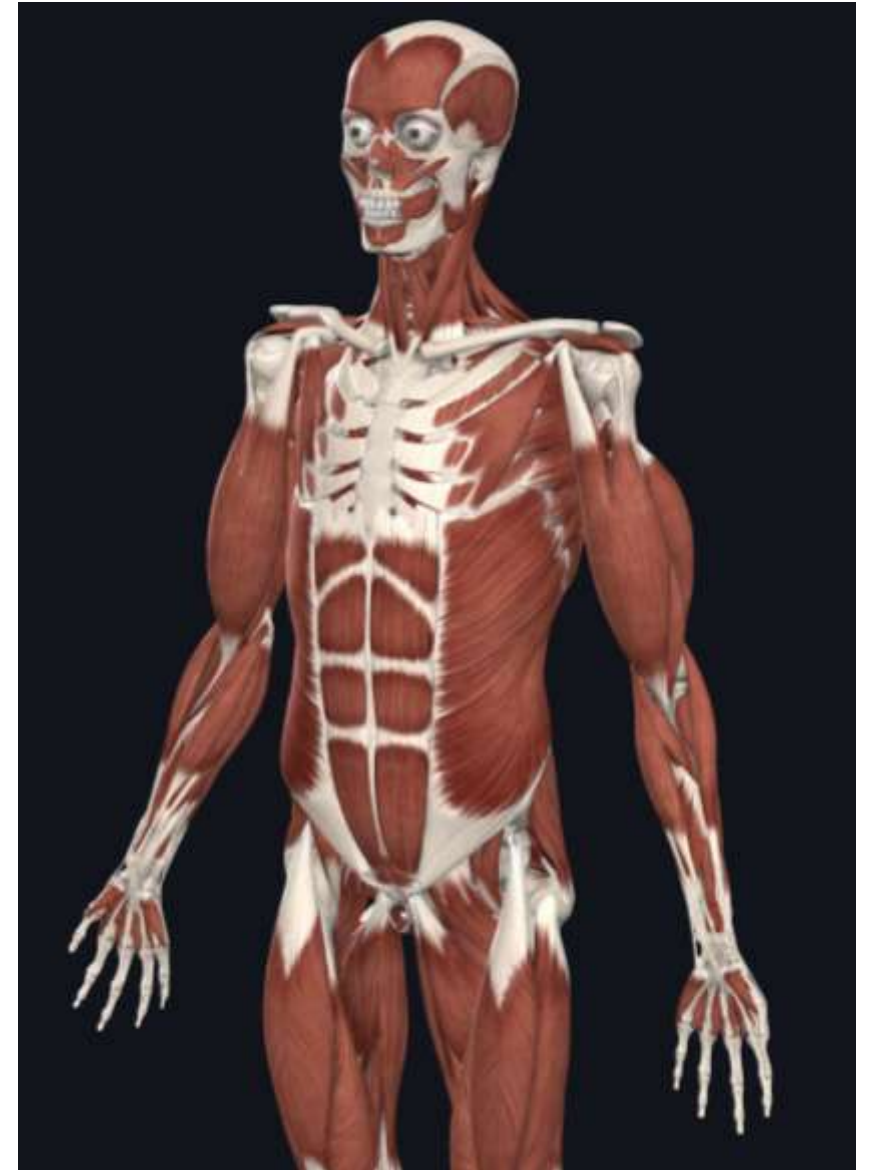


# Spatial Mapping

**Proprioceptor Space:** Information about the body that is within the skin.

Sensors located in the muscles (including the ocular muscles), tendons, and joints.

Provides information about the behavior of the controlled system.



# Spatial Mapping

**Visually Guided Movements:** Visual information about the target and the limb movement is expressed in terms of visual space and not ocular motor signal.

**Proprioceptive Guided Movement:** Proprioceptive information from the limb generates a movement path for the eyes and head to follow to bring the target into foveal view.

# Spatial Mapping

**Feedback:** Corrects for error after the movement occurs based on the comparison of desired and actual outcomes.

**Feedforward:** Utilizes the predicted sequence of the movement plan and sensed disturbances to compensate for an anticipated error before it occurs.



# Spatial Mapping

## Visually Guided Movements

There is visual spatial alignment of the various visual spatial maps available and a target is identified.

Based on this perceived map, a kinematic movement is programmed.

The coordination of these maps is verified through the feedforward and proprioceptive feedback systems.

To accomplish the movement goal requires a consistent adaptive movement.

The perceptual-motor system links body and object spatial maps to identify and reach the goal, i.e. reach for a cup or touch lights on the fixator or pegboard rotations, ect.



Reaching for a cup or glass in a 3-D world requires the integration of thousands of sensors, neurons, and motor units.

The muscles and joints have to work in synergy as one unit.

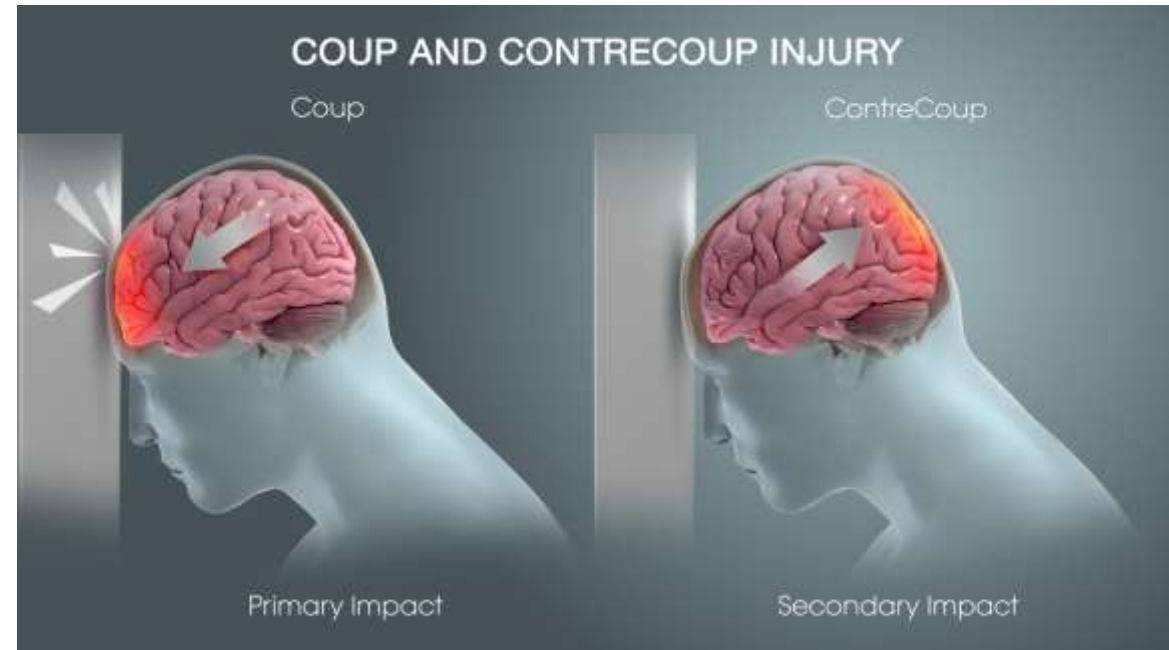


...the brain is used to predict the future, to anticipate the consequences of action (its own or that of others), and to save time.

*Alain Berthoz*

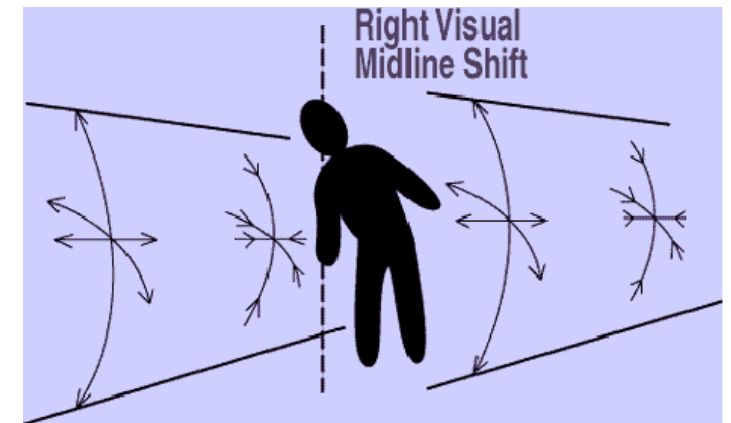
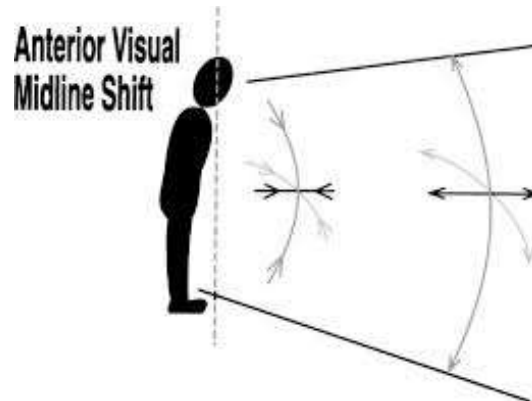
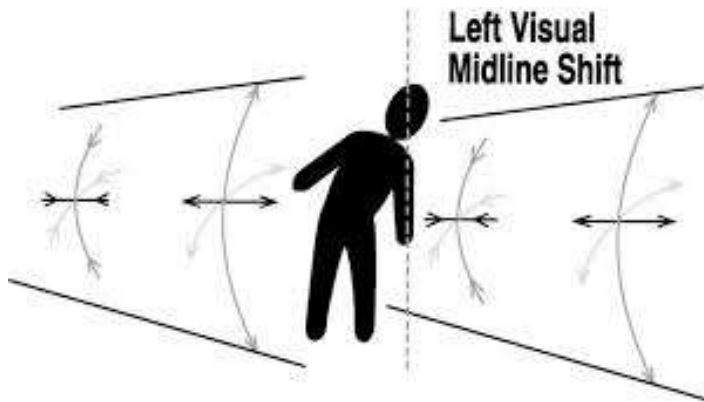
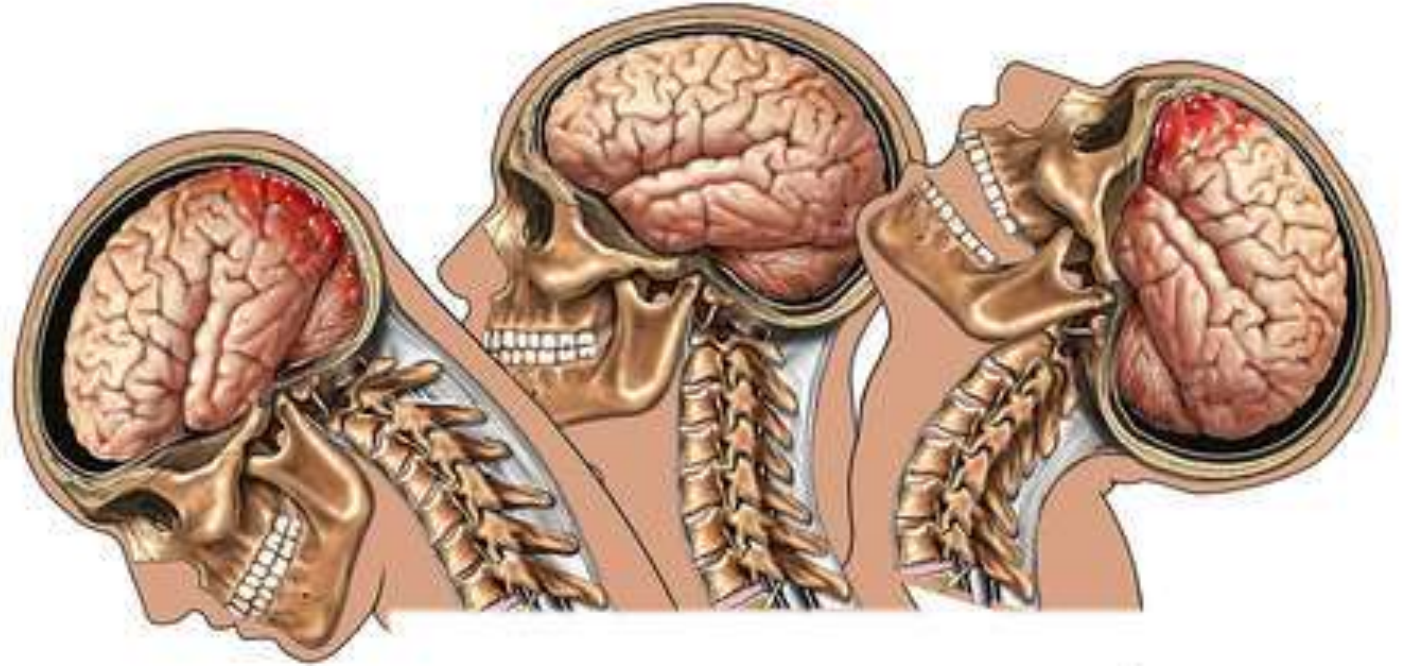
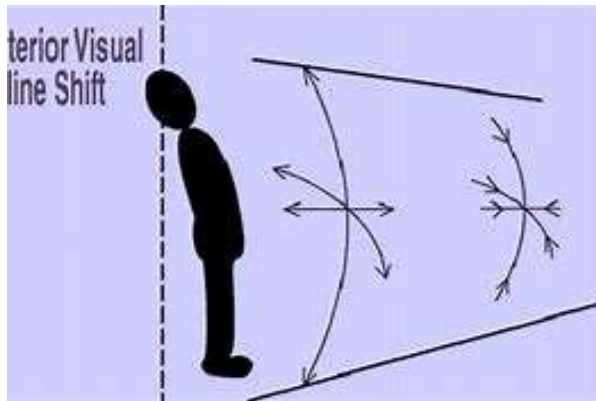


When the visual spatial map is altered through TBI or wearing prism goggles...



...the adaptive movement also changes.

# Visual Midline Shift Syndrome (VMSS)



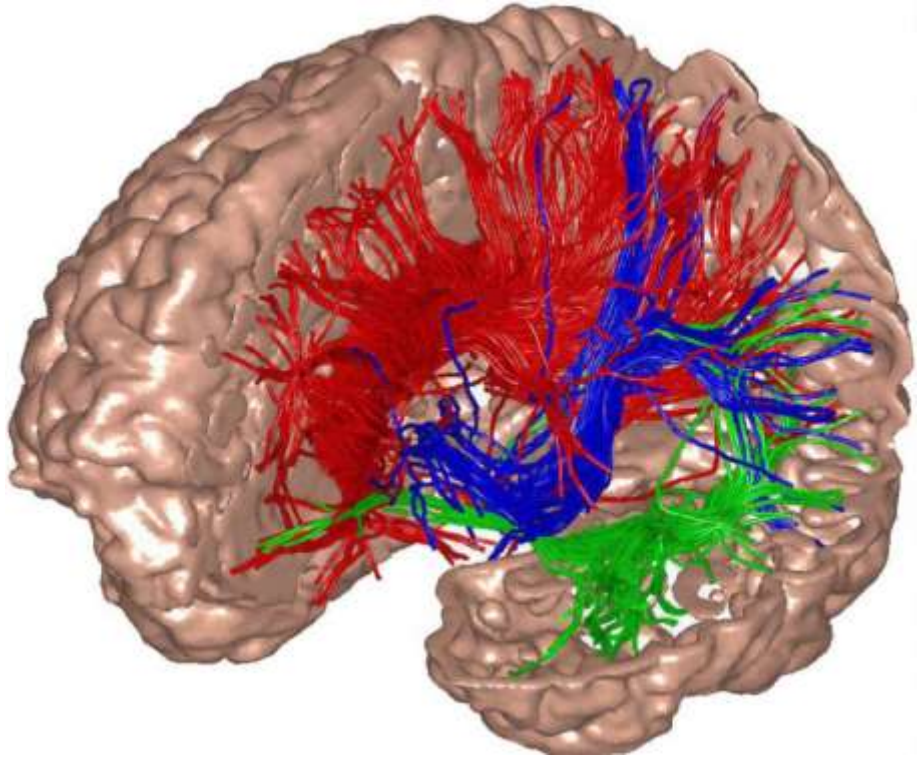
# Visual Midline Shift Syndrome (VMSS)

“Could the visual system somehow be involved in creating a distortion of space affecting the person’s perception of their own erect posture?”

“We have an elaborate neural organization of proprioceptive feedback and feedforward systems to give us an accurate spatial representation.”



# Visual Midline Shift Syndrome (VMSS)



We have axon collaterals from retina sending signals to areas other than the occipital cortex which communicate with kinesthetic, proprioceptive, tactile and vestibular systems.

# Visual Midline Shift Syndrome

When there is a neurological event and the body posture shifts to one side or the other, a hemiparesis is considered to have occurred.

Hemiparesis is a total or partial paralysis or weakness on one side of the body that results from disease of or injury to the motor centers of the brain.



# Visual Midline Shift Syndrome

When this happens, the kinesthetic and proprioceptive input from each side is different and this difference results in a spatial mismatch.

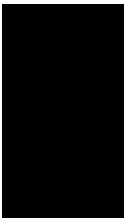
“That the ambient visual process attempts to balance this mismatch by neurologically creating an expansion and contraction of space in attempts to manage this dysfunction.”



# Visual Midline Shift Syndrome

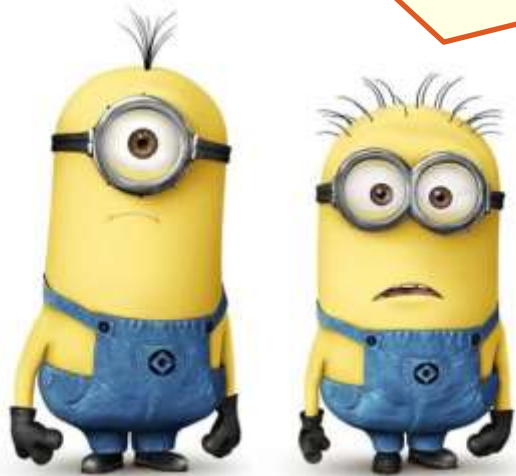
Walking and balance posture is often observed by watching a person lean to one side or the other.

Functional treatment is often using adaptive aids or providing feedback so the person can develop strategies to have a more erect posture.





If the VMSS postural adaptations are related to muscle weakness, then how is it that with the application of prism these patients magically develop instant strength for a more erect posture?





**Food for thought!**

What if there is a change in visual spatial map, due to TBI, where the programmed kinematic and motoric movement results in a postural tilt?



We organize our behavior around our perceived reality.  
When we change our perception we change our behavior.

**The visual system  
plays a larger role  
than vestibular to  
control body  
balance, posture  
and movement.**





Spatial Mapping (Matching)

Size/Shape Constancy

Relative Size



# Spatial Mapping

## Visually Guided Movements

There is visual spatial alignment of the various visual spatial maps available and a target is identified.

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To accomplish the movement goal requires a consistent adaptive movement.



# Shape or Form and Size Constancy

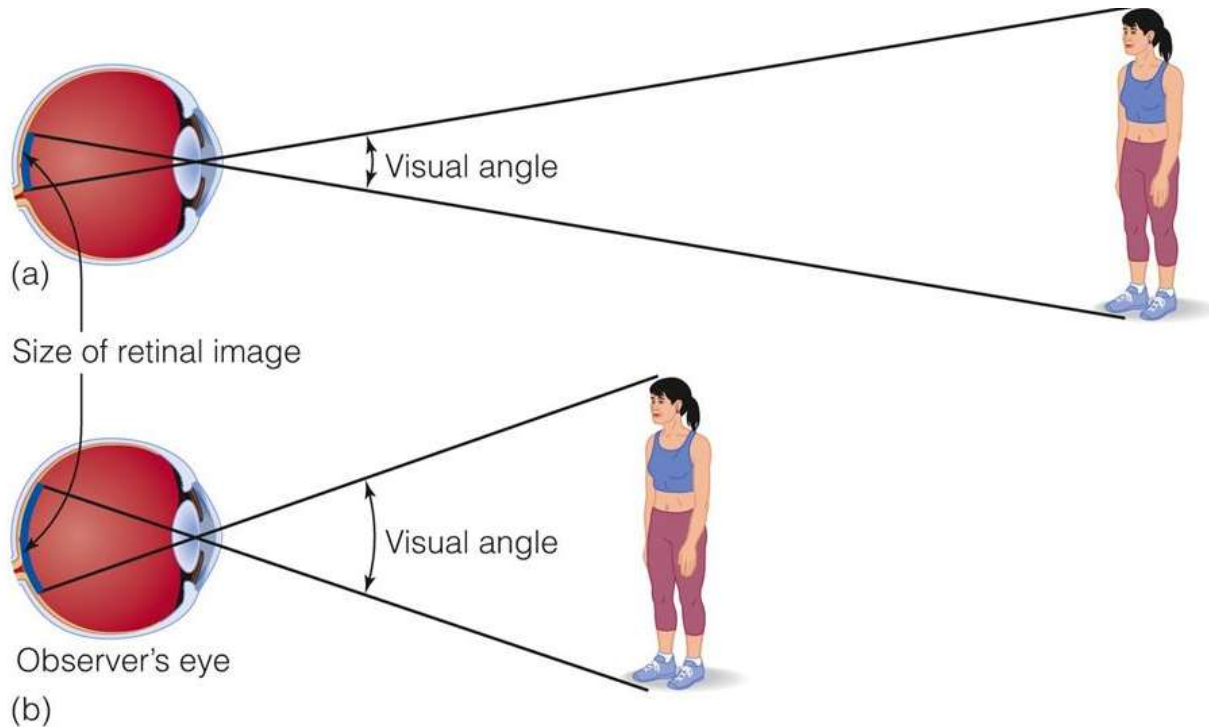
**Shape or Form Constancy:** Real objects are perceived to keep their shape or form despite the orientation of the image and the changing image size on the retina.

**Size Constancy:** Real objects are perceived to keep the same apparent size no matter how close or far away they are.



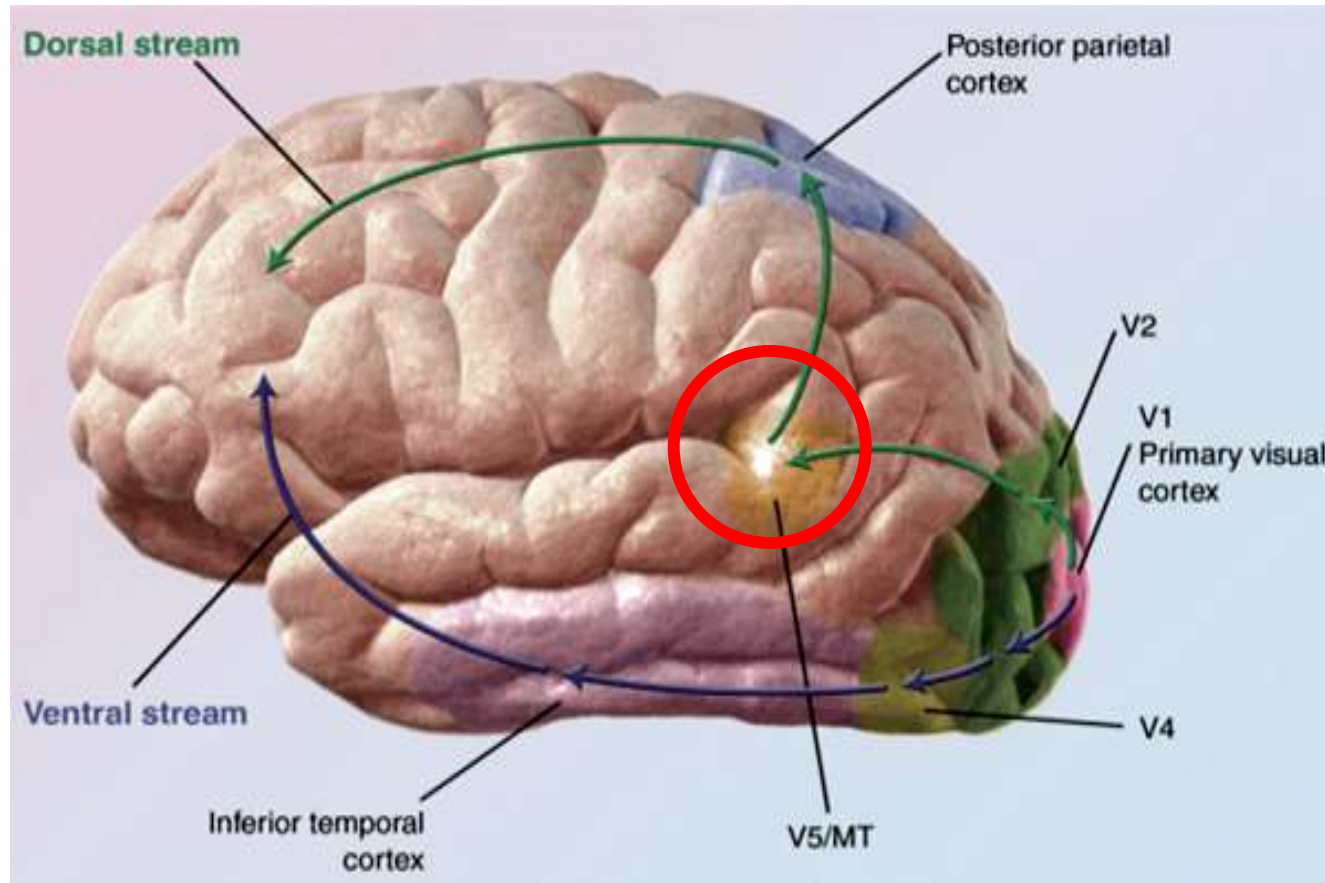
# Relative Size

Retinal image size helps to determine how close or how far an object may be located.





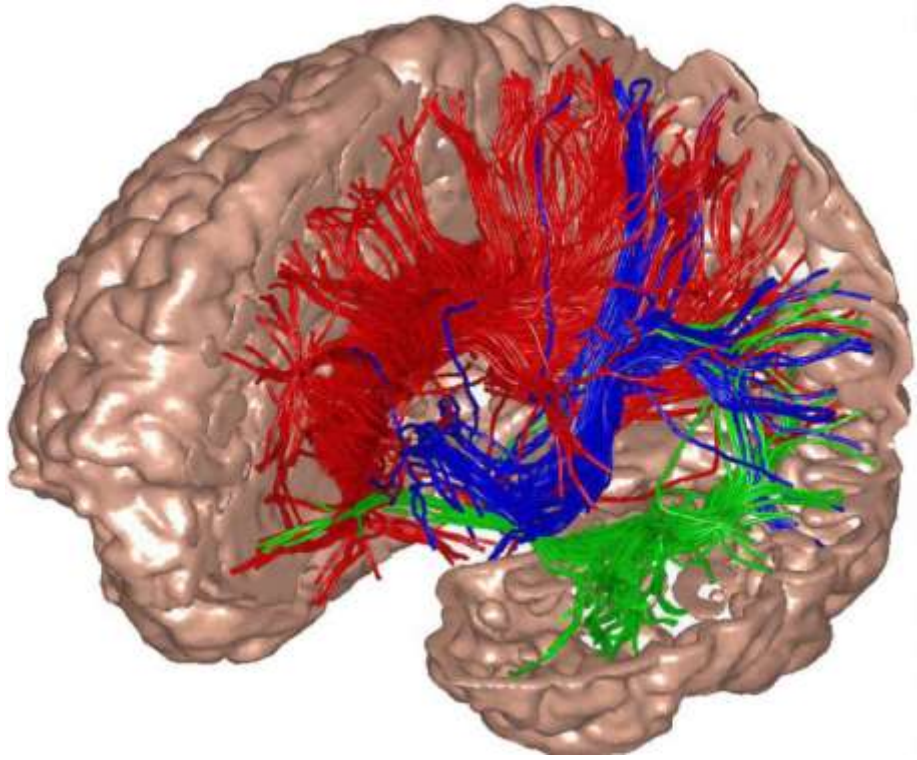
# Relative Size and Shape/Size Constancies



With intact neurology, the perceptual decision about object size, shape and form begins in early visual cortex-V1.

Then follows the dorsal stream to the parietal cortex and V5 and MT.

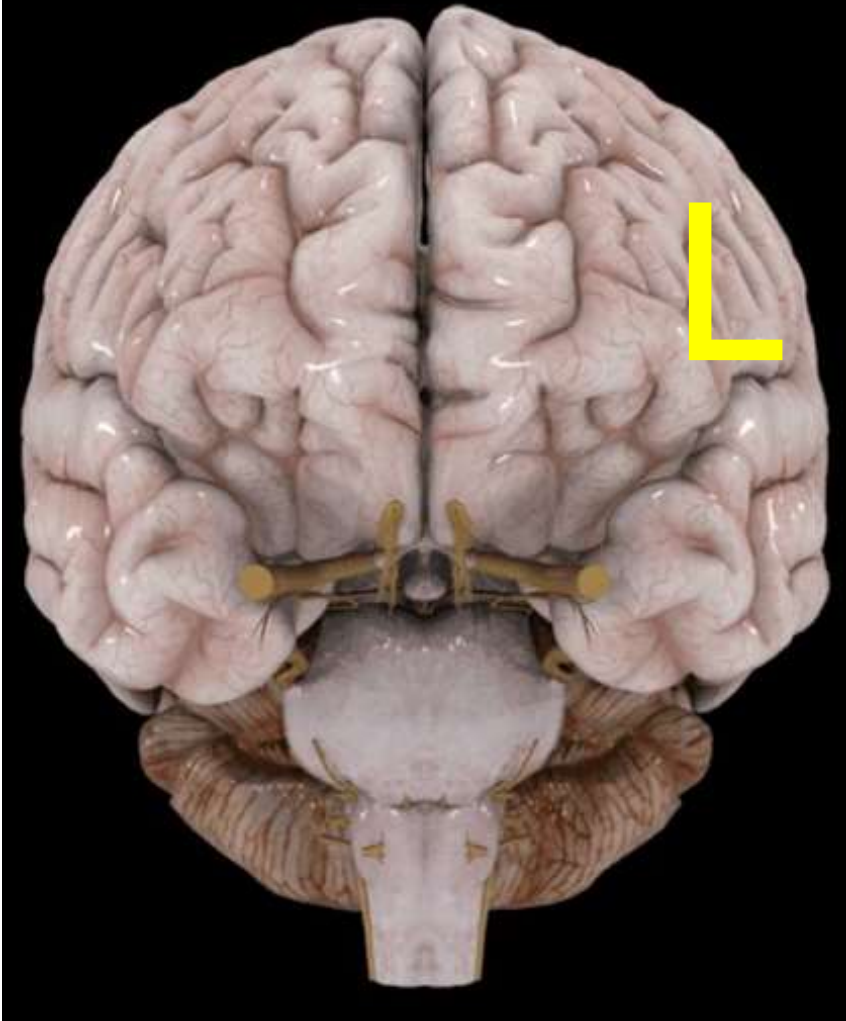
# Relative Size and Shape/Size Constancies



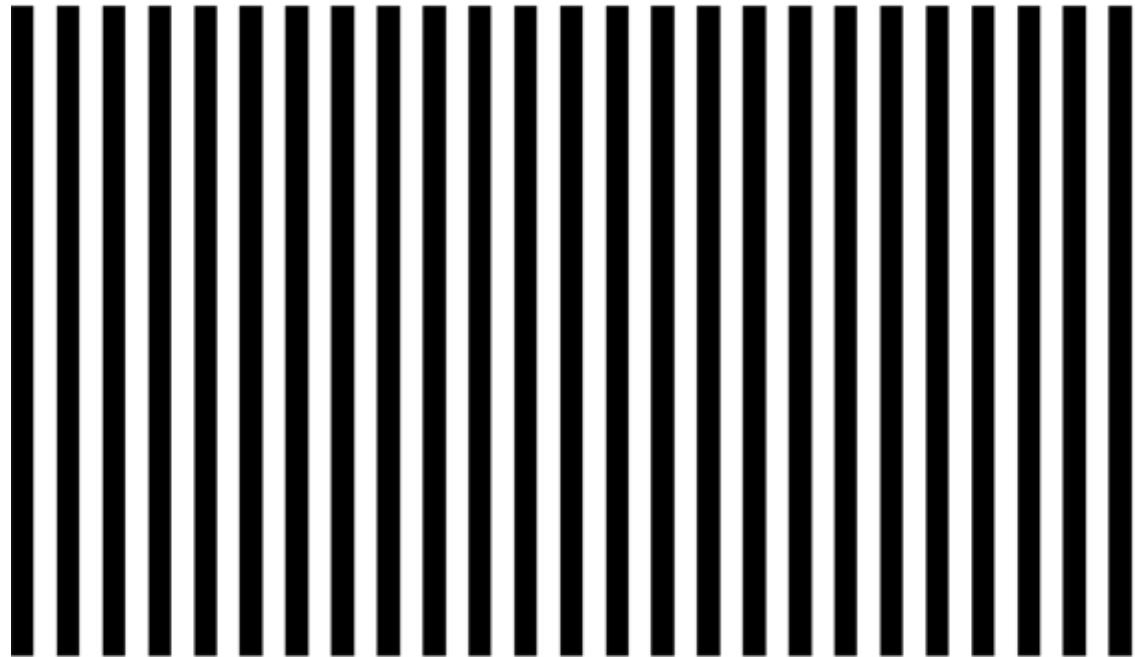
We have axon collaterals from retina sending signals to areas other than the occipital cortex which communicate with kinesthetic, proprioceptive, tactile and vestibular systems.

# Relative Size and Shape/Size Constancies

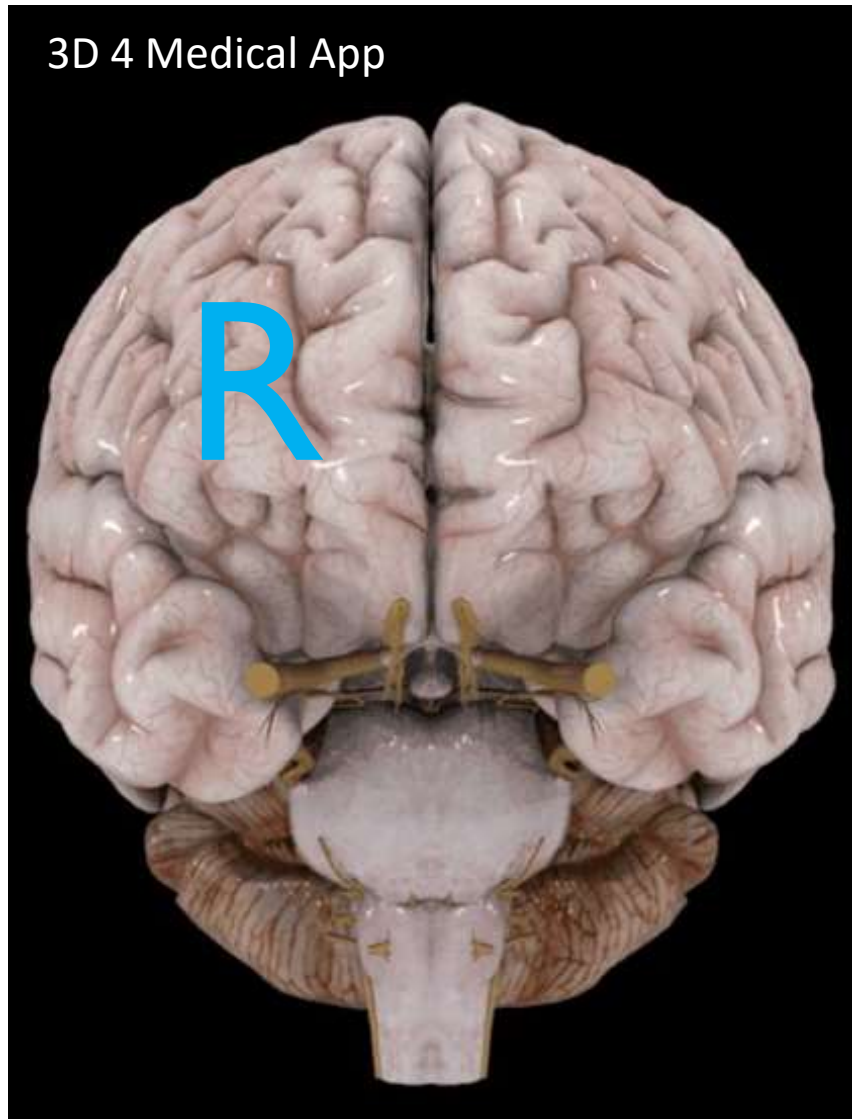
3D 4 Medical App



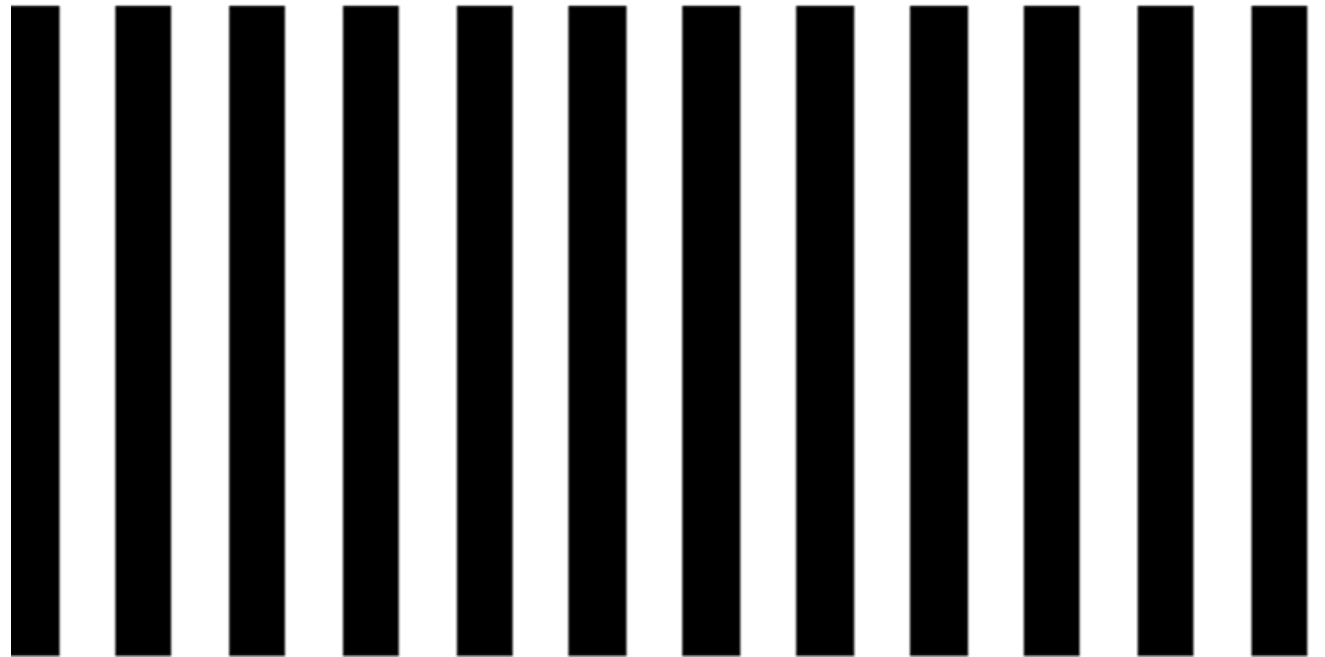
The left parietal cortex is more sensitive to higher spatial frequencies or smaller objects.



# Relative Size and Shape/Size Constancies

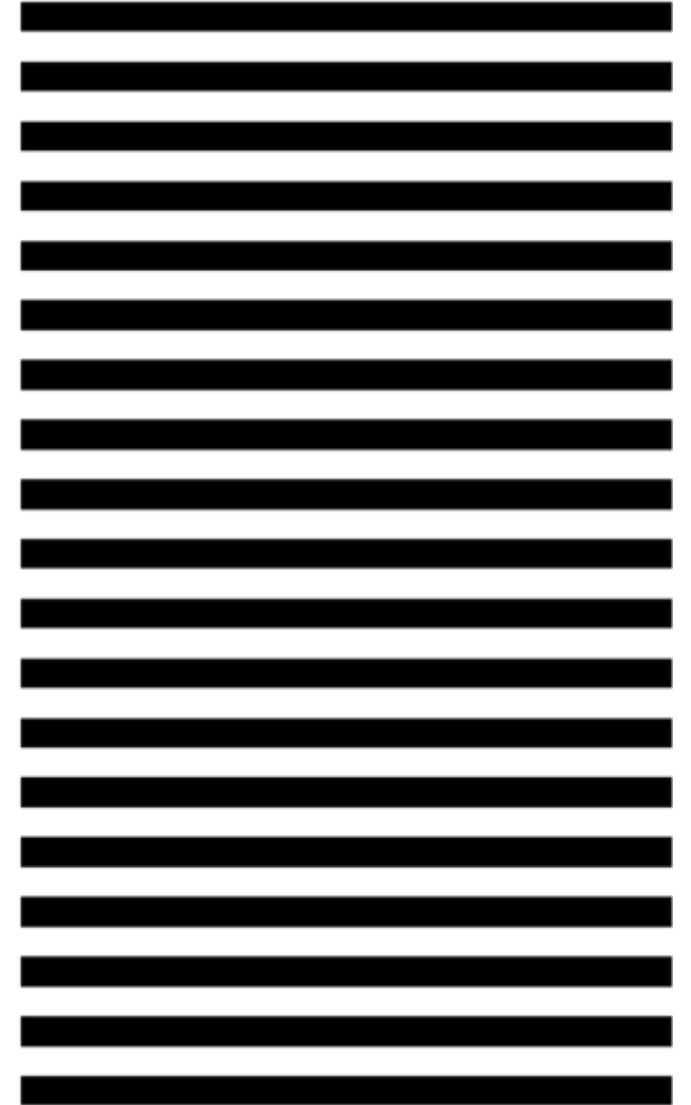
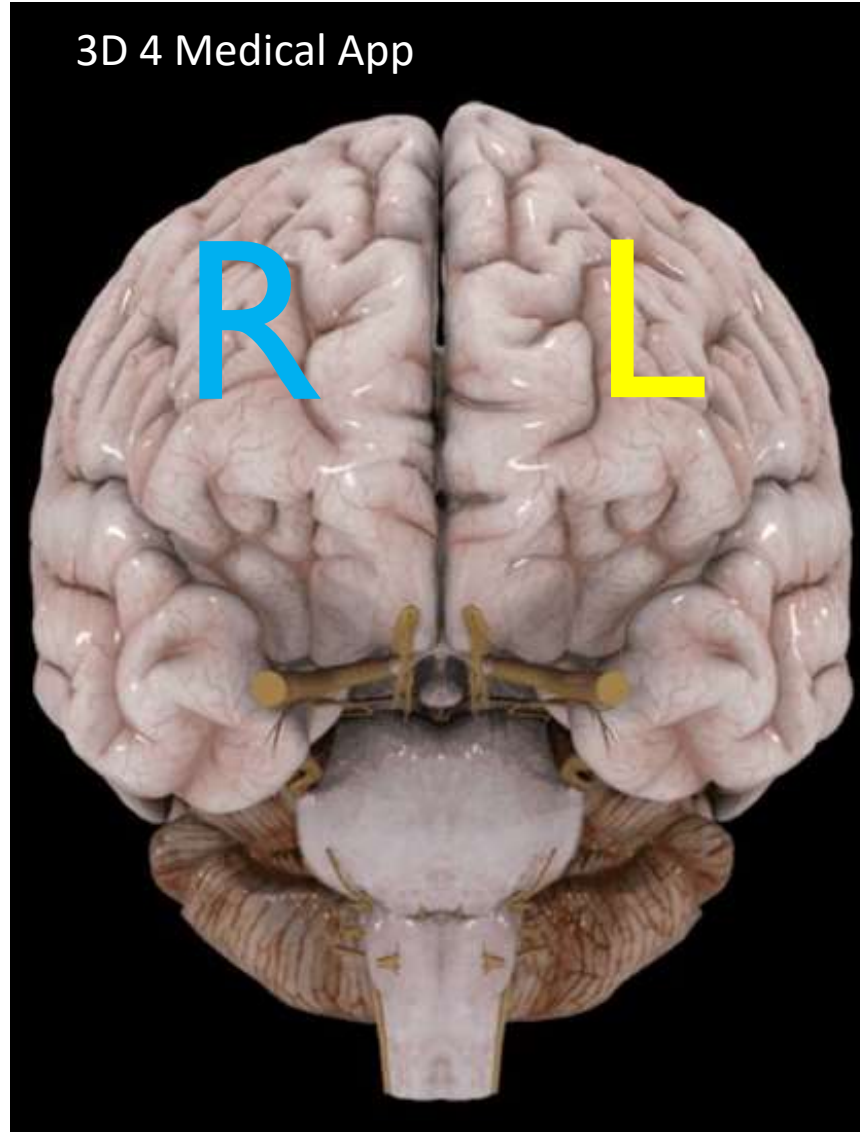
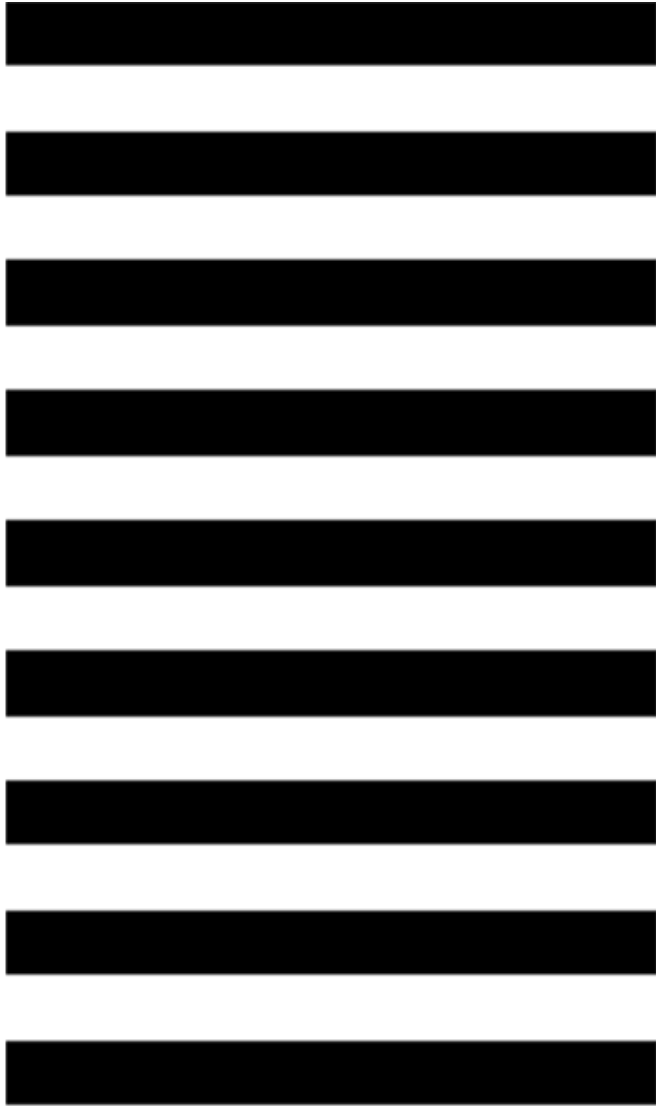


The right parietal cortex is more sensitive to lower spatial frequencies or larger objects.





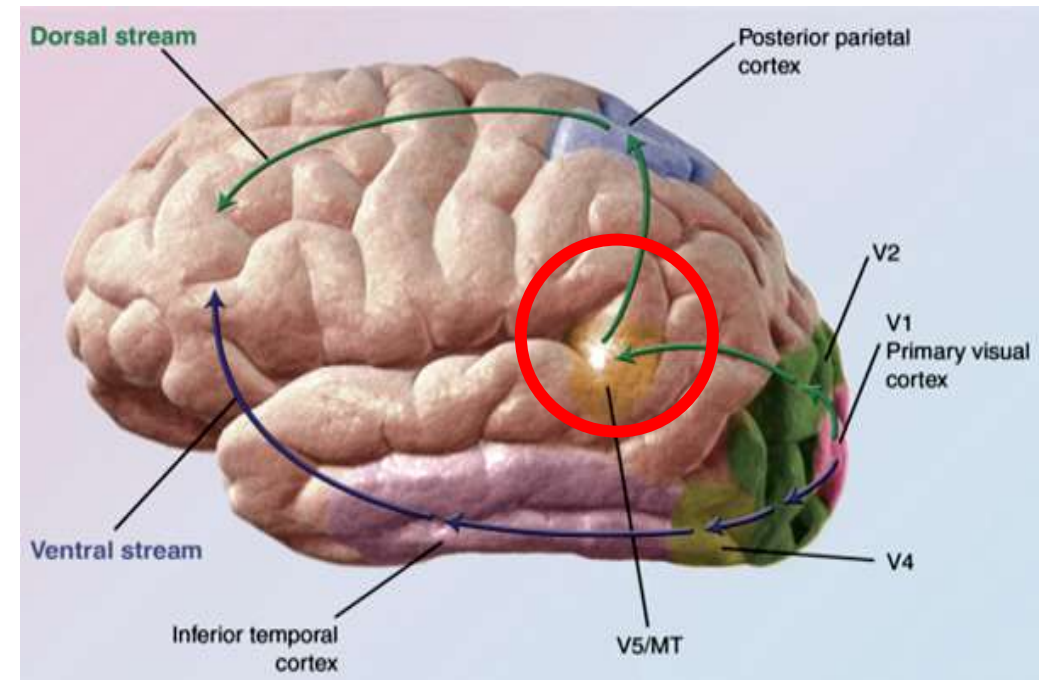
# Relative Size and Shape/Size Constancies



# Relative Size and Shape/Size Constancies

The brain is very active with inhibition and establishes a balance in perception and movement.

Berthoz: about 50% of the activity in the brain is active inhibition.



# TBI

Brain injury interferes with the brain's ability to function properly.





Spatial Map: The maps are discorded.

Shape/Size Constancy: unable to filter out the inaccuracies so there appears to be an irregular compression and expansion in the spatial maps.

Relative Size: The interpretation of these irregular compressions and expansions of closer and farther are viewed in a different way than they were used to seeing and the world looks different..



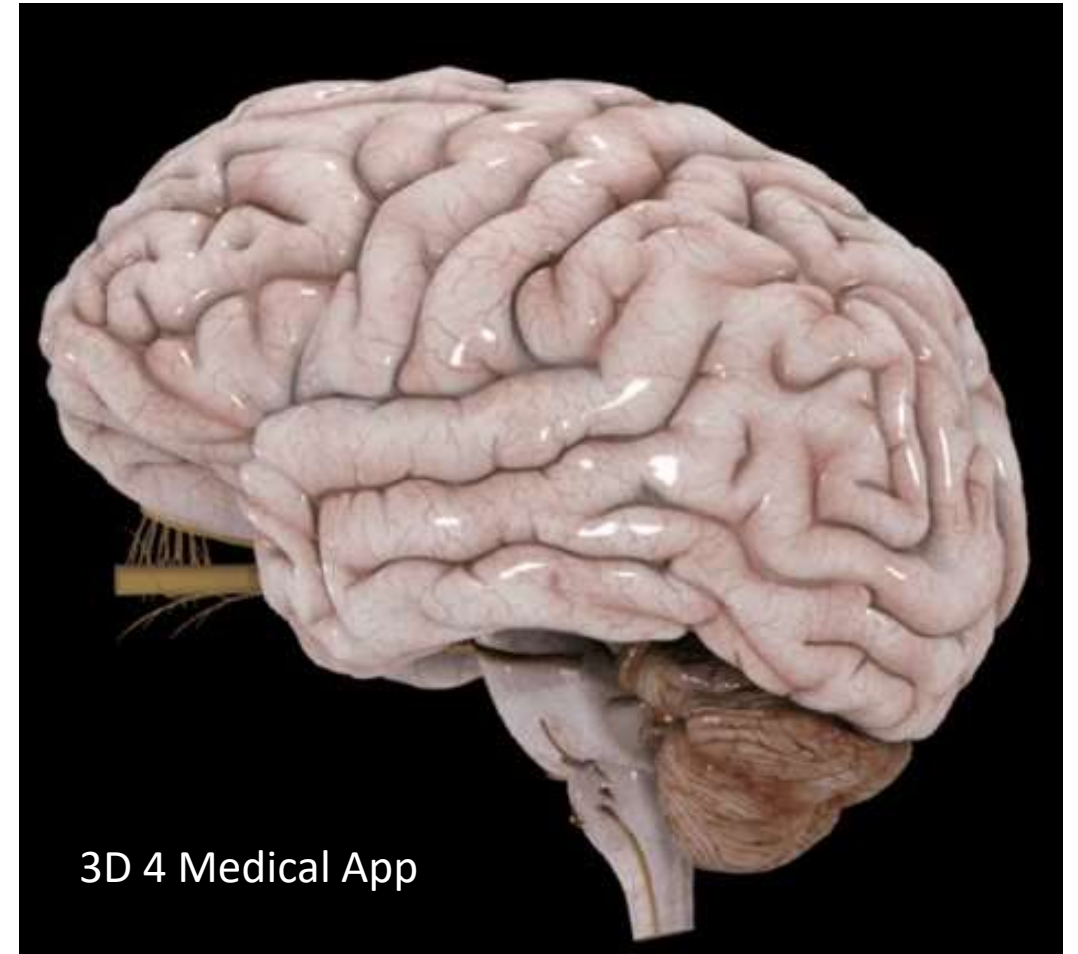


“Damage to the frontal lobe cause an apparent displacement of the vertical to the side of a lesion.”

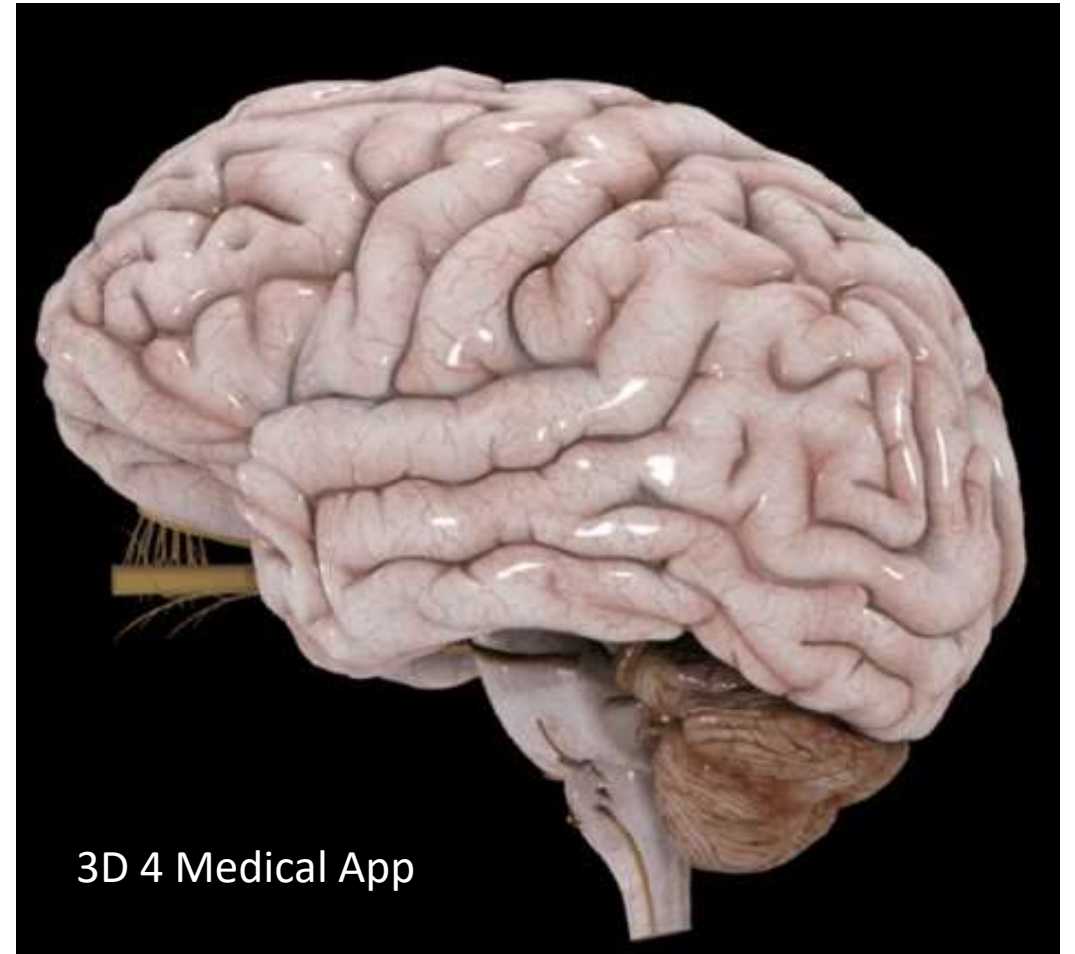
*Bender and Young 1948*

“Damage to the cerebellum on one side has been found to cause vertical lines, houses, trees, etc. to appear to tilt in the same direction.”

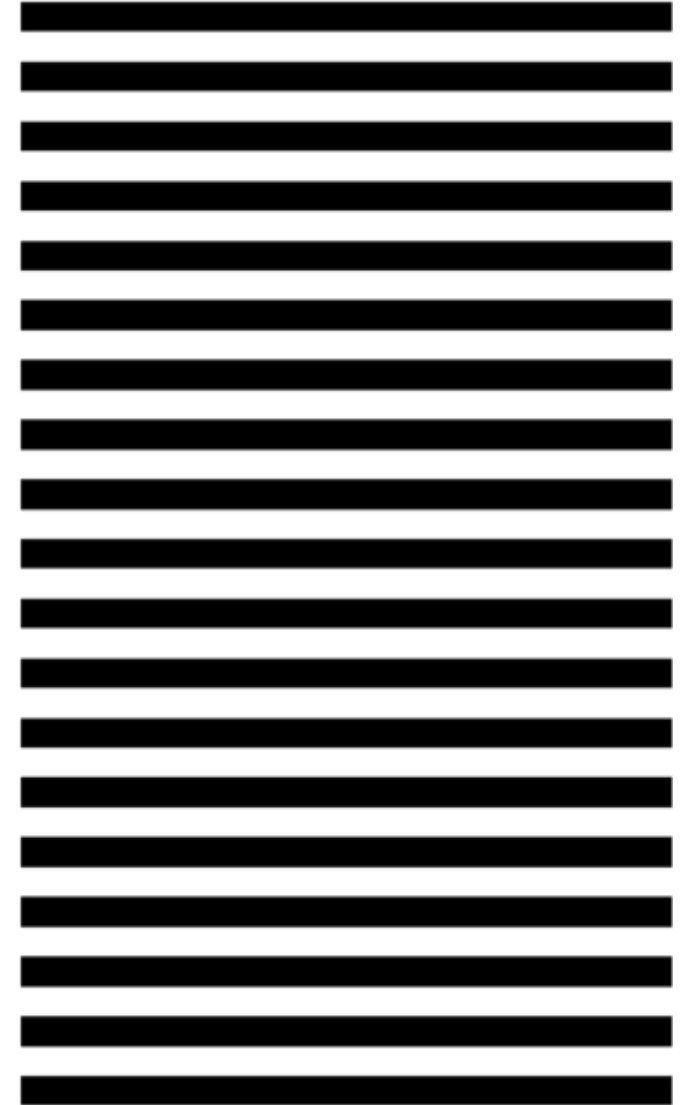
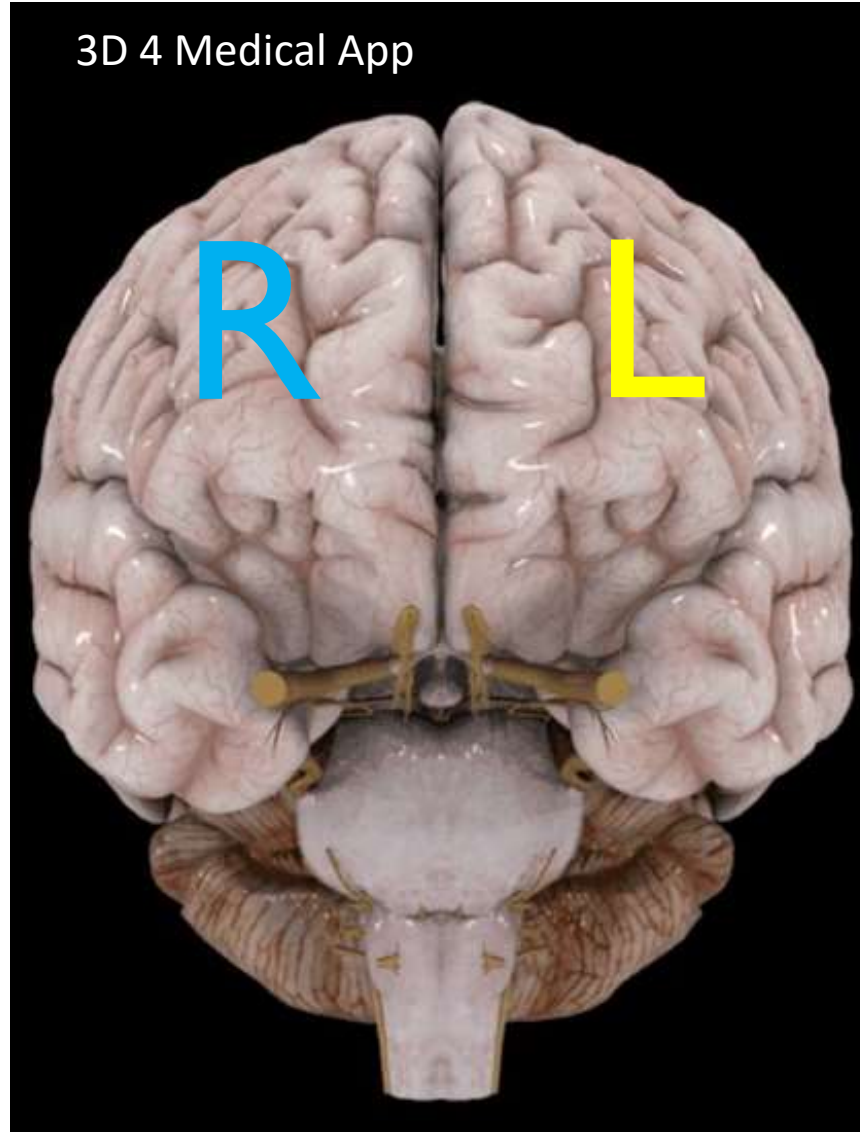
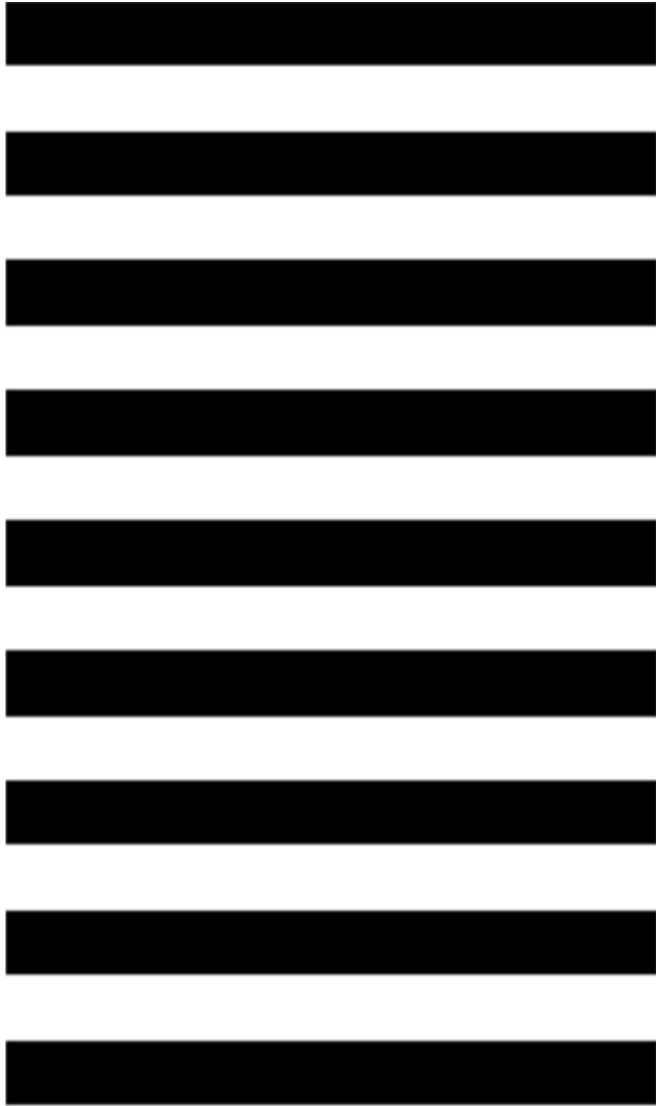
*Halpern 1949*



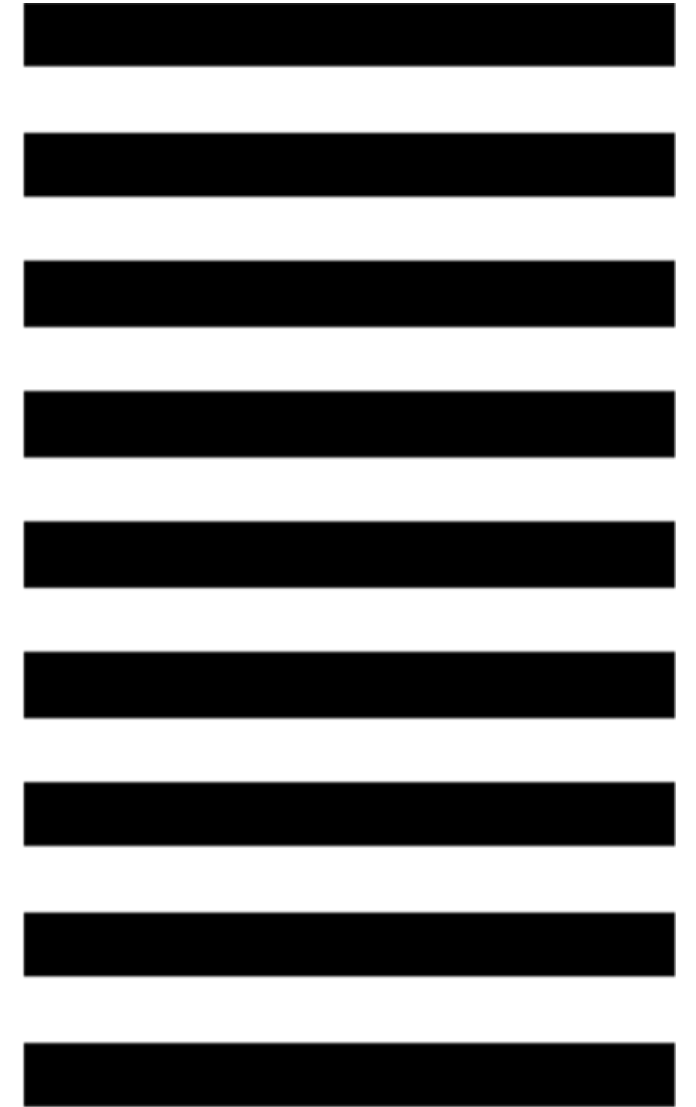
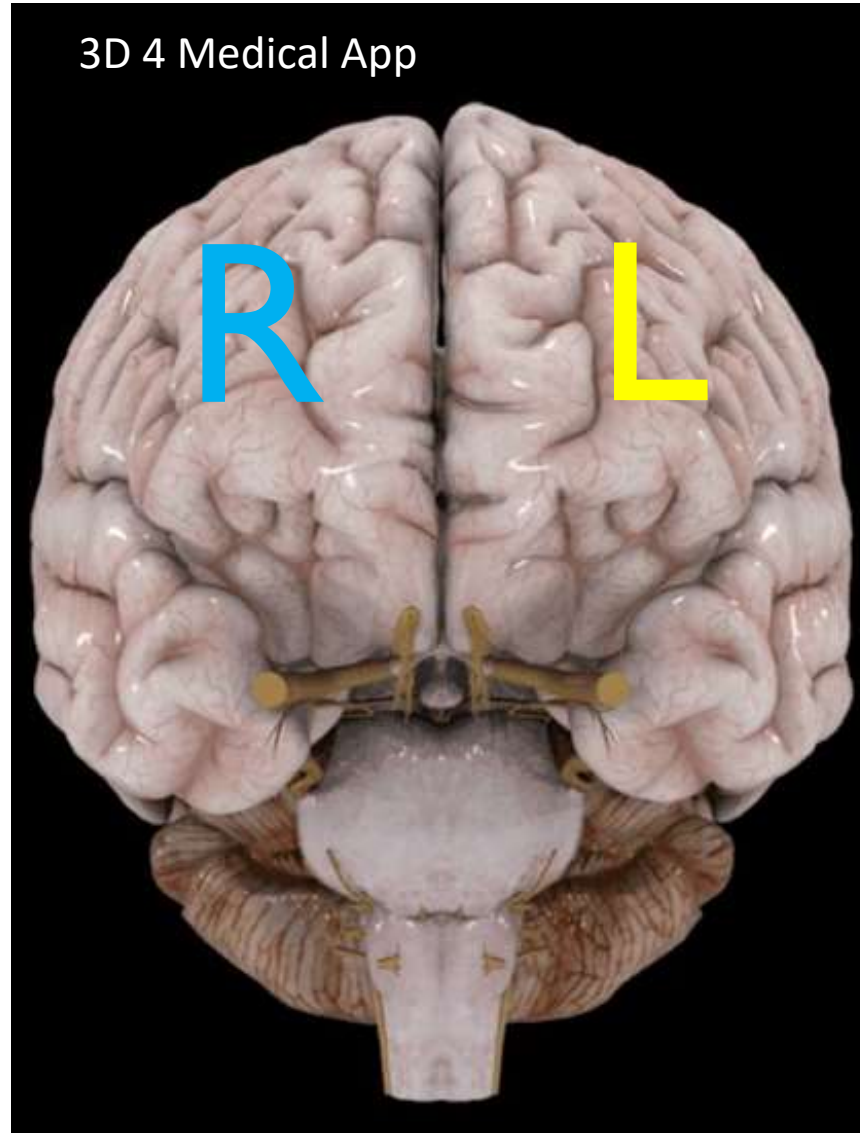
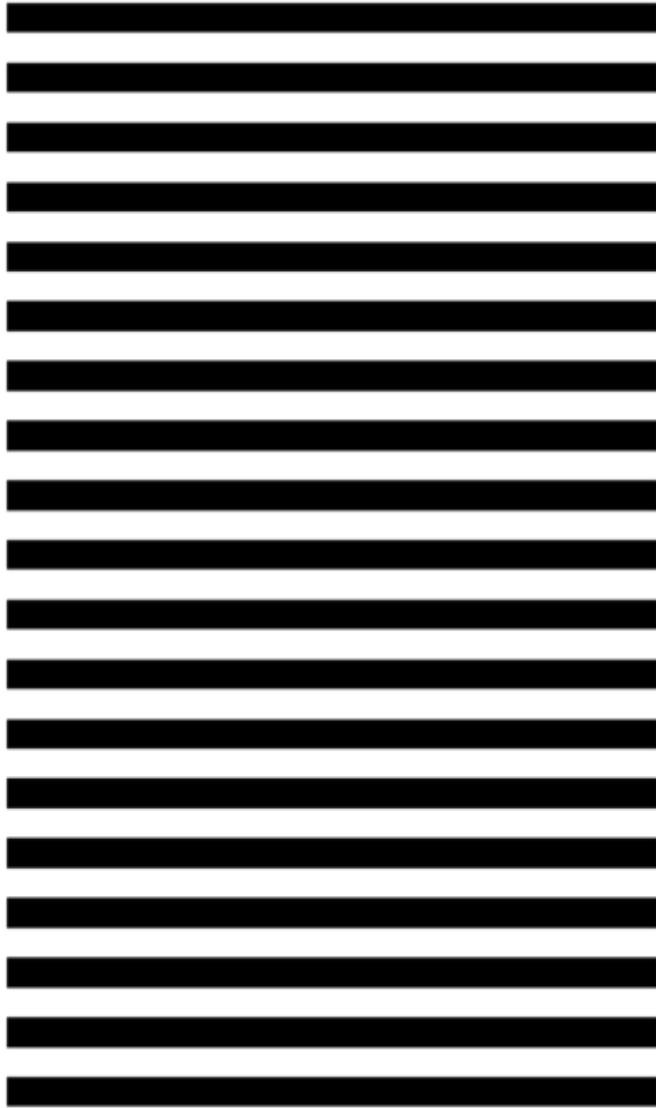
**“Damage to the occipital lobe did not result in a disturbance of the apparent vertical, even when such damage was accompanied by hemianopia.”**



# Relative Size and Shape/Size Constancies

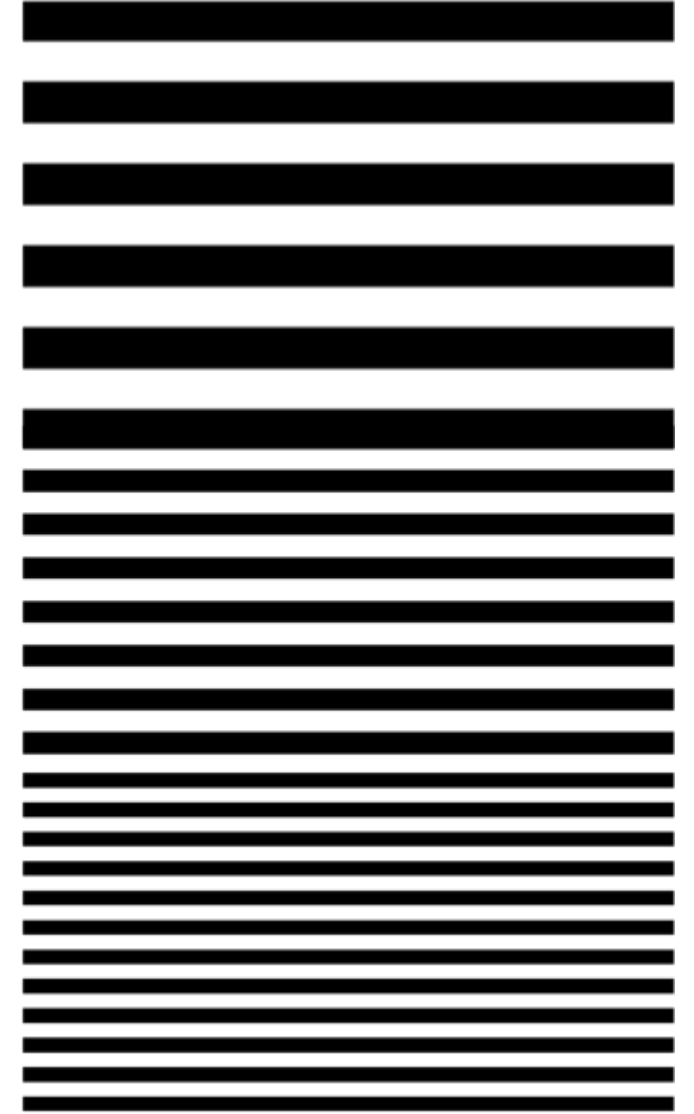
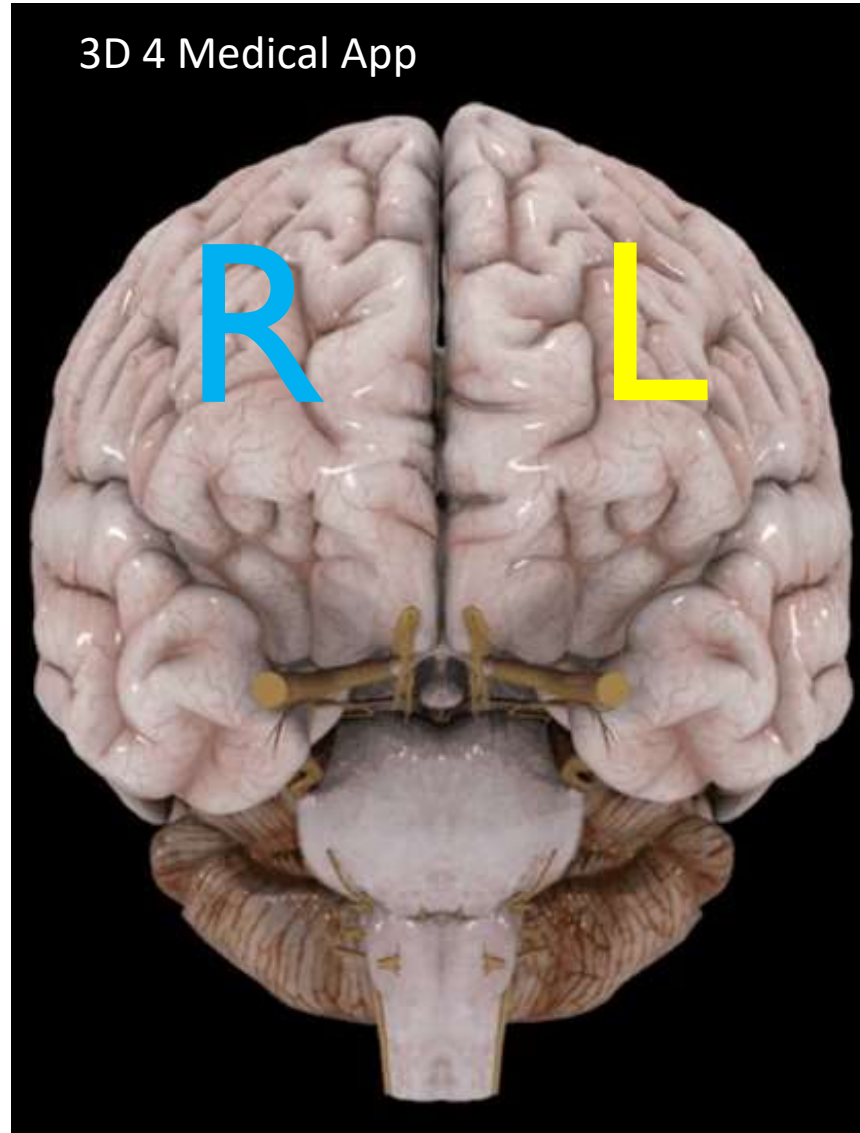
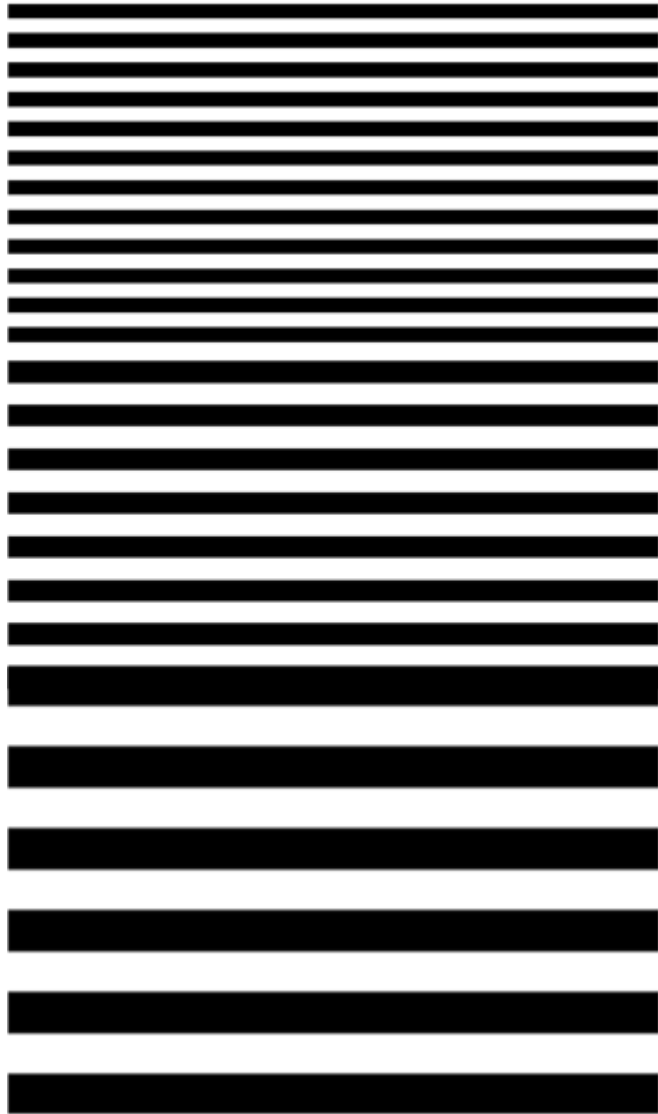


# Relative Size and Shape/Size Constancies

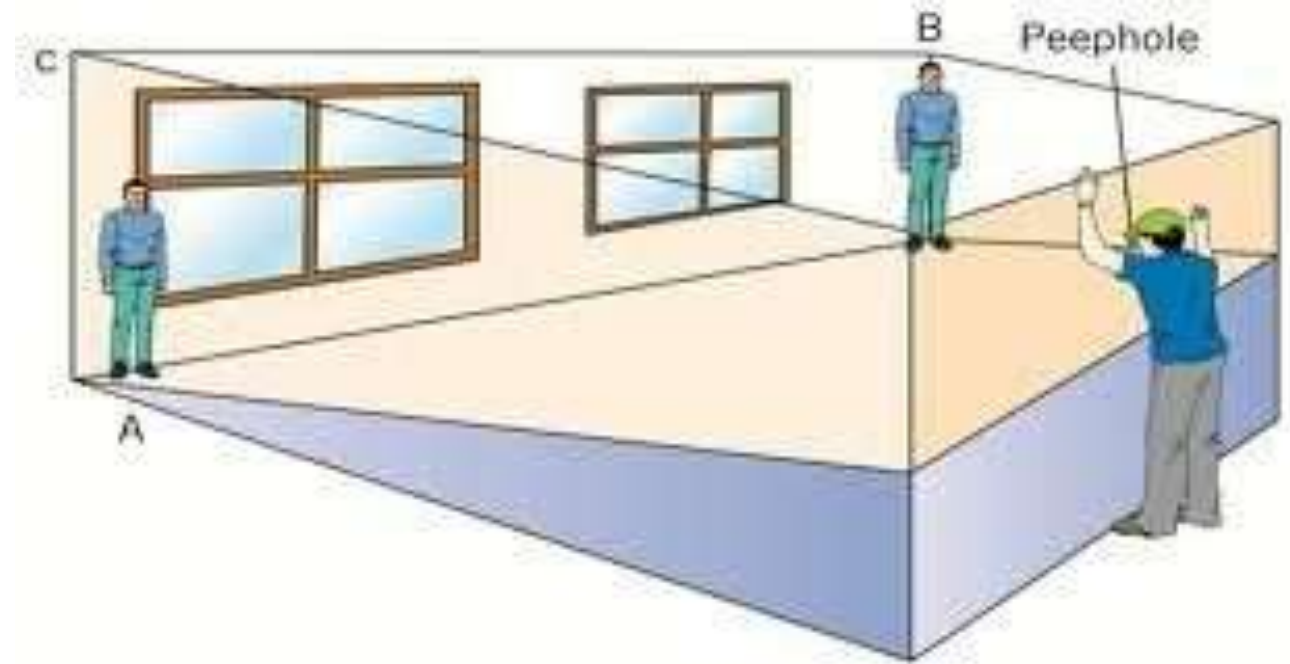




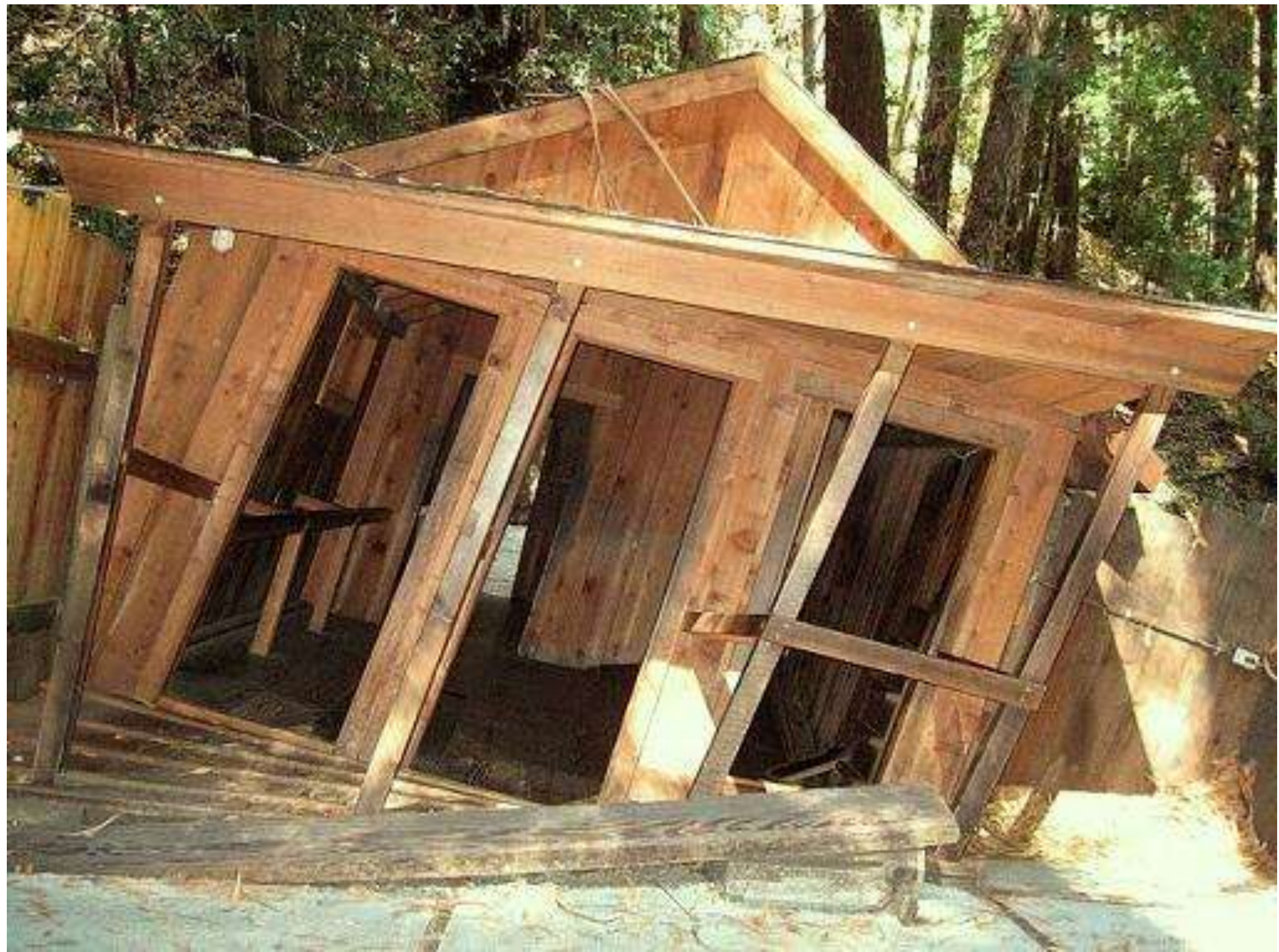
# Relative Size and Shape/Size Constancies



Their perception resembles an Ames Room.







# Vision Therapy

# Vision Rehabilitation

The application of prisms



# Spatial Transformation Properties of Prism

# Spatial Transformation Properties of Prism

The prism produces a linear asymmetric compression and expansion of real object space.

The perception of this illusion is that parts of the real object will appear closer and other parts farther away.

The prism also shifts the real object image and rotates it around the X, Y and Z axis planes.

# Spatial Transformation Properties of Prism

The prism adaptation paradigm evokes in the perceptual-motor system both ordinary and extraordinary capacities.

**Ordinary Capacity:** Rapid adaptive performance in the face of normal imprecision in perceptual and motor processes.

# Spatial Transformation Properties of Prism

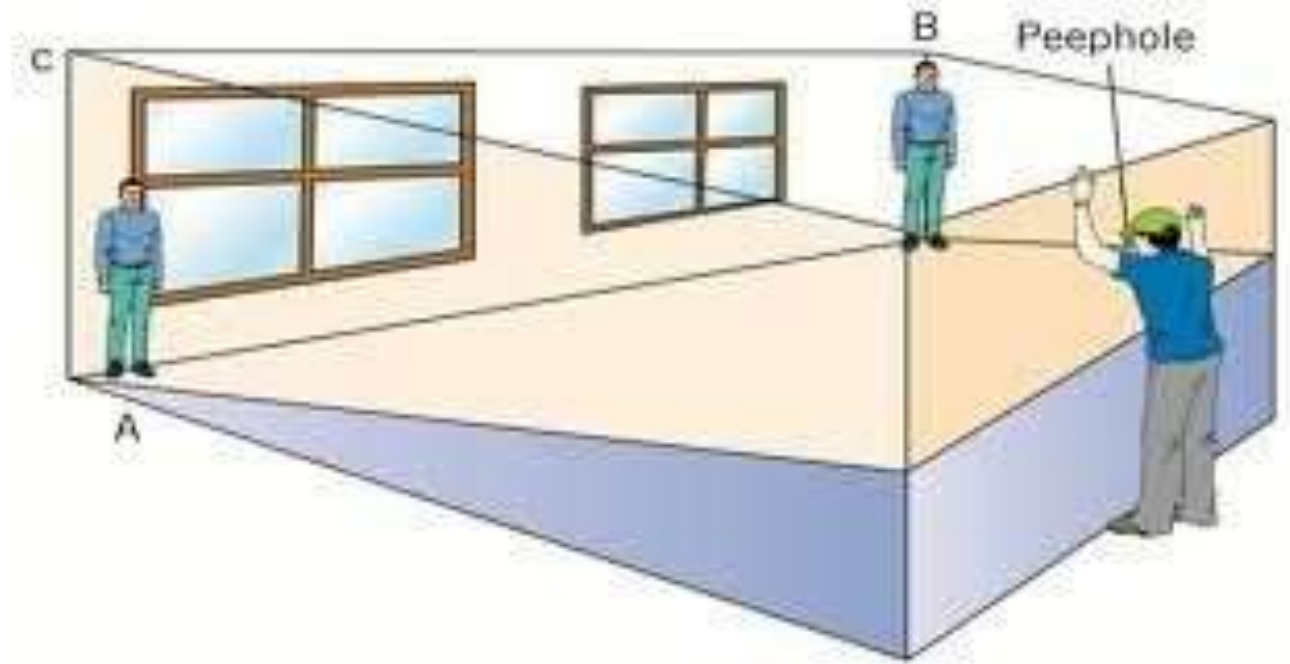
## **Extraordinary Capacity**

The gradual adaptive adjustment in the spatial mapping functions that enable spatial alignment among internal representations.



**Prism:** Any amount of prism will have the same basic properties.

Depending on the base orientation



**Floors Tilt:** up hill; down hill; up left and up right.

**Walls Tilt:** top closer; top farther; right side closer; right side farther.

# Vision Therapy / Vision Rehabilitation



OU: Pl Sph +1.75 add  
1D BD

One month

Reduced hip pain

Reduced trigeminal pain in  
her front teeth – has no  
nerves in her front teeth

Reduced headaches and  
tension in the neck

Improvement in thinking and  
information processing

Currently in VT

# Vision Therapy / Vision Rehabilitation



Improved gait and balance

Less dizziness

Has returned to work

Not in VT

OU +0.75 -0.75 x 180  
+2.75 add

(0.5 BR prism VT only)

# Spatial Transformation Properties of Prism

Prism transformed the real object visual environment in which the person lives.

The newer illusion of the external object environment map was now more aligned with the internal body spatial map.

This brings the person into better harmony with their world.



*That's all Folks!*

