



RV - AULA 03 - PSI3502/2018

Human Senses

Outline



Examine the behaviour and physiology of the most important of human senses.

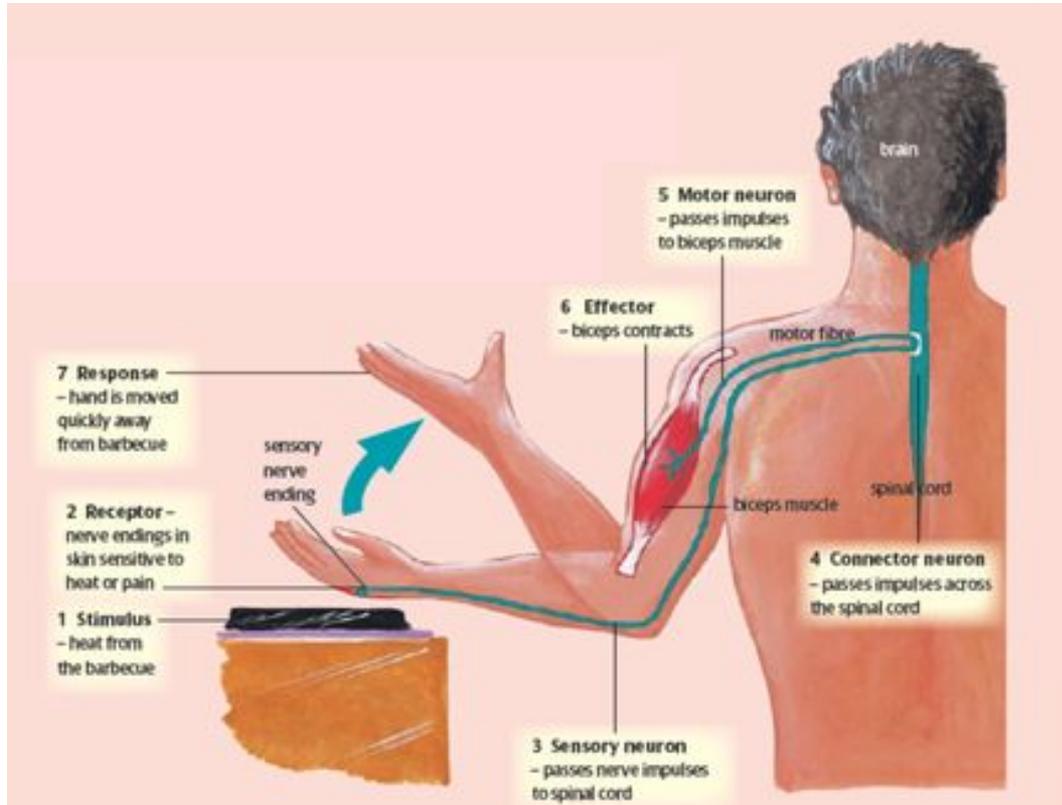
Talk about the human visual system.

Examine the human sense of hearing.

Examine the vestibular apparatus and its interplay with the human visual system.

Talk about haptic sense and sense of proprioception.

Human Senses



Purpose of senses



The human body is equipped with a large variety of senses.

The set of sensory systems present in the human body is a direct result of our evolution as a species.

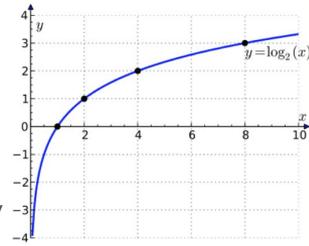
Hierarchy: VR systems follow it.

Senses, stimuli and sensation

Each sensory system responds to a particular physical phenomenon.

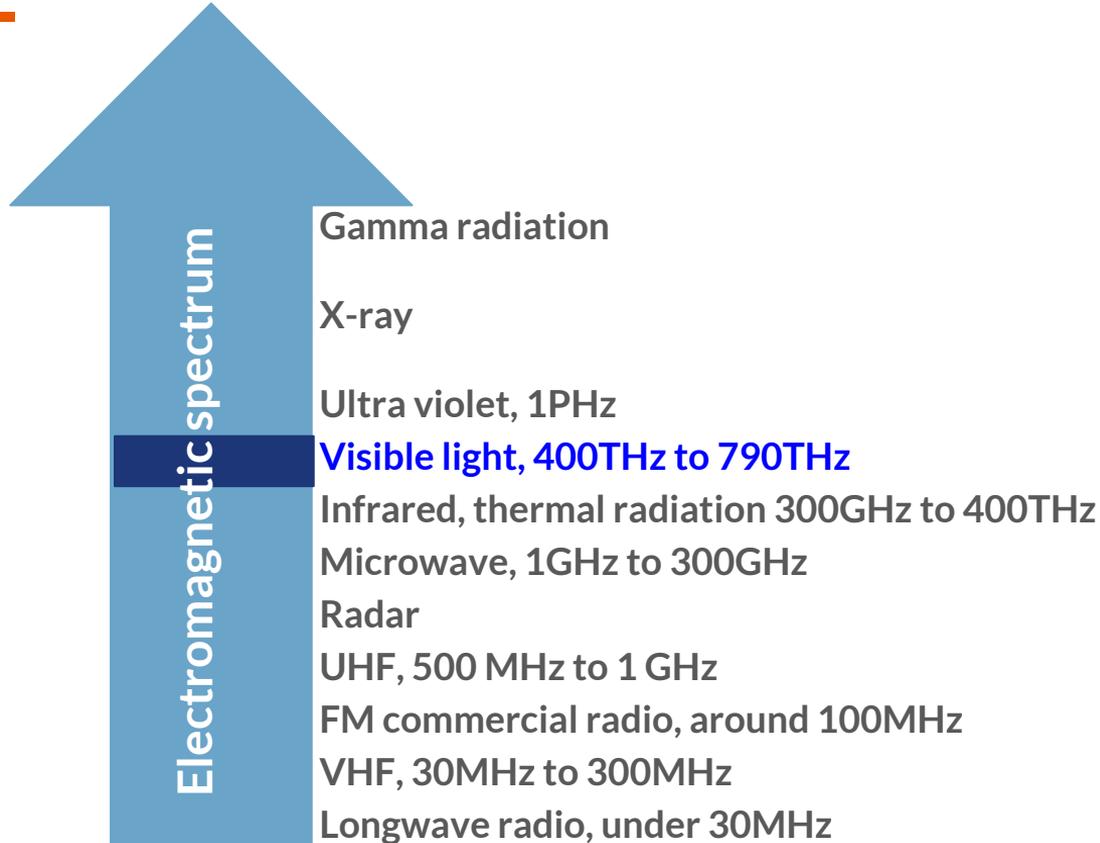
Stimuli gathered by receptors are transferred to the brain, where they generate **sensations**.

According to *Fechner's Law* the sensation generated by stimulus is proportional to the logarithm of its intensity



The perception is the result of a meaningful interpretation of sensations generated in the brain.

Senses, stimuli and sensation



Senses, stimuli and sensation

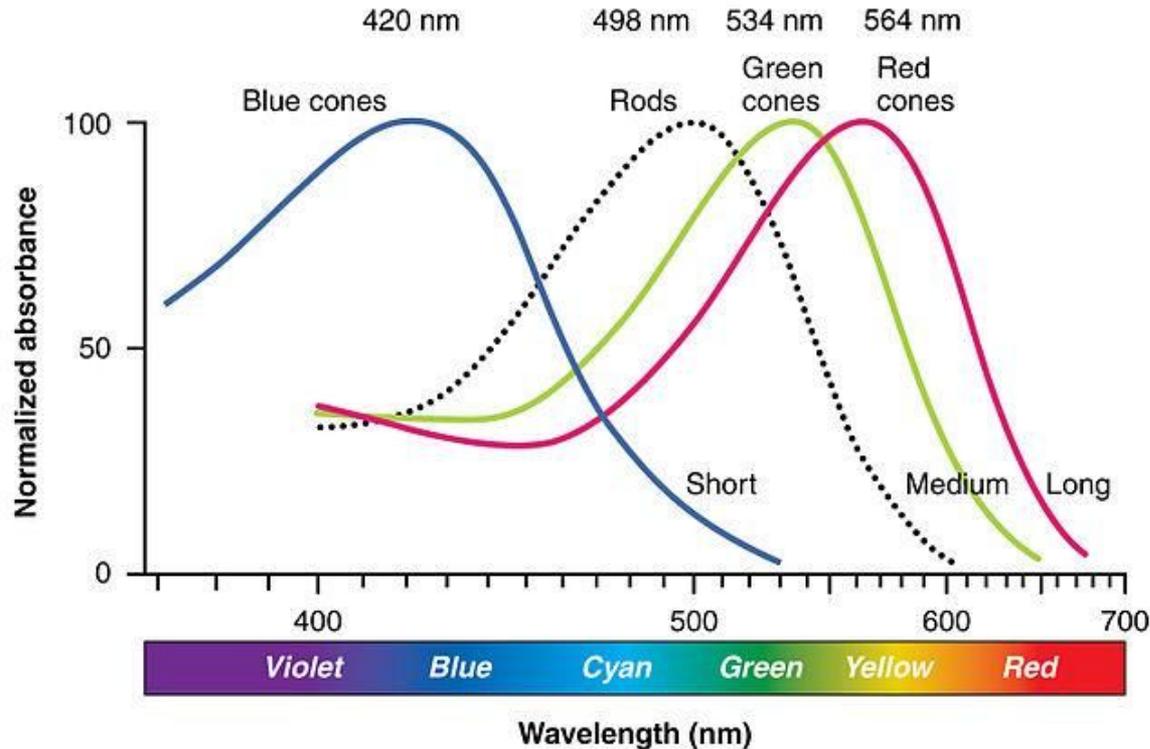
Each type of stimuli is registered by a particular type of reception, or a specialized sensory organ, which respond only to signals within a certain sensitivity range.

The smallest detectable difference between two levels of particular stimuli is known as **just-noticeable difference**.

Just-noticeable difference is proportional to the magnitude of the stimuli, as described by the so-called *Weber's Law*.

Stimulus masking.

Visual sense - a physical phenomenon



<https://ixora.io/projects/colorblindness/color-blindness-simulation-research/>

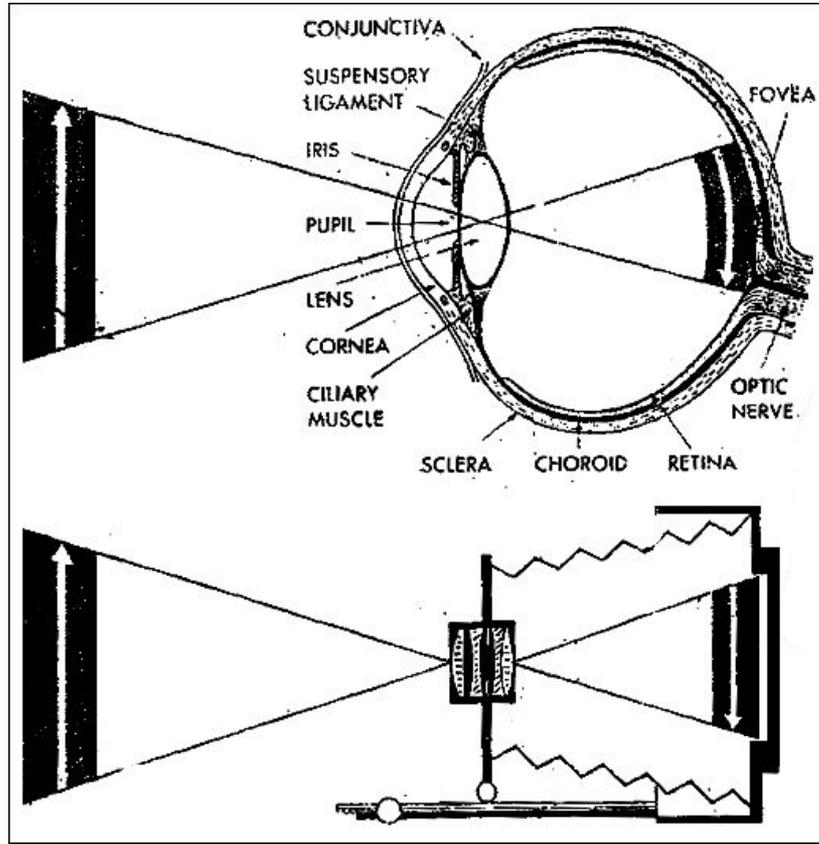
Visual sense - a physical phenomenon



Visible light: electromagnetic spectrum that is within the sensitivity range of human eyes, with wavelengths of 380 *nm* to 750 *nm*.

The human visual system is able to observe **two** properties of light: its **intensity** and **approximate wavelength**.

Visual sense - physiology



Perception of color



The human visual system has two distinct types of receptor rods.

The human retina contains around 12 million rods and only about 5 million cone cells.

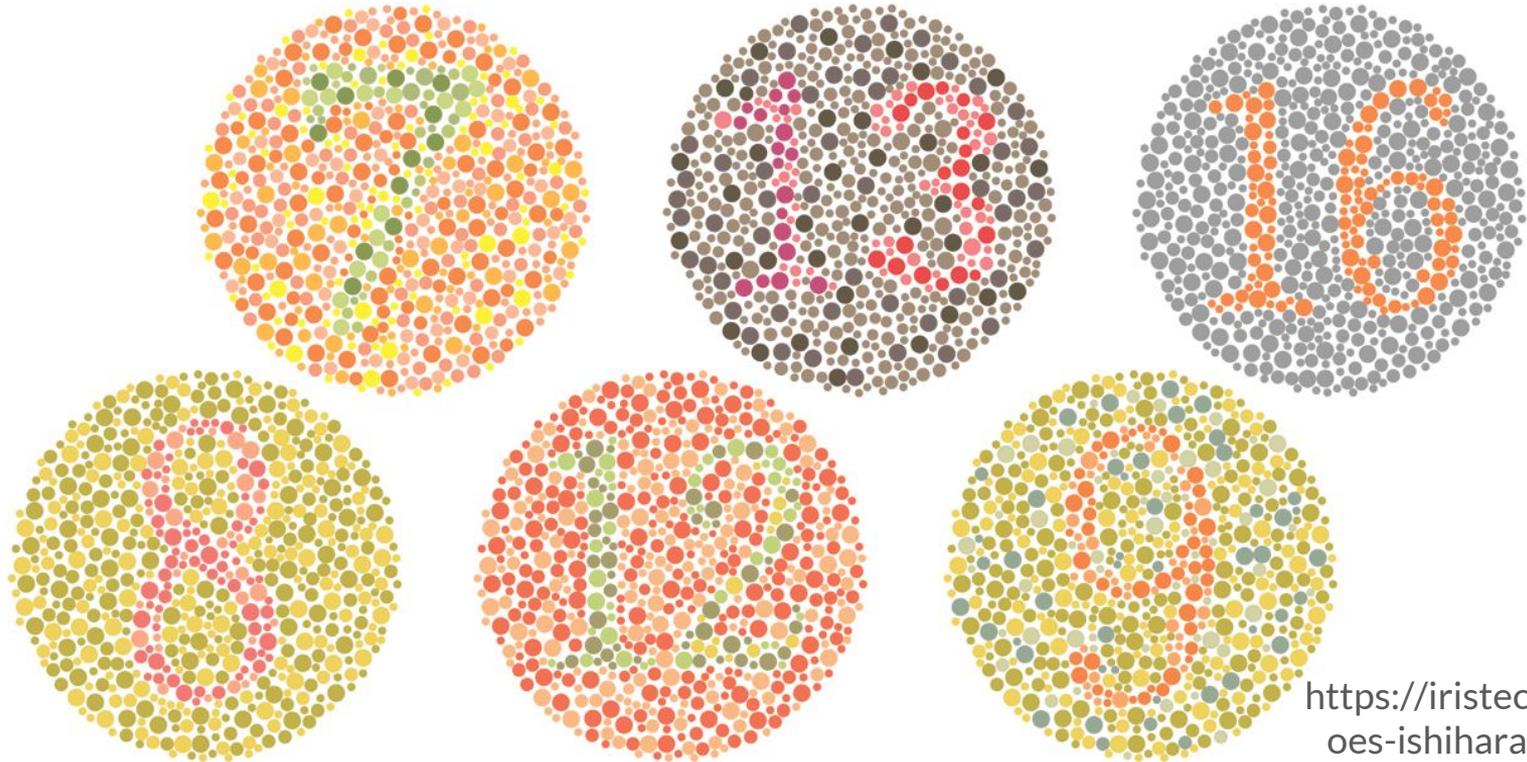
Three subtypes of cone cells corresponding to the three different wavelengths of light: *trichromatic color perception*.

Different combinations of frequencies can be interpreted as the same color: *color consistency*.

Color blindness: monochromacy and dichromacy.

Perception of color

Ishihara dot
pattern color
blindness test



<https://iristech.co/how-does-ishihara-test-work/>

Depth perception



The human visual system relies on two large groups of cues in order to extract information about the depth of a scene in three-dimensional spaces.

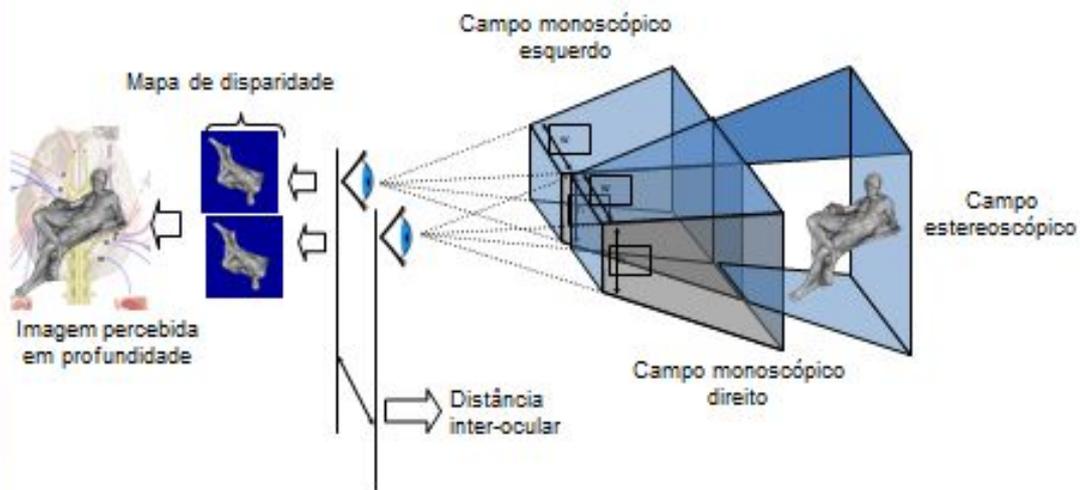
The first group is known as *binocular cues* and it includes *stereopsis* and *convergence*.

Depth perception

VISÃO ESTEREOSCÓPICA

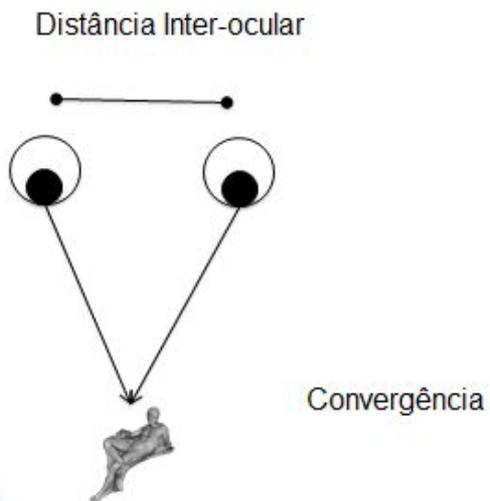
PERCEÇÃO HUMANA

- Fisiologicamente, o olho funciona como uma câmera.
- Psicologicamente, no entanto, a visão e a percepção são muito mais complexas.

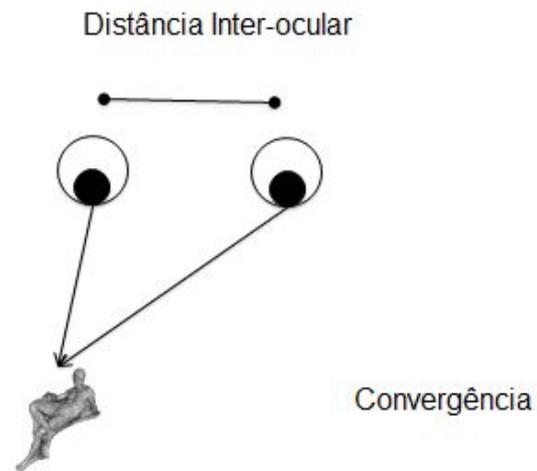


Depth perception

CONVERGÊNCIA

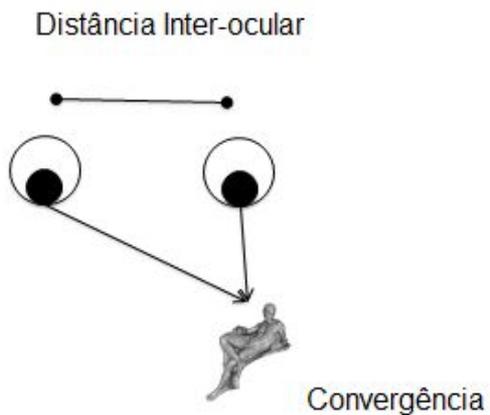


CONVERGÊNCIA

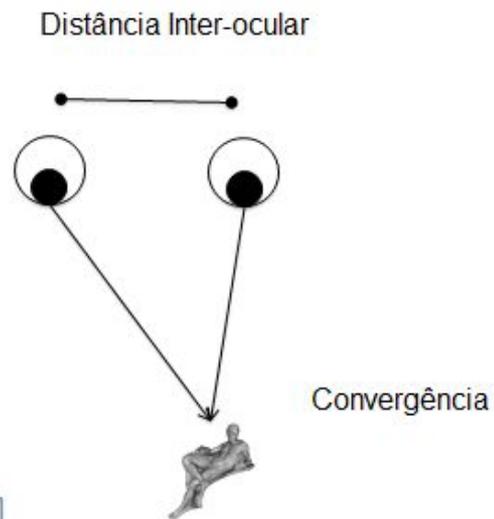


Depth perception

CONVERGÊNCIA



CONVERGÊNCIA



Depth perception



Monocular cues: relative size of objects

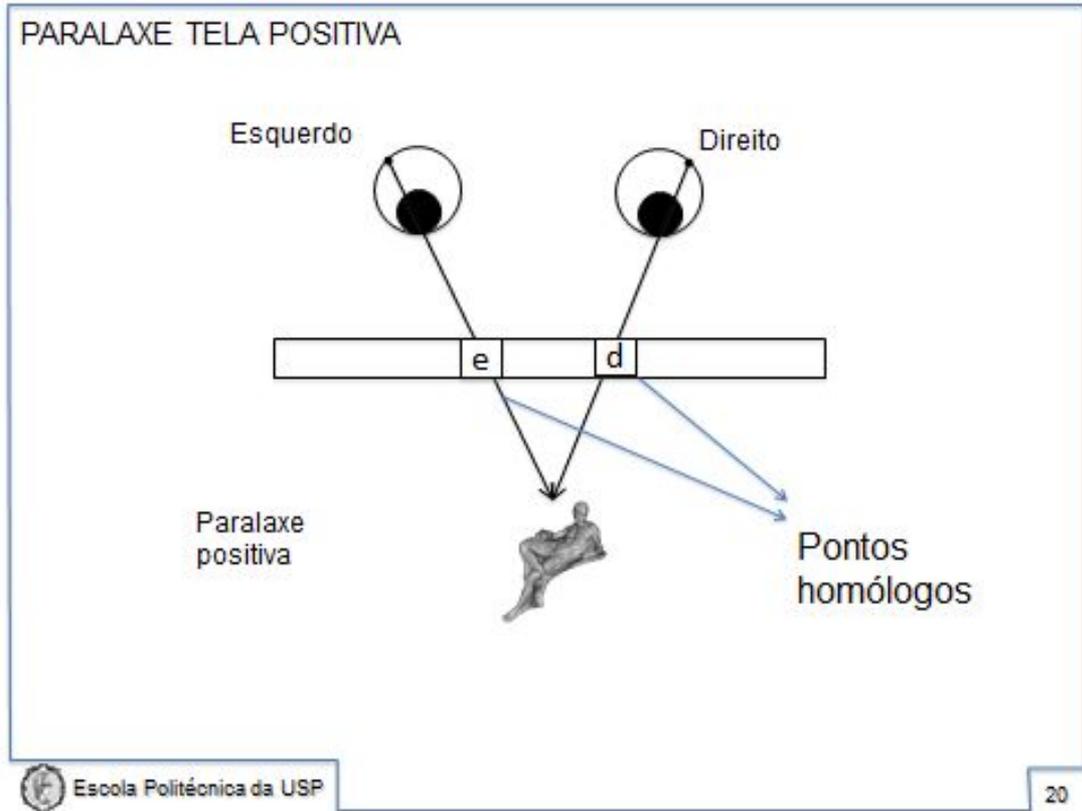
Perspective cues.

Texture gradient cues: shading and brightness.

Interposition.

Motion depth cues: parallax and optical expansion.

Depth perception

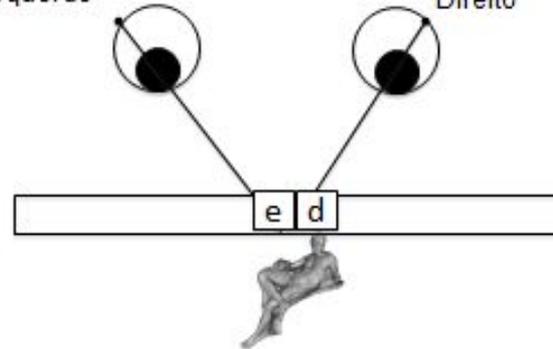


Depth perception

PARALAXE DE TELA ZERO

Esquerdo

Direito

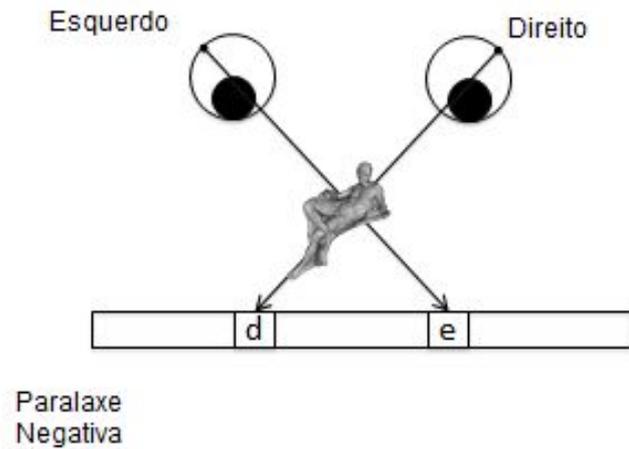


Paralaxe
Zero



Depth perception

PARALAX DE TELA NEGATIVA



Pattern recognition



The human brain tries to segment the image projected on the retina into areas of interest. There are several criteria, such as proximity, similarity in color, shading, texture or pattern, continuity, etc.

Since the brain relies on memory to interpret images, when it has several equally good candidates for the interpretation of a given image, and is unable to decide on a single one, it forms optical-illusions.

Pattern recognition

Pareidolia:



https://science.nasa.gov/science-news/science-at-nasa/2001/ast24may_1

Motion perception

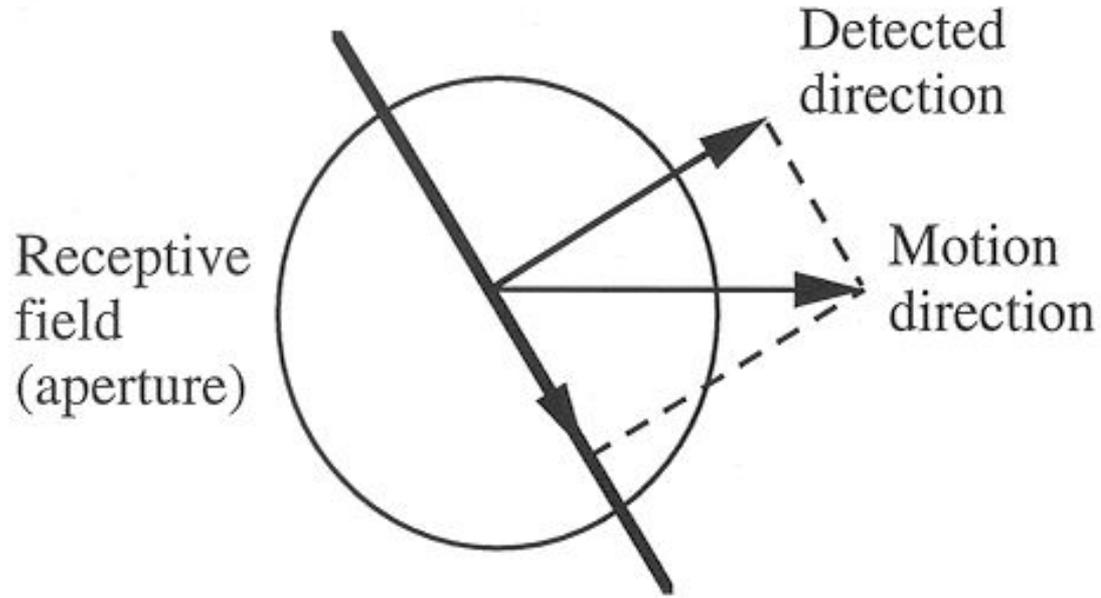


Motion perception is the ability to infer the direction and speed of motion of objects based on visual input.

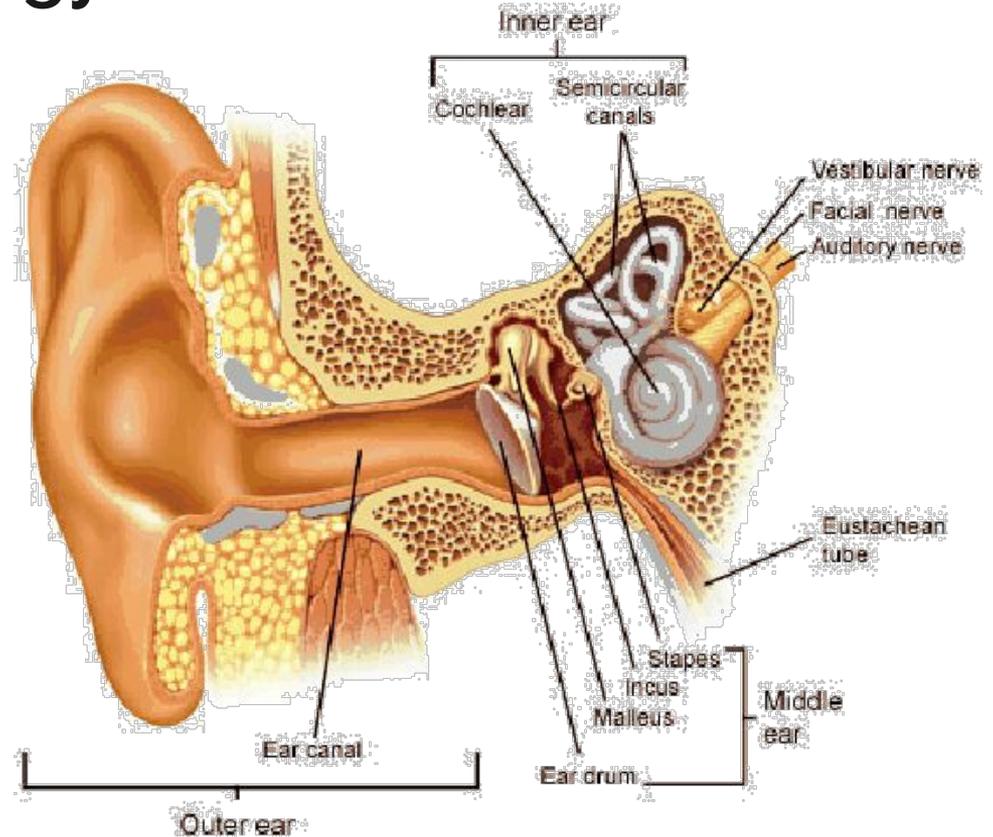
Hassestein-Reichardt detectors.

Aperture problem.

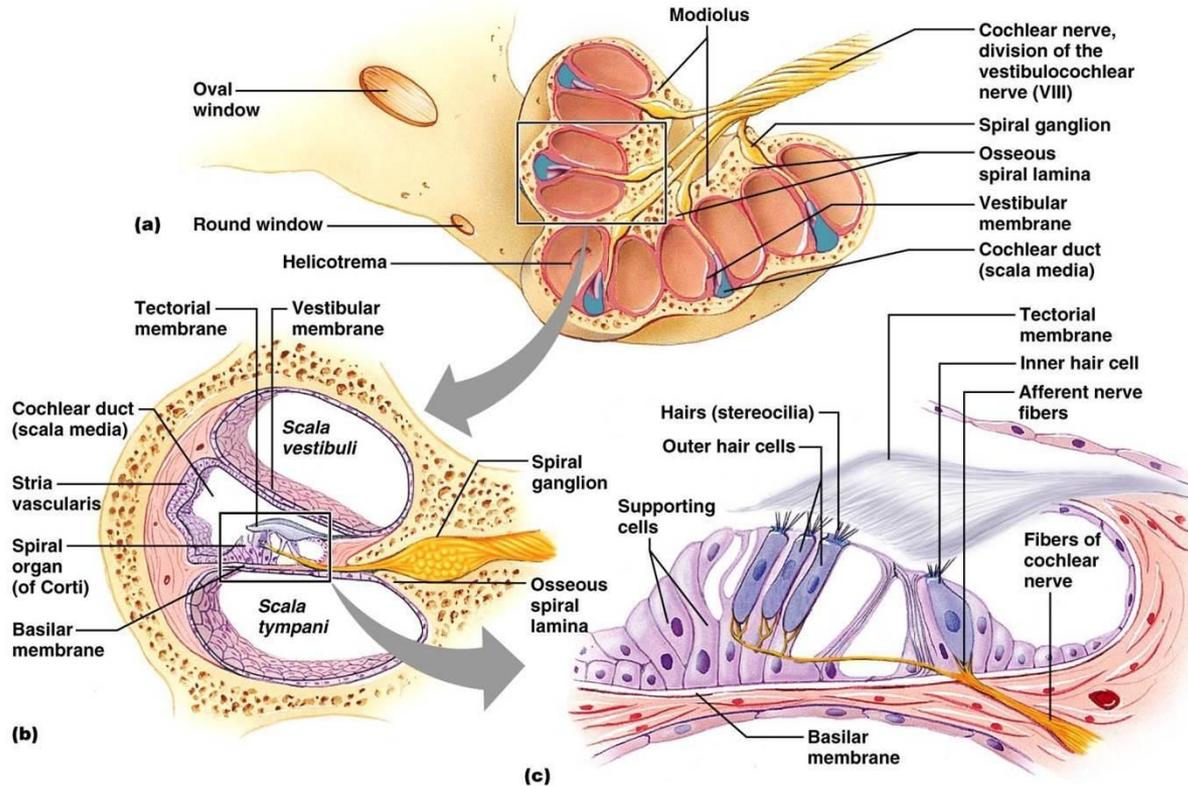
Motion perception



Audio sense-physiology



Audio sense-physiology



Audio-sense properties



The human auditory system is capable of detecting the signals within the frequency range of 20Hz to 20kHz . The peak sensitivity is in the range between 2 to 5 kHz .

The loudness or perceived volume of the sound is a subjective psychoacoustic property of the sound. It depends on the sound pressure level and frequency of the sound.

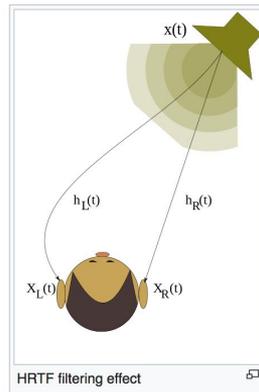
Auditory masking.

Sensing the direction of the sound

Better precision in the horizontal plane.

To determine the direction, the human brain relies on three sources:

- 1) Amplitude difference between left and right ear;
- 2) Time difference between ears;
- 3) Head-related transfer function (HRTF).



Haptic Sense



The sense of touch consists of multiple types of receptors situated in the human skin, including *mechanoreceptors*, *thermoreceptors* and *nociceptors*.

At least four major types of *mechanoreceptors*: *Meissner's corpuscles*, *Merkel's discs*, *Ruffini's endings* and *Pacinian corpuscles*.

Two classes of *thermoreceptors*, corresponding to the increase or decrease of temperature.

Sense of proprioception (propriocepção)

Also known as *kinesthesia* or muscle sense, is a sense of orientation and position of various body parts, above all limbs, in reference to each other.

It is a key part of so-called *muscle memory* and *hand-eye coordination*.

The sensory system responsible for proprioception relies on two major sources of information: the vestibular system and specialized receptors in joints and muscle tissue.

Sense of proprioception

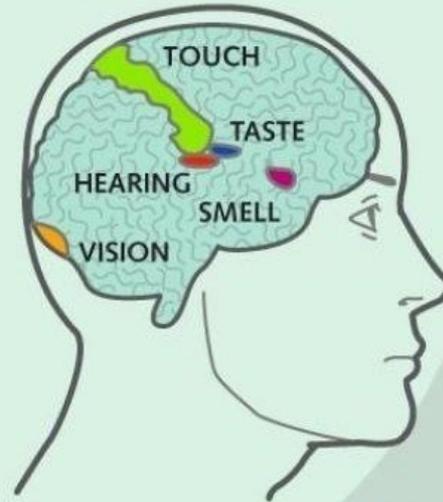


Responsible for the perception of the so-called passive force feedback of the input device.

Haptic and sense of proprioception are very decentralized, with a multitude of sensory organs dispersed throughout the human body.

Synesthesia

THE SCIENCE BEHIND SYNESTHESIA



The perception of our different senses is created and stored in separate areas of the brain.



At birth, neural connections between these centers are not as separate and many of these pathways or connections overlap.



In normal development:

- By four months, overlapping neural connections are pruned out.
- The vision center is separated from the hearing.



Some **failure** in this process is believed to be the cause of synesthesia.



In synesthesia, connections remain between **two or more** centers, especially those located close to each other, such as taste and hearing.



Neurologists and researchers have identified as many as **19** different forms of synesthesia, but many of them are quite rare. Some of the more common types are:



<http://www.meetthespearsons.com/blog/2015/10/what-in-the-world-is-synesthesia>



Referências

Virtual Reality and Virtual Environments in 10 Lectures - Stanislav Stankovic

E. H. Adelson, J. R. Bergen, “The plenoptic function and the elements of early vision”, in M. Landy and J. A. Movshon, (eds.), *Computation Models of Visual Processing*, MIT Press, Cambridge, 1991, pp. 3-20.

P. Kortum, *HCI Beyond the GUI: Design for Haptic, Speech, Olfactory, and Other Nontraditional Interfaces (Interactive Technologies)*, Morgan Kaufmann, First edition, May 9, 2008.

W. Richards “Stereopsis and Stereoblindness”, *Experimental Brain Research* 1970, Vol. 10, No. 4, 1970, pp. 380-388.

H. E. Ross, D. J. Murray, (Ed. and Transl.) *E. H. Weber on the Tactile Senses*, 2nd ed. Hove: Erlbaum (UK) Taylor & Francis.