



# Humans in HCI – An Introduction

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# Learning Goals

- Understanding how human cognitive and physical abilities and limitations define ergonomics in HCI

# Definition: Ergonomics

- the process of designing or arranging workplaces, products and systems so that they fit the people who use them.

<https://www.ergonomics.com.au/what-is-ergonomics/> Image Source

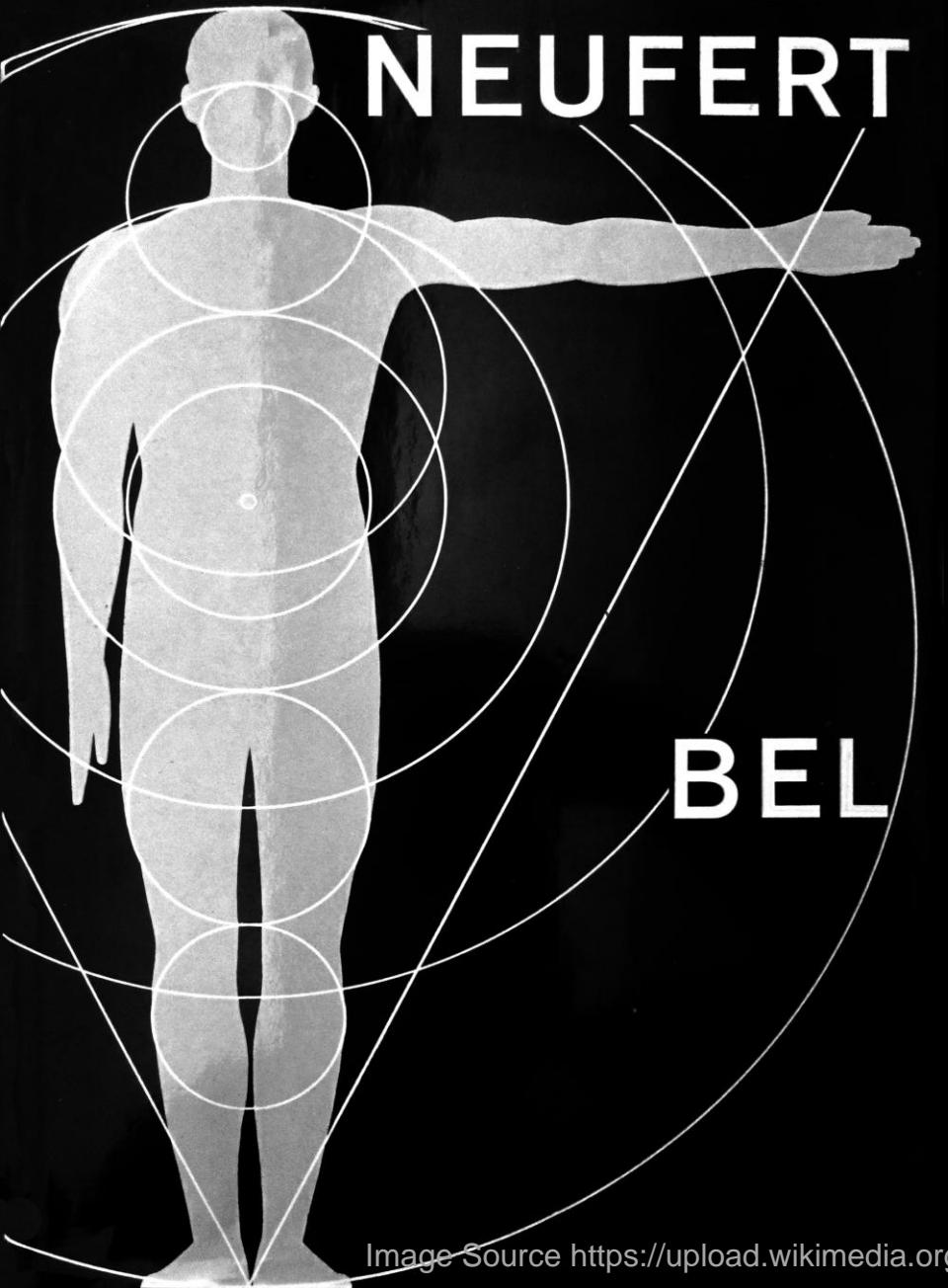
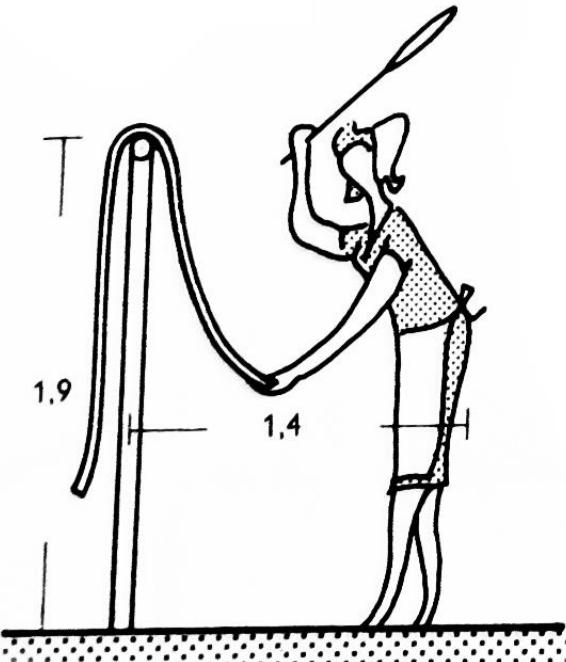
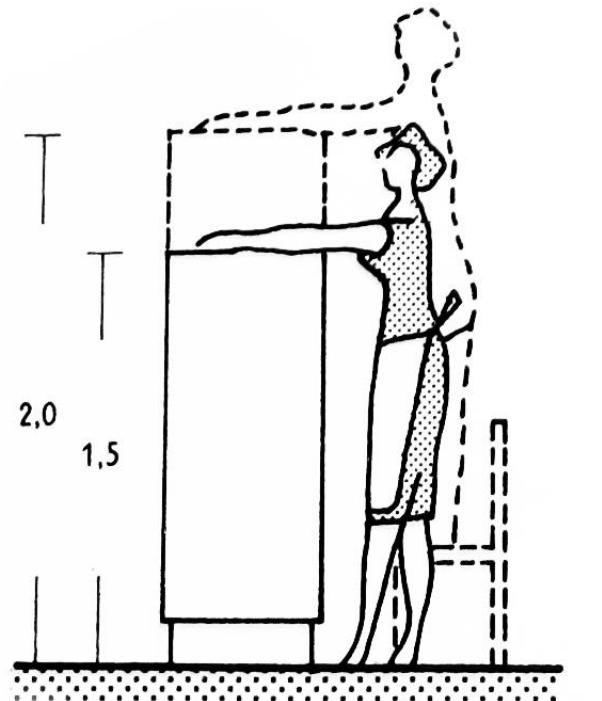


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# Ergonomics



Teppichklopftange



Zweckmäßige Schrankhöhen



Günstige Höhe für Abfall-eimer und dgl.

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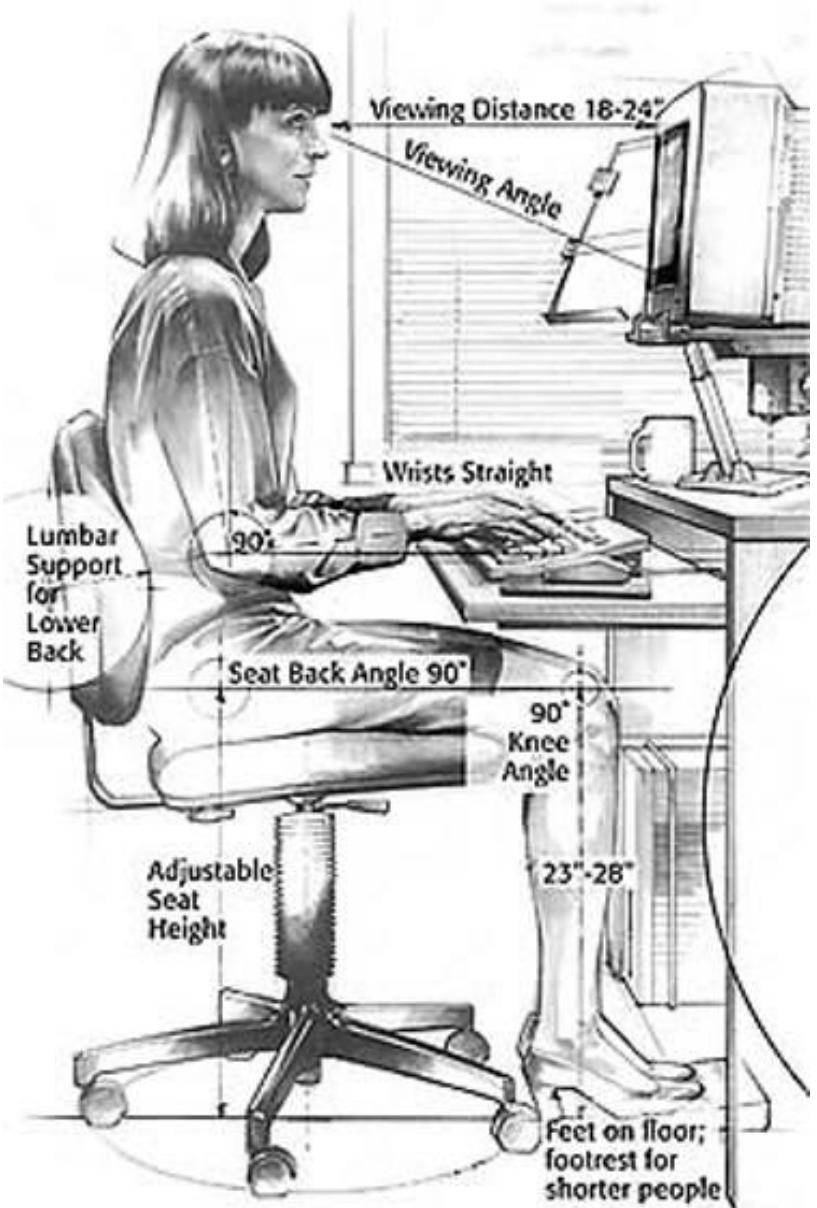


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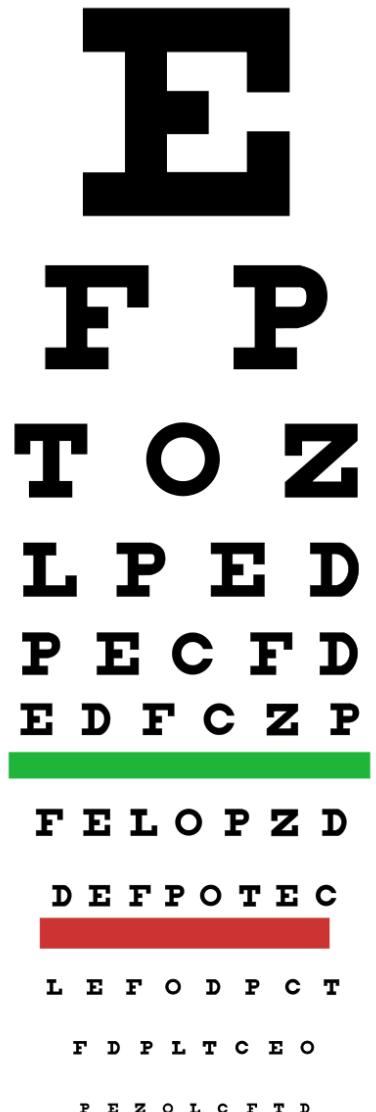


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**F P**  
**T O Z**  
**L P E D**  
**P E C F D**  
**E D F C Z P**  
**F E L O P Z D**  
**D E F P O T E C**  
**L E F O D P C T**  
**F D P L T C E O**  
**P E Z O L C F T D**



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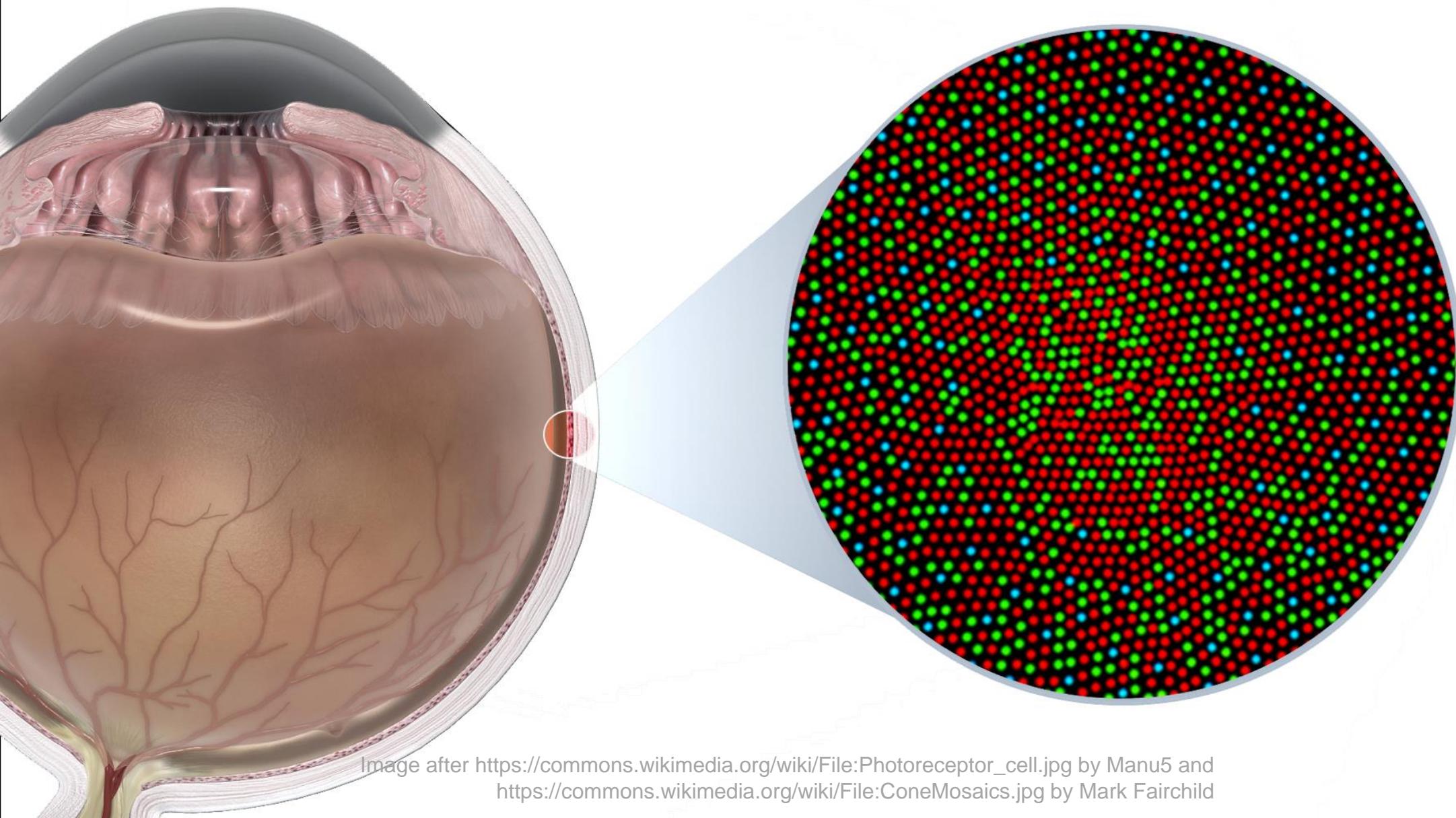


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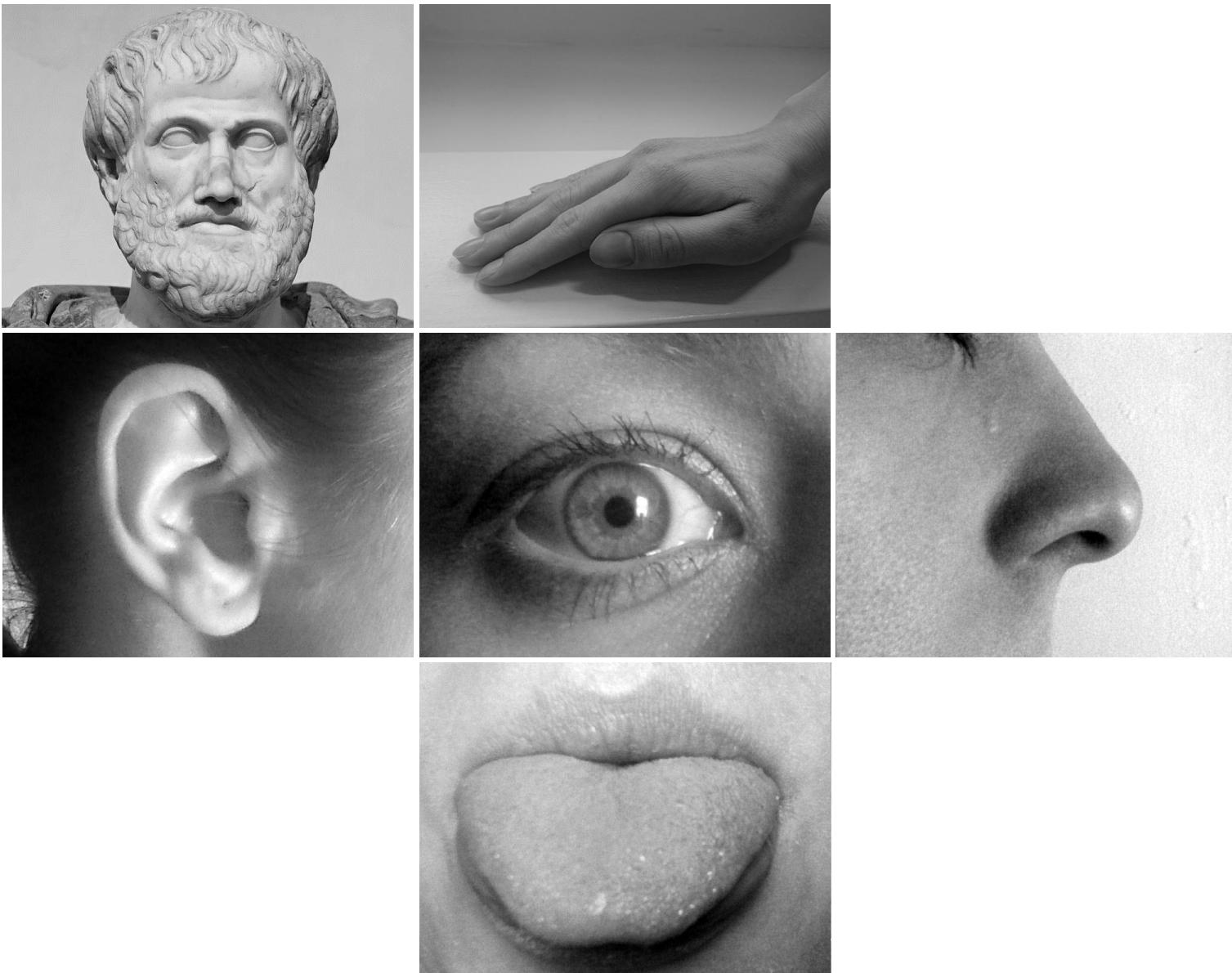


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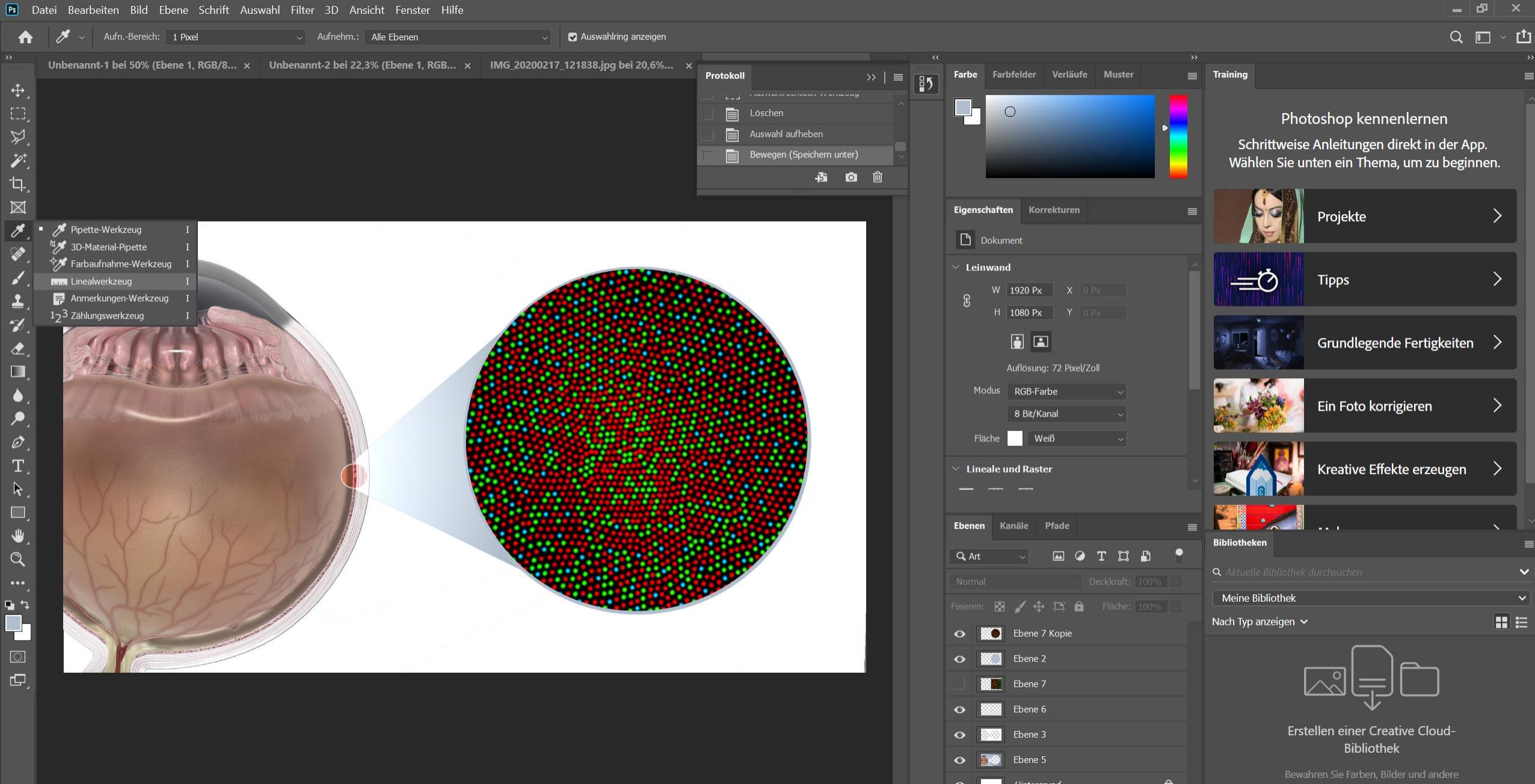




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# Humans in HCI

- Perception
- Cognition
- Emotions
- Motor system

<https://www.ergonomics.com.au/what-is-ergonomics/> Image Source

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Katrin Wolf



# Visual Perception

<https://pixnio.com/people/female-women/eye-gorgeous-fashion-portrait-woman-cute-face-eyes-blond-attractive>



# Learning Goals

- The human eye
- Sensory perception
- Stereoscopic vision

# Color perception

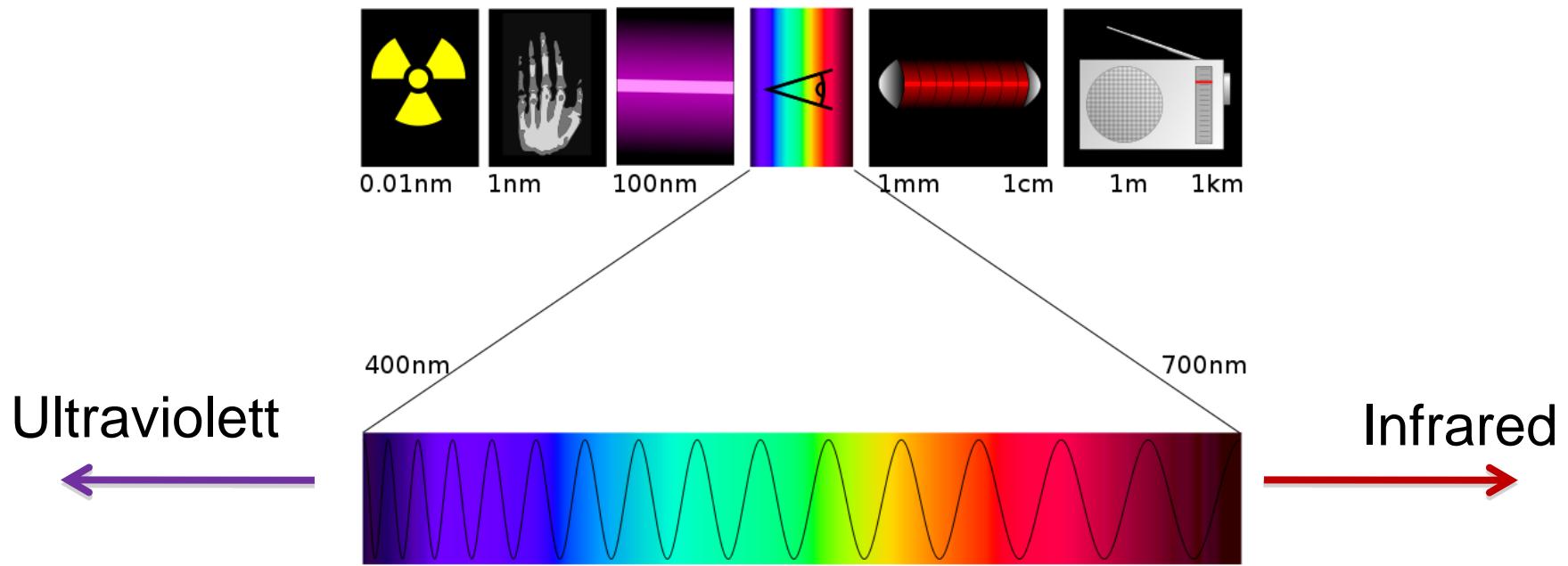


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# Light perception

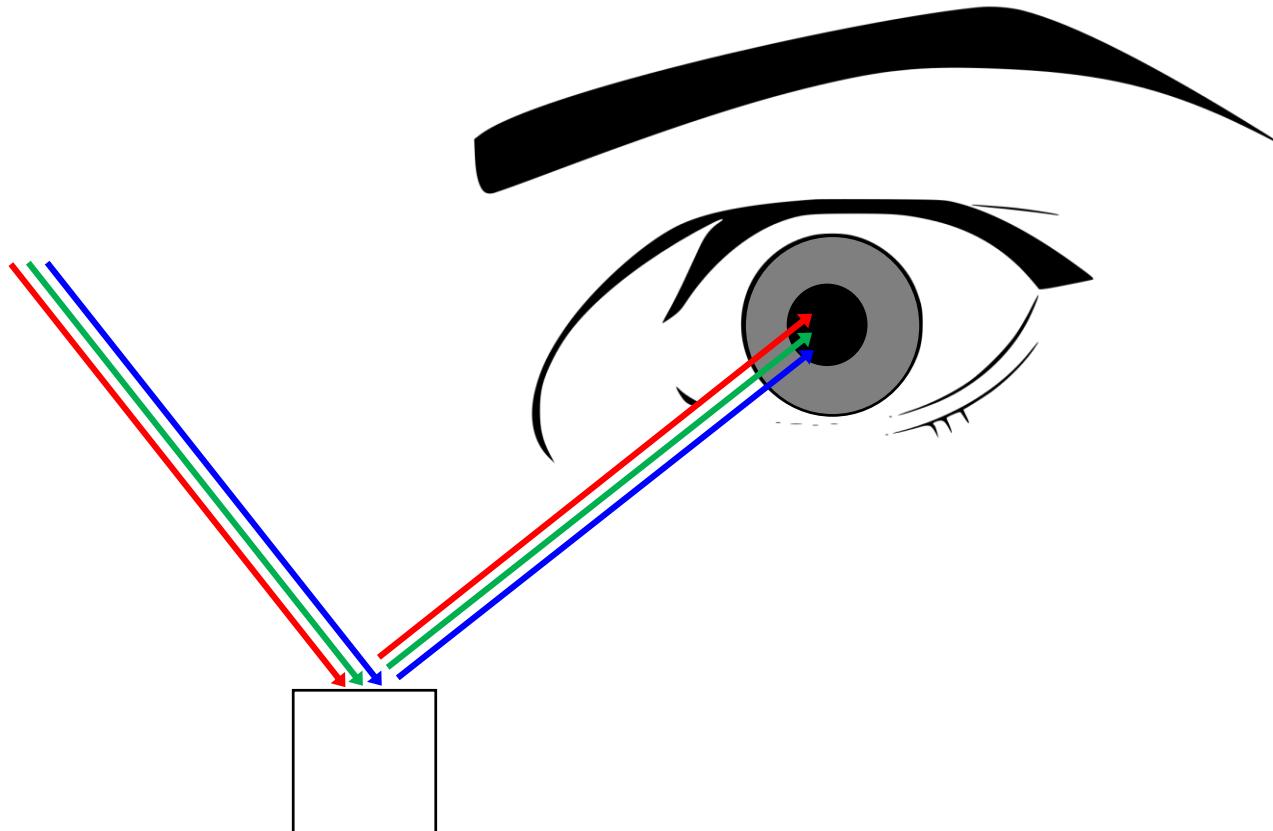


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# Light perception

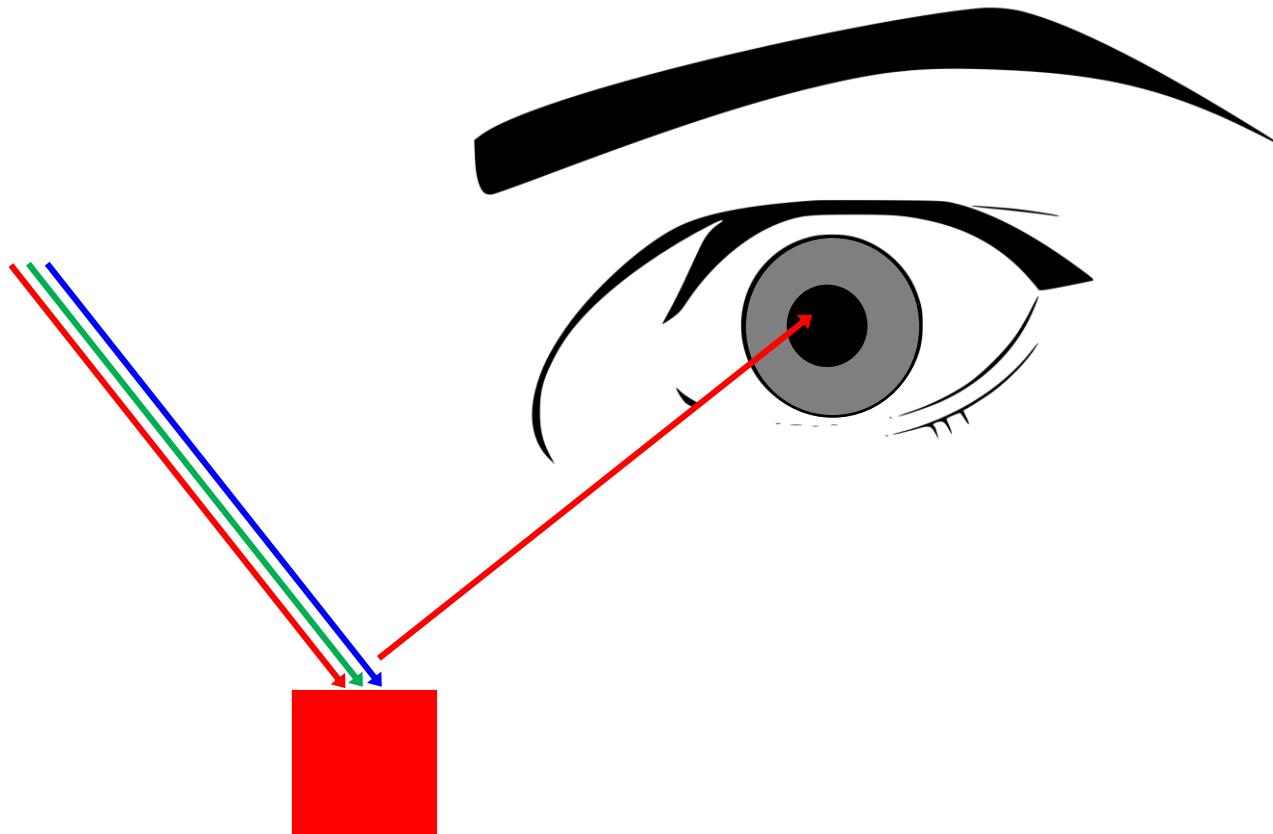


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# Light perception

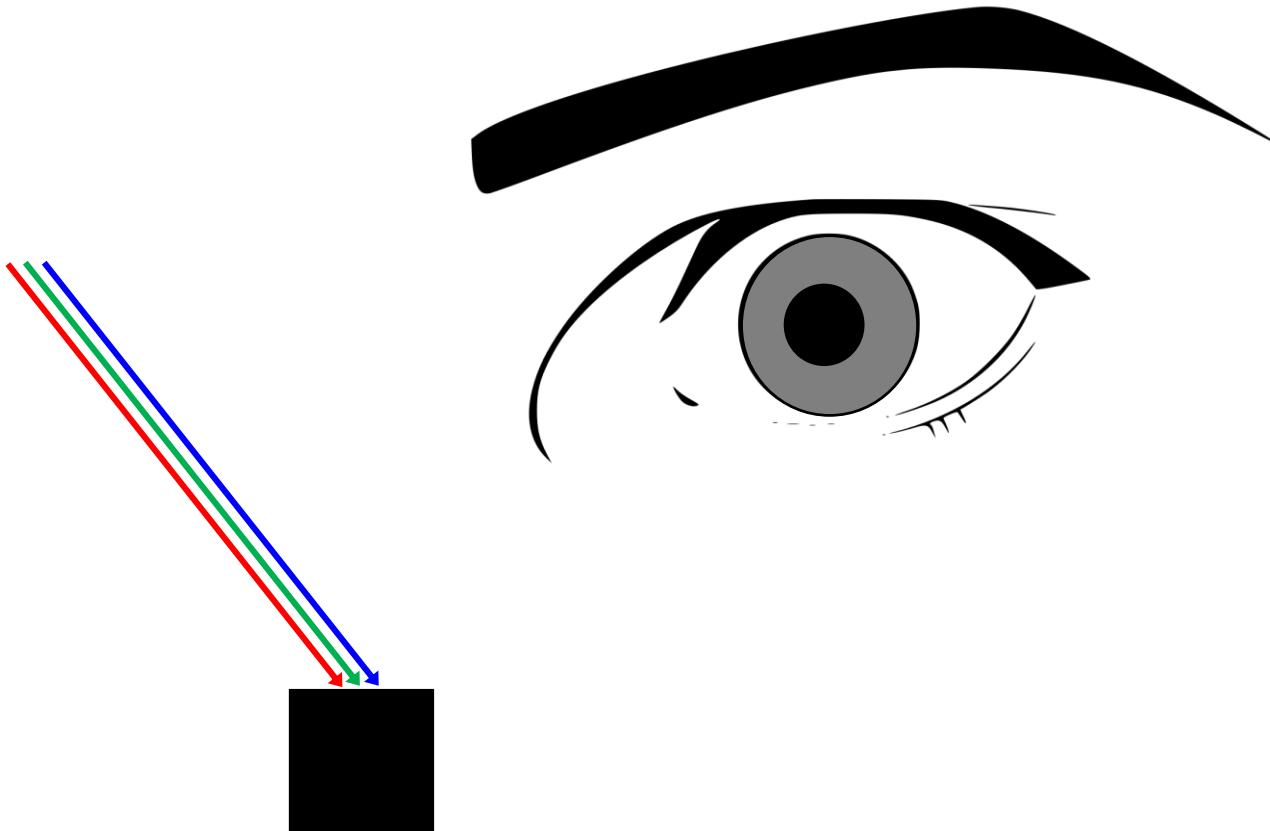


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# Light perception

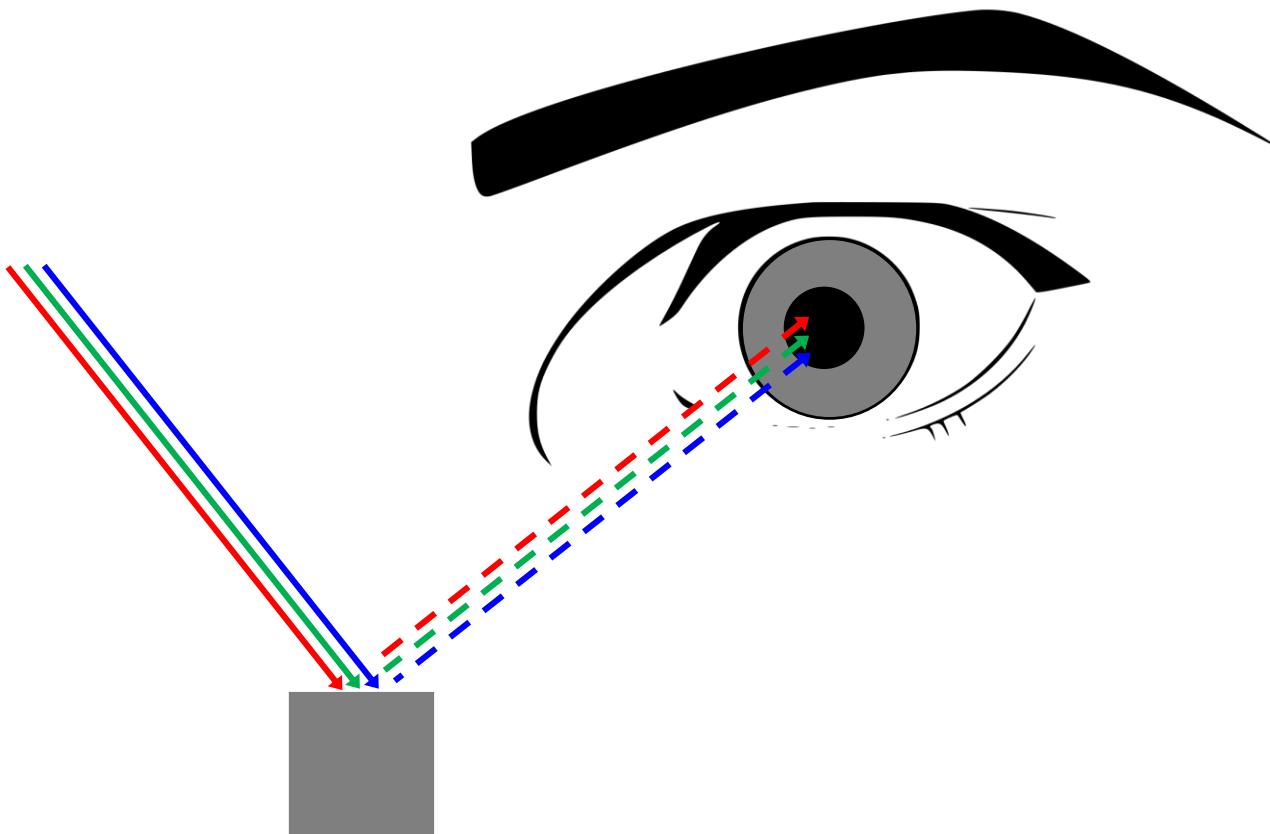


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# Light perception

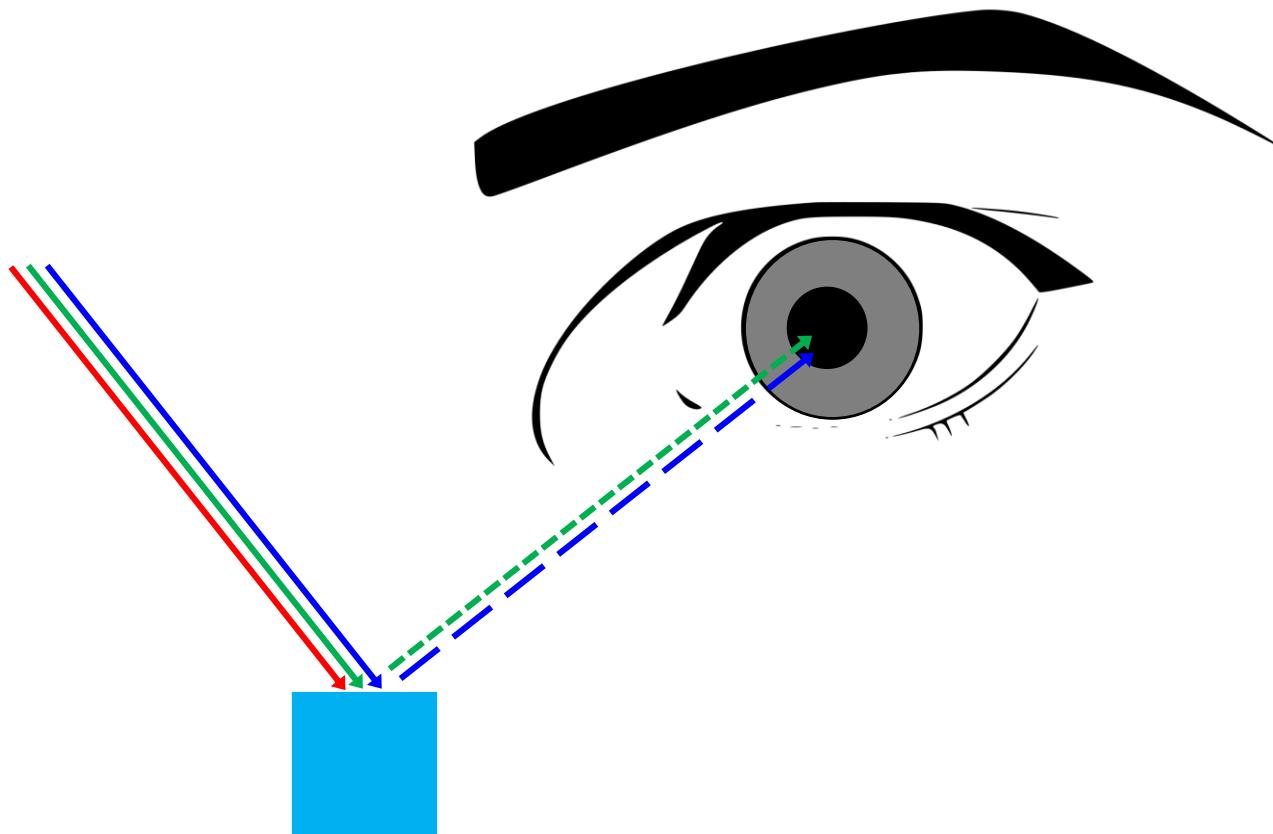


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# The eye

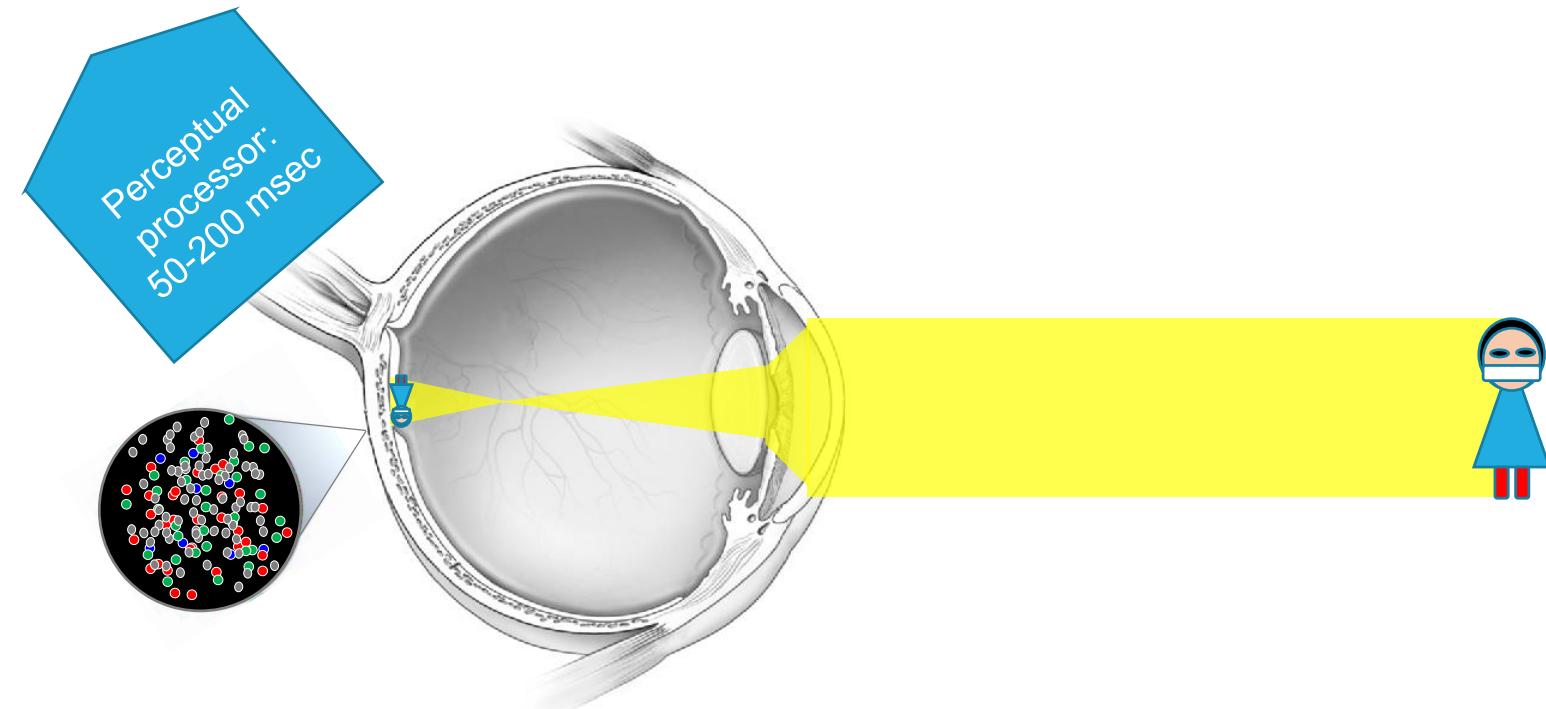


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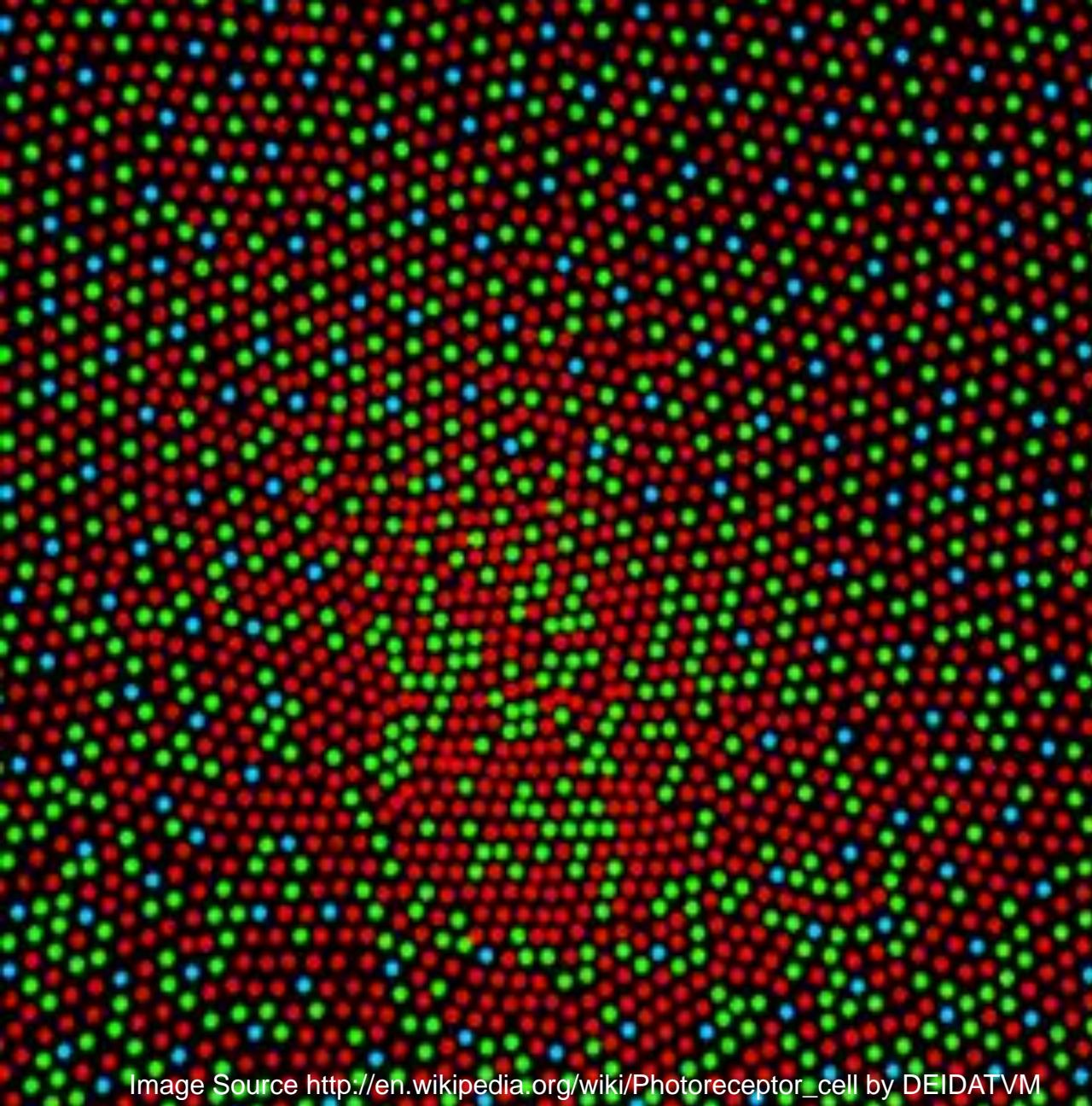
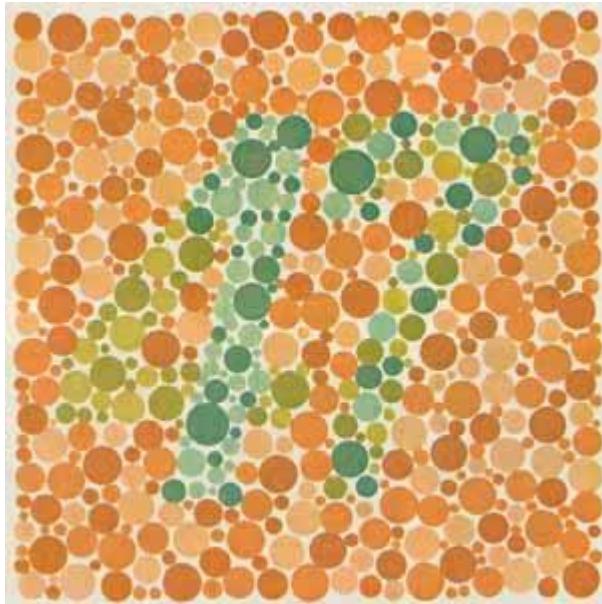


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# Color perception



- 10% of males & 1% of females are red/green blind (see 17)
- Rest sees 47

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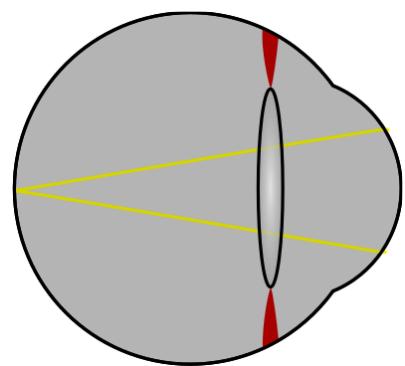
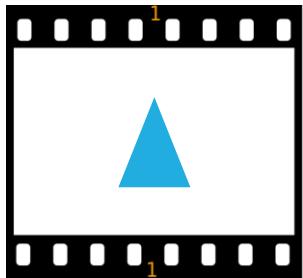
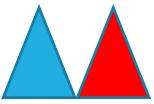
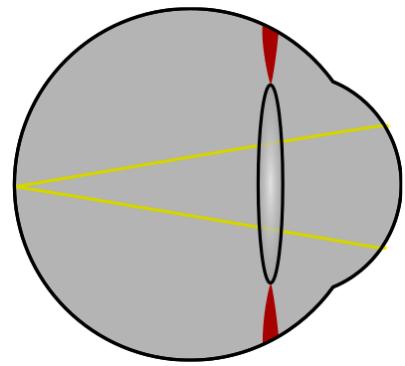
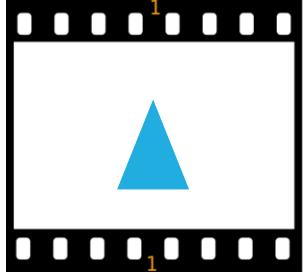


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# Vergence & accommodation

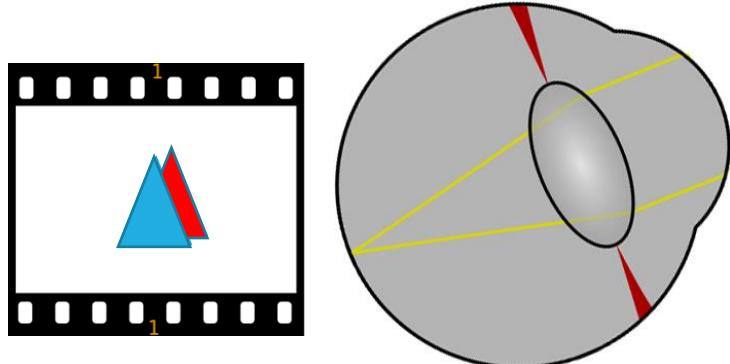
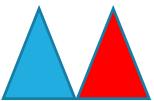
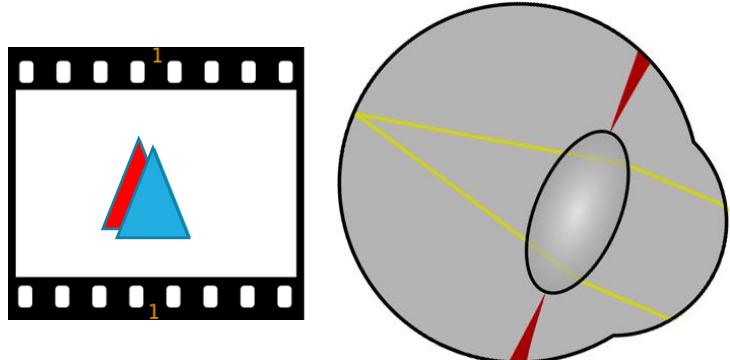


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- Vision adaptive to light
- Good resolution and color in central area
- Good motion perception in the periphery & dark
- Best contrast perception in red/green
- Limited temporal resolution (reaction speed)
- Perception of 2 images, one per eye

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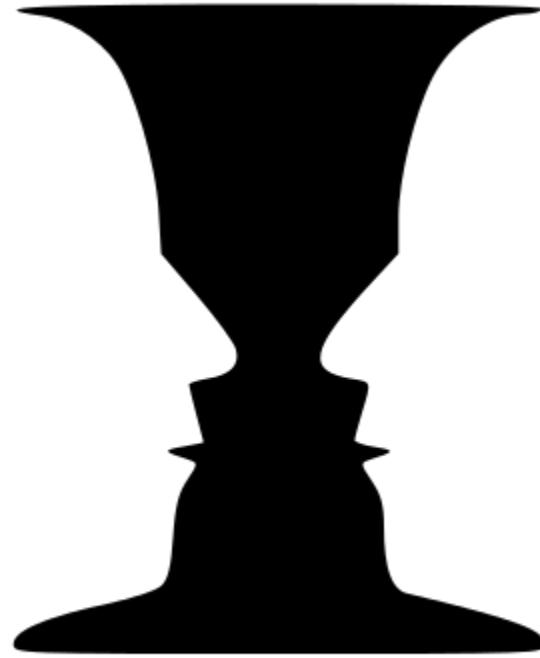
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# Cognition

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# Learning Goals

- Information processing
- Visual pre-processing
- Cognition
- Depth perception

# Visual information processing

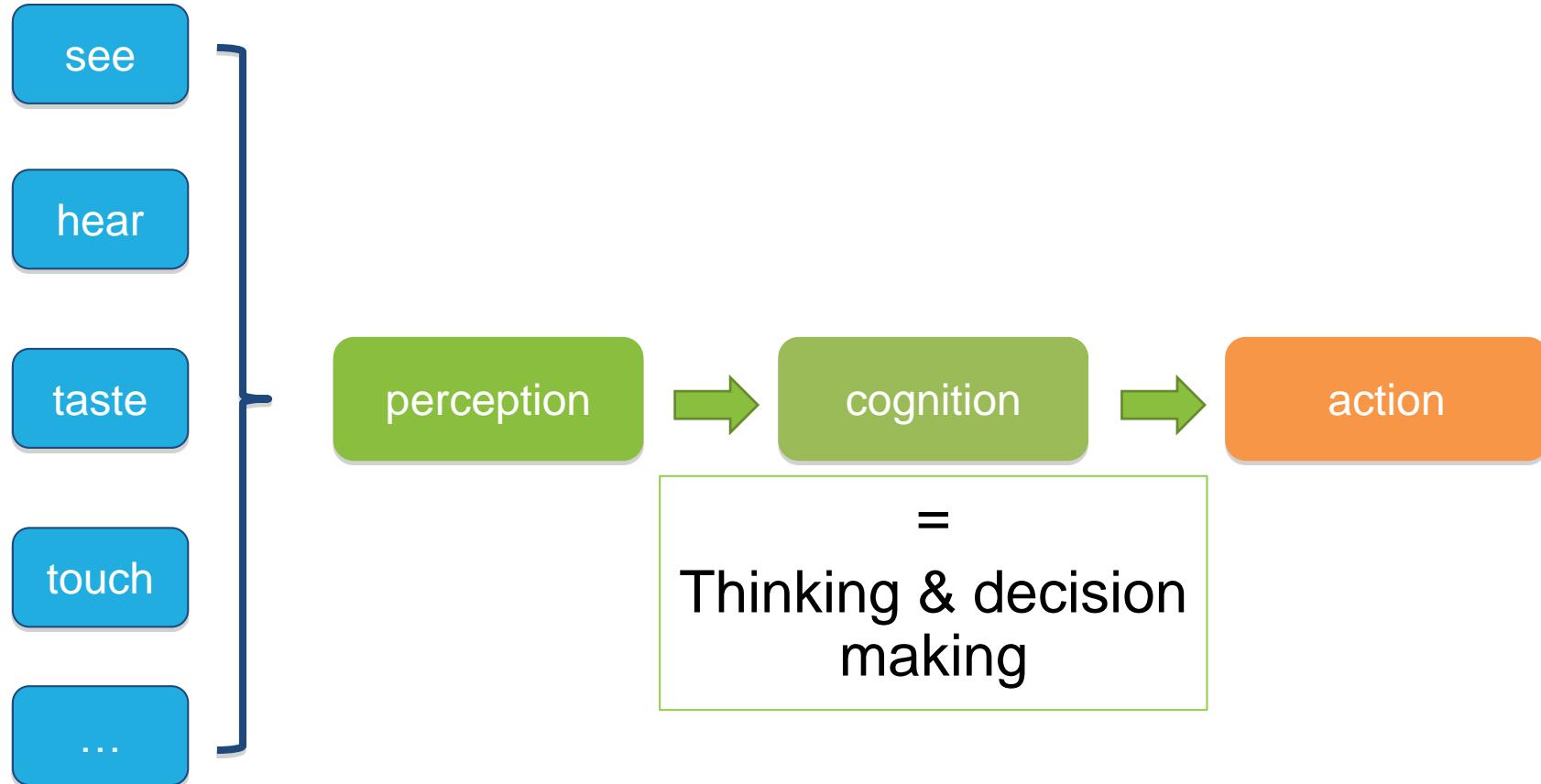
- Perception:  
sensors and signal processing in the eye and brain
- Cognition:  
“understanding” in the brain

Tendency to see what is known, wanted, anticipated



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# Human information processing



# Signal pre-processing

- Stimuli are pre-processed in the neuronal networks of the retina
- Example: edge intensification shown in Mach bands

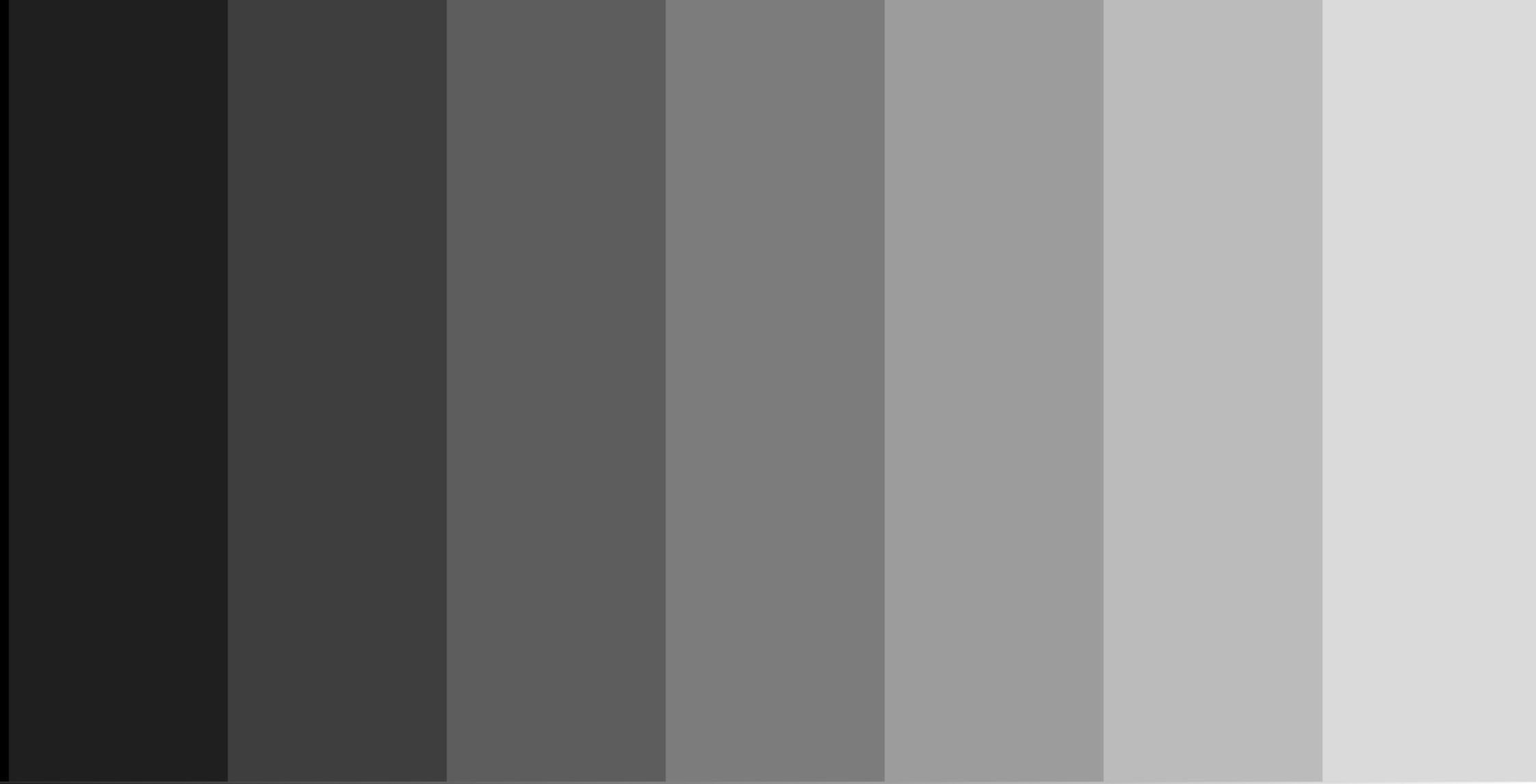


Image Source [https://de.wikipedia.org/wiki/Machsche\\_Streifen](https://de.wikipedia.org/wiki/Machsche_Streifen) by Poloni

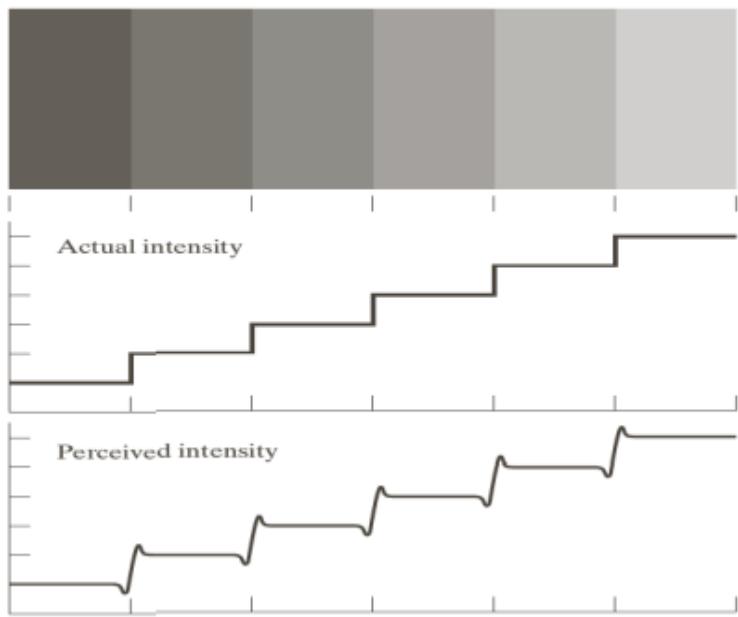
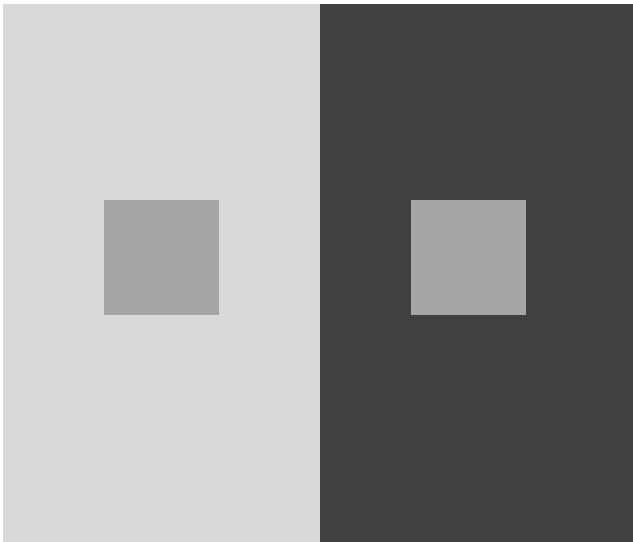


Image Source [https://de.wikipedia.org/wiki/Machsche\\_Streifen](https://de.wikipedia.org/wiki/Machsche_Streifen) by Poloni  
<https://cs.stackexchange.com/questions/117497/mach-band-effect> by Turing101

# Edge Detection through Contrast Intensification

- Simultaneous contrast



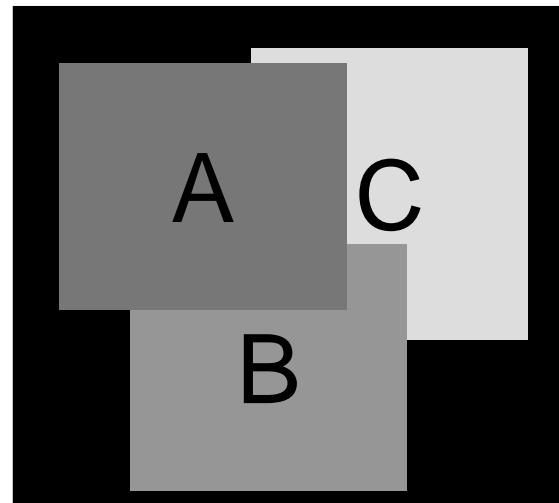
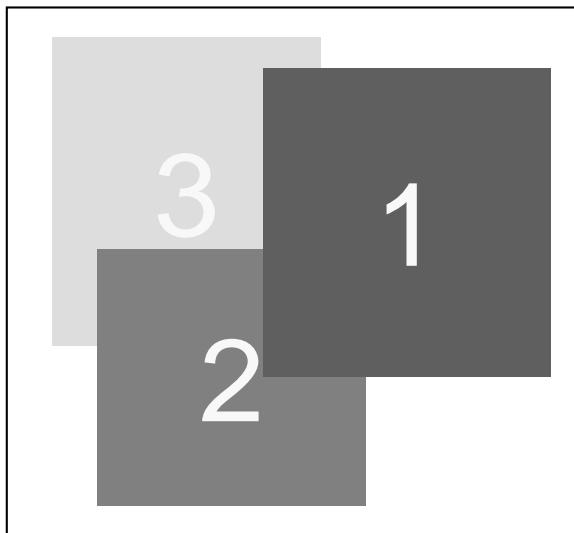
# Edge Detection through Contrast Intensification

- Simultaneous contrast



# Simultaneous Contrast

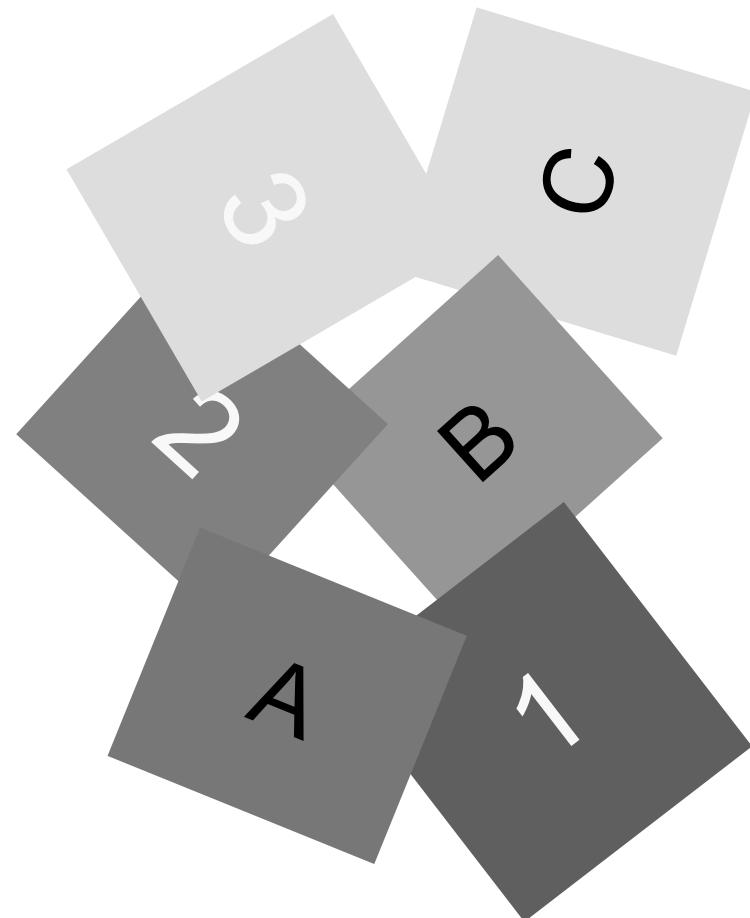
- Simultaneous contrast



Images by Albrecht Schmidt

# Simultaneous Contrast

- A != 1
- B != 2
- C = 3



Images by Albrecht Schmidt

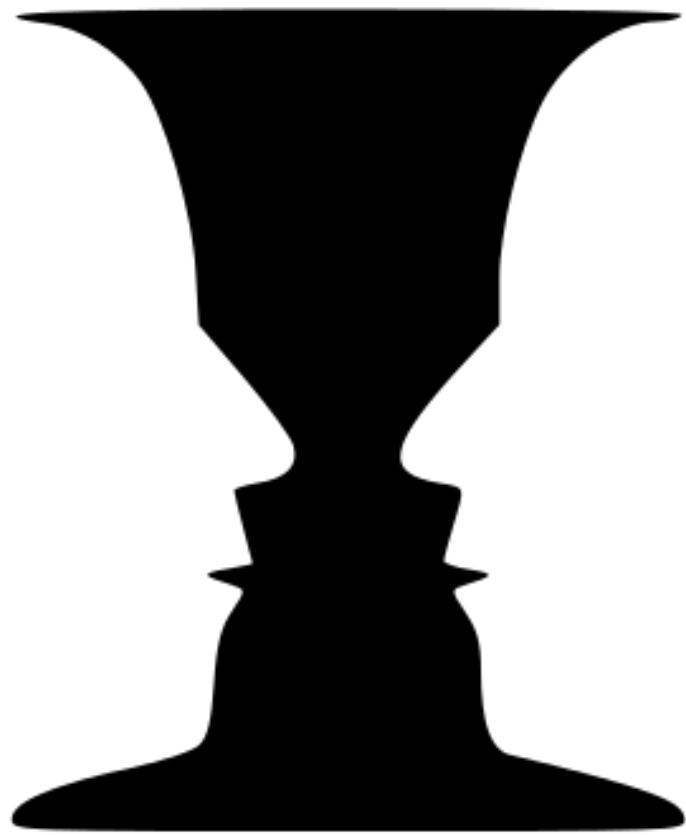


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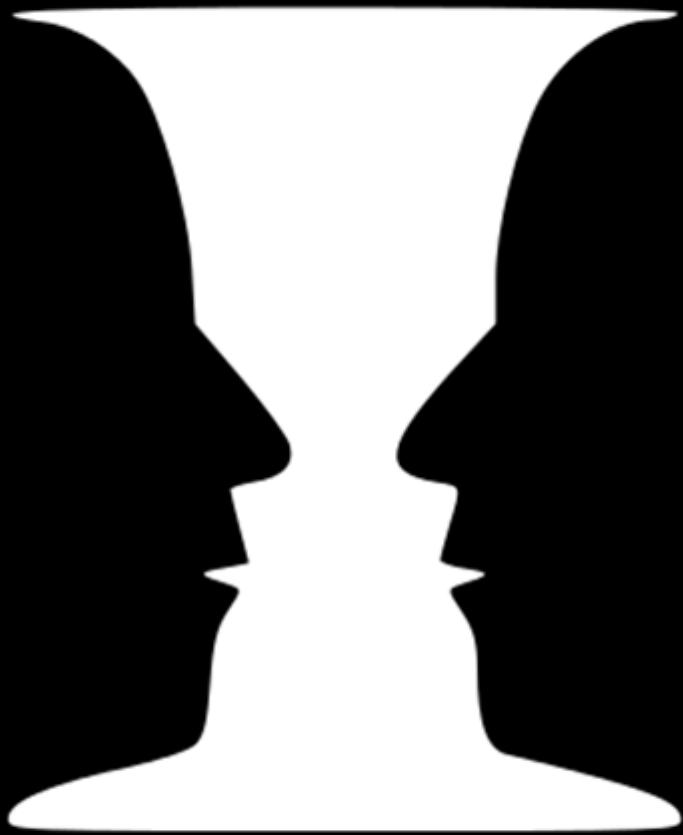
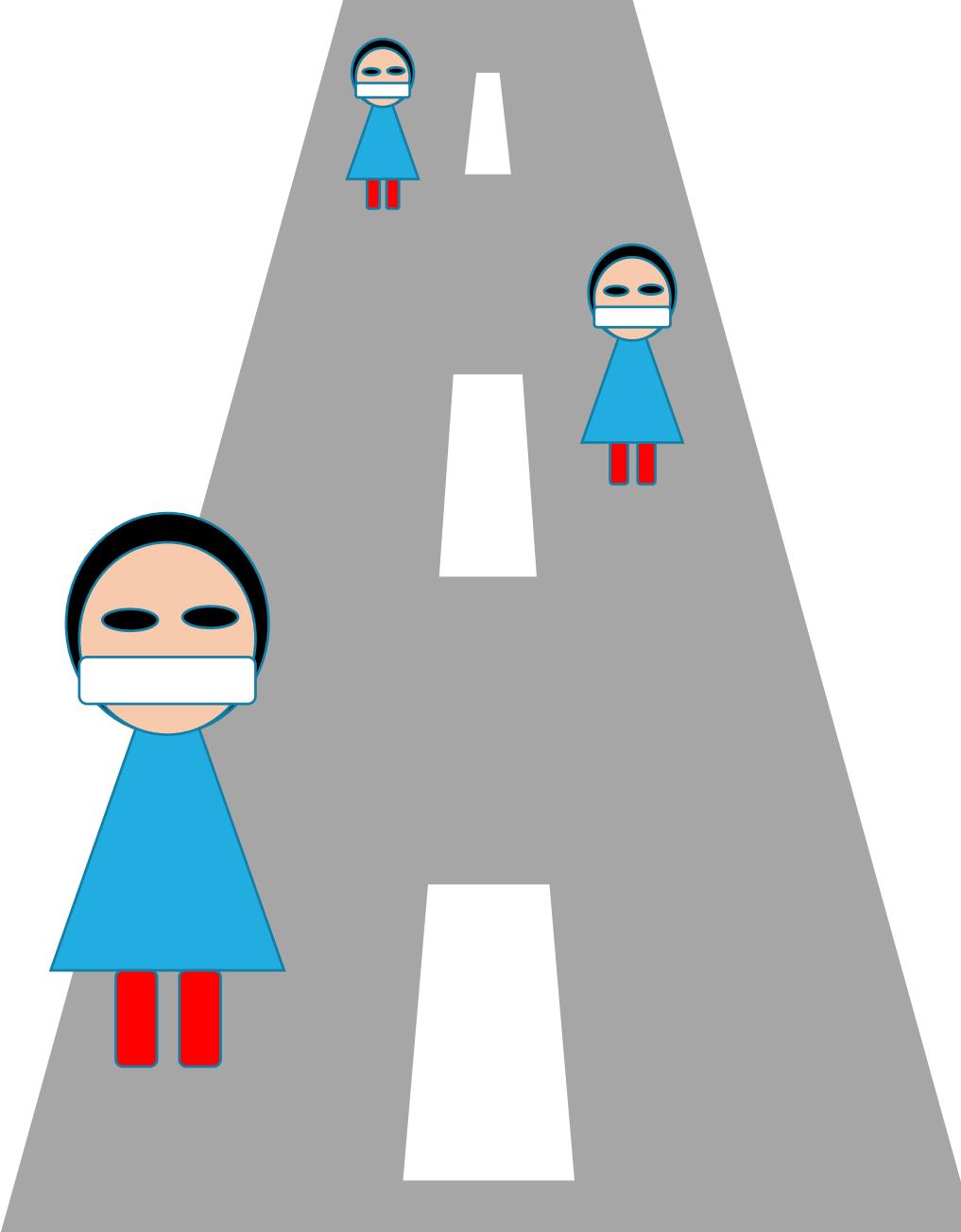
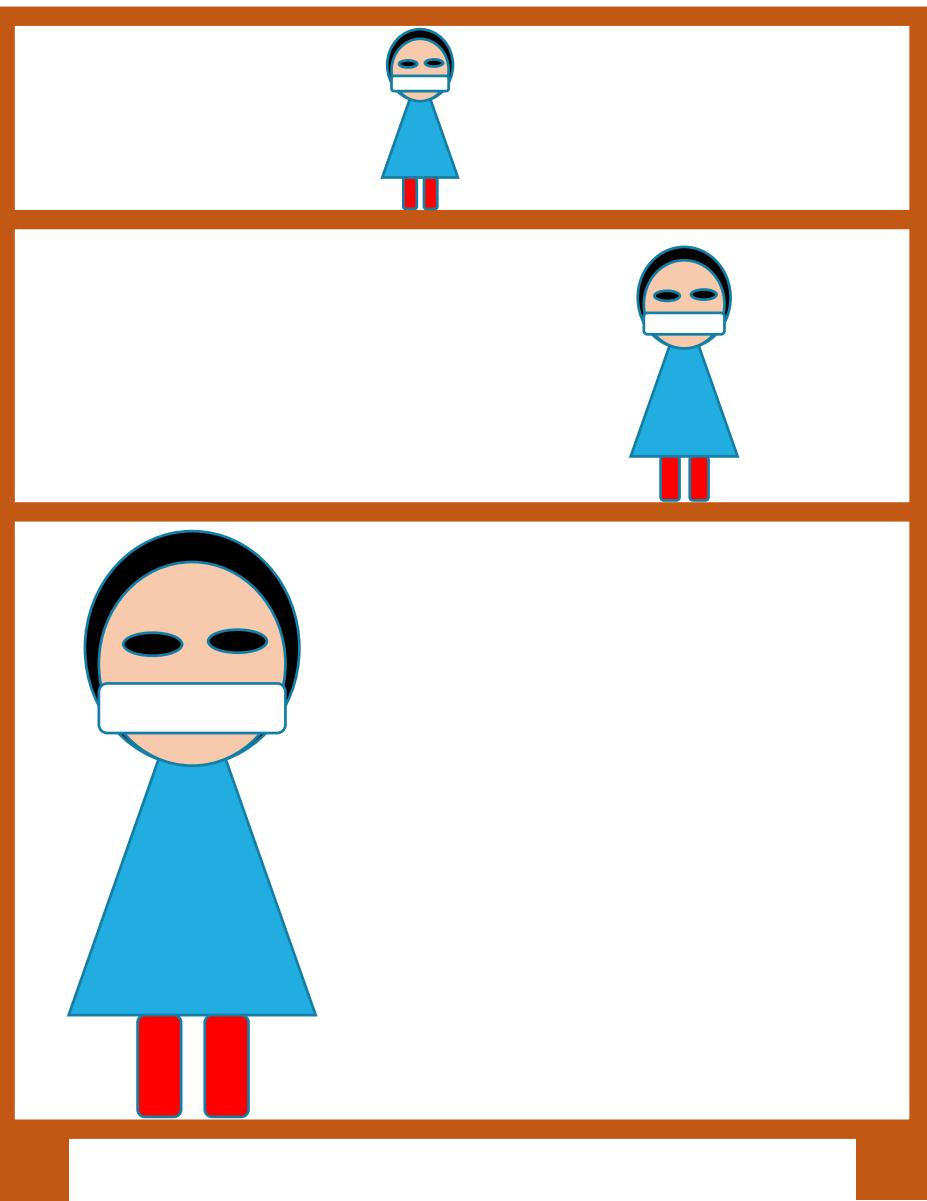
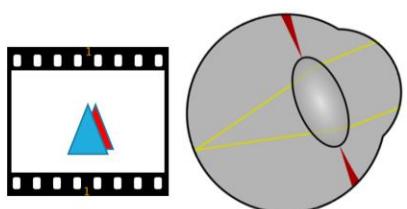
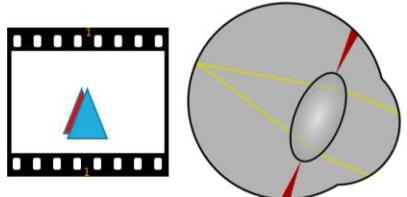
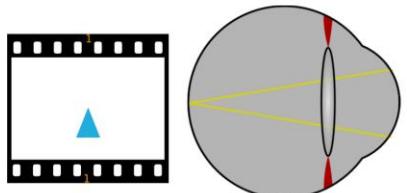
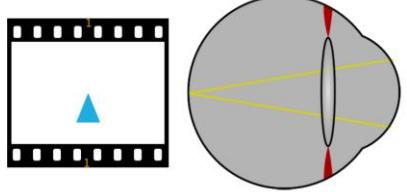


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## Depth perception

- Binocular disparity
- Vergence
- Accommodation



## Depth cues

- Blue / sharpness
- Occlusion
- Increased size over distance





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# Depth Perception

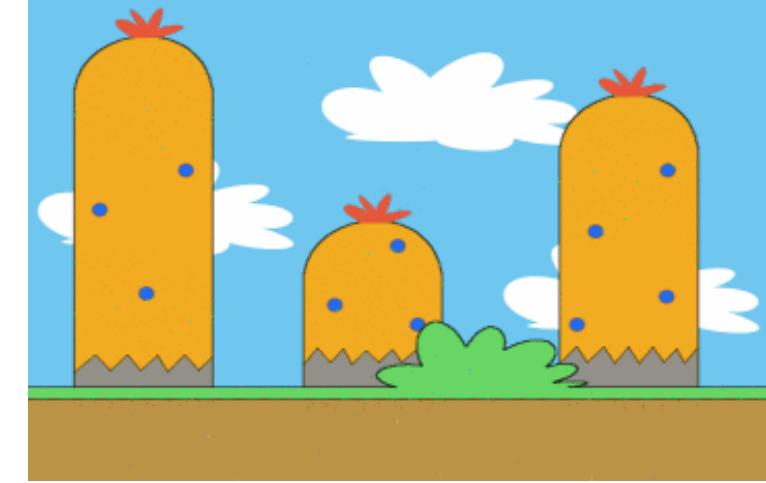
## Depth perception

- Binocular disparity
- Vergence
- Accommodation
- Shadows
- Atmospheric Lightning
- Perspectives
- Texture gradient (distortion over distance)
- Motion parallax

## Depth cues

- Size <> distance
- Occlusion
- Blue / sharpness

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# Visual information processing

- Perception:  
sensors and signal processing in the eye and brain
- Cognition:  
“understanding” in the brain

Tendency to see what is known, wanted, anticipated

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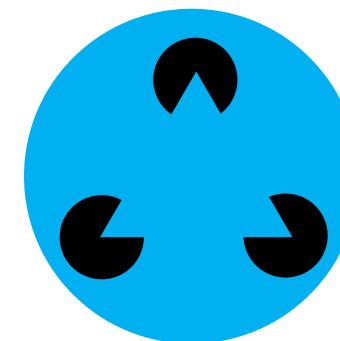
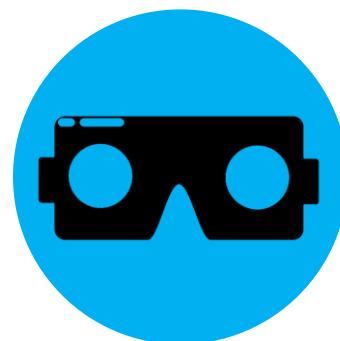
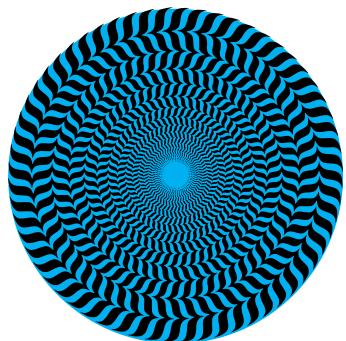


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# Gestalt Laws

Image <https://www.publicdomainpictures.net/pictures/170000/velka/tiger-clipart-illustration-1461009833u5d.jpg>



# Learning Goals

- Knowing the Gestalt Laws and recognizing their application in HCI



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# Background

- Visual perception of objects and the environment through recognizing patterns or configurations ( rather than individual elements)
- Wertheimer defines 1923 six Gestalt factors (later known as Gestalt Principles or Laws)<sup>1</sup>
- Stephen Palmer adds in the 90s three further Gestalt Laws<sup>2</sup>

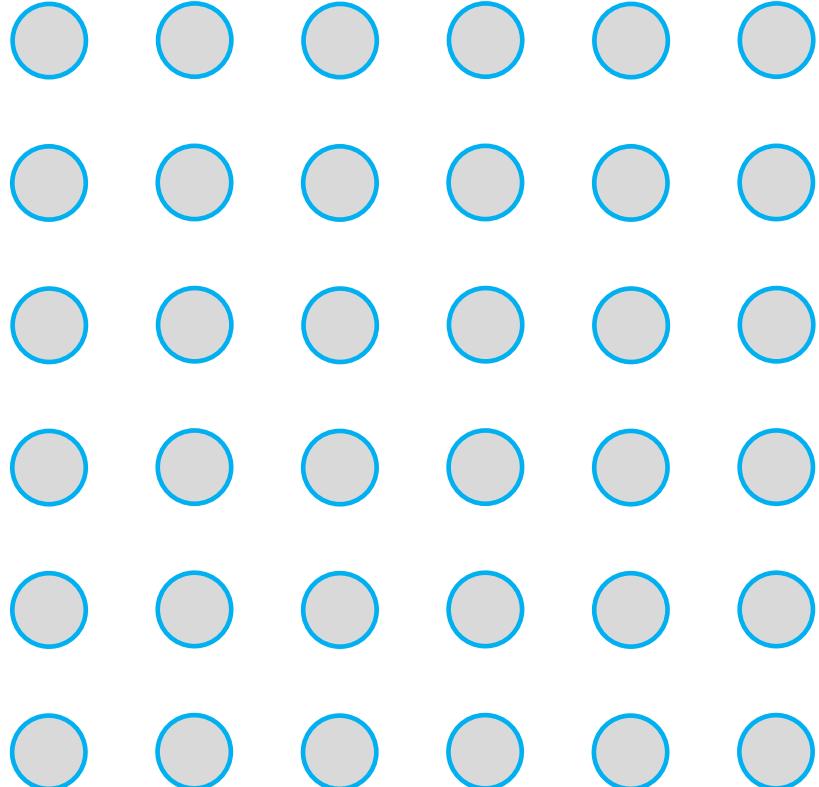
<sup>1</sup> Wertheimer (1923) Untersuchung zur Lehre von Gestalt: [http://gestalttheory.net/download/Wertheimer1923\\_Lehre\\_von\\_der\\_Gestalt.pdf](http://gestalttheory.net/download/Wertheimer1923_Lehre_von_der_Gestalt.pdf)

<sup>2</sup> Palmer (1999) Vision Science. MIT Press, Cambridge (USA), ISBN 0-262-16183-4

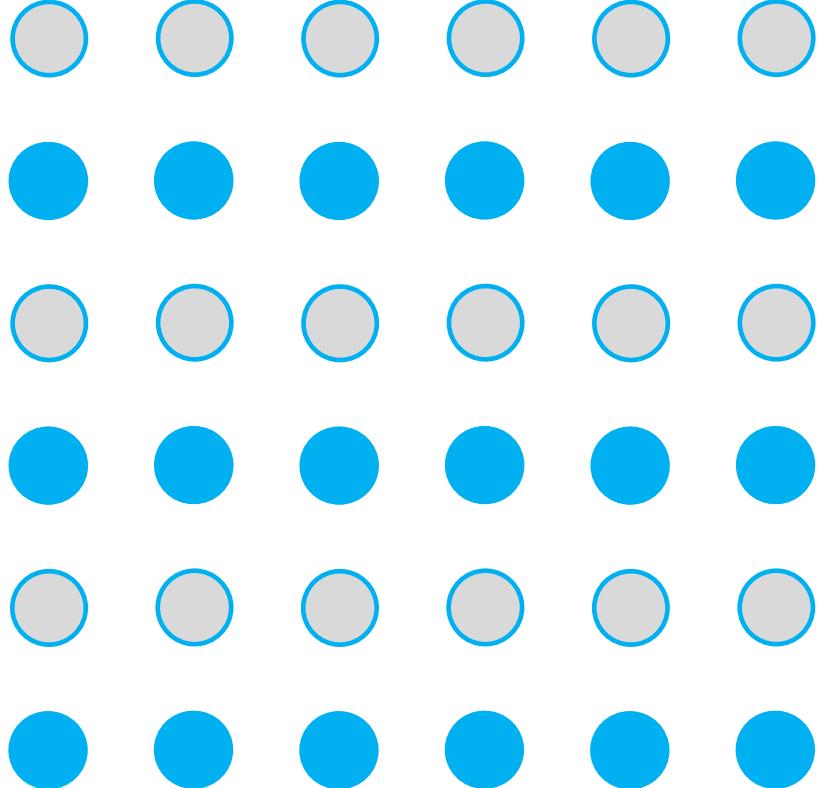
# Gestalt Laws

- Proximity
- Similarity
- Simplicity (good form / Prägnanz)
- Continuation
- Closure
- Common fate
- Common region
- Concurrency / simultaneousness
- Connectivity

# Proximity



# Similarity

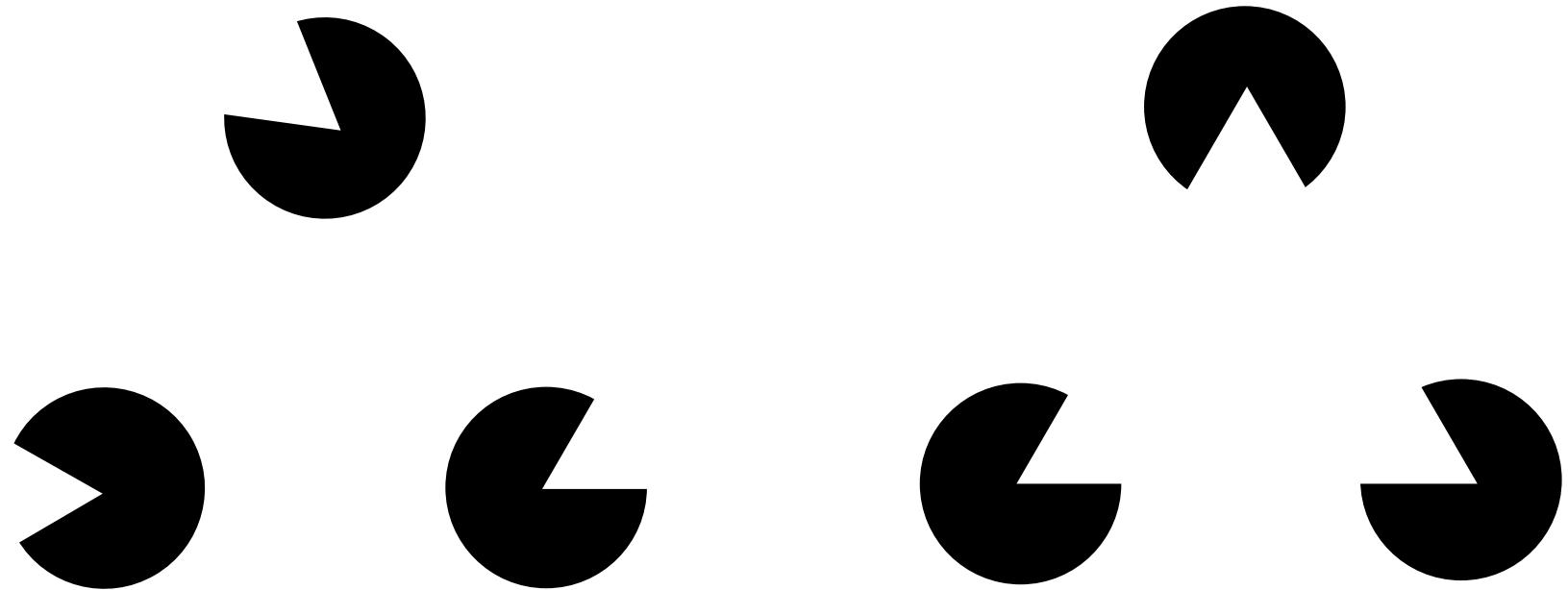


# Gestalt Law Application

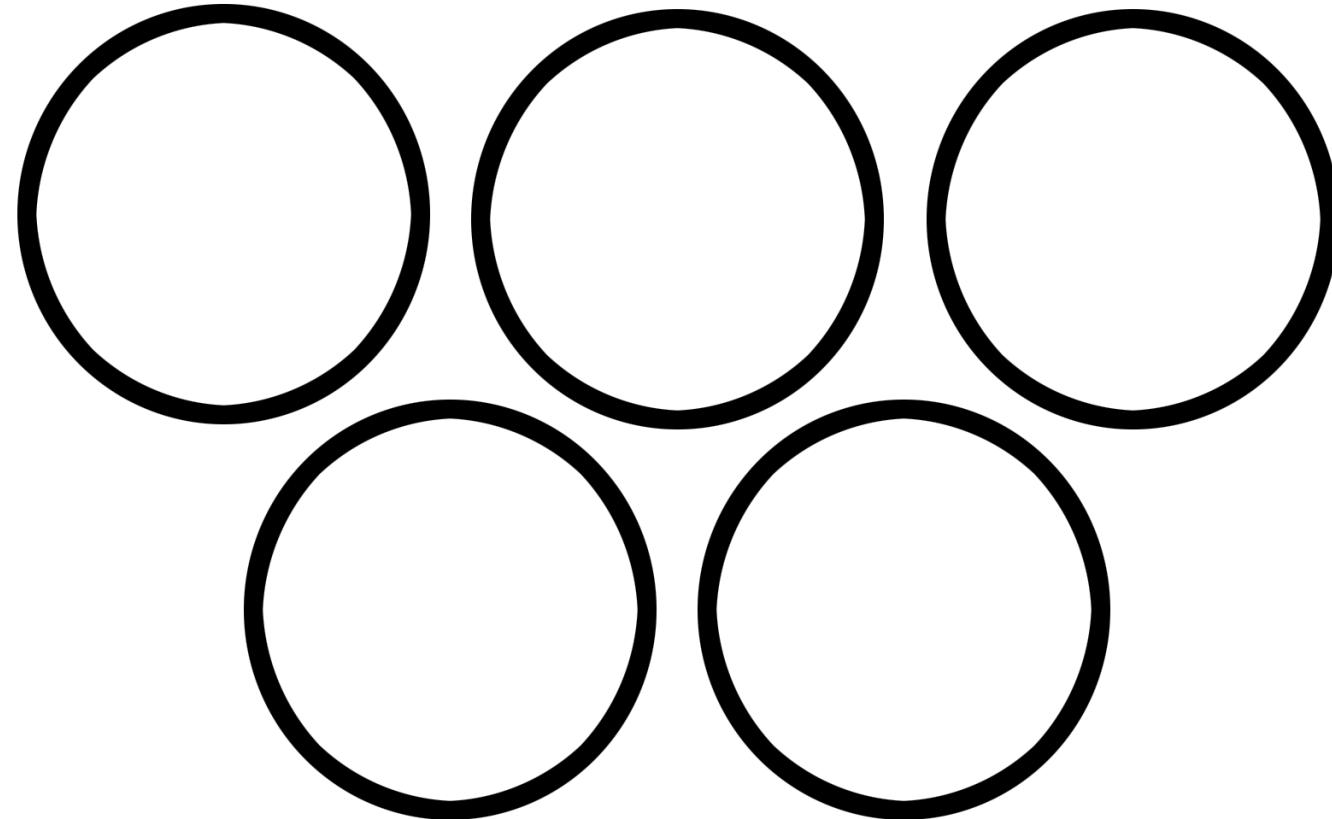


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# Simplicity / Good Form / Prägnanz



# Simplicity / Good Form / Prägnanz



# Continuation

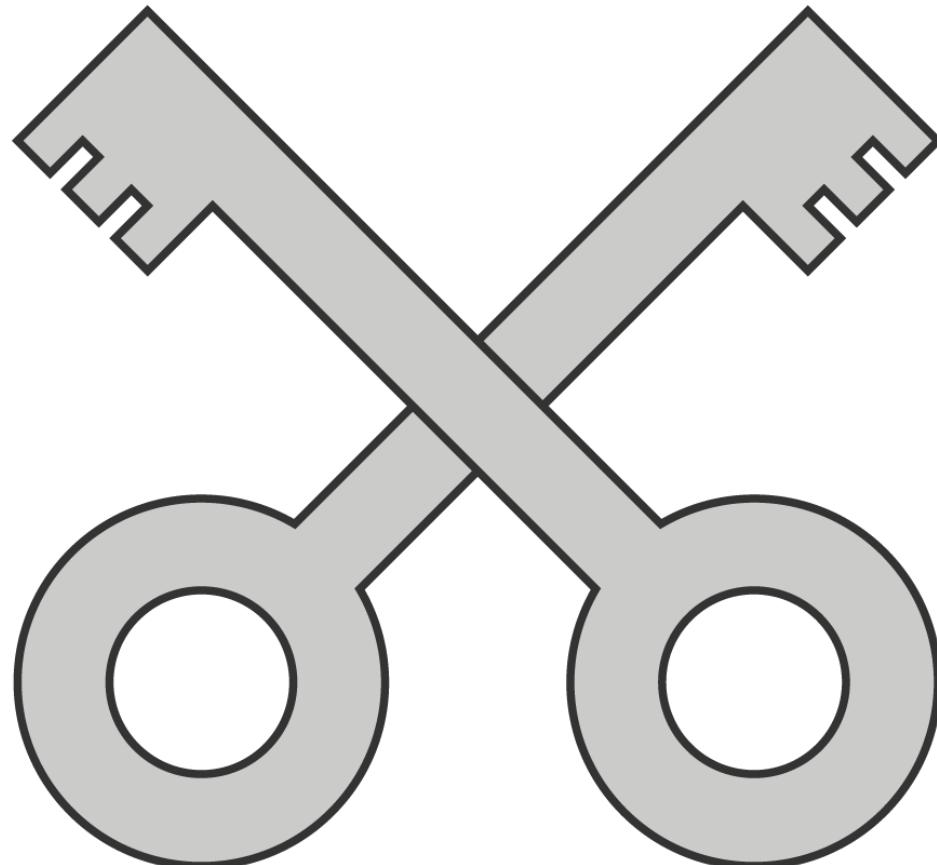


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Ps Datei Bearbeiten Bild Ebene Schrift Auswahl Filter 3D Ansicht Fenster Hilfe

Einfügen

Navi Dokumente

Übersicht

A) Tools

B) Mesh

C) Utilities

D) Adjustments

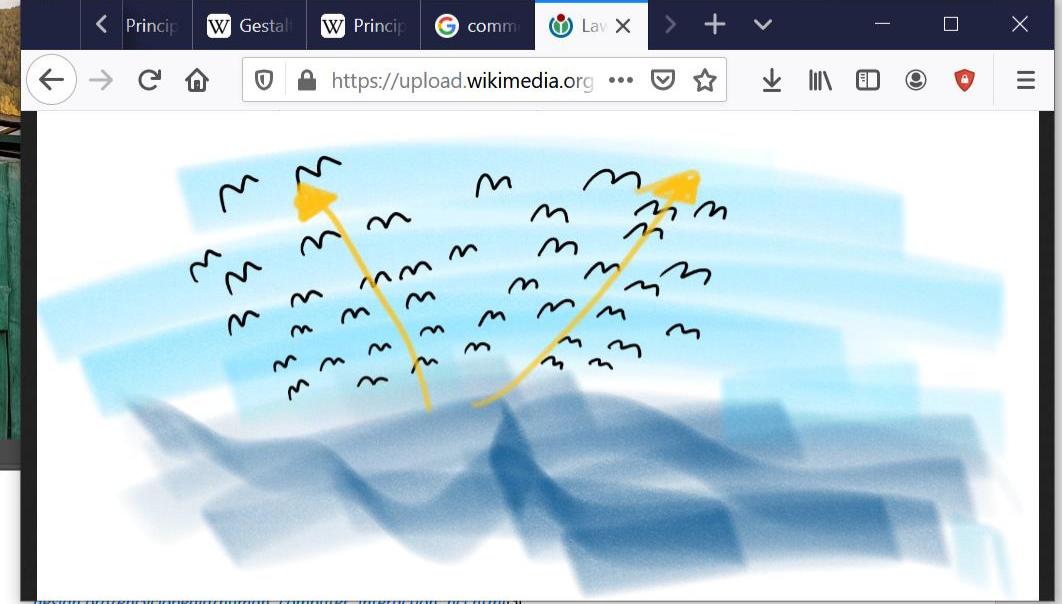
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**B) Maslow's Hierarchy of Needs (2 points)**

The motivation theory of Maslow was already published in 1943. Since then psychologists have extended Maslow's theory [1] and have proposed new concepts [2].

# Closure

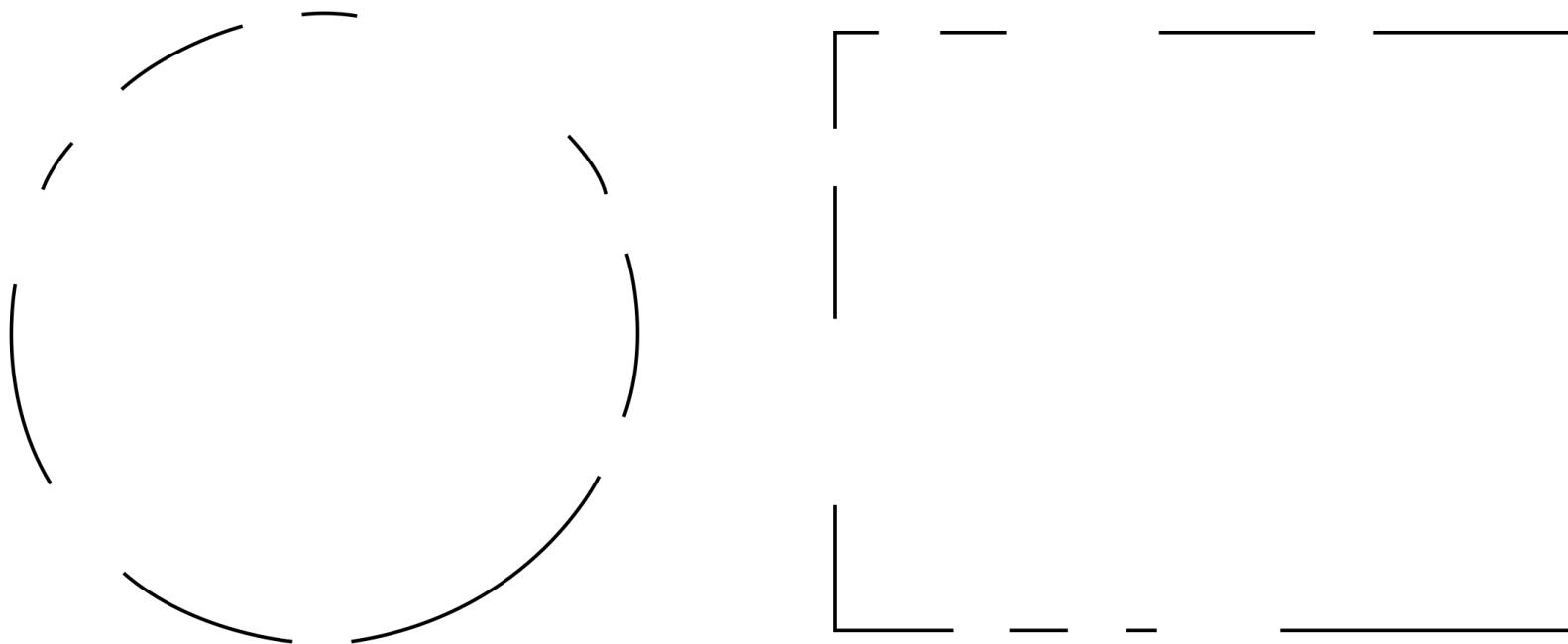


Image Source [https://en.wikipedia.org/wiki/Principles\\_of\\_grouping#/media/File:Gestalt\\_closure.svg](https://en.wikipedia.org/wiki/Principles_of_grouping#/media/File:Gestalt_closure.svg) by Kasufcgslfguhsne



Image Source <https://pxhere.com/en/photo/882726>



Image Source <https://www.pexels.com/photo/basket-shadow-sunset-2588638/> by Ryan O'Grady



Image Source <https://www.needpix.com/photo/download/673945/sketch-block-sketchy-block-draw-paint-art-portrait-pencil-drawing-less> by geralt

# Common Fate

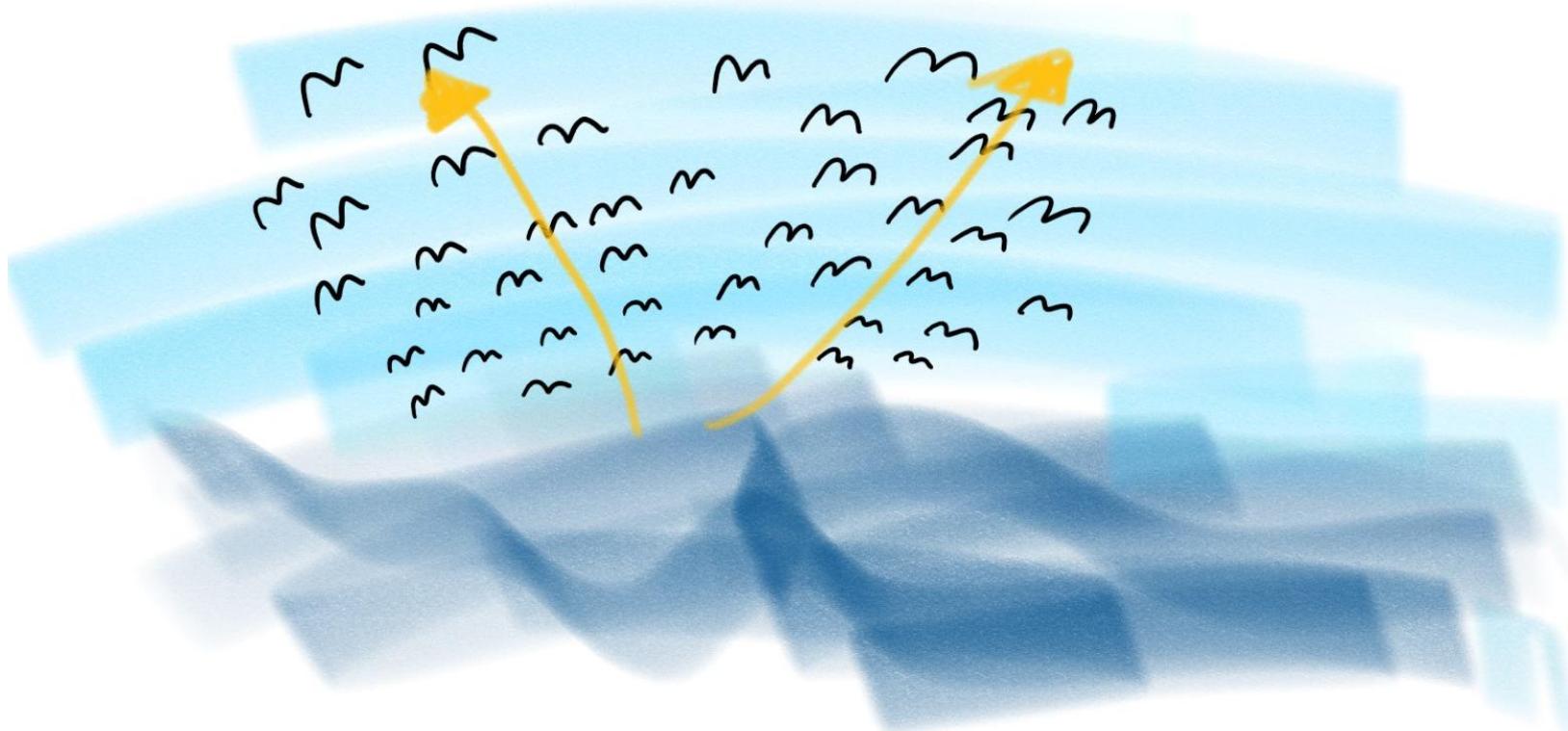


Image Source <https://upload.wikimedia.org/wikipedia/commons/d/d7/Lawofcommonfate.jpg> by BE12M

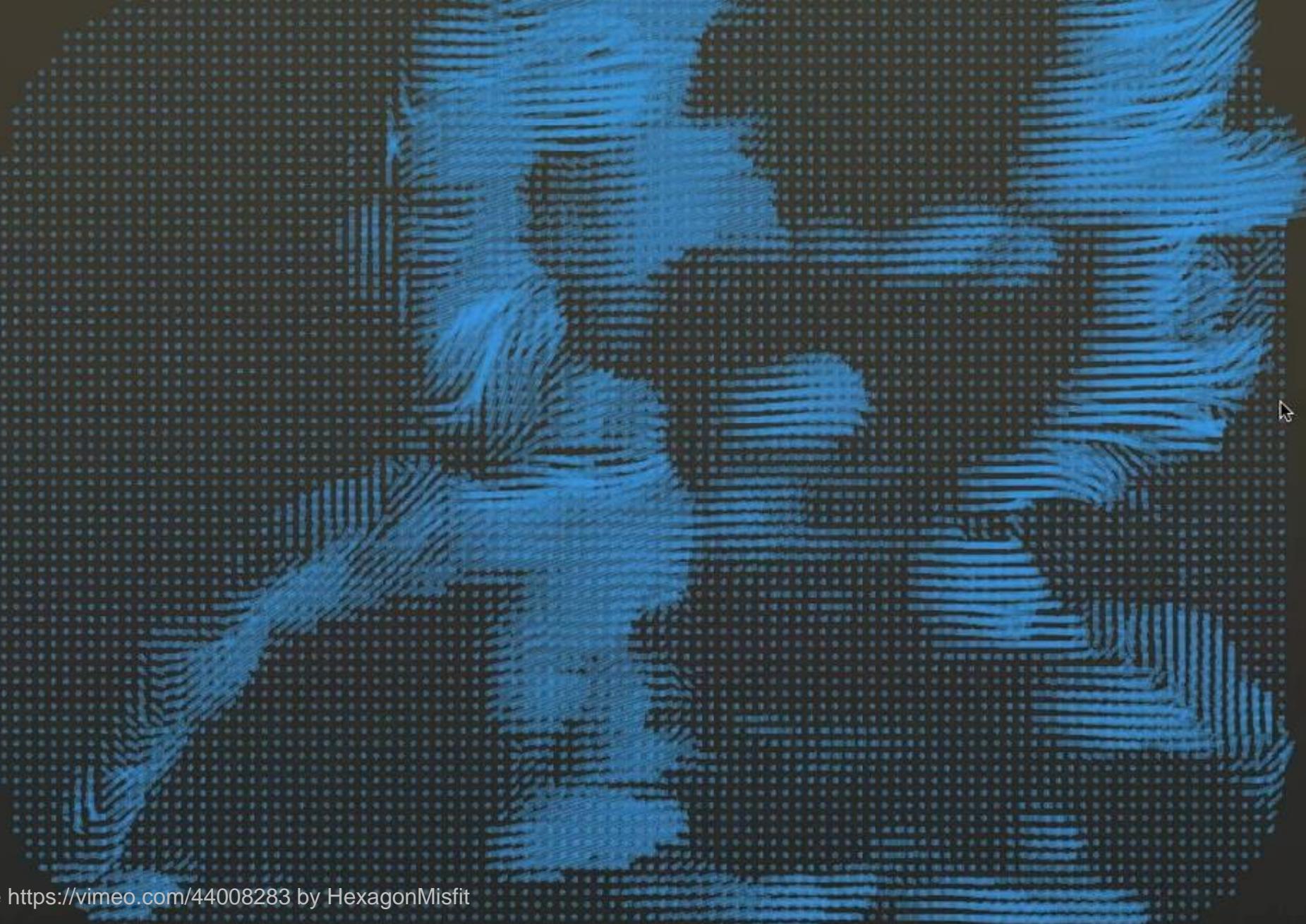


Image Source <https://vimeo.com/44008283> by HexagonMisfit

# Common Region

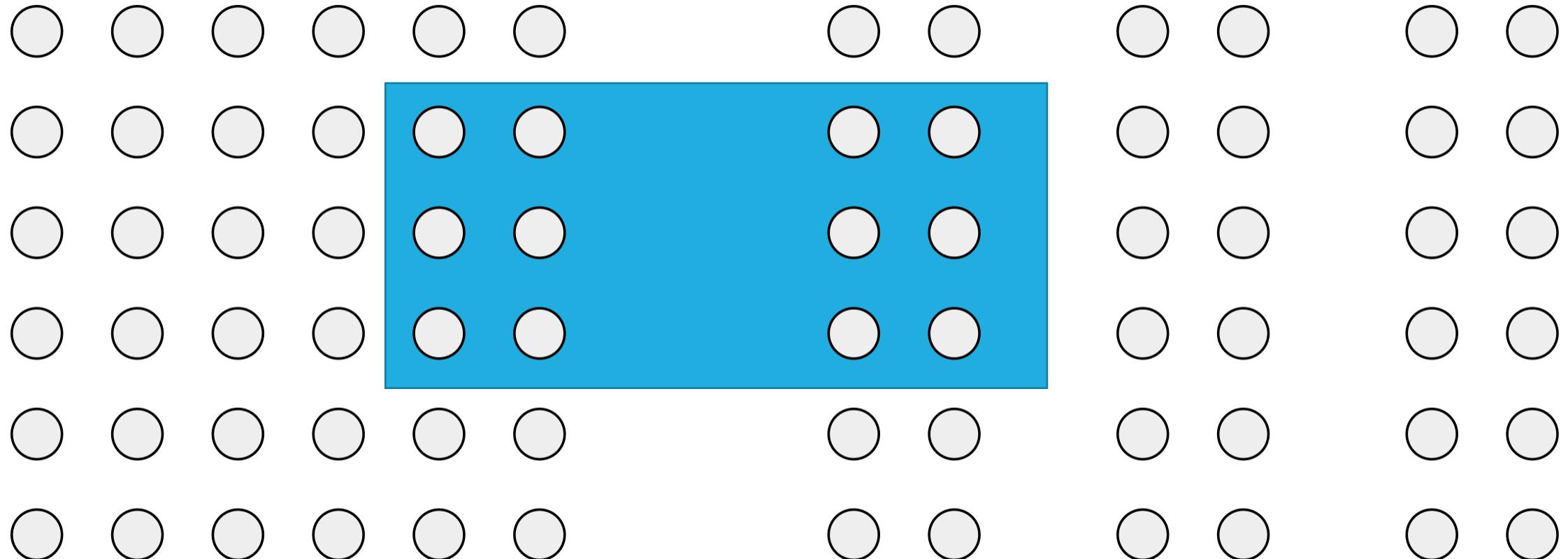
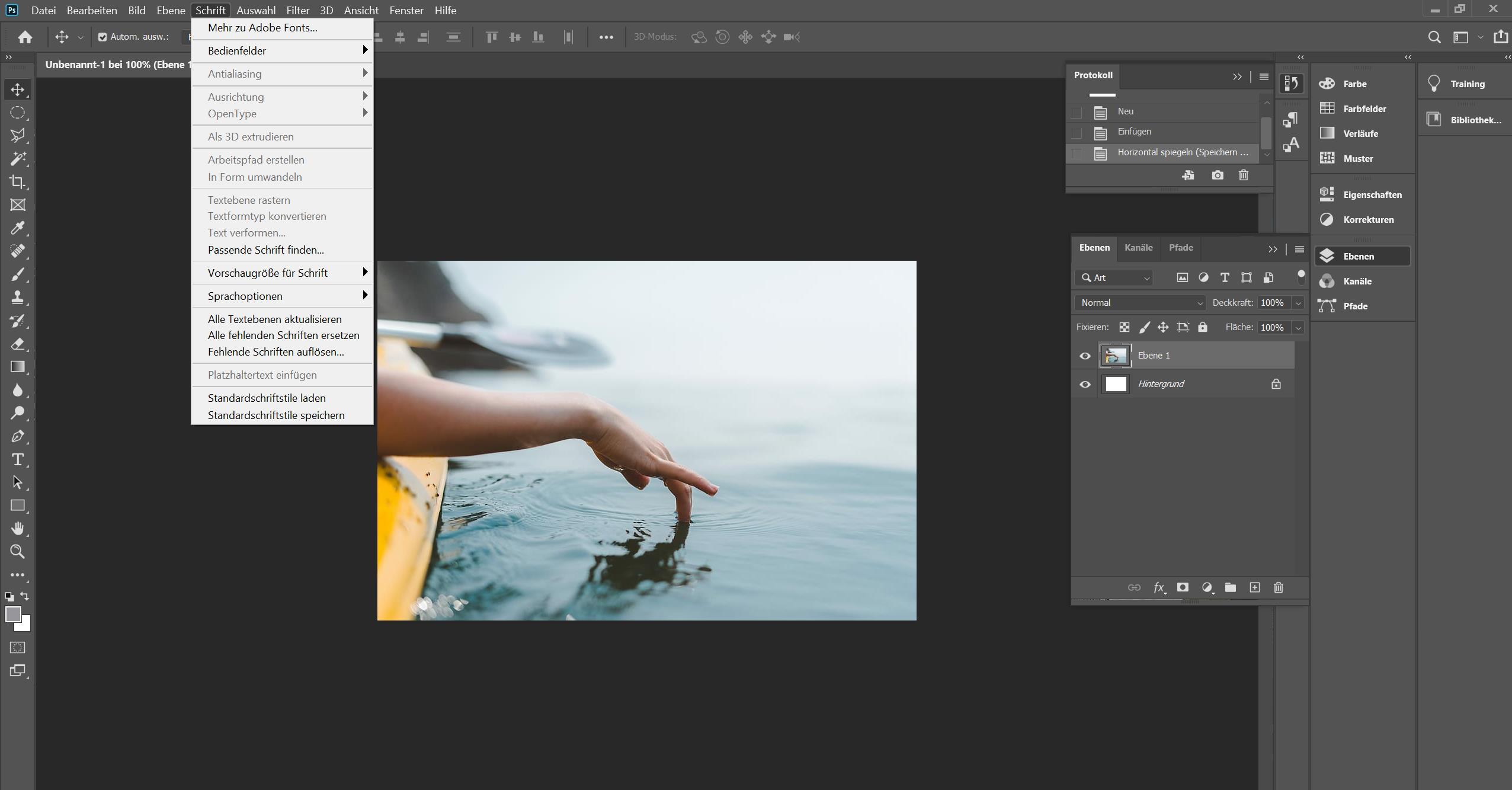
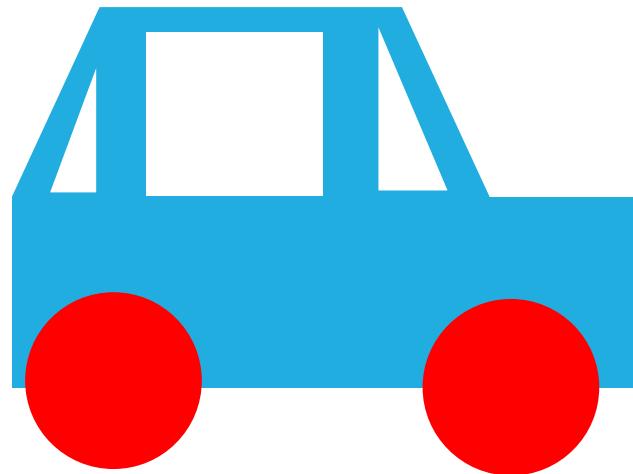


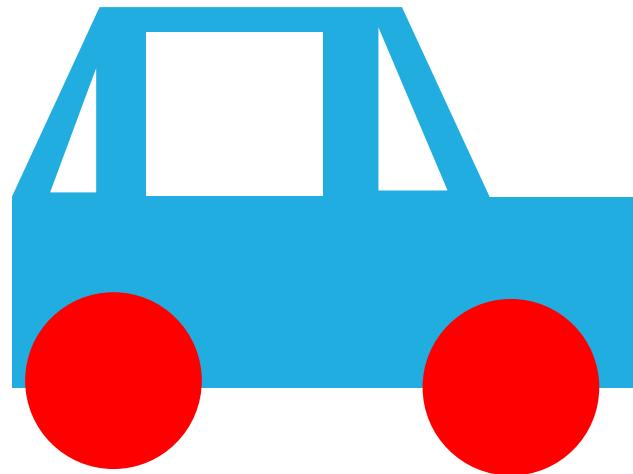
Image Source <https://upload.wikimedia.org/wikipedia/commons/d/d7/Lawofcommonfate.jpg> by BE12M



# Concurrency



# Concurrency



# Concurrency

Image Source <https://en.wikipedia.org/wiki/Animation#/media/File:Animhorse.gif> by Janke

# Connectivity

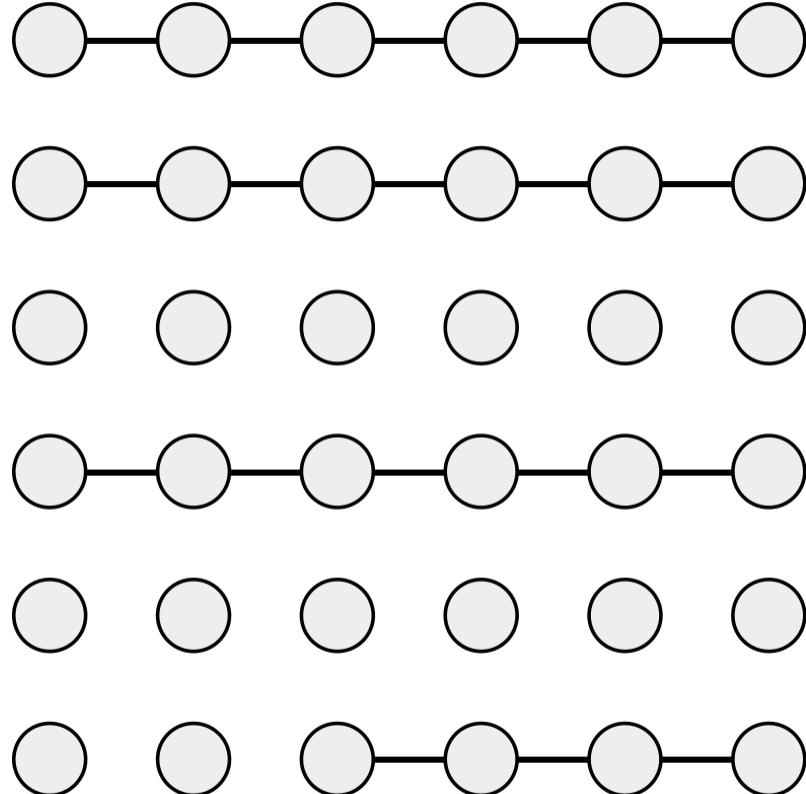
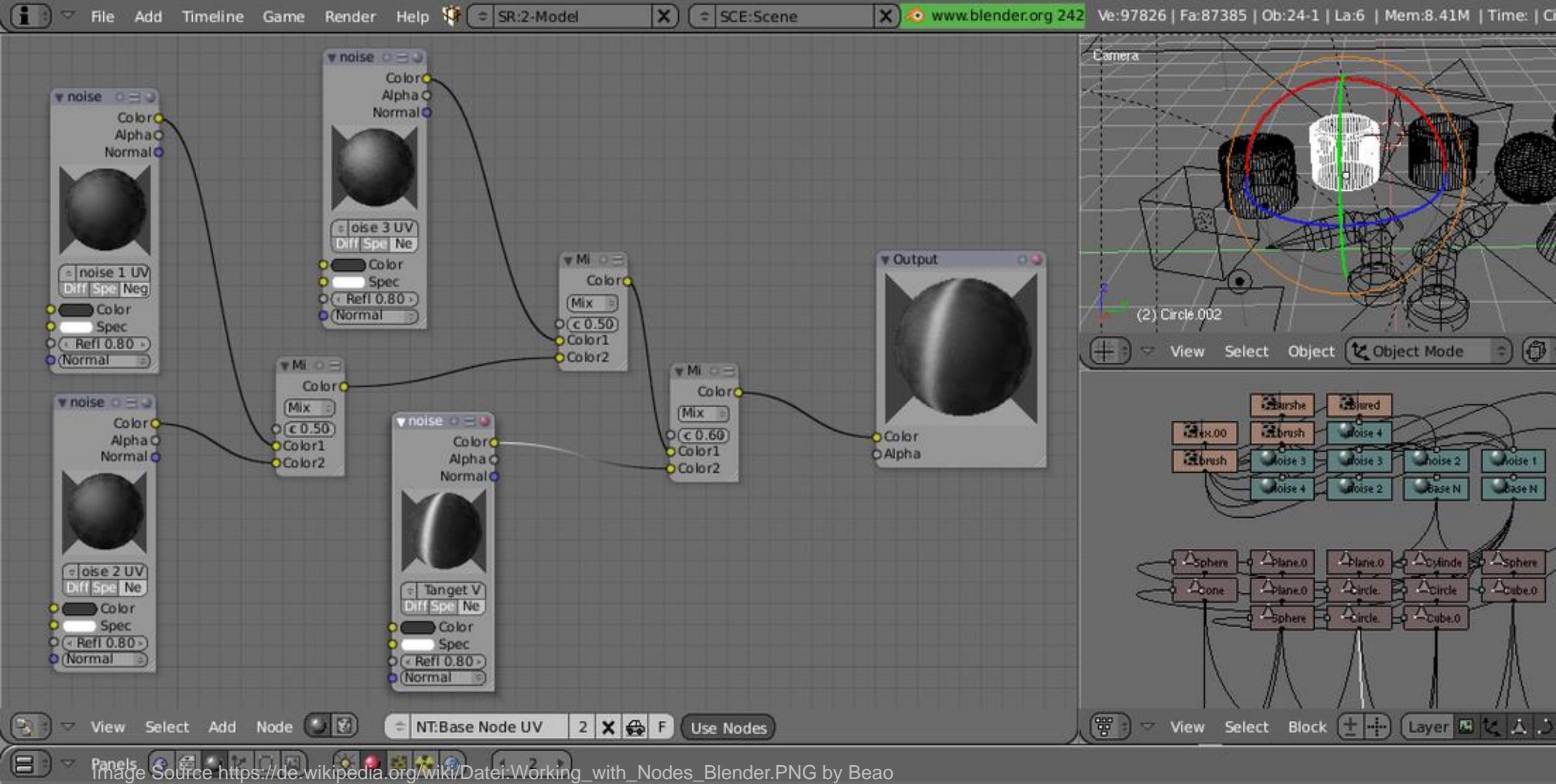


Image Source [https://commons.wikimedia.org/wiki/File:Gestalt\\_proximity.svg](https://commons.wikimedia.org/wiki/File:Gestalt_proximity.svg) by Cmglee



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# Hearing

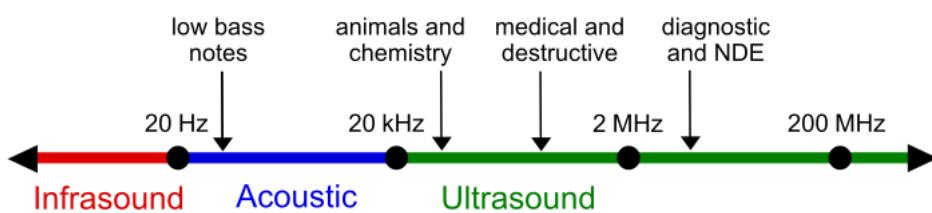
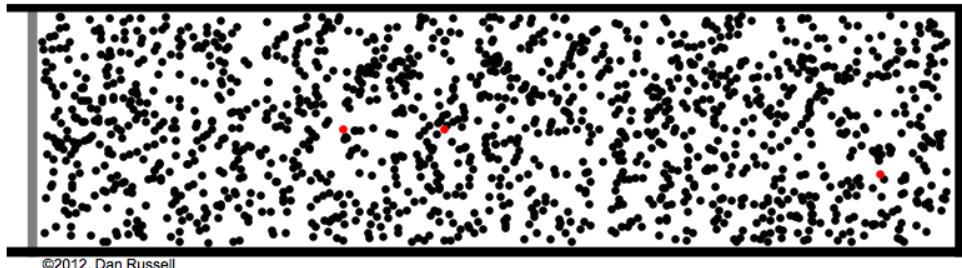
Image <https://pxhere.com/en/photo/1428401> by mbpogue



# Learning Goals

- Sound
- The ear
- Spatial hearing
- Sound filtering

# Sound

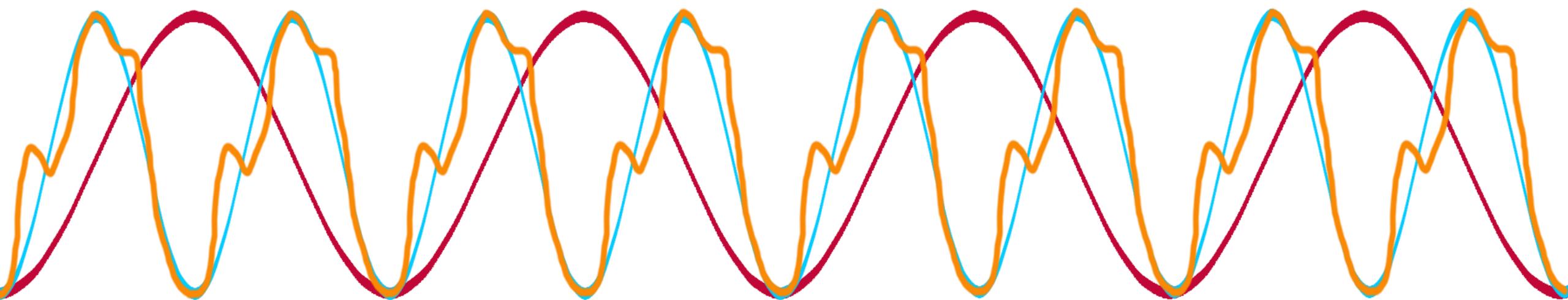


- Hearing: sensory perception of sound
- Sound: changes of air pressure in the perceivable frequency range

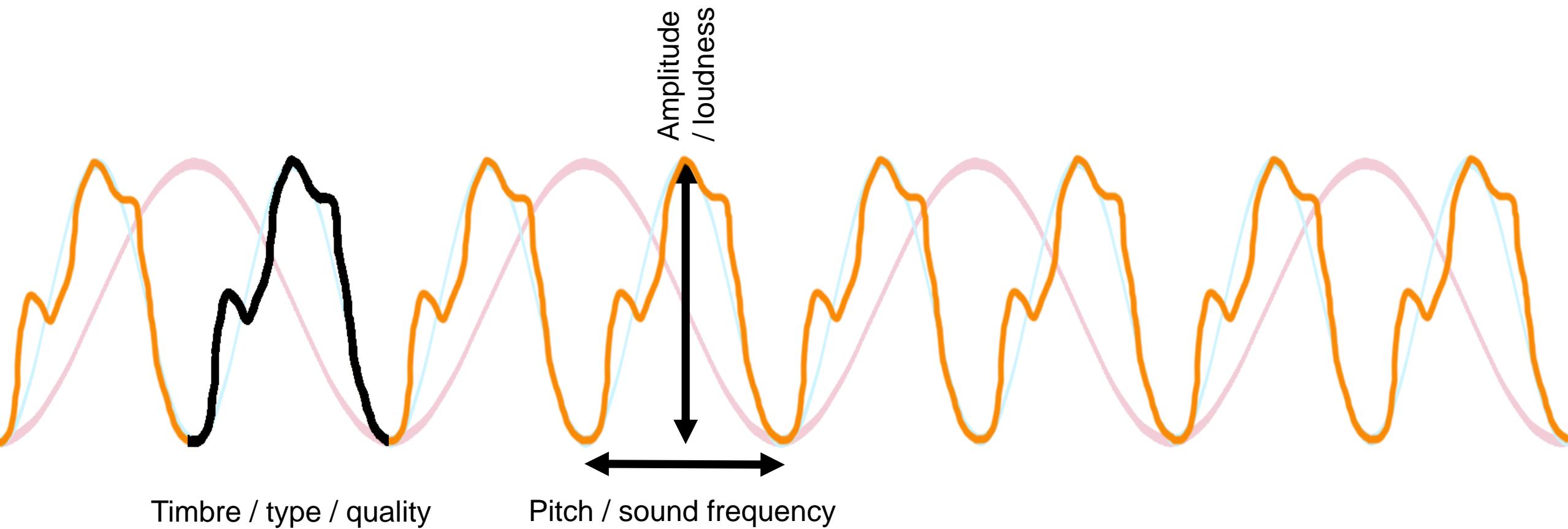
Image Source <https://commons.wikimedia.org/wiki/File:Standing.gif> by Daniel A. Russell & [https://commons.wikimedia.org/wiki/File:Ultrasound\\_range\\_diagram.svg](https://commons.wikimedia.org/wiki/File:Ultrasound_range_diagram.svg) by Mikhail Ryazanov

# Sound

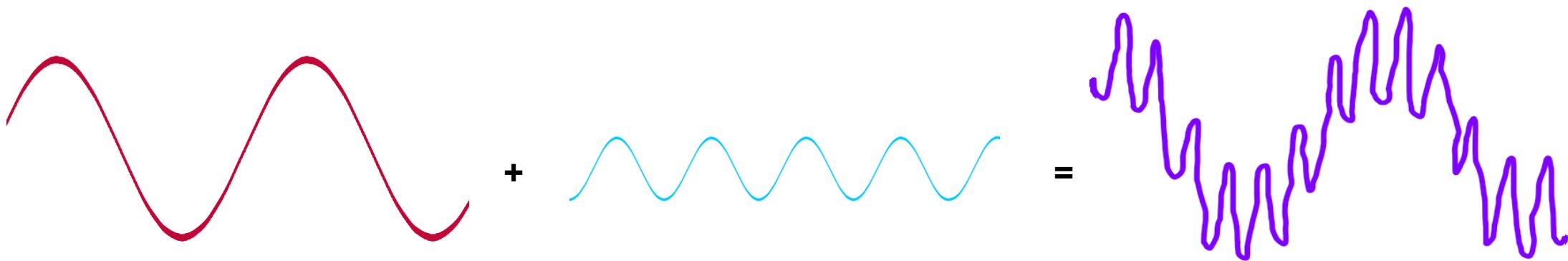
- C note 220Hz



# Sound



# Sound



# Sound

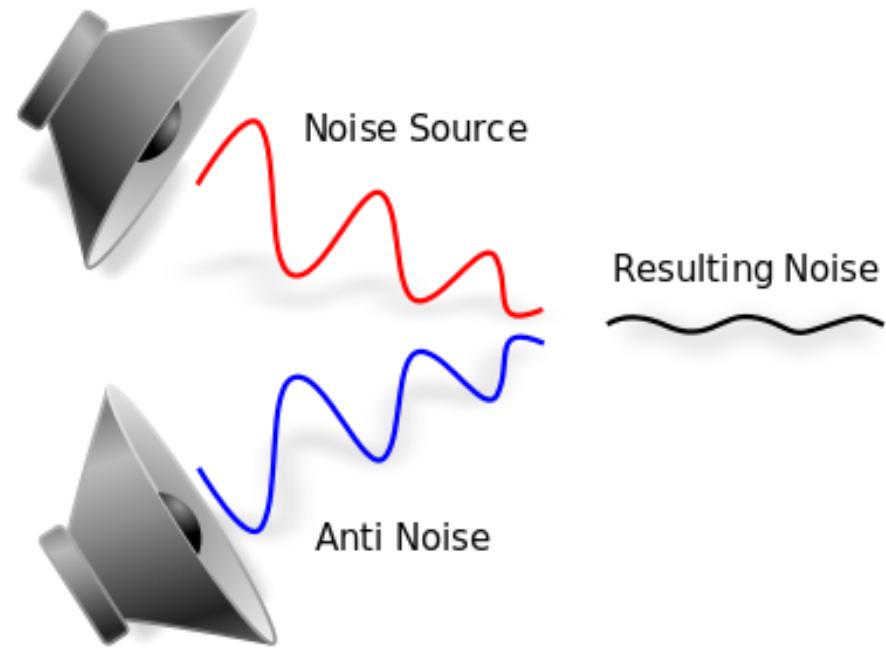
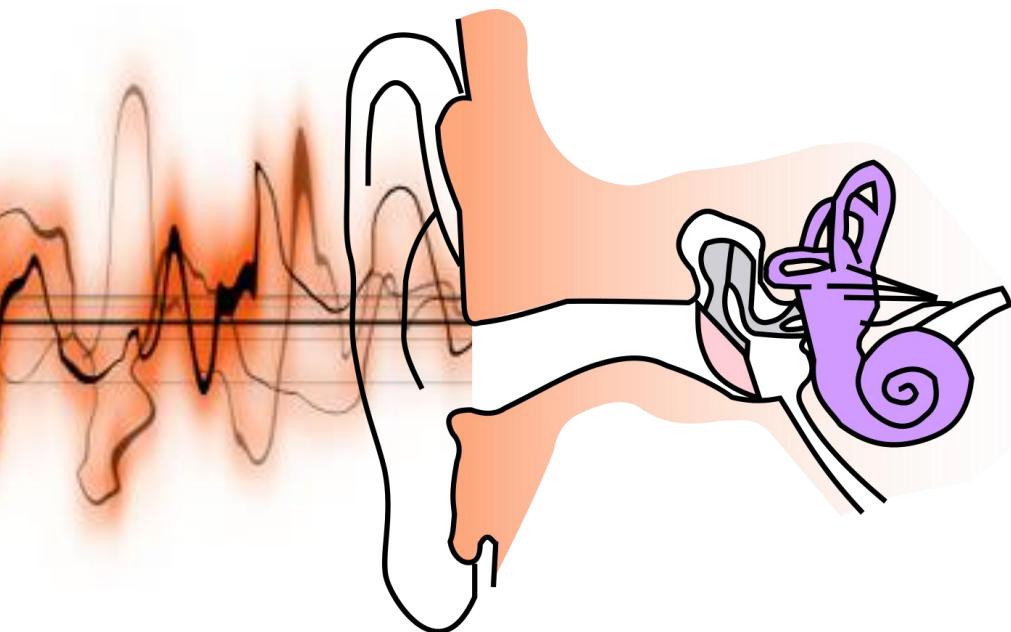


Image Source [https://commons.wikimedia.org/wiki/File:Active\\_Noise\\_Reduction.svg](https://commons.wikimedia.org/wiki/File:Active_Noise_Reduction.svg) by Marekich



Image Source <https://pixnio.com/de/media/schwarz-und-weis-ohr-brillen-hut-altmodisch>

# The ear



- outer ear: protects inner ear & amplifies sound
- middle ear: transmits sound waves as vibrations to inner-ear
- inner ear: chemical transmitters are released and cause impulses in auditory nerve

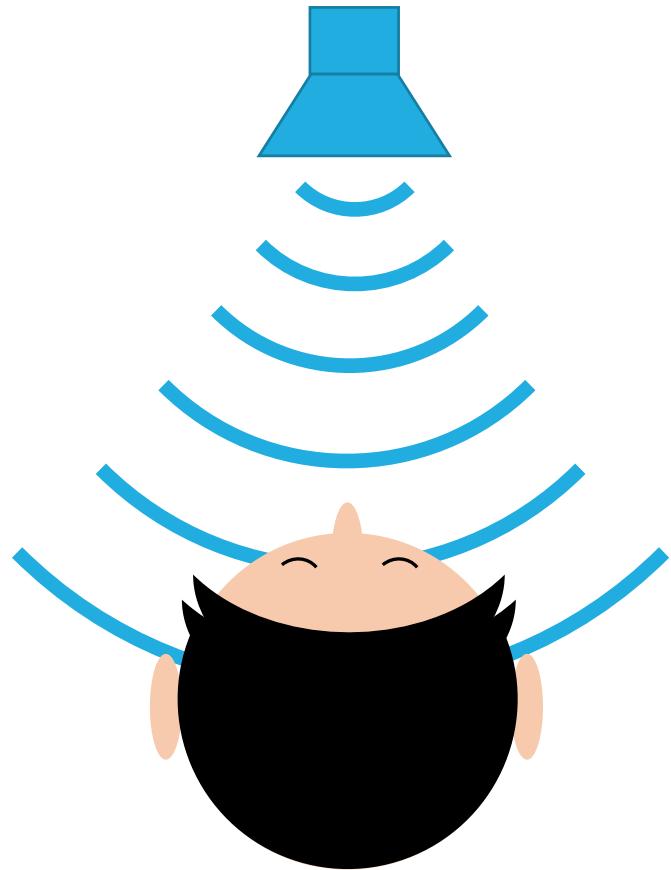
Image Source <https://de.wikipedia.org/wiki/Datei:Ear-anatomy-notext-small.svg> by Surachit



Image <https://www.pexels.com/photo/crowded-street-with-cars-passing-by-708764/> by suzukii xingfu

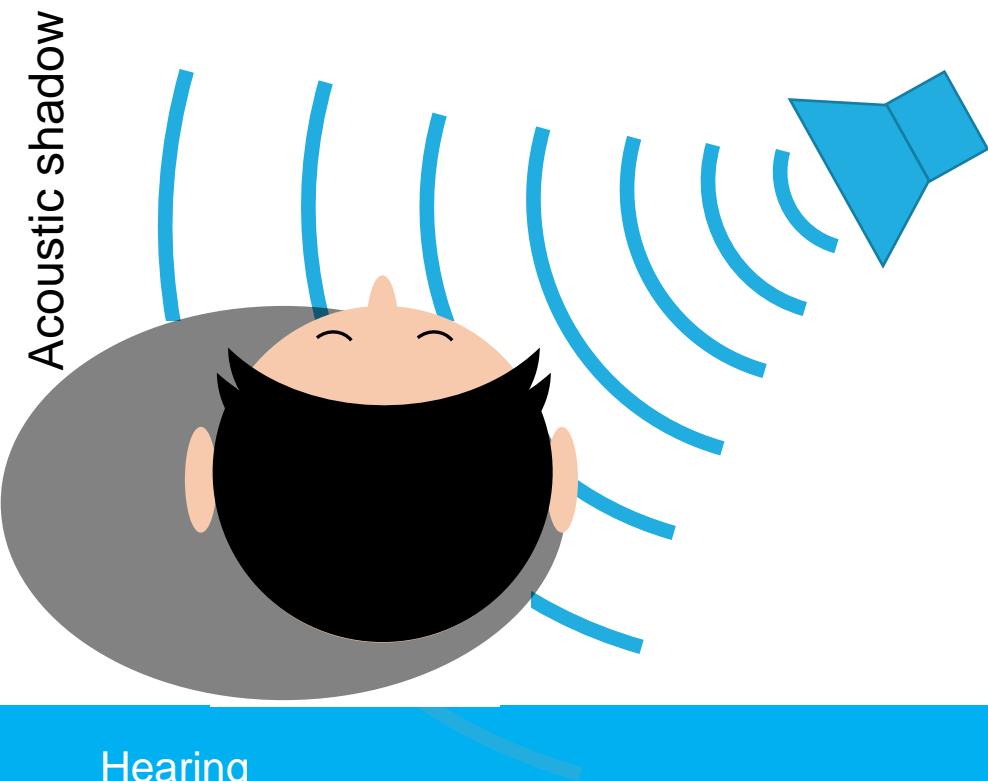
- Information about the environment
- Type of sound source
- Distance and direction through spatial hearing

# Spatial Hearing



- Time:  
equal
- Amplitude:  
equal
- Sound wave form:  
equal

# Spatial Hearing



- Interaural time difference (ITD)
- Interaural intensity difference (IID)
- Head related transfer function (HRTF)
- Works better for high frequencies

# Head related transfer function

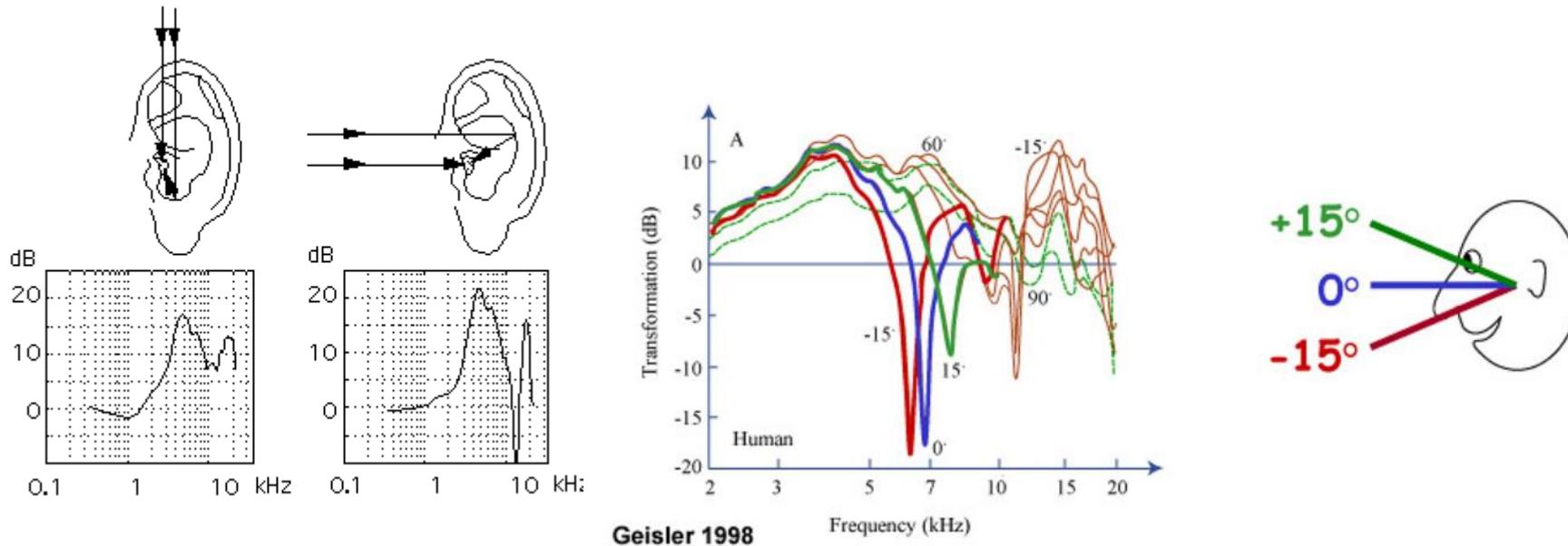


Image Source <https://upload.wikimedia.org/wikipedia/commons/1/19/Binaural.gif> by T.A.V. Multimedia. Andreu & Vila & <https://www.flickr.com/photos/mitopencourseware/4809307652> by MIT OpenCourseWare



Image Source [https://upload.wikimedia.org/wikipedia/commons/4/48/Georg\\_Neumann\\_Ku\\_100\\_Dummy\\_Head.jpg](https://upload.wikimedia.org/wikipedia/commons/4/48/Georg_Neumann_Ku_100_Dummy_Head.jpg) by EJ Posselius



Image Source <https://www.pexels.com/de-de/foto/20-25-jahre-alt-cocktail-stunde-cocktails-coole-party-2788687/> by Vanessa Pardo

# Auditory Information Filtering

- Examples:
  - Focusing on a conversation at a party
  - Listening in the neighbor conversations at a party
  - Recognizing when somebody speaks out your name
- The auditory system filters incoming information and allows selective hearing
  - Selectively hearing sound in environment with background noise
  - Spotting keyword, e.g. cocktail party phenomenon

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# Haptics

Image <https://www.wallpaperflare.com/person-touching-body-of-water-person-touching-body-of-water-during-daytime-wallpaper-zthoe>



# Learning Goals

- The somatosensory system
- Haptics
- Applications in HCI

# Somatosensory System

- informs us about objects in our external environment through touch and about the position and movement of our body parts through the stimulation of muscle and joints.

Patrick Dougherty, Department of Anesthesiology and Pain Medicine, MD Anderson Cancer Center  
(content provided by Chieyeko Tsuchitani), <https://nba.uth.tmc.edu/neuroscience/m/s2/chapter02.html>



# Touch

Image Source <https://www.flickr.com/photos/bpprice/14862350066> by brando



## Proprioception: movement (kinesthetic)

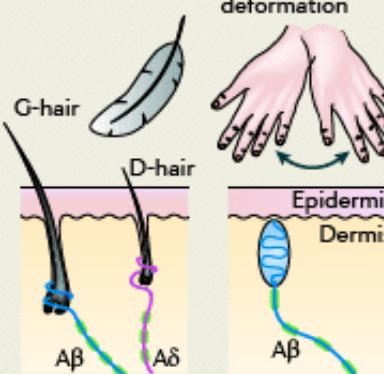
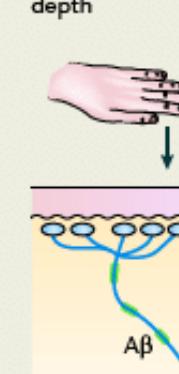
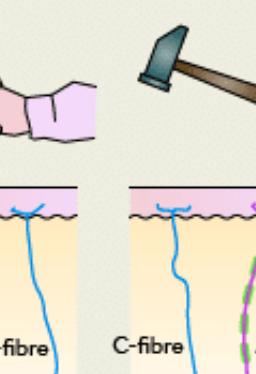
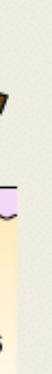
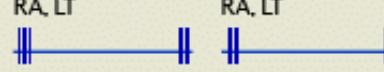
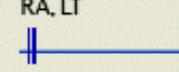
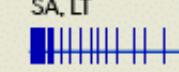
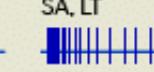
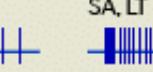
Image Source [https://de.wikipedia.org/wiki/Datei:Running\\_Man\\_Kyle\\_Cassidy.jpg](https://de.wikipedia.org/wiki/Datei:Running_Man_Kyle_Cassidy.jpg) by Kyle Cassidy



# Proprioception: position

Image Source: <https://pixabay.com/de/photos/yoga-pose-asana-2959233/> by andiP

Modality	Sub Modality	Sub-sub Modality
Pain	sharp cutting pain	
	dull burning pain	
	deep aching pain	
Temperature	warm/hot	
	cool/cold	
Touch	itch/tickle & crude touch	
	discriminative touch	touch pressure flutter vibration
Proprioception	position: static forces	muscle length muscle tension joint pressure
		muscle length muscle tension
		joint pressure
		joint angle

Receptor subtype	Hair follicles	Meissner corpuscle	Pacinian corpuscle	Merkel cell-neurite complex	Ruffini corpuscle	C-fibre LTM	Mechano-nociceptor Polymodal nociceptor
Skin stimulus	Light brush	Dynamic deformation	Vibration	Indentation depth	Stretch	Touch	Injurious forces
							
Afferent response	RA, LT	RA, LT	RA, LT	SA, LT	SA, LT	SA, LT	SA, HT
Stimulus							
Receptive field							
Perceptual functions	Skin movement	Skin motion; detecting slipping objects	Vibratory cues transmitted by body contact when grasping an object	Fine tactile discrimination; form and texture perception	Skin stretch; direction of object motion, hand shape and finger position	Pleasant contact; social interaction	Skin injury; pain

Mechanoreceptors

RA/SA rapidly/slowly adapting; LT/HT low/high threshold

Suslak, Thomas. (2015). There and back again: a stretch receptor's tale. Thesis,  
[https://www.researchgate.net/publication/292449835\\_There\\_and\\_back\\_again\\_a\\_stretch\\_receptor's\\_tale](https://www.researchgate.net/publication/292449835_There_and_back_again_a_stretch_receptor's_tale)

# Somatosensory System

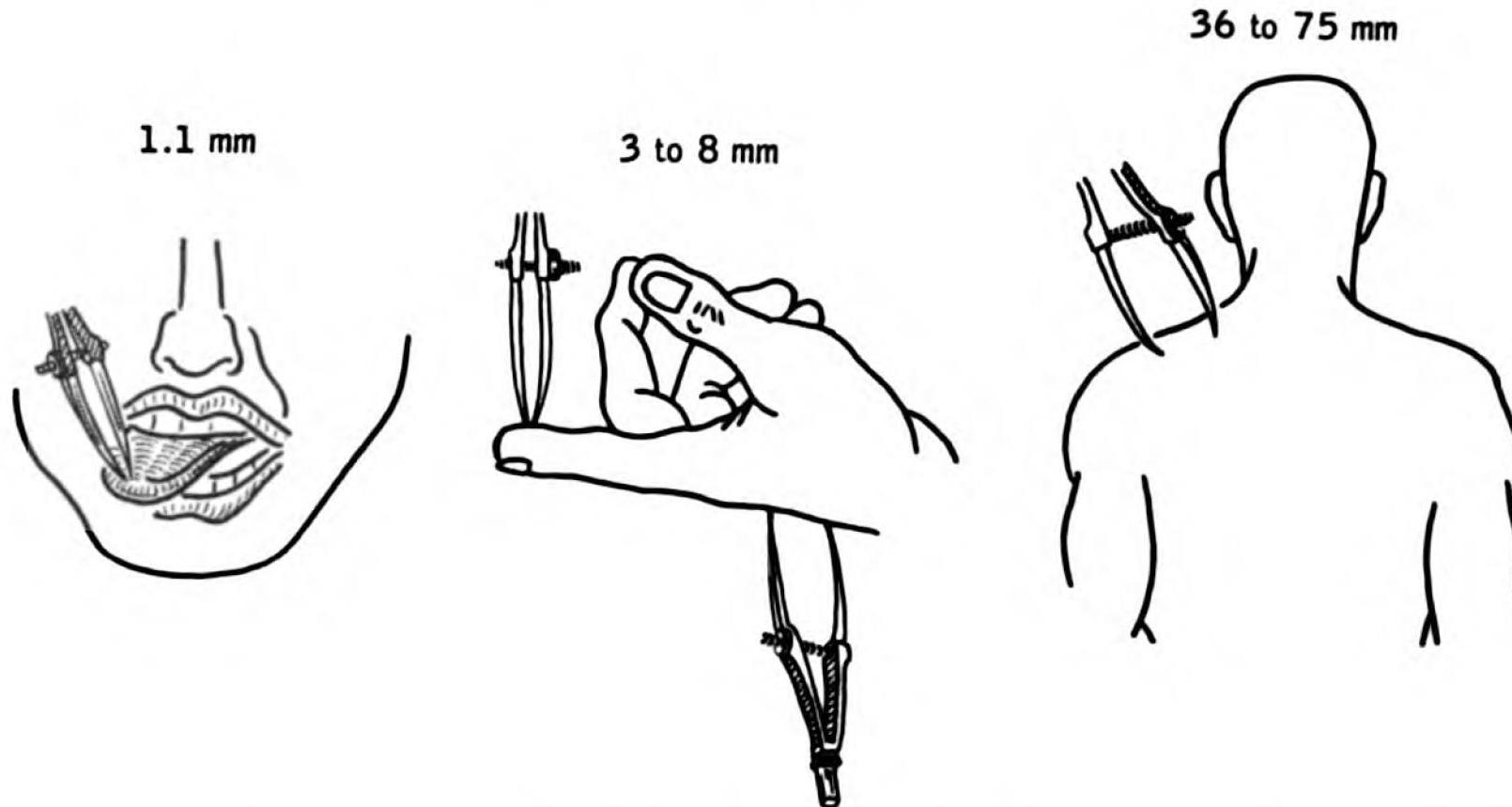


Image Source [https://en.wikipedia.org/wiki/Two-point\\_discrimination#/media/File:Lawrence\\_1960\\_8.11.png](https://en.wikipedia.org/wiki/Two-point_discrimination#/media/File:Lawrence_1960_8.11.png) by House, Earl Lawrence. Pansky, Ben. - A functional approach to neuroanatomy 1960

# Somatosensory System

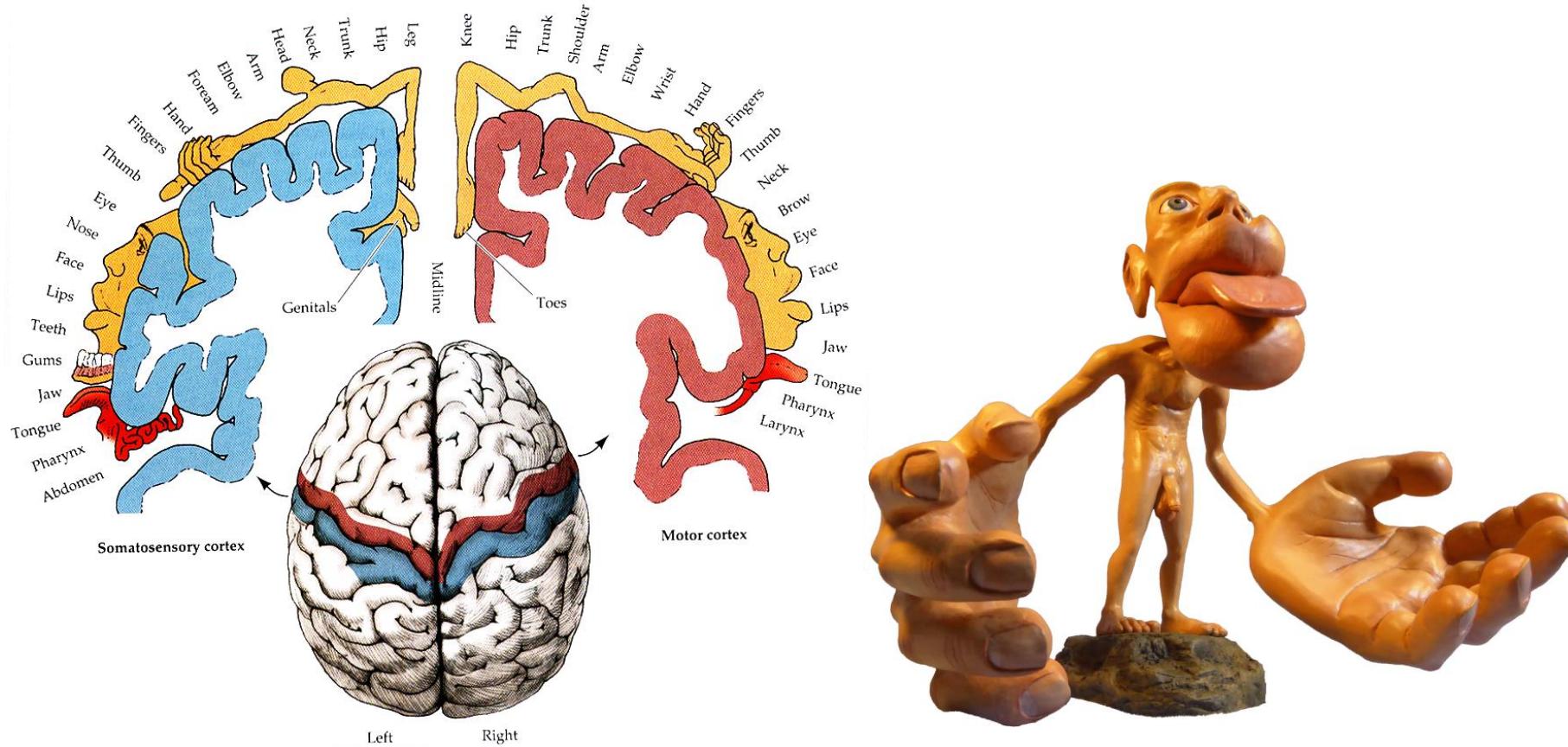


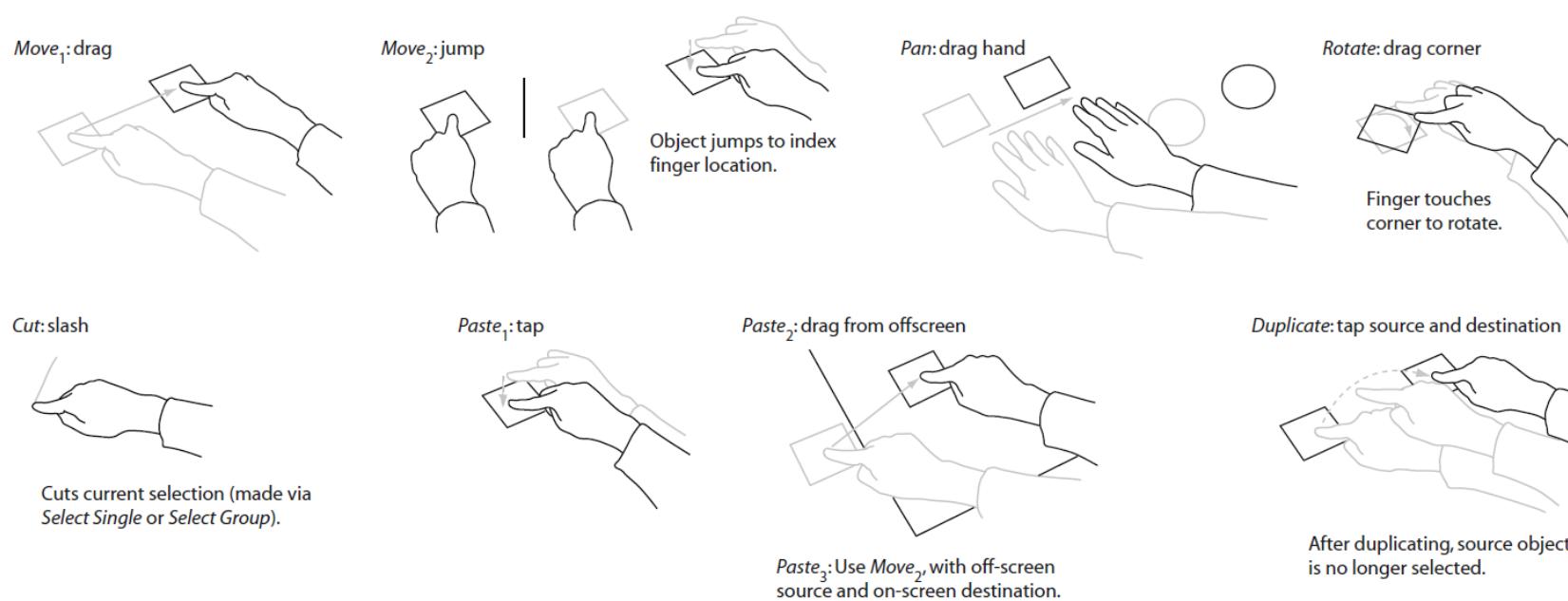
Image adapted from <https://www.flickr.com/photos/46006858@N05/8641421501> by Gary Kirwan & [https://en.wikipedia.org/wiki/Cortical\\_homunculus#/media/File:Front\\_of\\_Sensory\\_Homunculus.gif](https://en.wikipedia.org/wiki/Cortical_homunculus#/media/File:Front_of_Sensory_Homunculus.gif) by Mpj29

# Haptics

- Haptic perception: active exploration of surfaces and objects by a moving subject, as opposed to passive contact by a static subject during *tactile perception*.<sup>1</sup>
- Haptic technology: creates an experience of touch by applying forces, vibrations, or motions to the user.<sup>2</sup>

<sup>1</sup> Weber, E. H. (1851). Die Lehre vom Tastsinne und Gemeingefühle auf Versuche gegründet. Friedrich Vieweg und Sohn | <sup>2</sup> Gabriel Robles-De-La-Torre. "International Society for Haptics: Haptic technology, an animated explanation". Isfh.org. Archived from the original on 2010-03-07

# Haptics in HCI



Jacob O. Wobbrock, Meredith Ringel Morris, and Andrew D. Wilson. 2009. User-defined gestures for surface computing. CHI '09

# Haptics in HCI



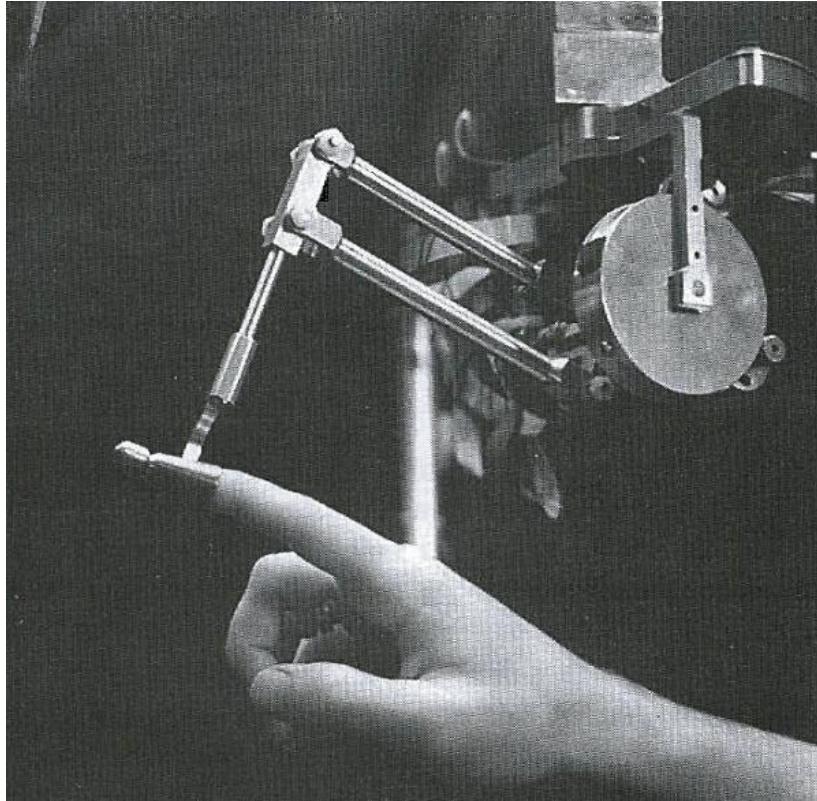
Image Source <https://www.needpix.com/photo/1005794/mobile-phone-smartphone-mobile-phone-phone-icon-to-call-screen-phone-call-call> by ElisaRiva

# Haptics in HCI

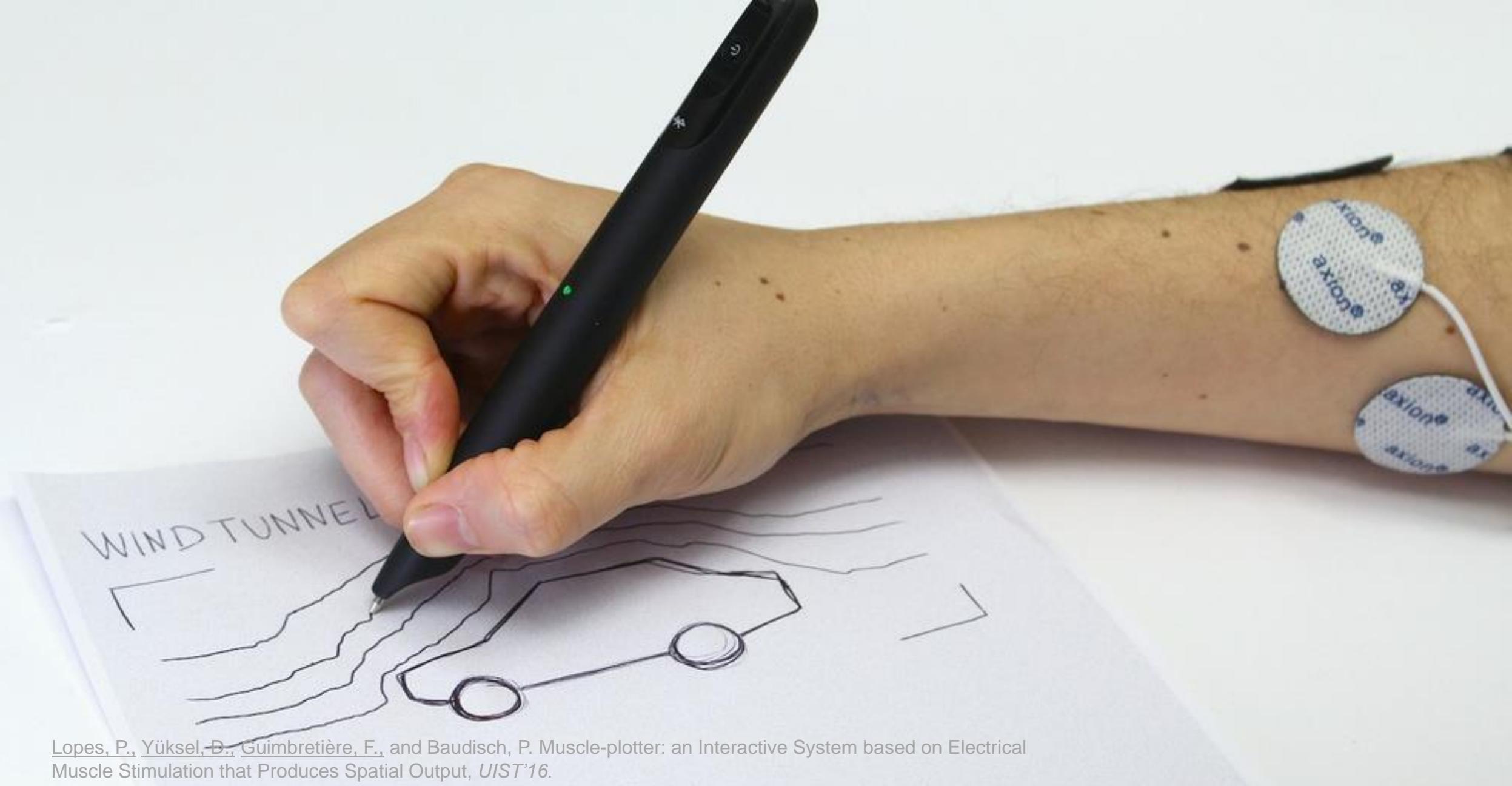


Image Source Raphael Wimmer and Sebastian Boring. 2009. HandSense: discriminating different ways of grasping and holding a tangible user interface. TEI '09

# Haptics in HCI

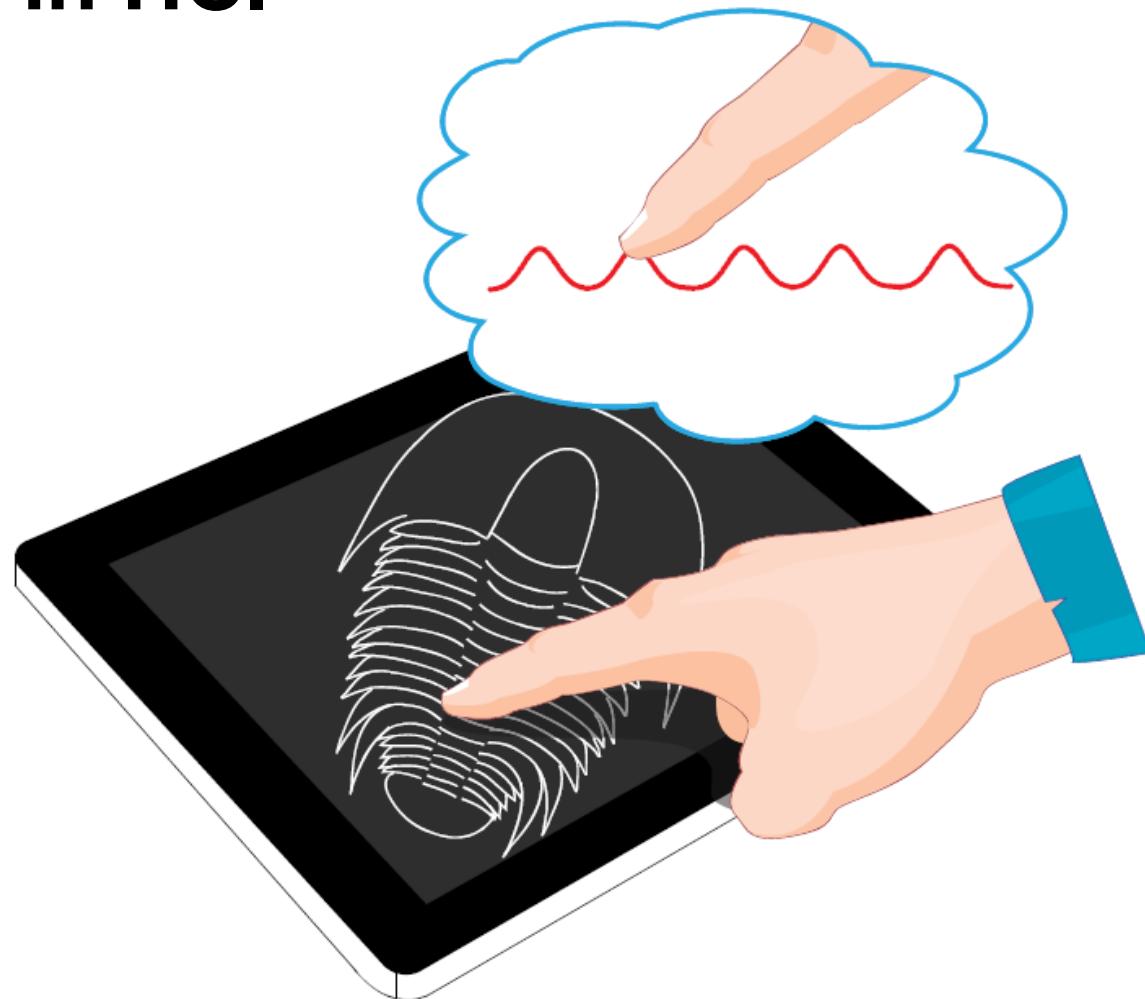


Massie, T. H., & Salisbury, J. K. (1994, November). The phantom haptic interface: A device for probing virtual objects. In *Proceedings of the ASME winter annual meeting, symposium on haptic interfaces for virtual environment and teleoperator systems* (Vol. 55, No. 1, pp. 295-300).



Lopes, P., Yüksel, D., Guimbretière, F., and Baudisch, P. Muscle-plotter: an Interactive System based on Electrical Muscle Stimulation that Produces Spatial Output, *UIST'16*.

# Haptics in HCI



Seung-Chan Kim, Ali Israr, and Ivan Poupyrev. 2013. Tactile rendering of 3D features on touch surfaces. UIST '13



Katrin Wolf and Timm Bäder: Illusion of Surface Changes induced by Tactile and Visual Touch Feedback. In CHI Extended Abstracts (CHI EA) 2015

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# Attention & Memory

Image <https://www.piqsels.com/de/public-domain-photo-sdevi/download>



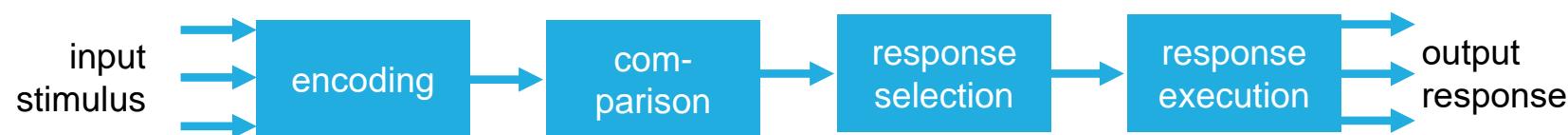
# Learning Goals

- Human Information Processing Model
- Attention
- Memory

# Human Information Processing

## Sequential four-stage process

- Encode stimulus received from the environment into an internal representation
- Compare the encoded stimulus with stored / memorized representation
- Formulate / select a response to received and encoded stimulus
- Act on the stimulus and execute the response

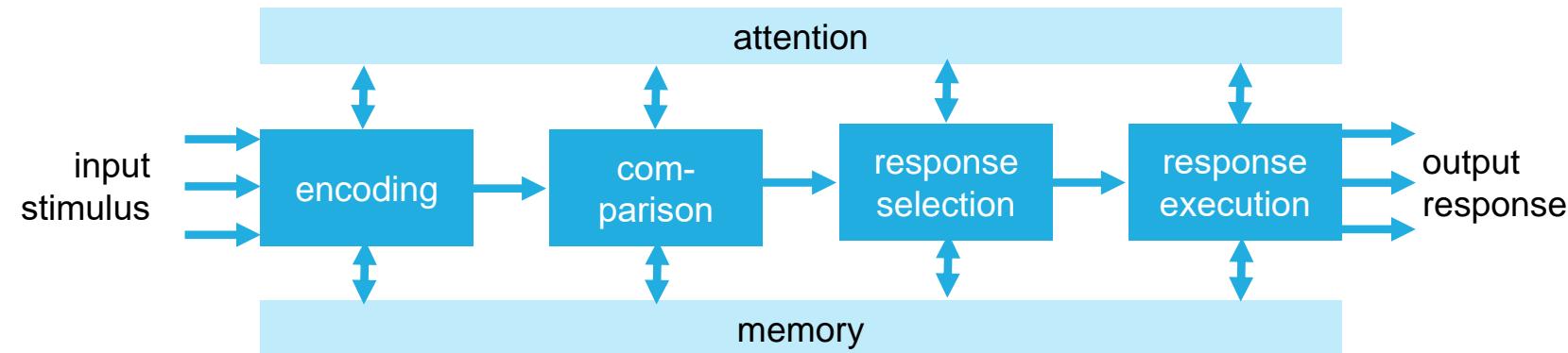


Lindsay, P.H. and Norman, D.A. (1977). Human Information Processing: An Introduction to Psychology, 2nd edition. New York: Academic Press. Source (text, image): <http://web.cs.dal.ca/~jamie/teach/NickGibbins/psych.html>

# Human Information Processing

## Extended four-stage process

- Attention and memory are relevant in all 4 stages



Barber, P (1988). Applied Cognitive Psychology. London: Methuen.

Source (text, image): <http://web.cs.dal.ca/~jamie/teach/NickGibbins/psych.html>

# Input: Information transmission rates

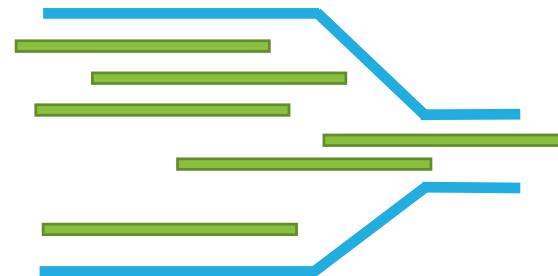
Sensory system	Bits per secons
Eyes	10,000,000
Skin	1,000,000
Ears	100,000
Smell	100,000
Taste	1,000

- Limited capacities for processing and saving information for cognition & memory
- No equal thresholds: inter- & intra-individual variance
- => Filtering attention & selecting information

<https://www.britannica.com/science/information-theory/Physiology>

# Attention

- = cognitive process of selectively concentrating on a sub-set of stimuli while ignoring other perceivable stimuli
- Broadbent's filter model of attention:
- all stimuli are processed initially for basic physical properties including
  - Color
  - Form
  - Motion (orientation response / reflex)
  - Pitch
  - Loudness
  - Direction (remember Cocktail Party Effect)



# Broadbent's filter model of attention

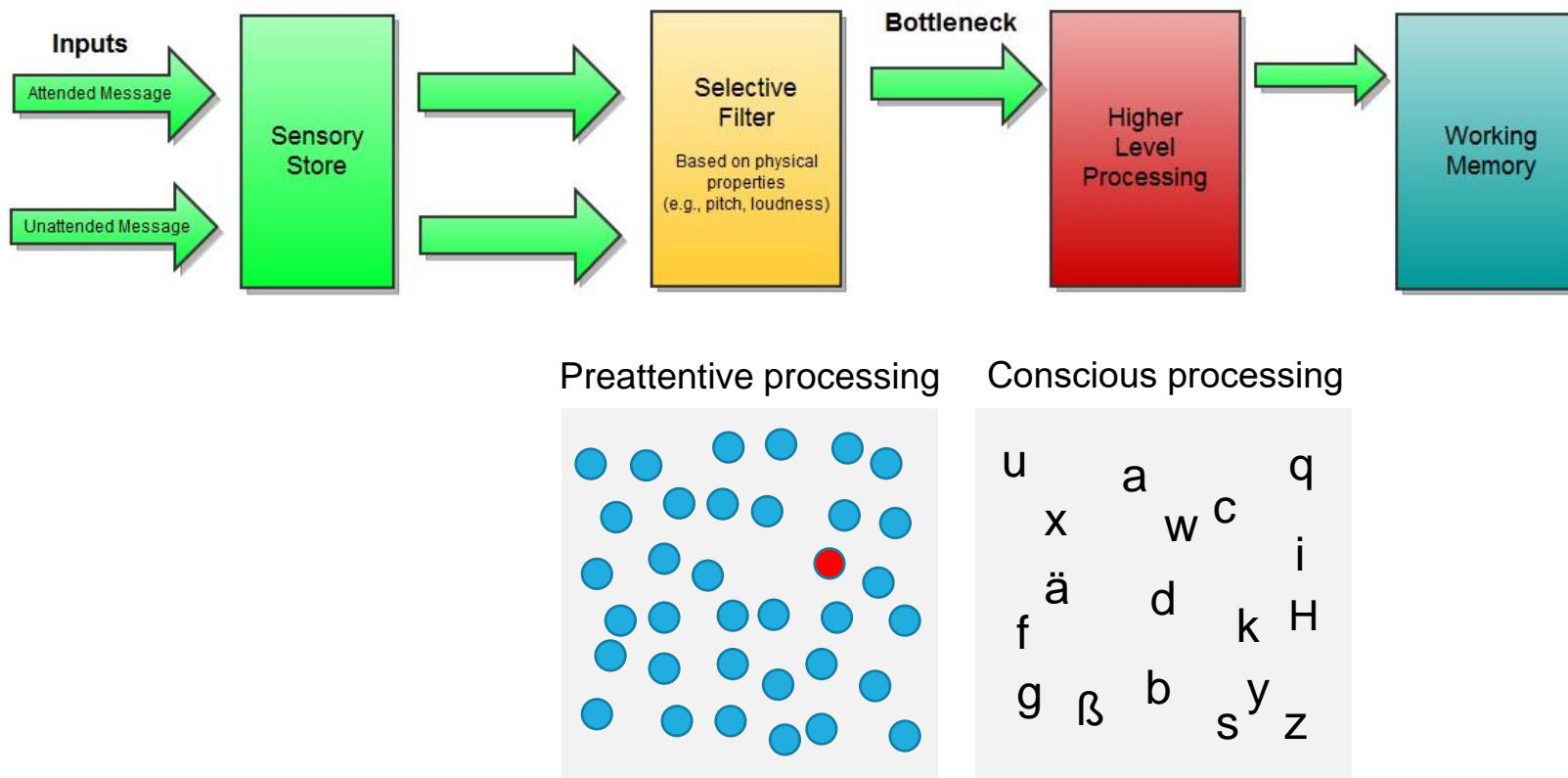


Image Sources [https://en.wikipedia.org/wiki/Broadbent%27s\\_filter\\_model\\_of\\_attention#/media/File:Broadbent\\_Filter\\_Model.jpg](https://en.wikipedia.org/wiki/Broadbent%27s_filter_model_of_attention#/media/File:Broadbent_Filter_Model.jpg) by Kyle.Farr

# Broadbent's filter model of attention

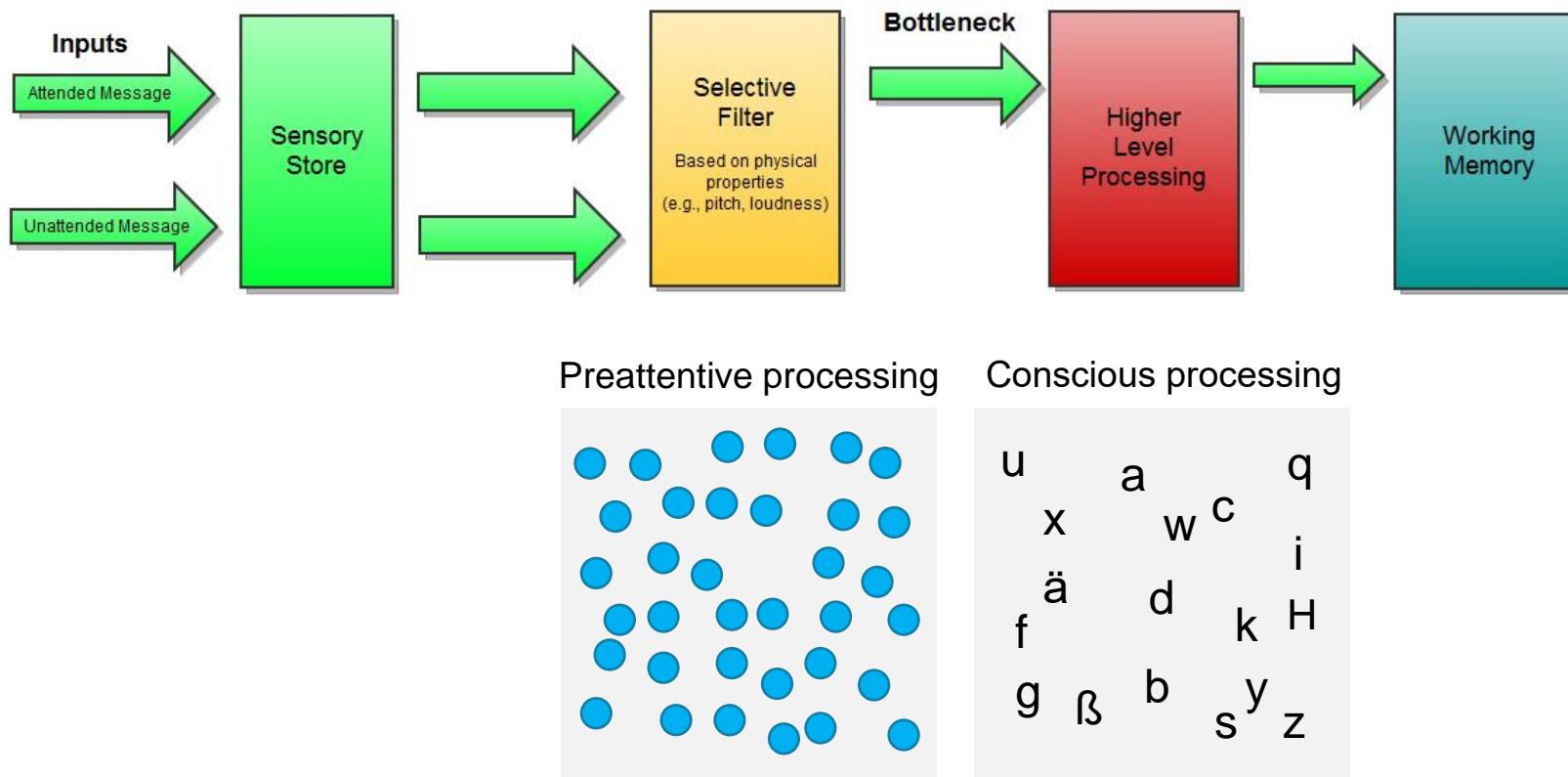


Image Sources [https://en.wikipedia.org/wiki/Broadbent%27s\\_filter\\_model\\_of\\_attention#/media/File:Broadbent\\_Filter\\_Model.jpg](https://en.wikipedia.org/wiki/Broadbent%27s_filter_model_of_attention#/media/File:Broadbent_Filter_Model.jpg) by Kyle.Farr

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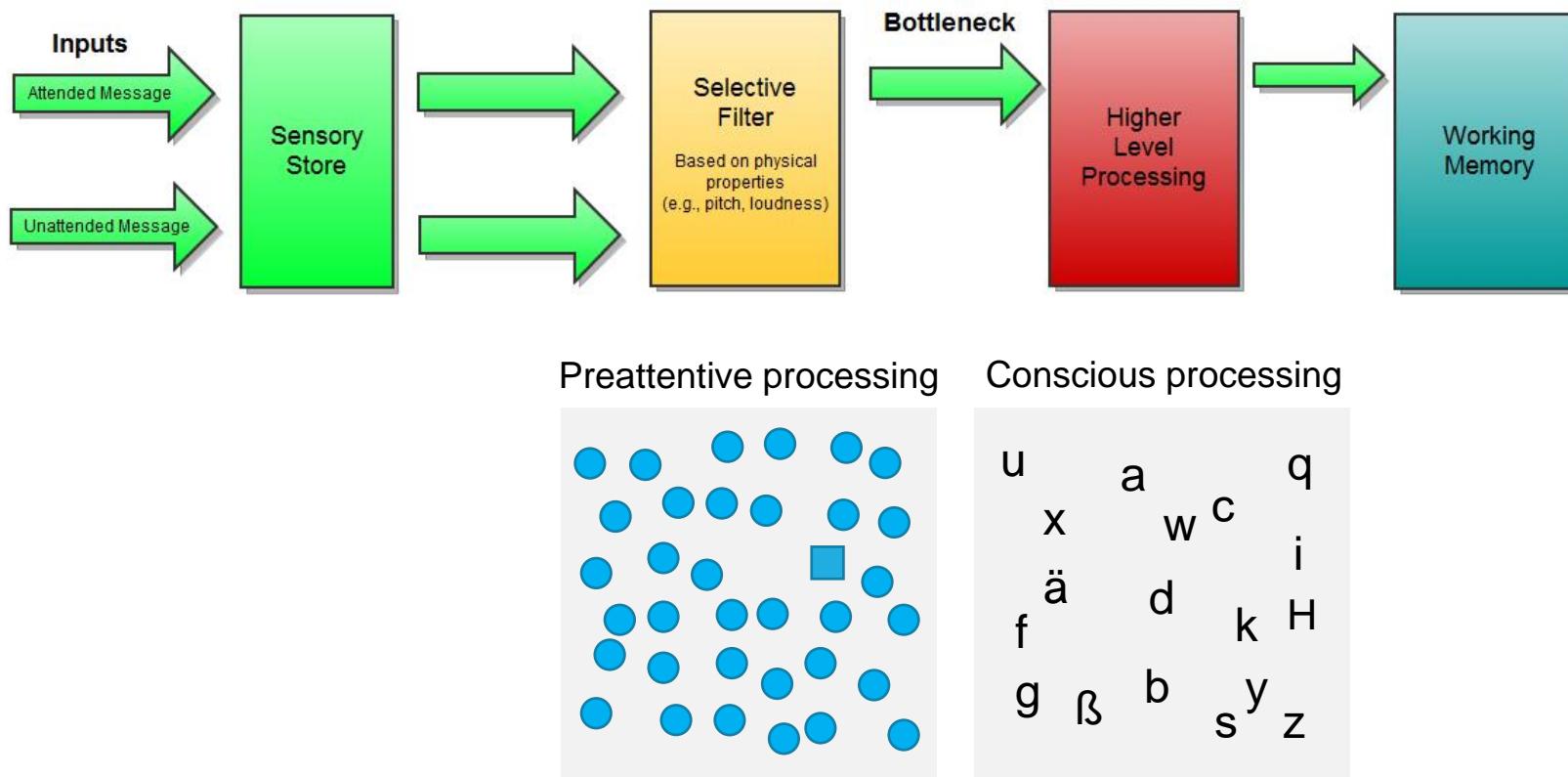


Image Sources [https://en.wikipedia.org/wiki/Broadbent%27s\\_filter\\_model\\_of\\_attention#/media/File:Broadbent\\_Filter\\_Model.jpg](https://en.wikipedia.org/wiki/Broadbent%27s_filter_model_of_attention#/media/File:Broadbent_Filter_Model.jpg) by Kyle.Farr



Image Source <https://www.pexels.com/de-de/foto/album-bilder-fotos-image-724644/>



# Memory

- Involves encoding and recalling knowledge and acting appropriately
- We don't remember everything - involves filtering and processing
- Context is important in affecting our memory
- We recognize things much better than being able to recall things
  - The rise of the GUI over command-based interfaces
- Better at remembering images than words
  - The use of icons rather than names

# Multi-Store Model for visual and oral perception

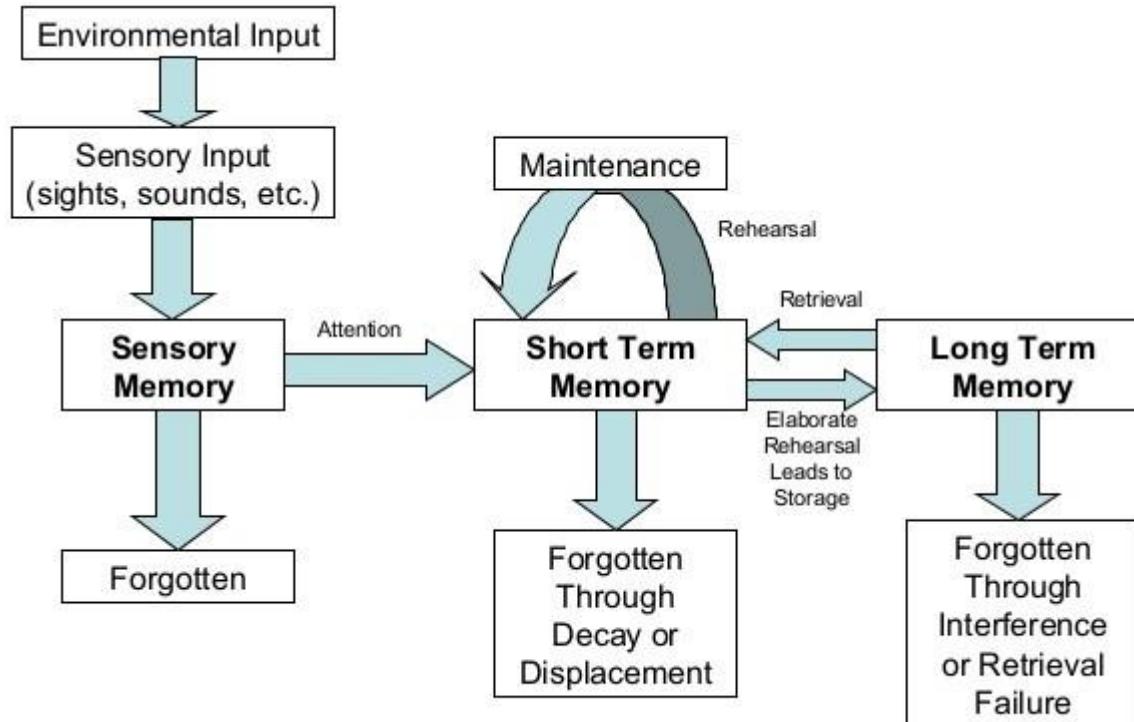
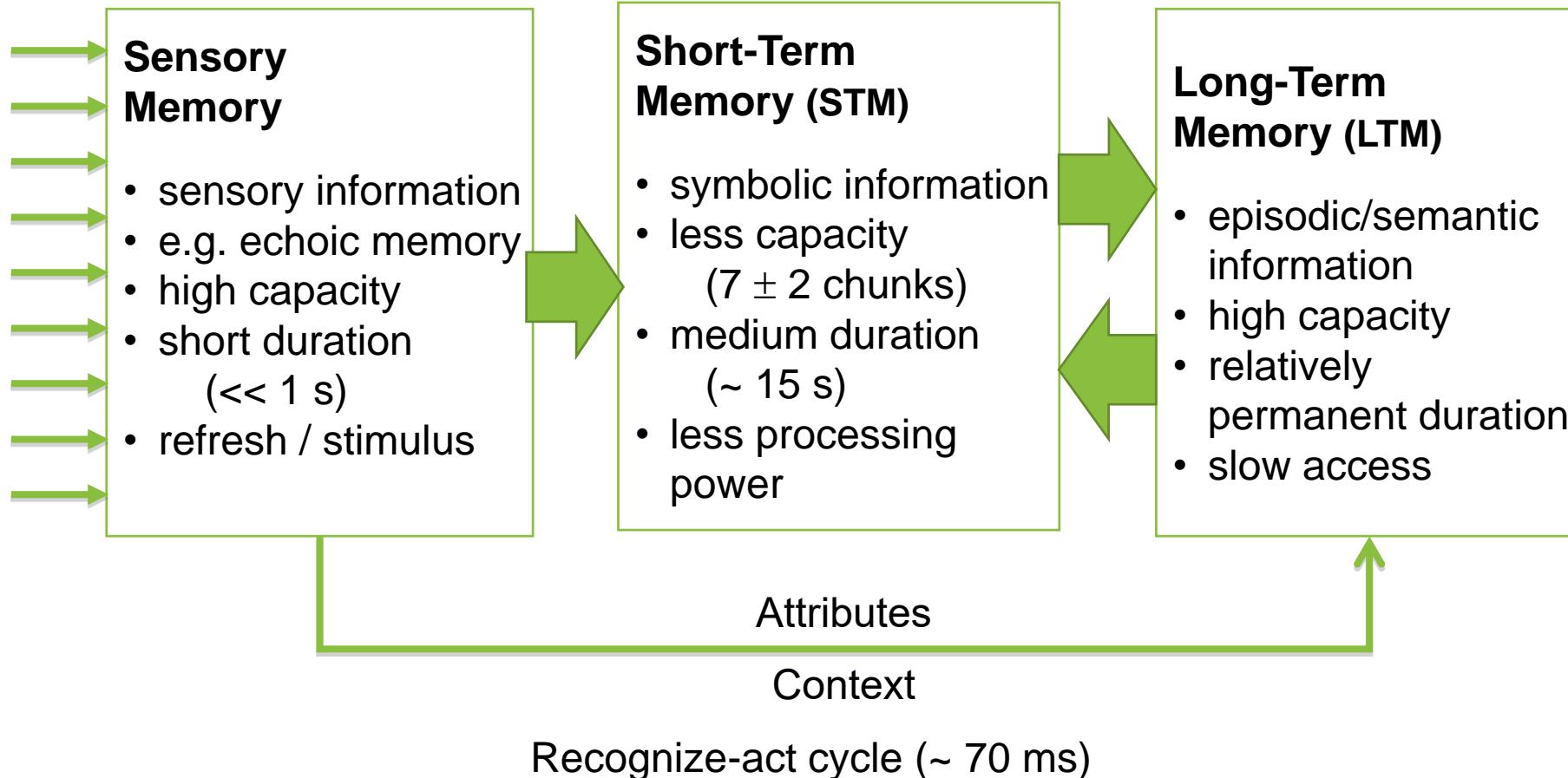


Image Source [https://en.wikipedia.org/wiki/Information\\_processing](https://en.wikipedia.org/wiki/Information_processing) adapted by Dkahng from Atkinson, R.C. and Shiffrin, R.M. (1968). 'Human memory: A Proposed System and its Control Processes'

# Multi-Store Model for visual and oral perception



# Memory: Short Term Memory (STM)

Mini exercise: watch & remember

Gesundbrunnen

Uooikpnjmн ztgtzgrт URK

782108673 876221 9912

Duobus litigantibus tertius  
gaudet

جامعة

человéк

# Memory: Short Term Memory (STM)

Mini exercise: recall

Gesundbrunnen

Uooikpnjmн ztgtzgrт URK

782108673 876221 9912

Duobus litigantibus tertius  
gaudet

جامعة

человéк

# The problem with the classic '7±2'

- People's immediate memory capacity is very limited
- In general you can remember 5-9 chunks
- Chunks can be letters, numbers, words, sentences, images
- ...  
...

221217891335

<http://www.well.com/user/smalin/miller.html> The Psychological Review, 1956, vol. 63, pp. 81-97

# The problem with the classic '7±2'

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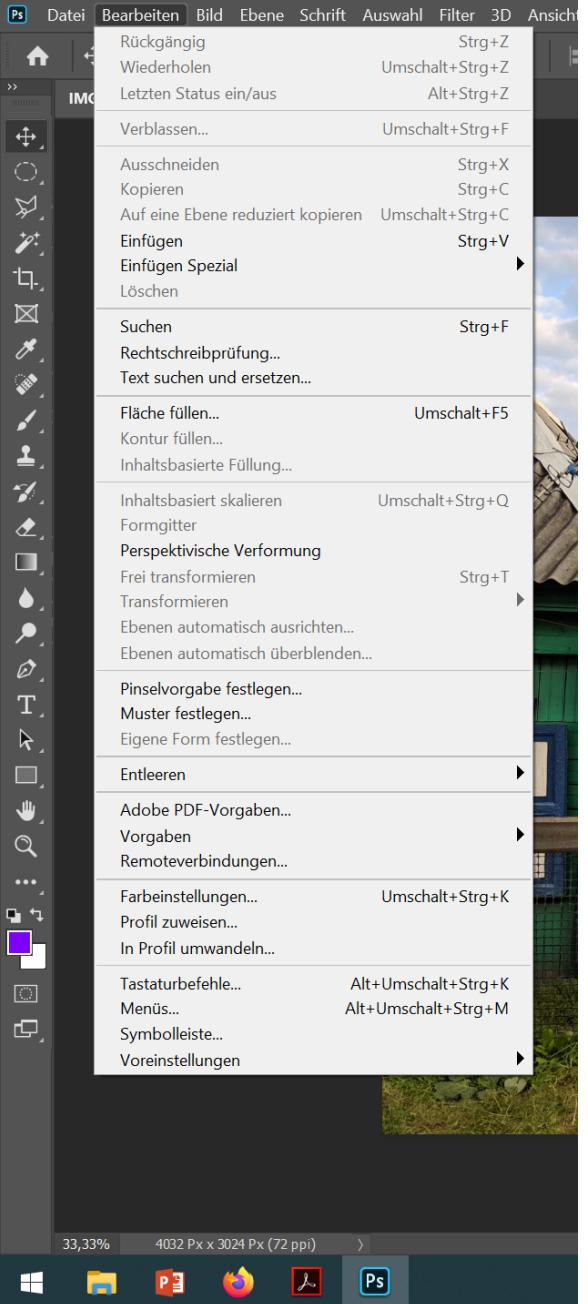


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Telefon: 030 4504-0  
E-Mail: [www\[at\]beuth-hochschule.de](mailto:www[at]beuth-hochschule.de)

Image Sources <https://pixabay.com/de/photos/frankreich-franz%C3%B6sische-revolution-63022/> & <https://www.needpix.com/photo/1867851/egyptian-girl-class-teenager-pretty-youth-smiling-children-female-cheerful>

# Wrong application of the theory

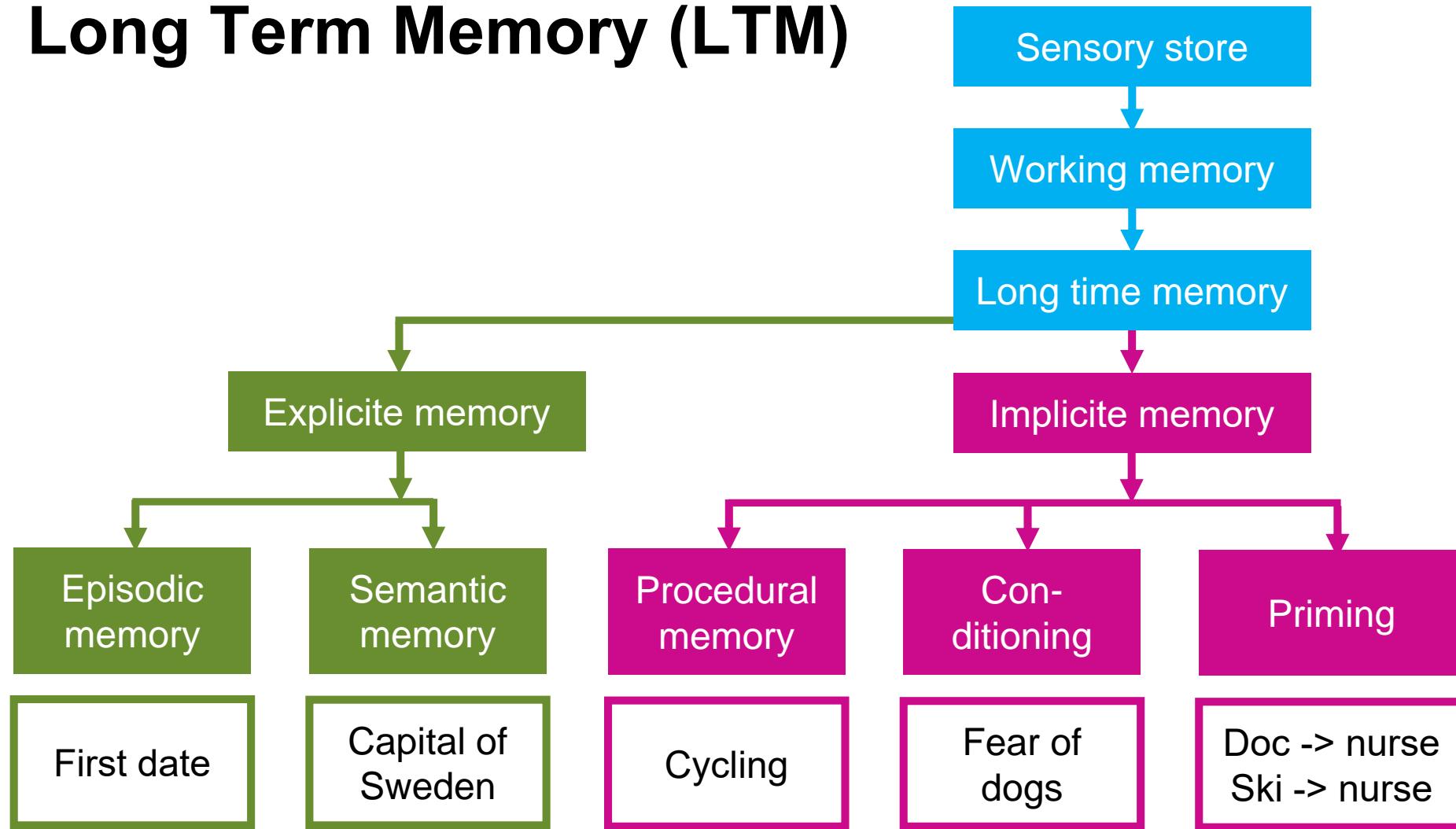
- Wrong interpretation
  - Present only 7 options on a menu
  - Display only 7 icons on a tool bar
  - Place only 7 items on a pull down menu
  - Place only 7 tabs on the top of a website page
- But why this is wrong?
  - Its about reading not recalling!
  - People can scan / read lists of bullets, tabs, menu items



# Resulting UI Guidelines

- Do not overload the STM
  - Use known symbols
  - Notes, menus, lists (WYSIWYG)
  - Grouping, chunks (complex super symbols)
  - Short, closed actions

# Long Term Memory (LTM)



# Long Term Memory (LTM)

- Loss of access instead of erasing (forgetting)
- Duration depends on the intensity and the quality of memorizing
- The following can train your LTM
  - Learning by repeated practicing
  - Active learning (learning by doing)
  - Illustrate and visualize words

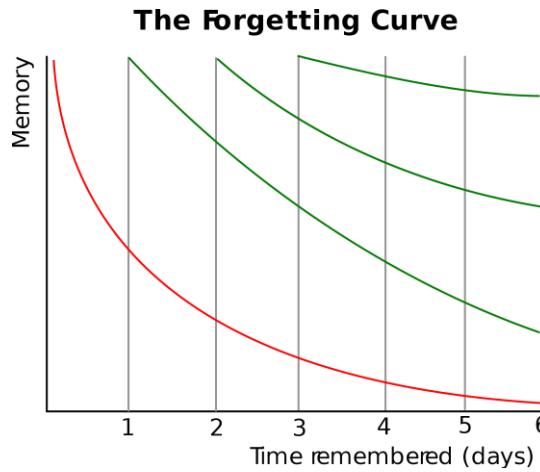


Image Source <https://de.wikipedia.org/wiki/Vergessenskurve#/media/Datei:ForgettingCurve.svg> by Icez

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# Cognitive Models of Human (Inter-)action

Image adapted from <https://www.flickr.com/photos/falequin/8443342362> by Freddie Alequin & <https://www.flickr.com/photos/pzado/16950126282> by Erik Araújo



# Learning Goals

- Model Human Processor
- Multiple Resource Theory

# Model Human Processor

- Very simple “model” of a human interacting with a computer
- The model describes the human as three sub-systems
  - Perceptual system (input: from the real world)
  - Motor system (output: manipulate the real world)
  - Cognitive system (connection between input and output, basic processing and memory)

Card, S.K; Moran, T. P; and Newell, A. *The Model Human Processor: An Engineering Model of Human Performance.* In K. R. Boff, L. Kaufman, & J. P. Thomas (Eds.), **Handbook of Perception and Human Performance.** Vol. 2: Cognitive Processes and Performance, 1986, pages 1–35.

# Model Human Processor

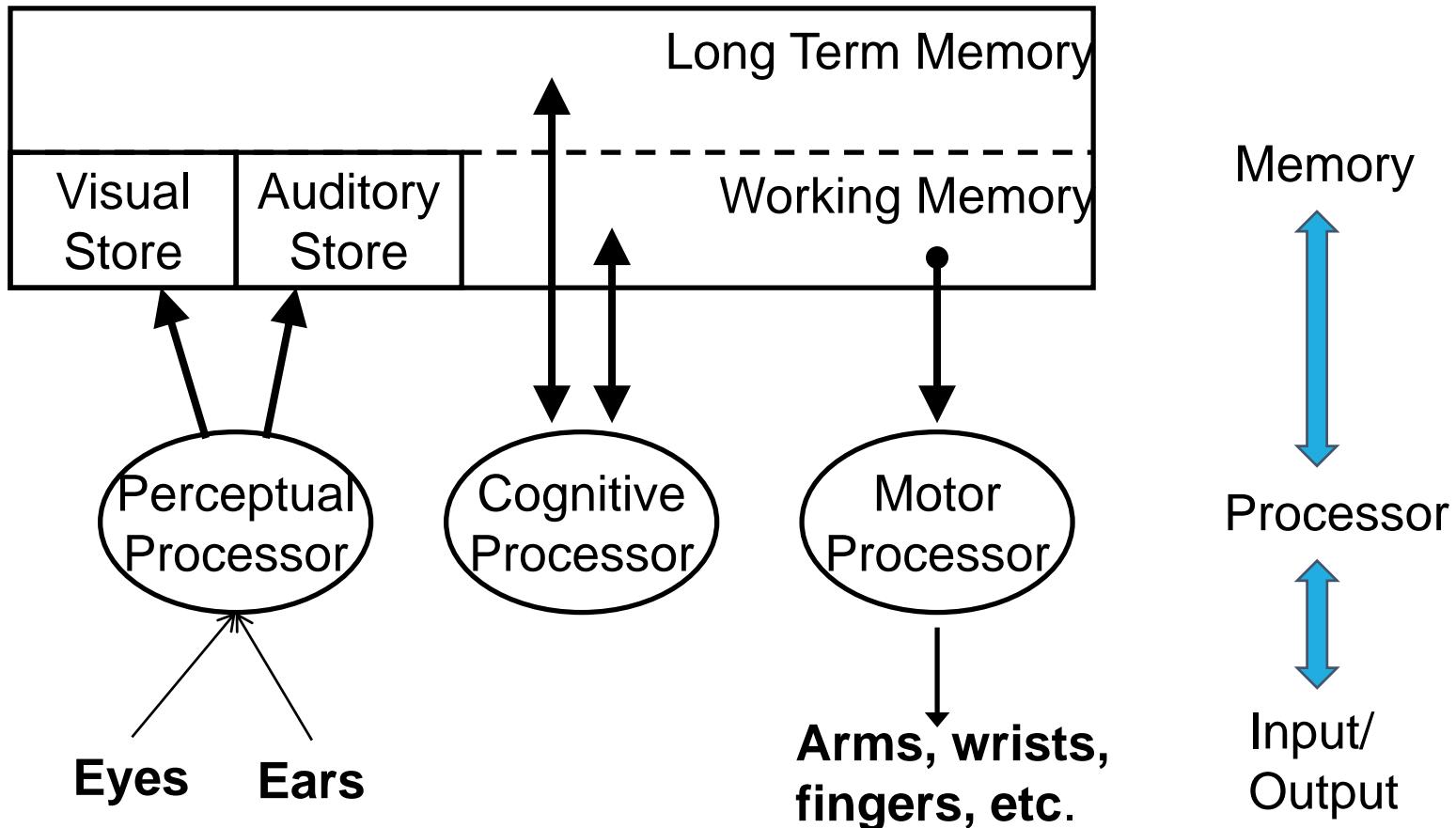
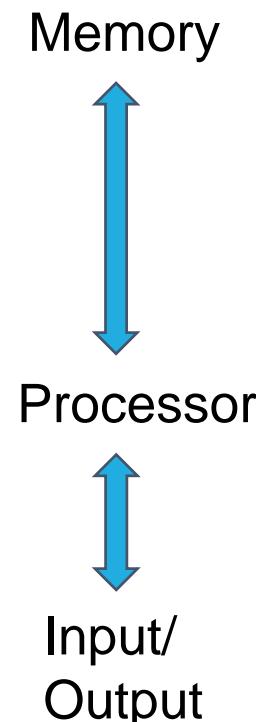


Image from Brian P. Bailey, Computer Science 498bpb, Psychology of HCI  
<http://www-faculty.cs.uiuc.edu/~bpbailey/teaching/2004-Fall/cs498/>



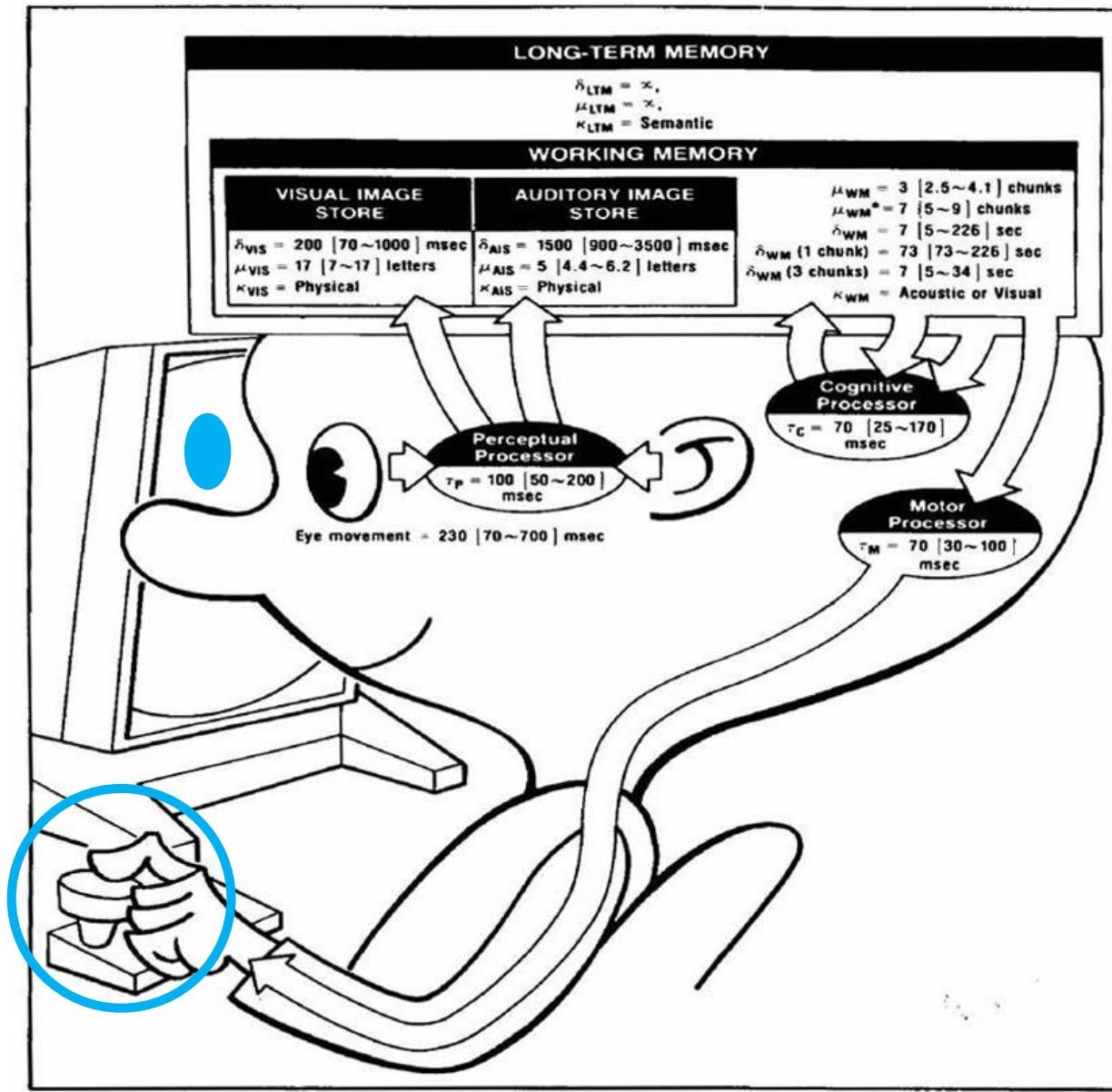


Image [http://en.wikipedia.org/wiki/Human\\_processor\\_model](http://en.wikipedia.org/wiki/Human_processor_model)

# Model Human Processor

- Reaction/processing time, example:
  - Perception (stimulus); typical time: TP ~ 100ms
  - Simple decision; typical time: TC ~ 70ms
  - Minimal motion; typical time: TM ~ 70ms  
(example for complex motor action see Fitts' law, KLM)
- Overall time for operation where there is a sequential processing
  - pressing a button when a light comes on is about 240ms  
 $T = TP + TC + TM$
  - Matching a symbol and then pressing one of two buttons is about 310ms (2TC because there is comparison and decision)  
 $T = TP + 2TC + TM$
- Processing can also be parallel  
(e.g. phoning while writing, talking while driving, ...)

# Limitations of a "single-resource" theory of attention

A photograph of a woman with long brown hair, seen from the side and back, multitasking. She is wearing a black top and a silver necklace. Her left hand holds a silver video game controller with a circular trackball. Her right hand holds a black smartphone. She appears to be looking at both devices simultaneously. The background is a textured, light-colored wall.

Image Source [https://upload.wikimedia.org/wikipedia/commons/c/c8/Multitasking\\_%281272935961%29.jpg](https://upload.wikimedia.org/wikipedia/commons/c/c8/Multitasking_%281272935961%29.jpg) by Lisa Cyr

# Multiple Resource Theory

- Instead of one “pool” of resources, there are several different capacities of resources:
  - Modalities: visual or auditory
  - Information type: spatial or verbal
  - Responses: manual, spatial, vocal, verbal
  - Stages of processing: early (perception/cognition) or late (responding)
- Tasks using same resources interfere each other
- Tasks using different resources can be done “simultaneously”

Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002.

# Multiple Resource Theory

- Driving straight & talking do not interfere:
  - Driving (eye-hand): processing of spatial information
  - Conversation (ear-cognition-mouth): verbal information

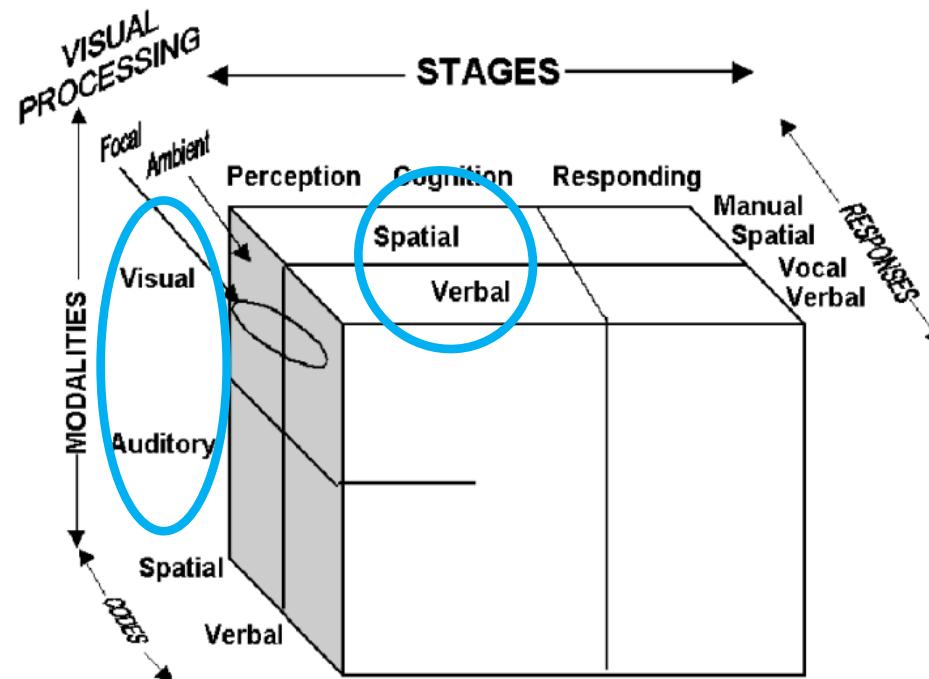


Image: Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002. &  
<https://www.piqsels.com/en/public-domain-photo-jjmiz>

# Multiple Resource Theory

- Conversation (**ears**-cognition-mouth) and using the navigation assistant (**ears**-hand) interfere

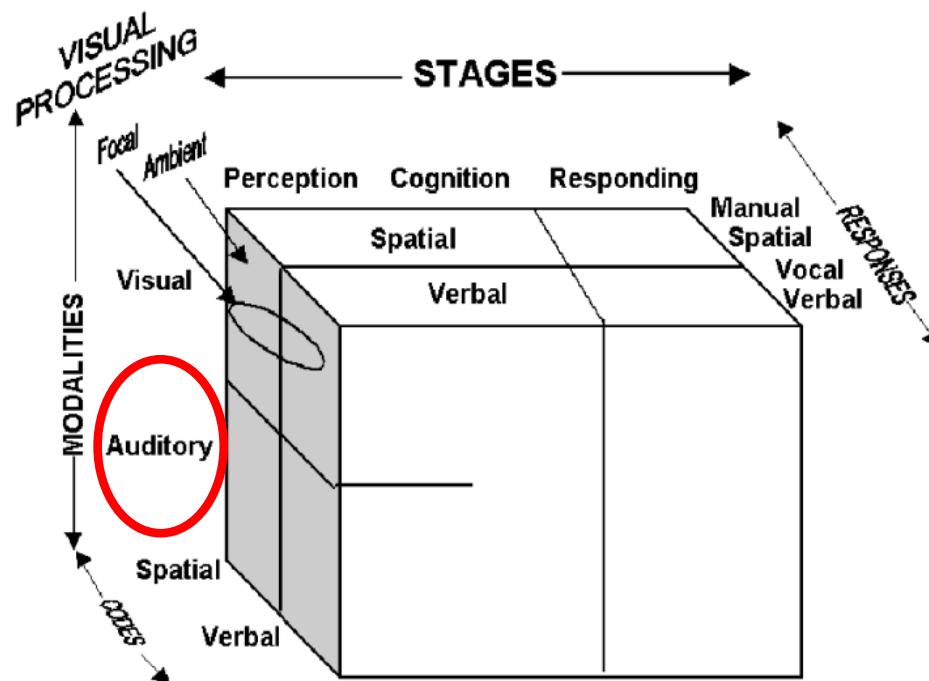


Image: Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002. & <https://www.piqsels.com/en/public-domain-photo-jjmiz>

# Multiple Resource Theory

- Deep conversation (ears-**cognition**-mouth) and complex driving maneuver, e.g. lane changes (eyes-**cognition**-hand) interfere

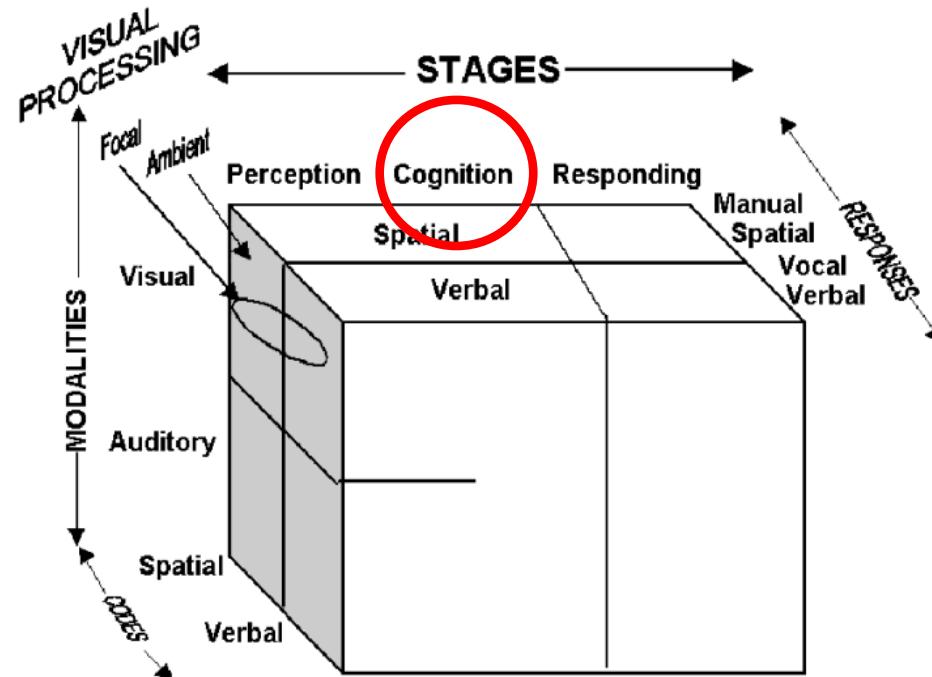


Image: Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002. & <https://www.piqsels.com/en/public-domain-photo-jjmiz>

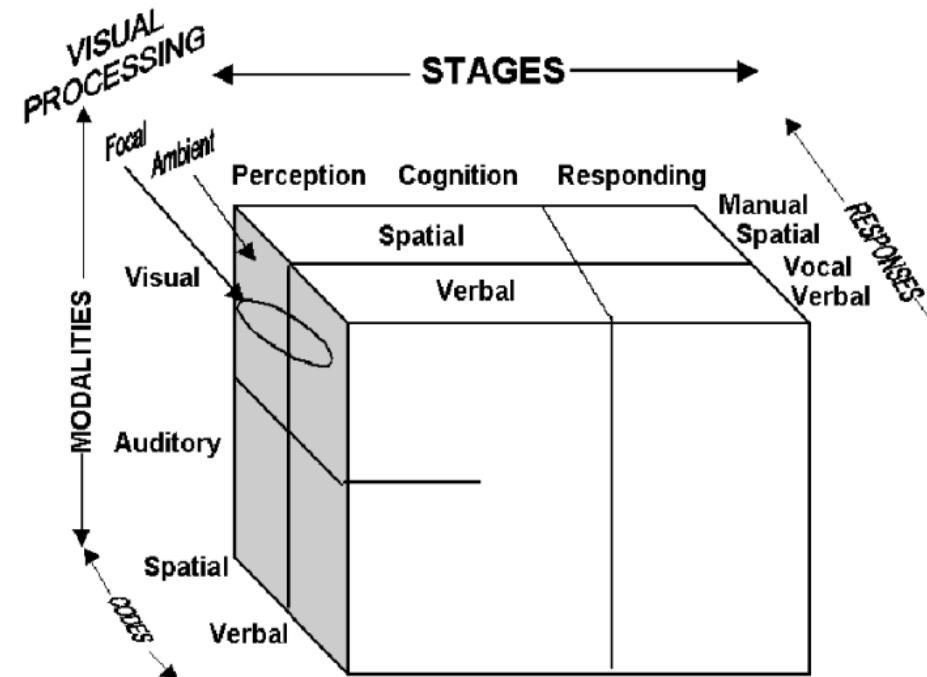


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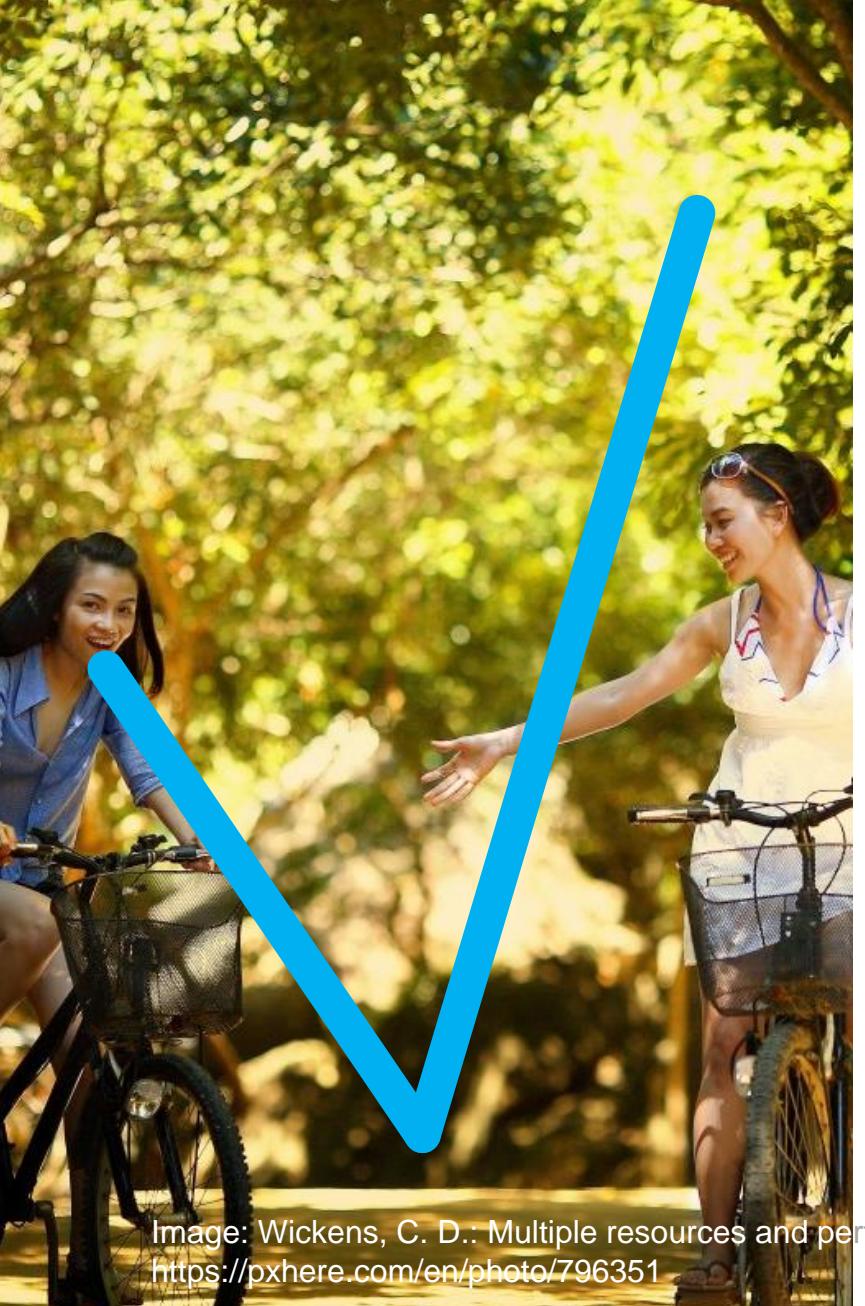
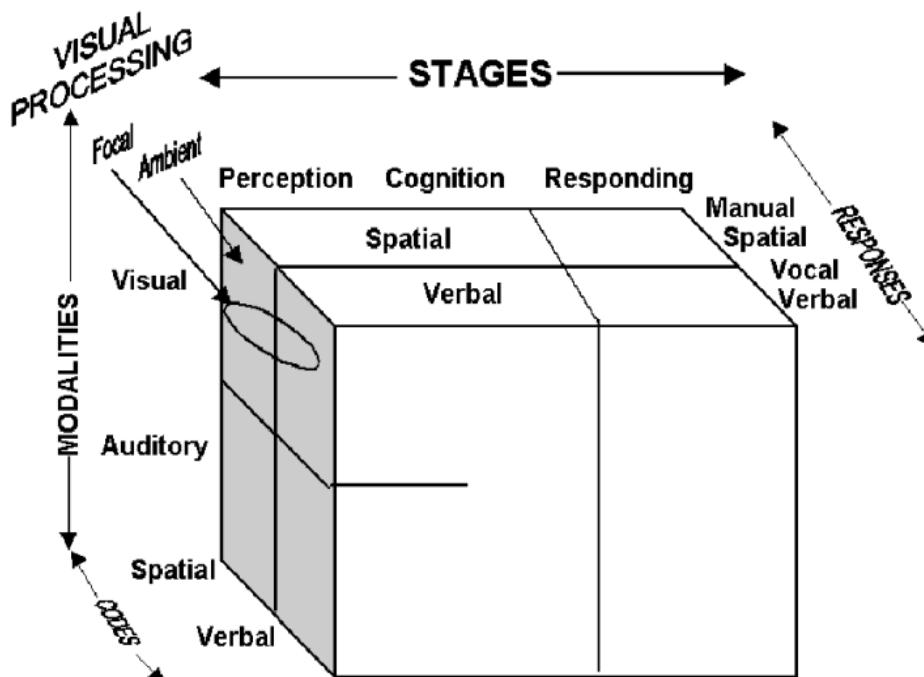


Image: Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002. & <https://pxhere.com/en/photo/796351>



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# Emotions

Image Source <https://www.flickr.com/photos/62337512@N00/2665226890> by anthony kelly



# Learning Goals

- Understanding how emotions evolve
- Expressions of emotions
- Emotions for HCI

# What we've learnt

- Emotions:
  - Enforce to store information in long time memory (LTM)
  - Slow down process of forgetting
  - Influence the response choice in the human information processor (LTM: conditioning)
  - Are caused by needs and goals:

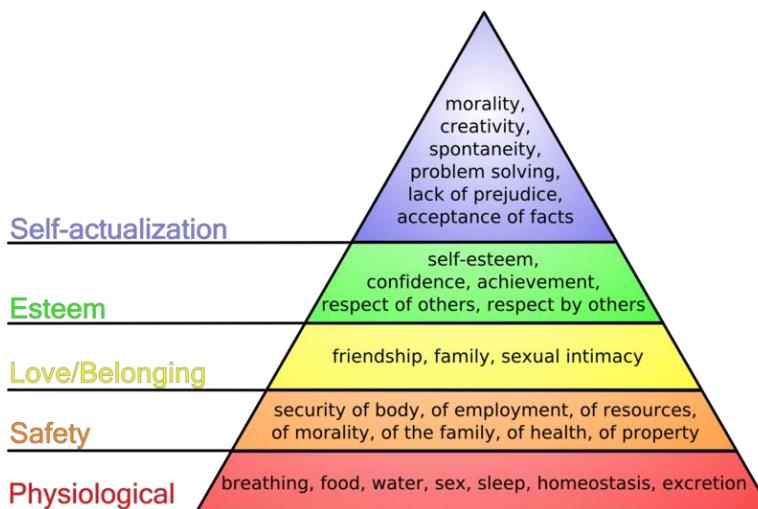


Image Source [https://de.m.wikipedia.org/wiki/Datei:Maslow%27s\\_hierarchy\\_of\\_needs.png](https://de.m.wikipedia.org/wiki/Datei:Maslow%27s_hierarchy_of_needs.png) by J. Finkelstein

# Emotions

- Various theories of how emotion works
  - James-Lange: emotion is **our interpretation of a physiological response to a stimuli**  
“we are sad because we cry...”
  - Cannon: emotion is a **psychological response to a stimuli**
  - Schachter-Singer: emotion is the result of our **evaluation of our physiological responses**, in the light of the whole situation we are in
- Emotion clearly involves both cognitive and physical responses to stimuli

# Basic Emotions

Reference	Basic emotions						Other	
	“The Big Six”							
	Happiness (joy, enjoyment, play)	Sadness (grief)	Anger (rage)	Disgust	Fear/ anxiety	Surprise		
Plutchnik (1980)	✓	✓	✓	✓	✓	✓	Acceptance, anticipation	
Oatley and Johnson-Laird (1987)	✓	✓	✓	✓	✓	✗	—	
Ekman and Cordaro (2011)	✓	✓	✓	✓	✓	✓	Contempt	
Izard (2011)	✓	✓	✓	✗	✓	✗	Interest	
Levenson (2011)	✓	✓	✓	✓	✓	✓	Interest <sup>a</sup> , relief <sup>a</sup> , love <sup>a</sup>	
Panksepp and Watt (2011)	✓	✓	✓	✗	✓	✗	Seeking, lust, care	

# Emotion Expressions

## Facial Expressions



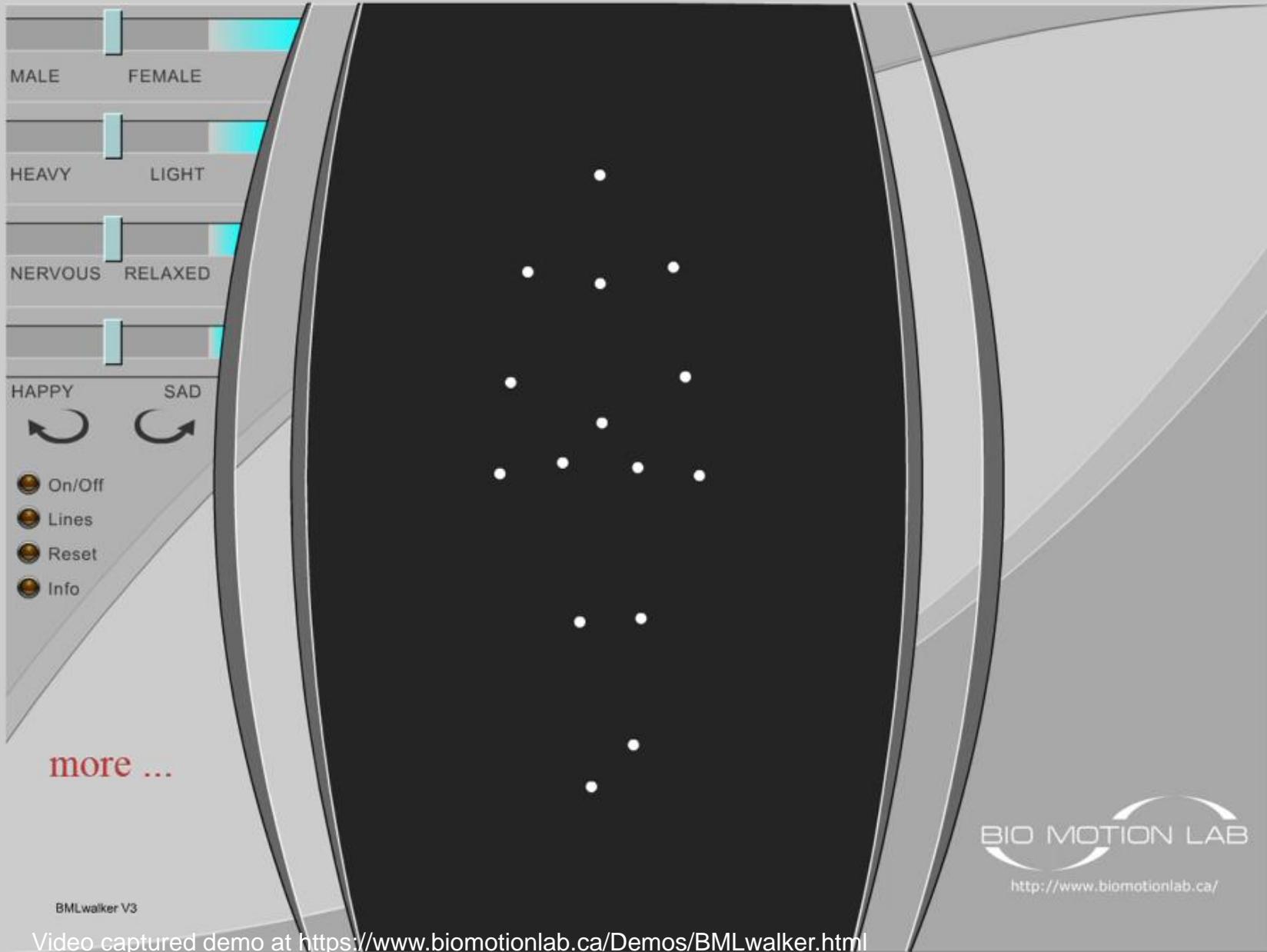
Image Source [https://upload.wikimedia.org/wikipedia/commons/4/4d/Universal\\_emotions7.JPG](https://upload.wikimedia.org/wikipedia/commons/4/4d/Universal_emotions7.JPG) by Icerko Lýdia

# Emotion Expressions

## Body Pose



Schindler et al. (2008) Recognizing emotions expressed by body pose: A biologically inspired neural model



# Emotion Expressions

## Voice

	Fear	Anger	Sadness	Happiness	Disgust
Speech rate	Much faster	Slightly faster	Slightly slower	Faster or slower	Very much slower
Pitch average	Very much higher	Very much higher	Slightly lower	Much higher	Very much lower
Pitch range	Much wider	Much wider	Slightly narrower	Much wider	Slightly wider
Intensity	Normal	Higher	Lower	Higher	Lower
Voice quality	Irregular voicing	Breathy chest tone	Resonant	Breathy blaring	Grumbled chest tone
Pitch changes	Normal	Abrupt on stressed syllables	Downward inflections	Smooth upward inflections	Wide downward terminal inflections
Articulation	Precise	Tense	Slurring	Normal	Normal

Brave, Scott & Nass, Clifford. (2002). Emotion in Human–Computer Interaction. The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications. 10.1201/b10368-6.

# Emotion Expressions

## Communication

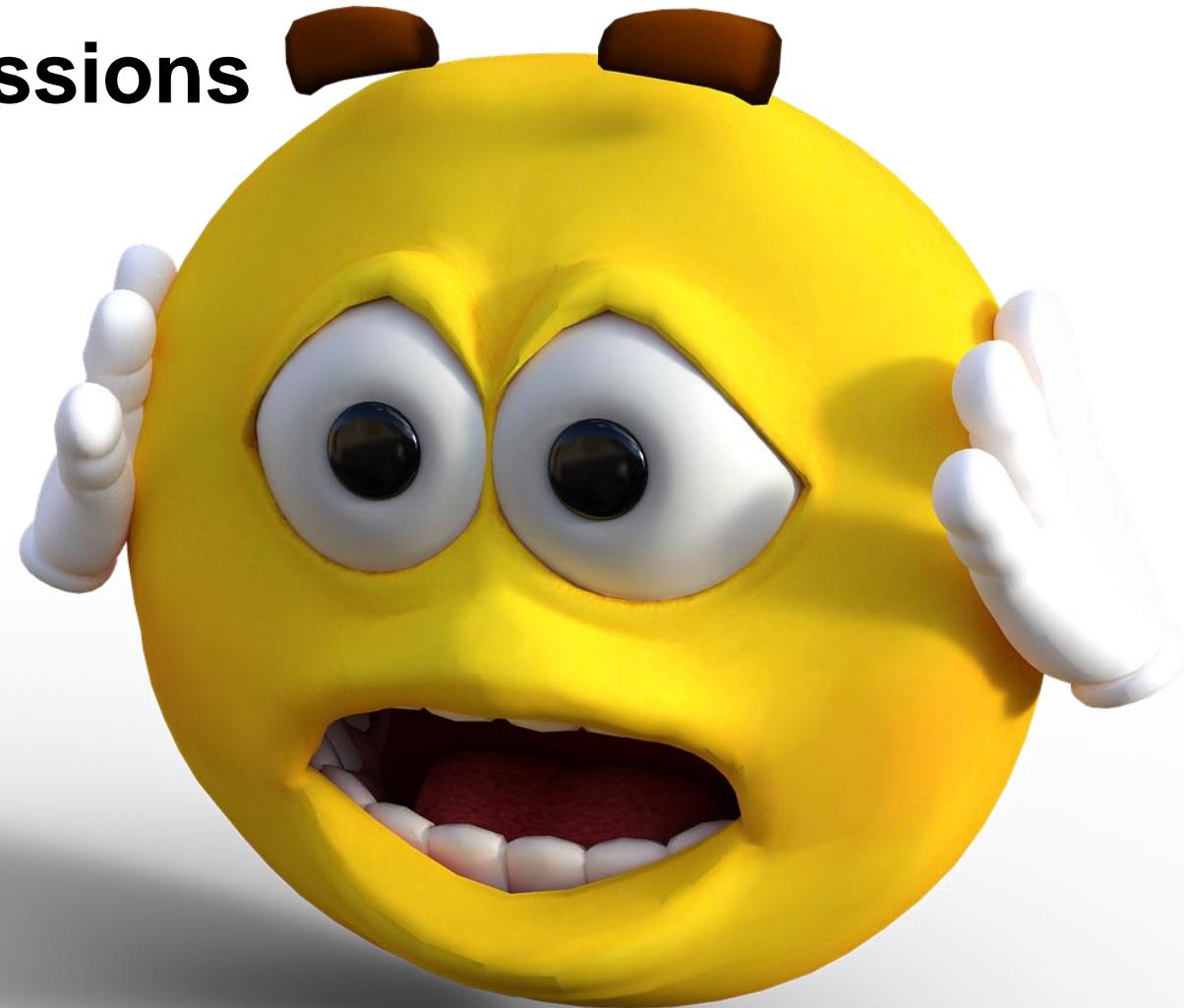
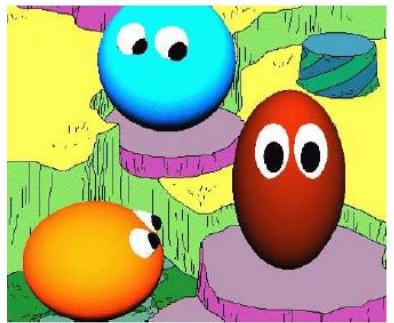


Image Source <https://pixabay.com/de/illustrations/smiley-emoticon-emoji-gelb-freude-4836210/>



(a)



(b)



(c)



(d)



(e)



(f)



(g)



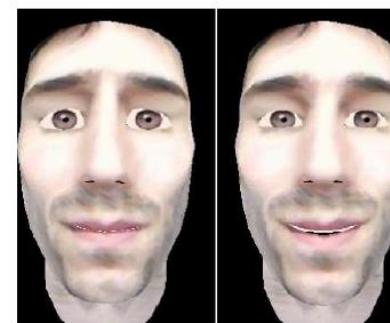
(h)



(i)



(j)



(k)



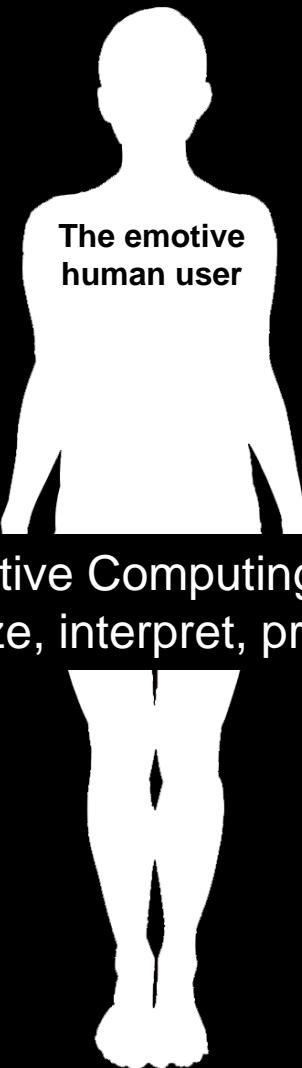
(l)

Vinayagamoorthy, Vinoba, Marco Gillies, Anthony Steed, Emmanuel Tanguy, Xueni Pan, Celine Loscos, and Mel Slater. "Building expression into virtual characters." (2006).

# Affects

- The biological response to physical stimuli is called *affect*
- Affect influences how we respond to situations
  - positive → creative problem solving
  - negative → narrow thinking
- “Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks”

(Donald Norman)



Affective Computing:  
systems and devices that can recognize, interpret, process, and simulate human affects

Image after <https://affect.media.mit.edu/areas.php> &  
<https://www.needpix.com/photo/672566/female-standing-people-lifestyle-women-woman-standing-adult-healthy-girl> by PoseMuse

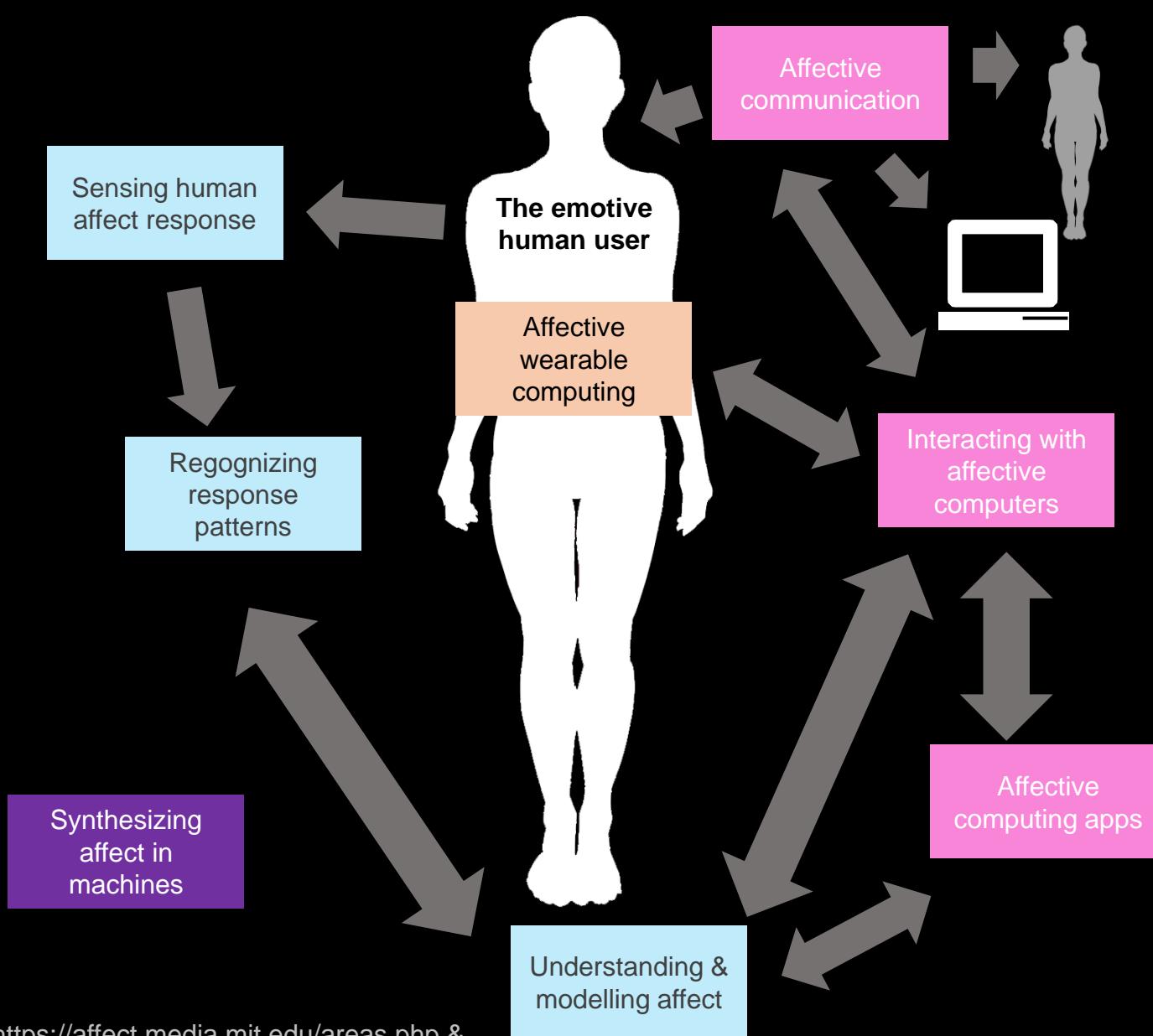
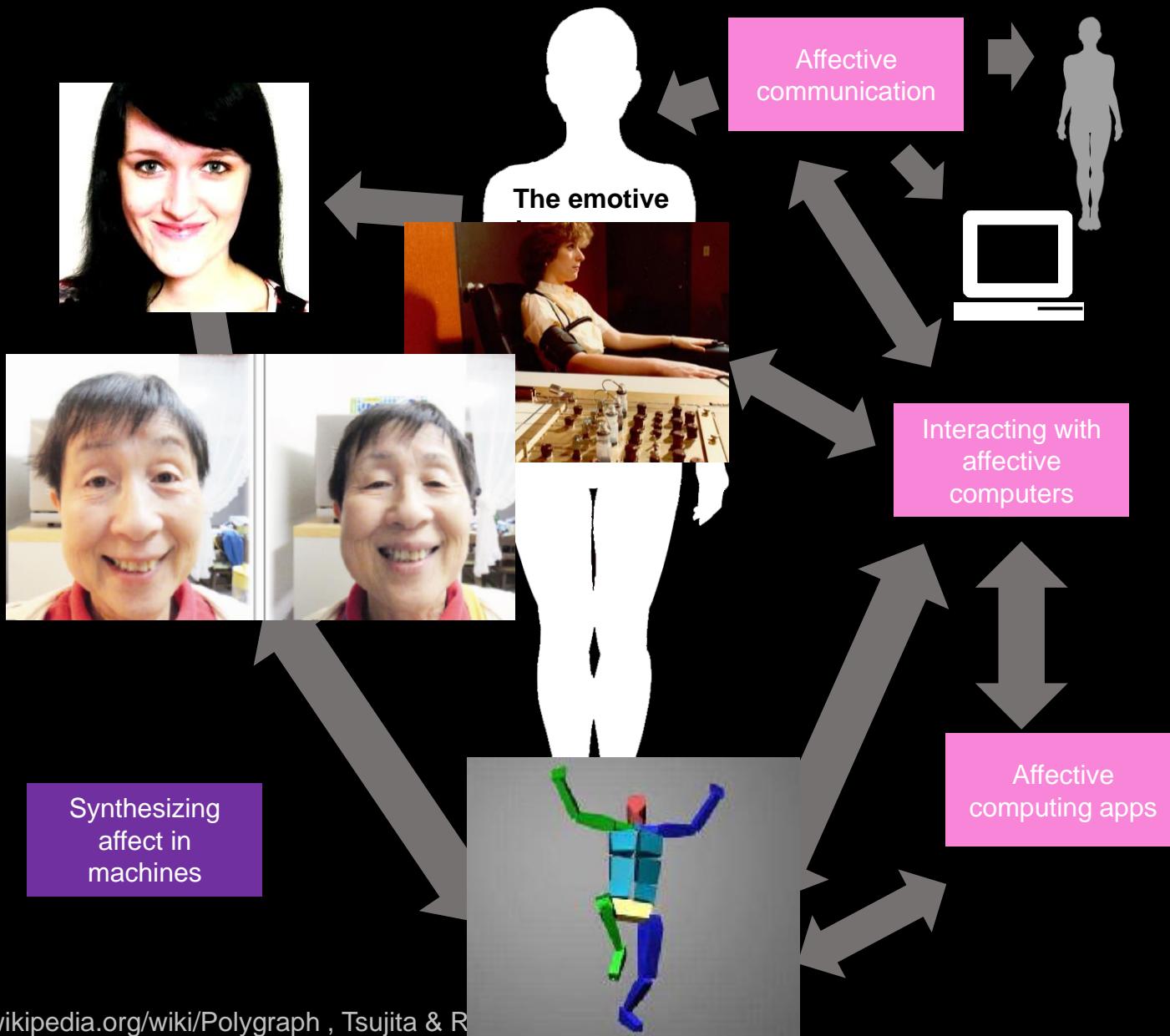
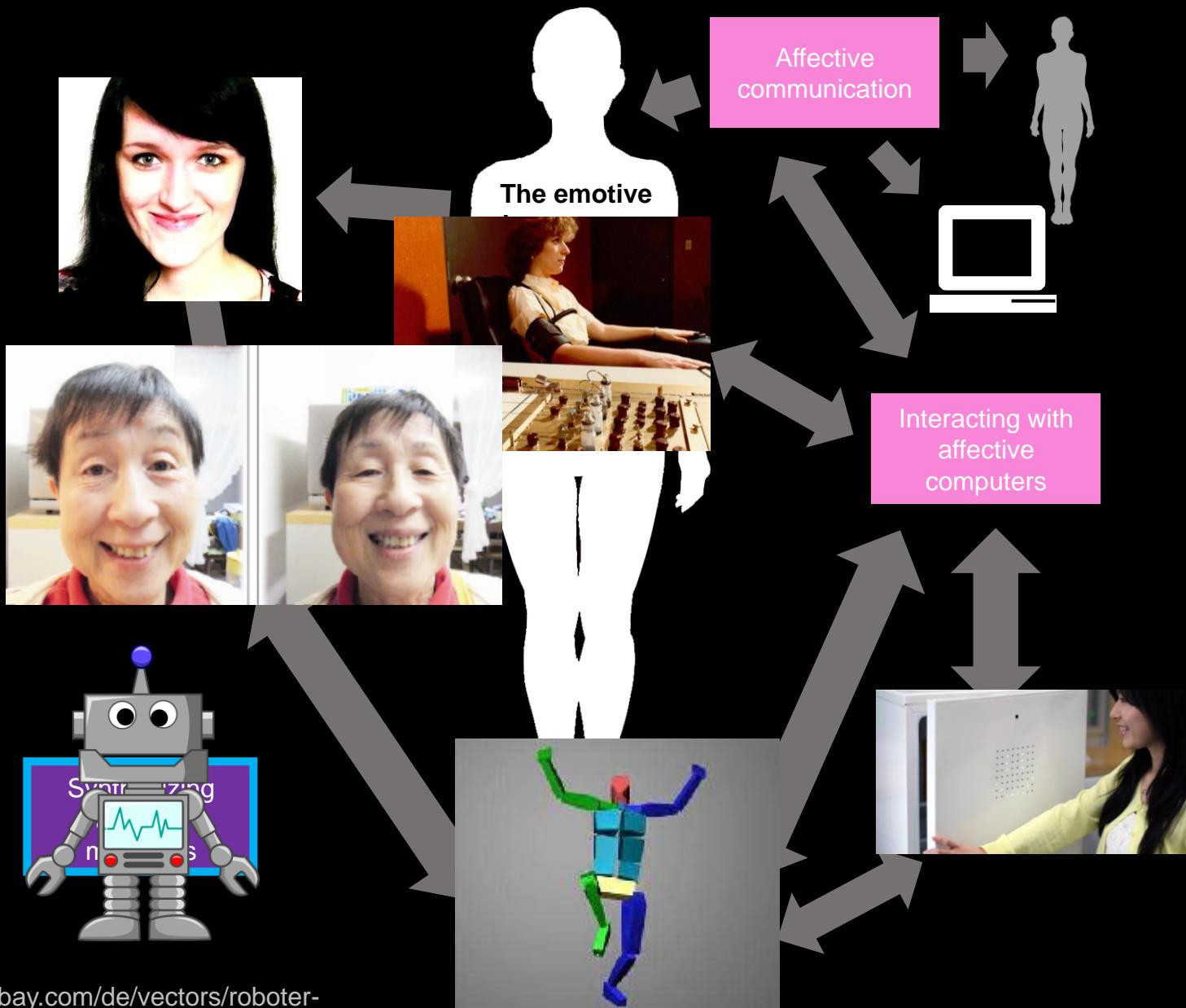


Image after <https://affect.media.mit.edu/areas.php> & <https://www.needpix.com/photo/672566/female-standing-people-lifestyle-women-woman-standing-adult-healthy-girl> by PoseMuse



<https://en.wikipedia.org/wiki/Polygraph> , Tsujita & R  
Us Happier & Kleinsmith, & Bianchi-B.: Recognizing Affective Dimensions from Body Posture.



<https://pixabay.com/de/vectors/roboter-schnurrbart-wissenschaft-161367/> & Tsujita & Rekimoto, Smiling Makes Us Happier & Kleinsmith

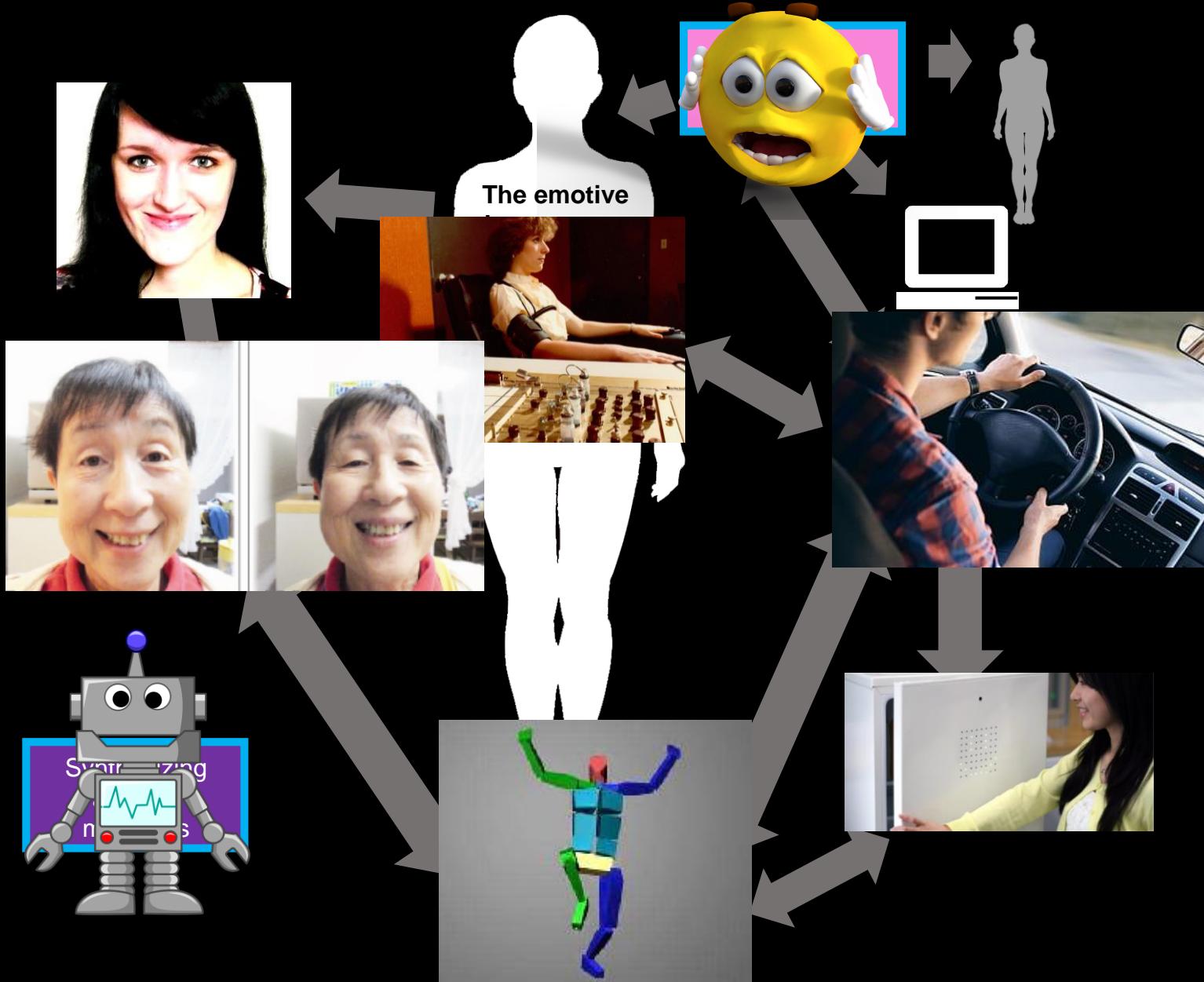
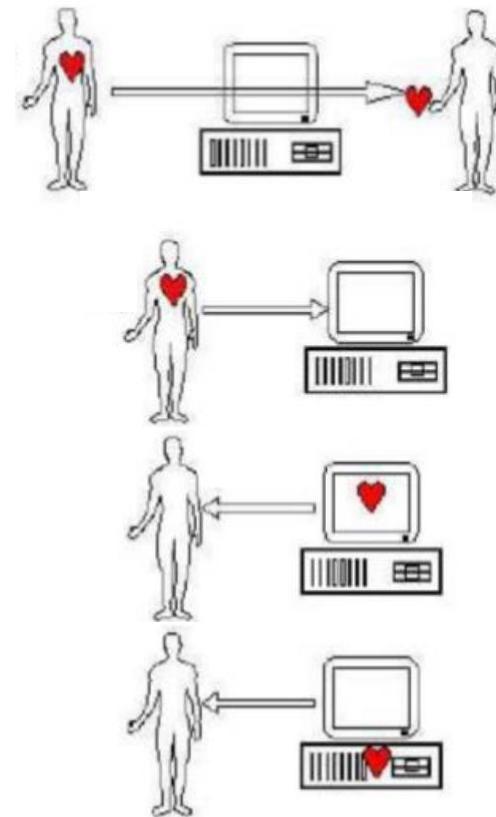


Image Sources <https://www.pxfuel.com/en/free-photo-qkvff>

# Possible Uses of Emotions



- Broadcast: provide a special channel for emotional communication, such as 'emoticons' used in e-mails : )
- Recognition: emotional can be analyzed and used to alter the system reaction (such as Tsujita & Rekimoto)
- Simulation: Emotional expression can be mimicked by the system in order to enhance a natural interface (characters, agents, robots)
- Modeling: Internal models to represent user (virtual user studies)

Burkhardt, Felix, et al. "Emotion detection in dialog systems: applications, strategies and challenges." 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops. IEEE, 2009.

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# Motor System

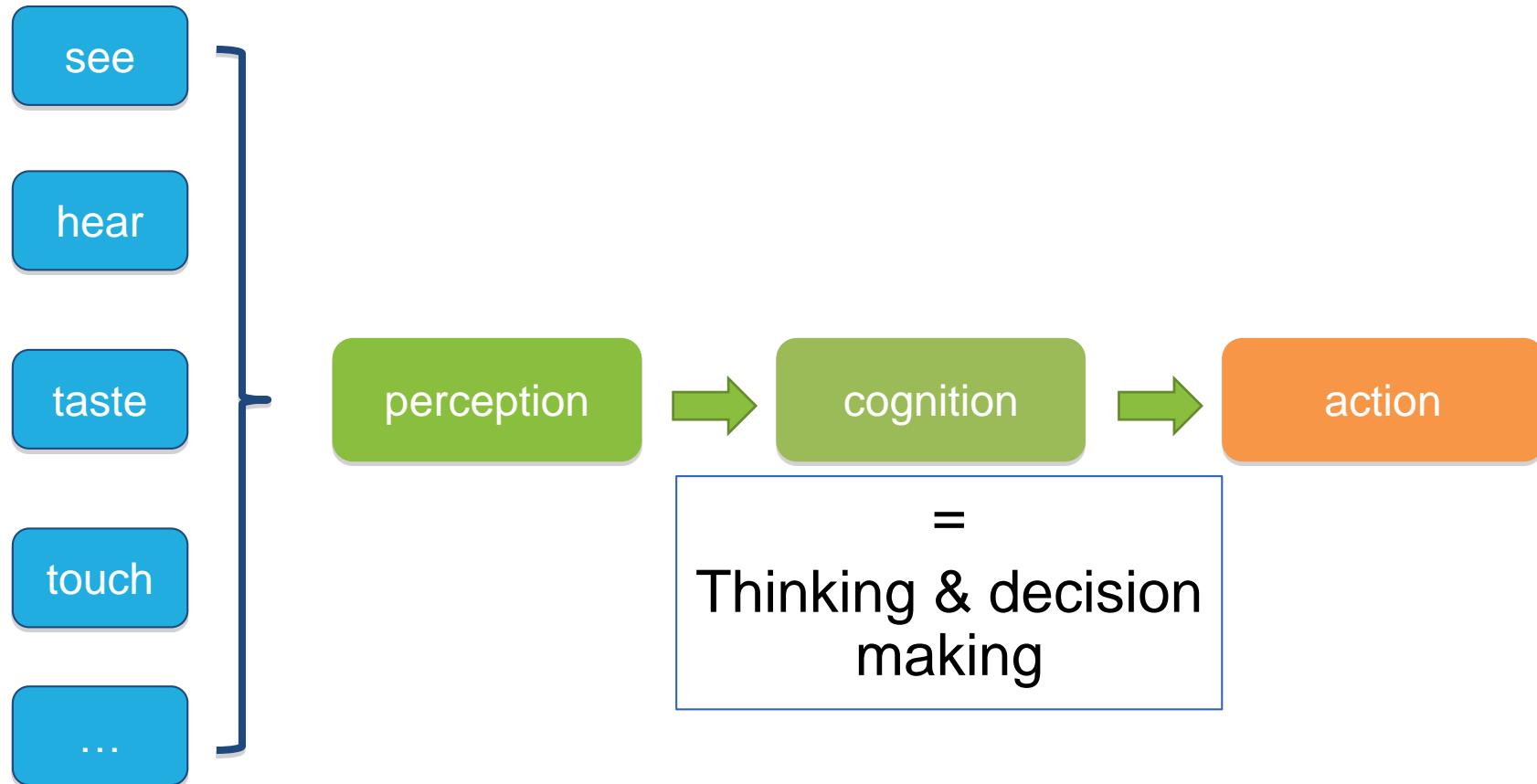
Image Source <https://pxhere.com/de/photo/1584193> by Muddu36



# Learning Goals

- Motor cortex
- Physical ergonomics
- Ergonomic design guidelines

# Human information processing



# What we've learnt

## Somatosensory System

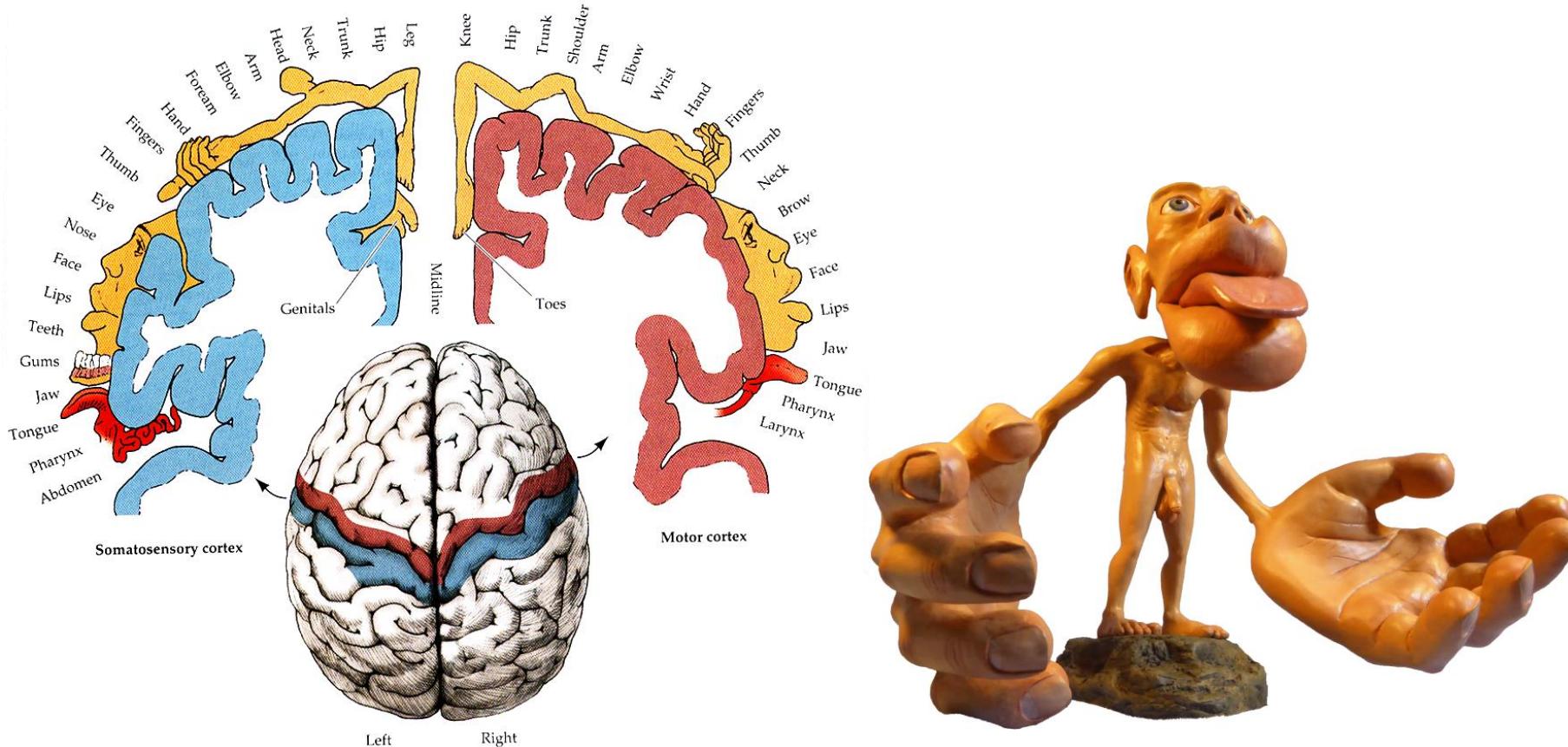


Image adapted from <https://www.flickr.com/photos/46006858@N05/8641421501> by Gary Kirwan & [https://en.wikipedia.org/wiki/Cortical\\_homunculus#/media/File:Front\\_of\\_Sensory\\_Homunculus.gif](https://en.wikipedia.org/wiki/Cortical_homunculus#/media/File:Front_of_Sensory_Homunculus.gif) by Mpj29

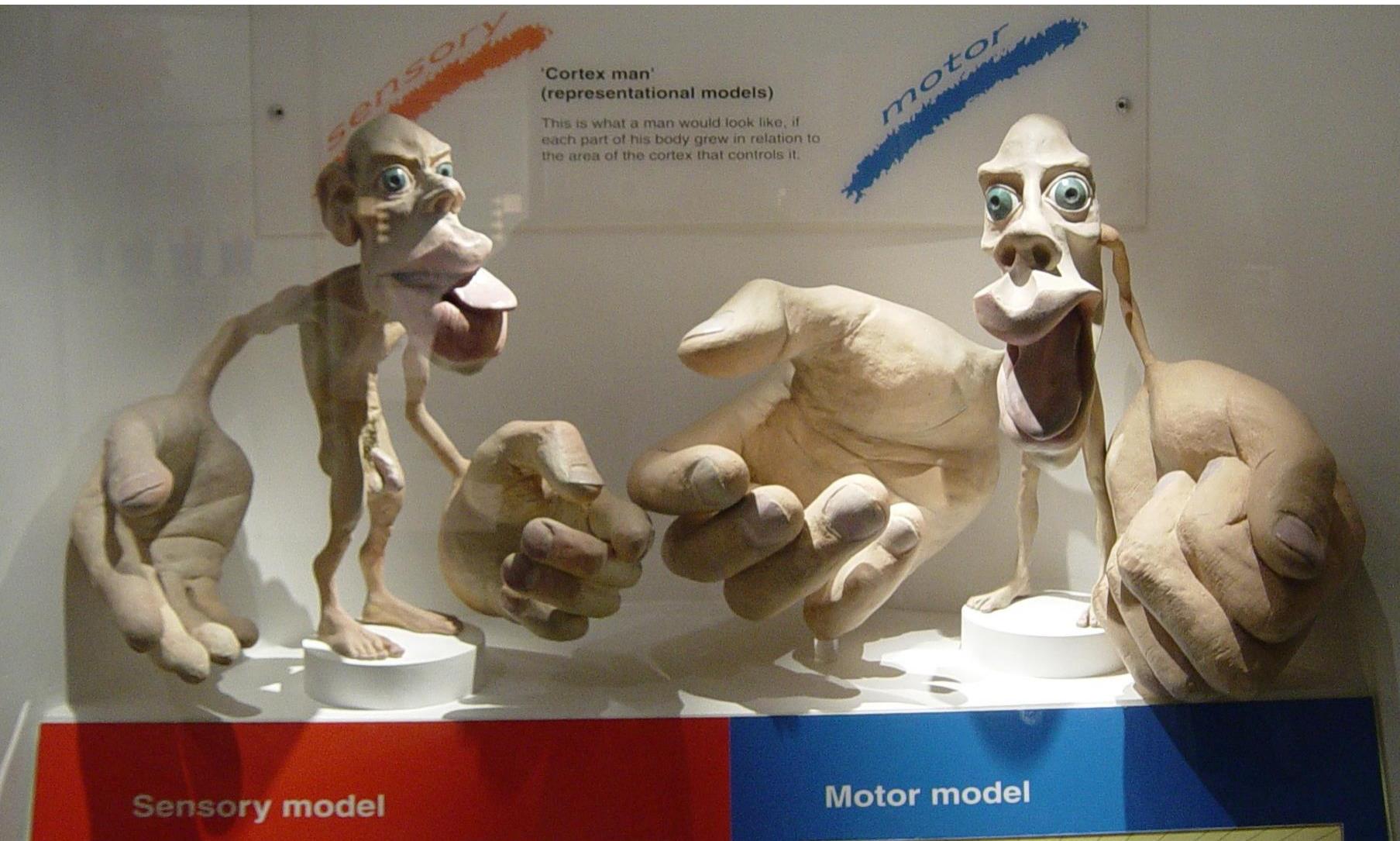
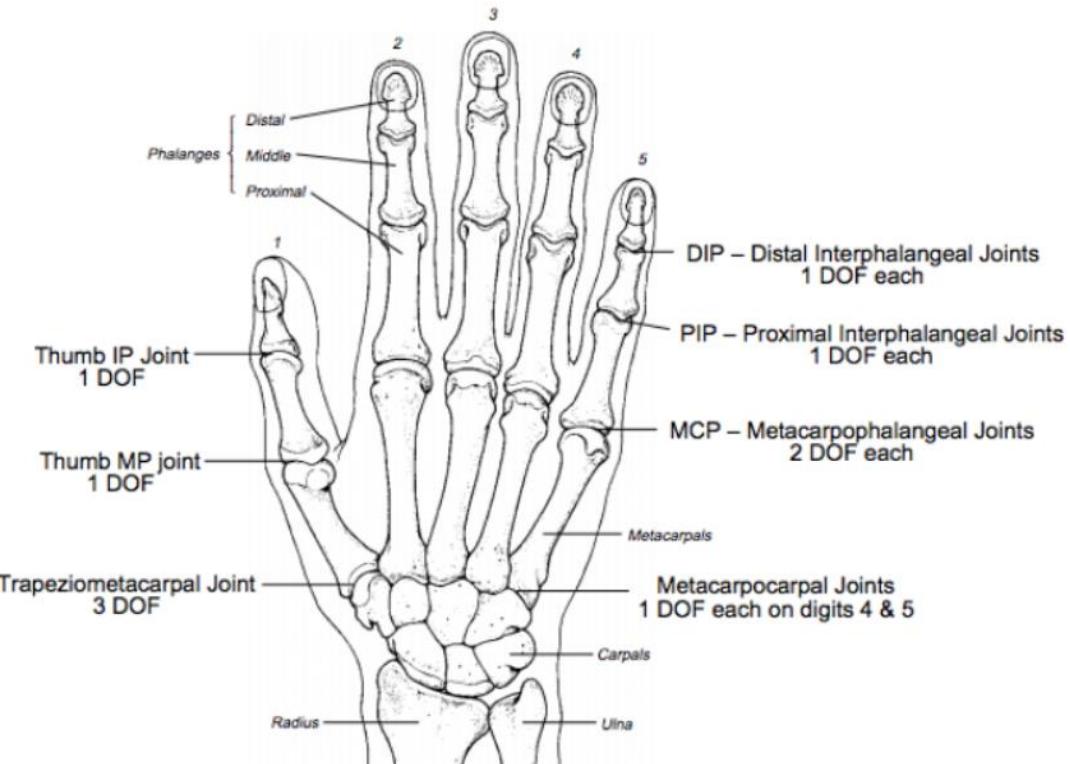


Image Source [https://en.wikipedia.org/wiki/Cortical\\_homunculus#/media/File:Sensory\\_and\\_motor\\_homunculi.jpg](https://en.wikipedia.org/wiki/Cortical_homunculus#/media/File:Sensory_and_motor_homunculi.jpg) by Dr. Joe Kiff

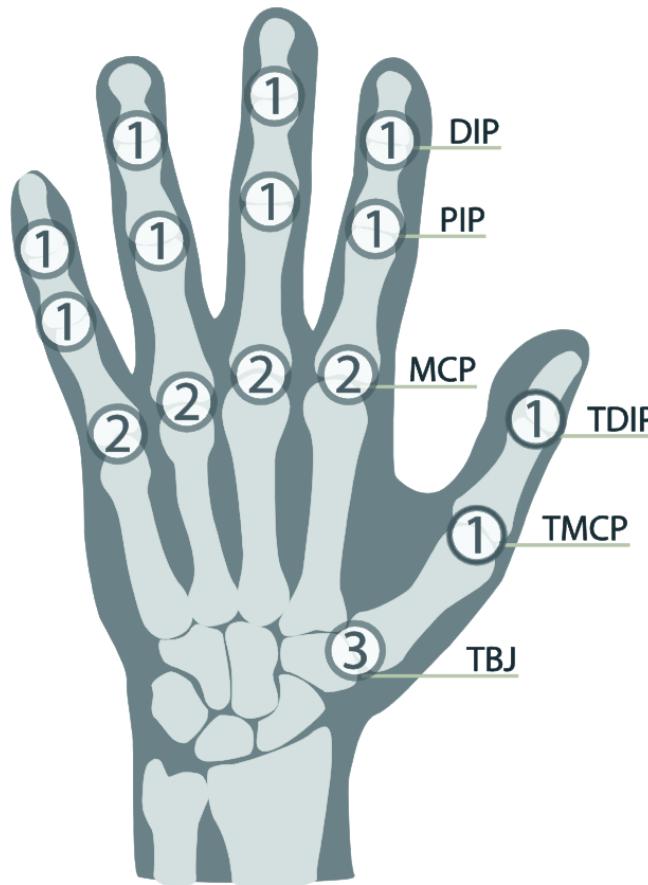
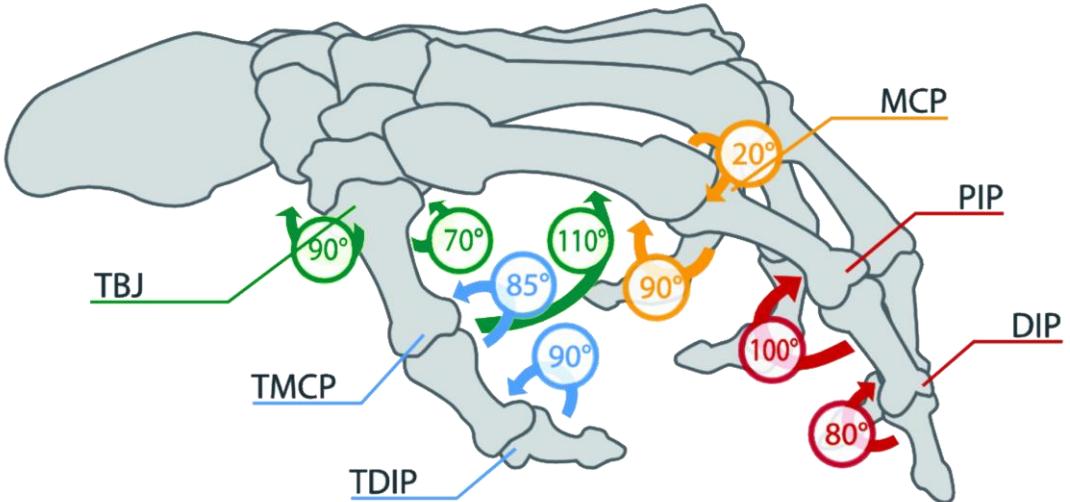
# Hand



DOF = Degree of Freedom

Image Source Various hand motions: Sturman, D. J. (1992), Whole-hand Input, PhD thesis, Massachusetts Institute of Technology.

# Hand



③ 3 DOF = Degree of Freedom

Image Source Katrin Wolf, Markus Schneider, John Mercouris and Christopher-Eyk Hrabia: Biomechanics of Front-and Back-of-Tablet Pointing with Grasping Hands. International Journal of Mobile Human Computer Interaction

# Hand

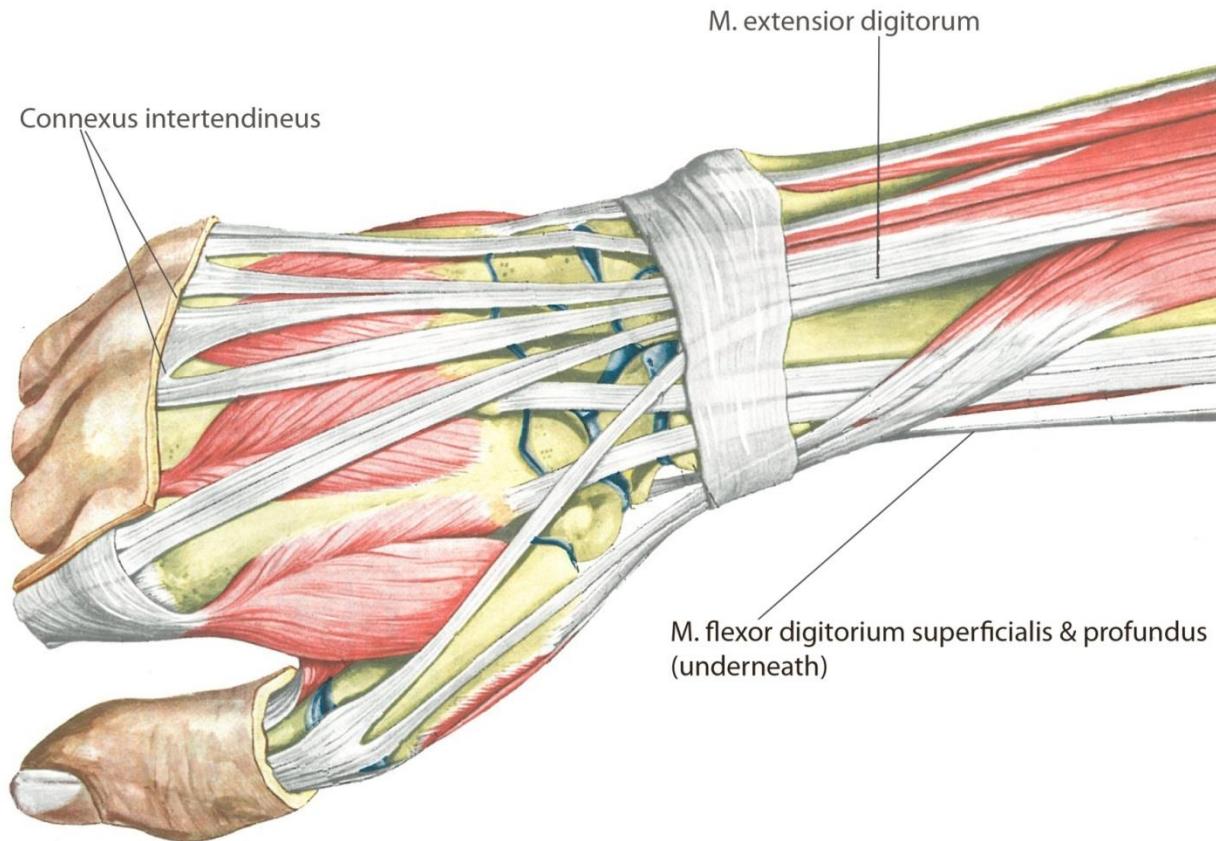


Image adapted from Spalteholz (1960): Hand-atlas of human anatomy.

# Manual Ergonomic Factors

- Size of objects we can grasp
- Weight of objects we can lift
- Force we can apply with fingers and hand
- Movements with fingers and hands we can do
- Areas we can reach with fingers and hands
- Time it takes to move a finger, e.g. to touch a button



Image Source [https://en.wikipedia.org/wiki/File:Trackman\\_marble\\_wheel.JPG](https://en.wikipedia.org/wiki/File:Trackman_marble_wheel.JPG) by Brad Kennedy

# Ergonomic Gesture Design

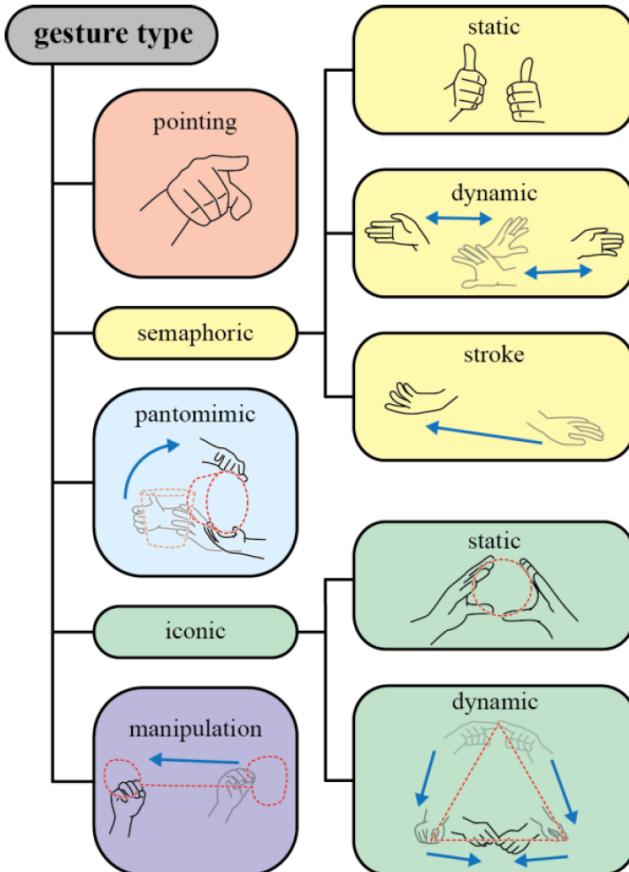
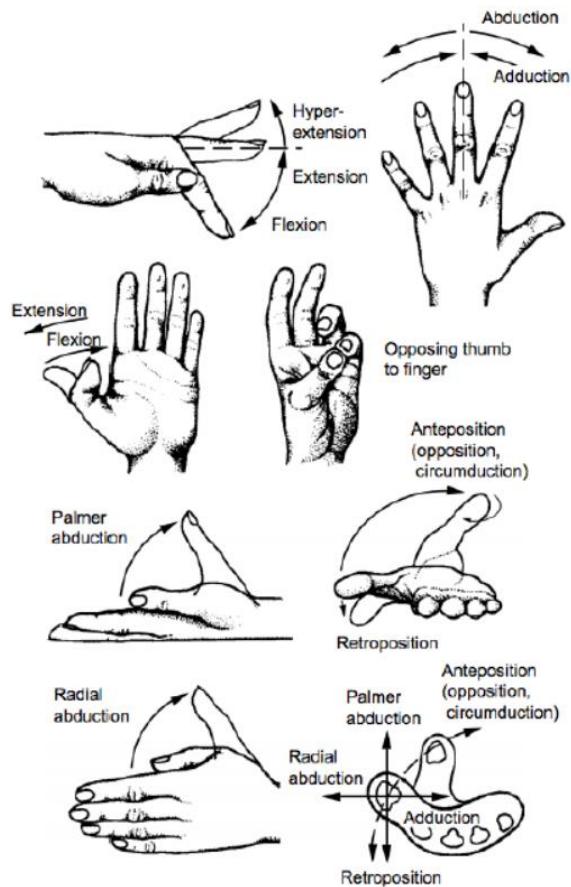


Image Source Various hand motions: Sturman, D. J. (1992), Whole-hand Input, PhD thesis, Massachusetts Institute of Technology.  
& Aigner et al. (2012) Understanding Mid-Air Hand Gestures: A Study of Human Preferences in Usage of Gesture Types for HCI.

# Ergonomic Gesture Design



Image Source Katrin Wolf, Anja Naumann, Michael Rohs and Jörg Müller: Taxonomy of microinteractions: defining microgestures based on ergonomic and scenario-dependent requirements. INTERACT 2011

# Ergonomic Gesture Design

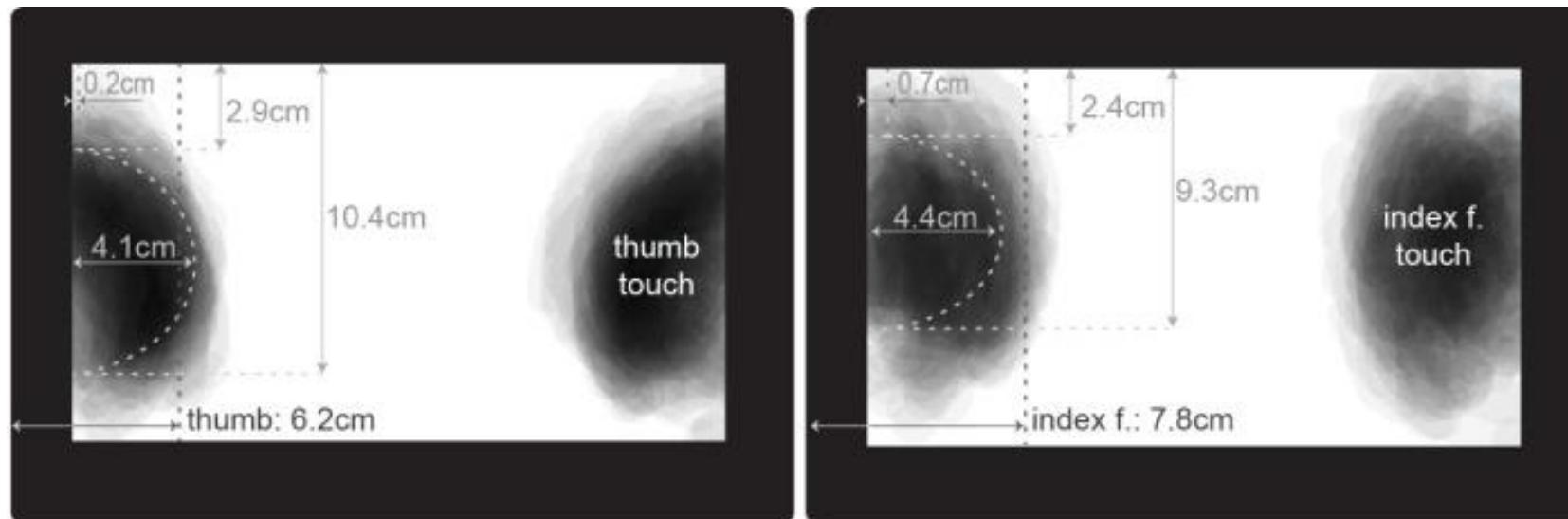


Image Source Katrin Wolf, Robert Schleicher and Michael Rohs: Touch Accessibility on the Front and the Back of held Tablet Devices. EuroHaptics 2014

# Ergonomic Gesture Design

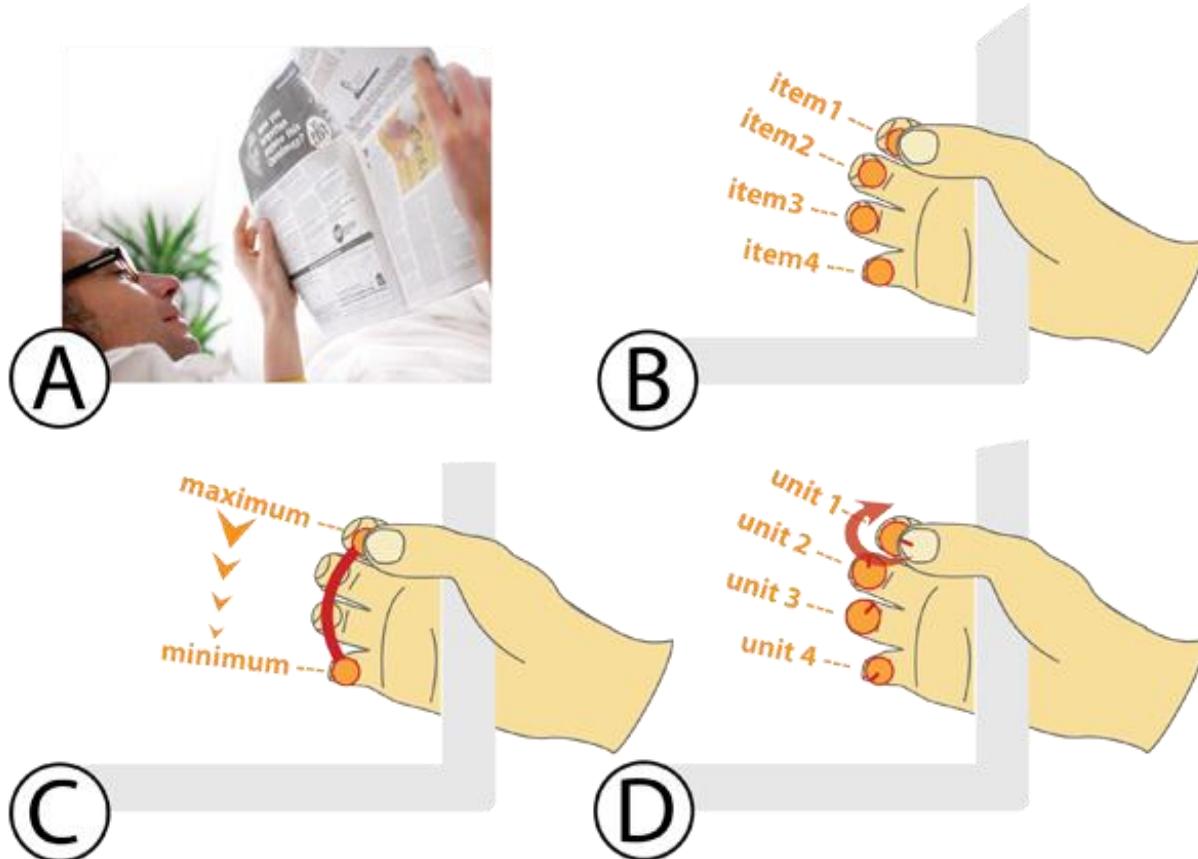


Image Source Katrin Wolf, Christian Müller-Tomfelde, Kelvin Chen and Ina Wechsung: PinchPad: performance of touch-based gestures while grasping devices. TEI 2012

# Ergonomic Gesture Design

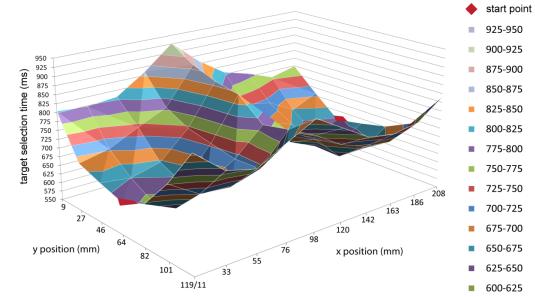


Image Source Katrin Wolf, Markus Schneider, John Mercouris and Christopher-Eyk Hrabia: Biomechanics of Front- and Back-of-Tablet Pointing with Grasping Hands. International Journal of Mobile Human Computer Interaction

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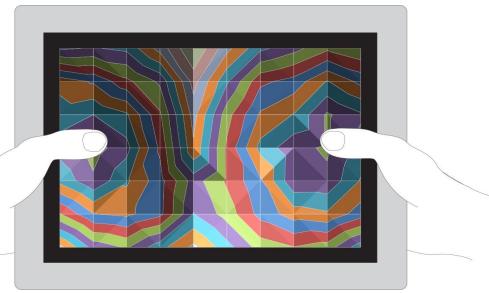
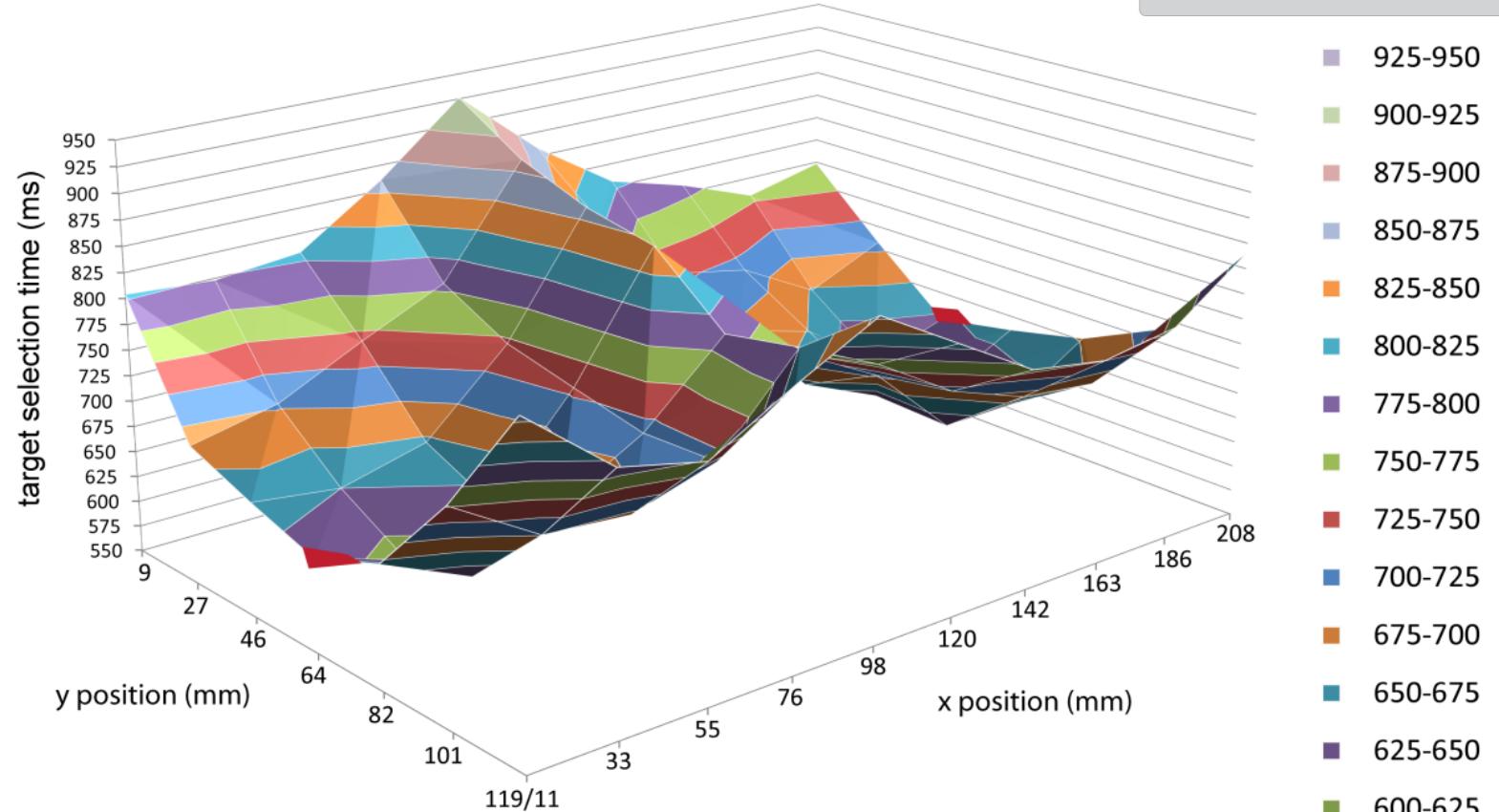


Image Source Katrin Wolf, Markus Schneider, John Mercouris and Christopher-Eyk Hrabia: Biomechanics of Front- and Back-of-Tablet Pointing with Grasping Hands. International Journal of Mobile Human Computer Interaction

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