Friedrich-Alexander-Universität
Technische Fakultät

Machine Learning
Data Analytics

FAU

Human Computer Interaction

Discussion Session 2: Humans I

Prof. Dr. Björn Eskofier
Machine Learning & Data Analytics (MaD) Lab
Summer term 2024

Design for Humans

Humans

Know the human

Humans are very **complex**!
Even psychology only explains parts

Physiology (e.g., size, strength, degrees of freedom, fatigue)

Psychology (e.g., Memory, perception, cognition)

Emotions (e.g., Gender, abilities, and disabilities)

Soft factors (e.g., Aesthetics, motivation, pleasure, experience)

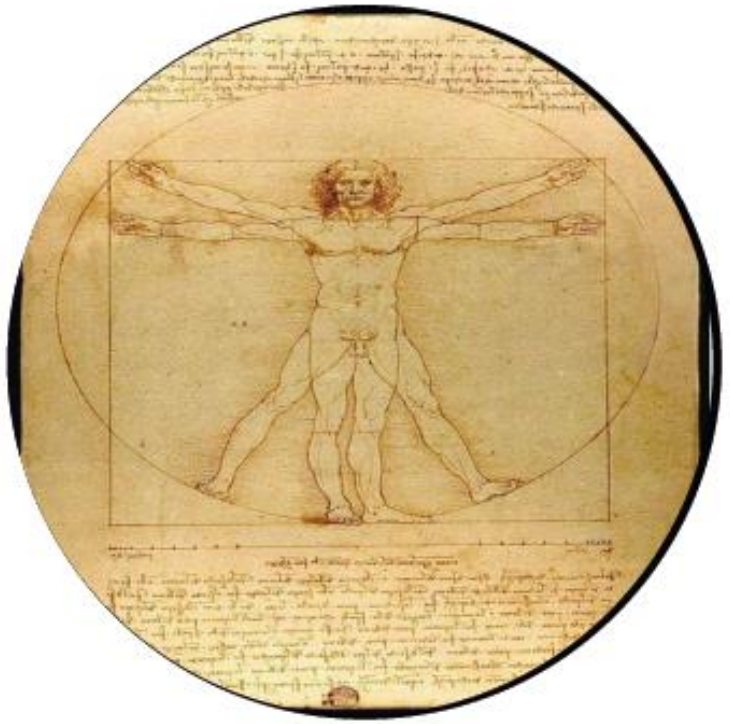
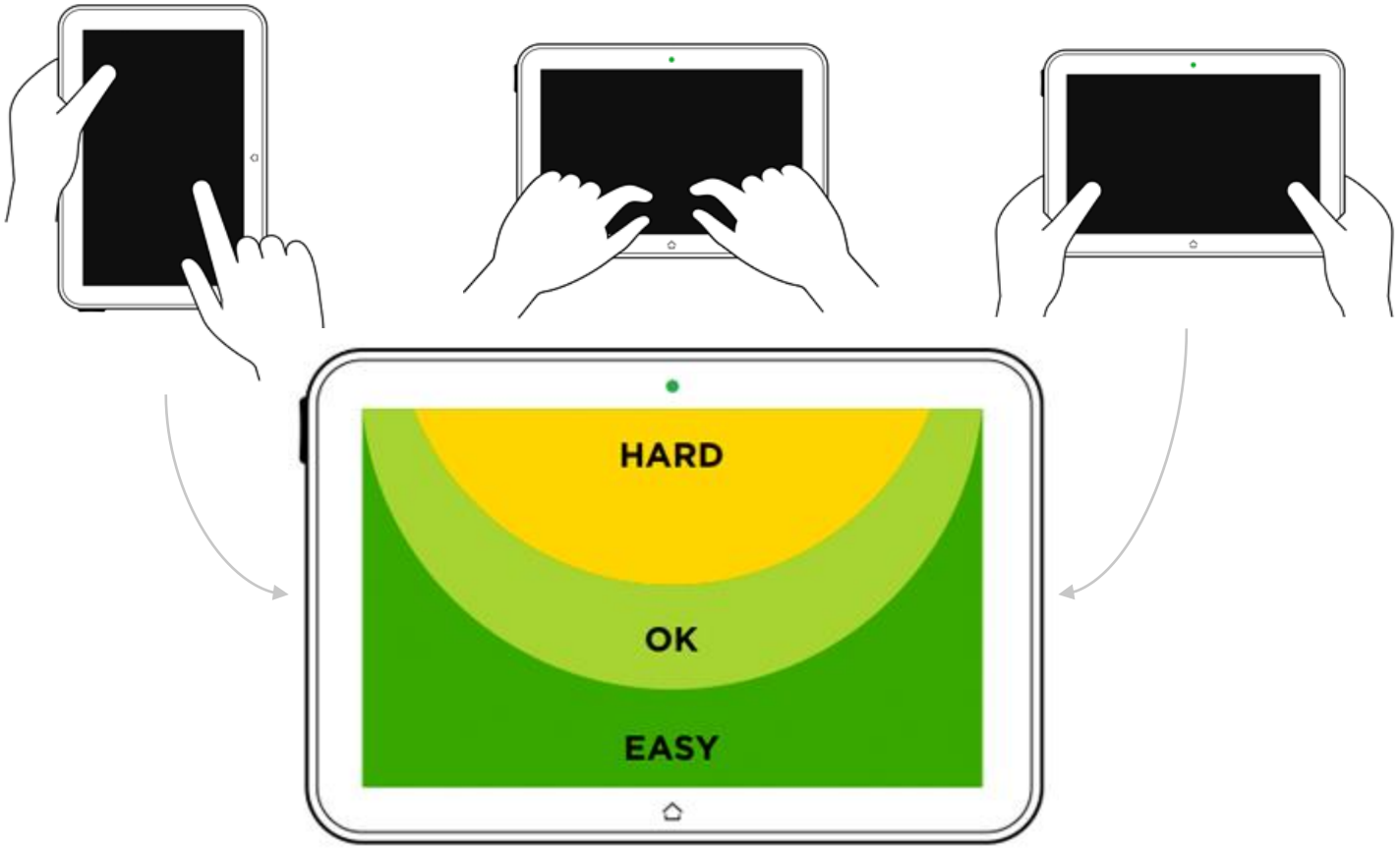


Photo by Luc Viatour drawing by Leonardo da Vinci
https://en.wikipedia.org/wiki/File:Da_Vinci_Vitruve_Luc_Viatour.jpg

What has to be considered?

Design for Touch

https://buildfire.com/mobile-web-design/



https://www.lukew.com/ff/entry.asp?1649

Human Abilities

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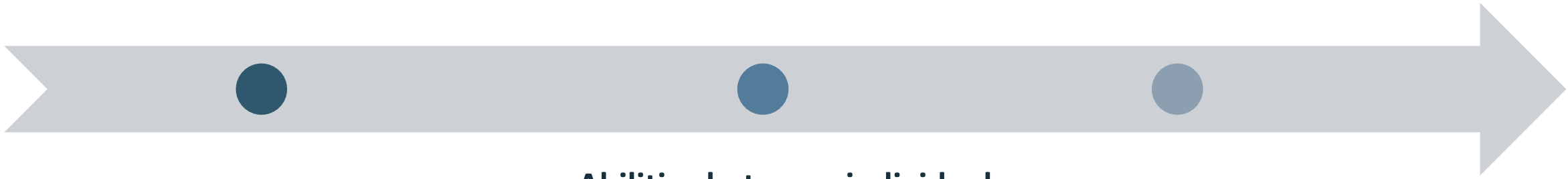
Abilities of un-augmented users in general do not change a lot over time, e.g.

- Ability to cope with cognitive load
- Willingness to cope with stress
- Time one can concentrate on a particular problem

Abilities of one individual user changes over time

(e.g. getting old)

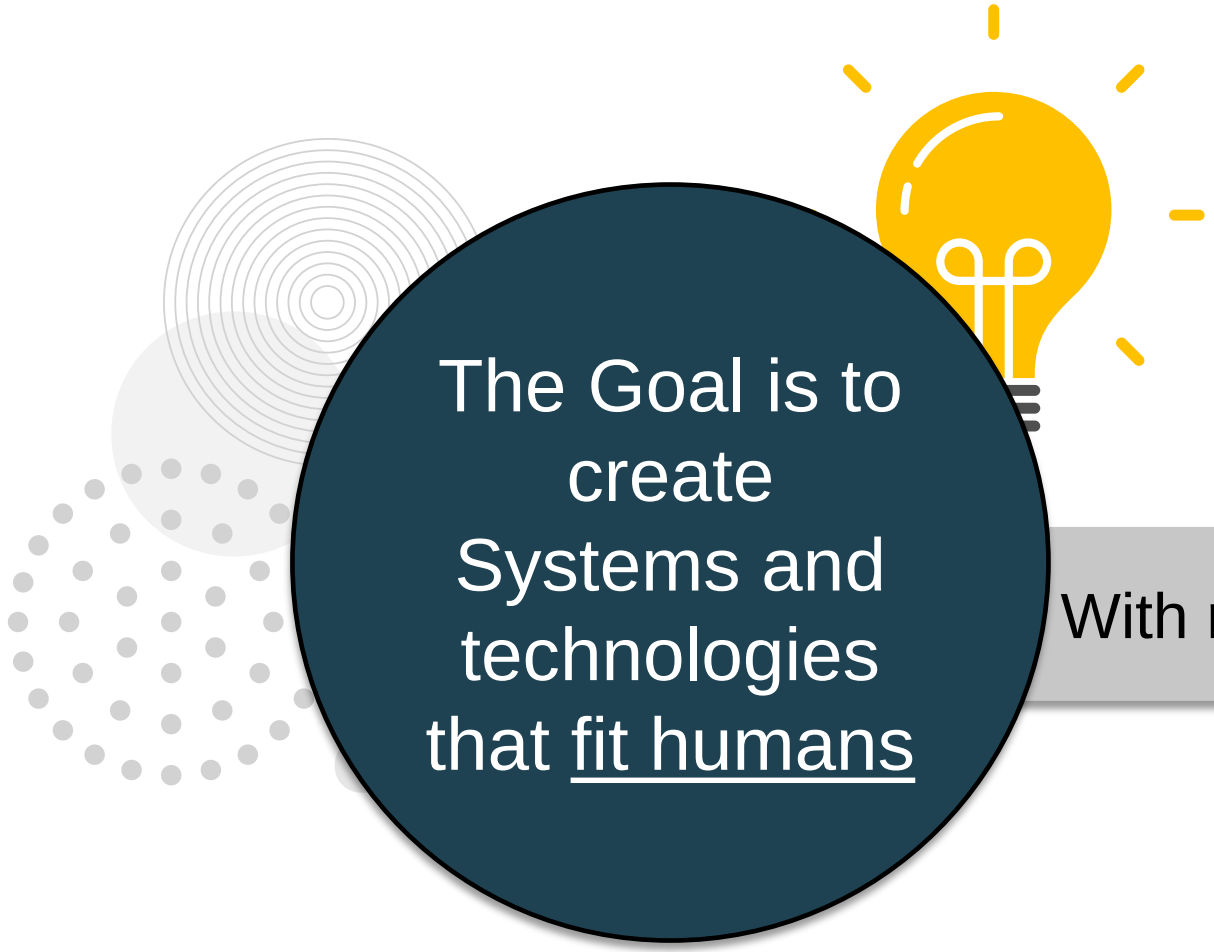


Abilities between individual users vary a lot

- Long term, e.g. gender, physical and intellectual abilities
- Short term, e.g. effect of stress or fatigue

Humans

Design for the human



With regard to

Physiology

Psychology and cognitive abilities

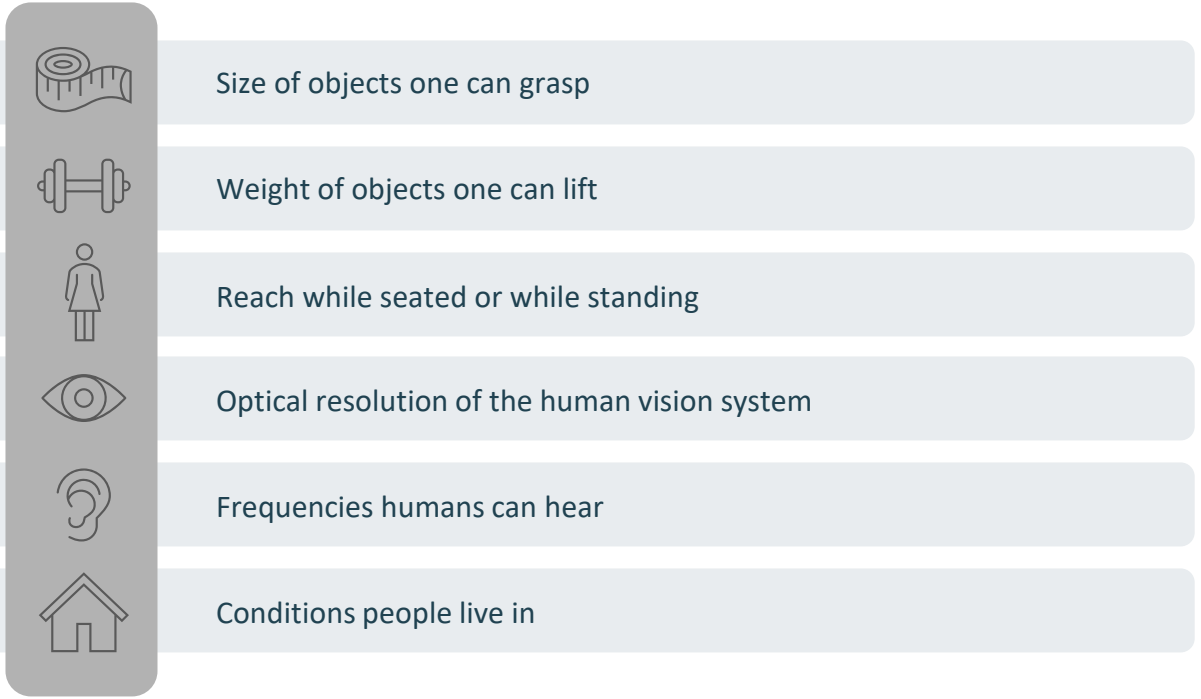
Emotions

Humans - Excurse: Physiology

Humans – Excurse: Physiology

1. Examples for physiological limitations

On the one hand humans have a lot of abilities through their specific physiology but on the other hand also lots of examples where you have physiological limitations:



Size of objects one can grasp

1. Examples for physiological limitations

When you think about Bergkirchweih in Erlangen. You get 1l Maßkrug: For some people this is easy to grab and lift.

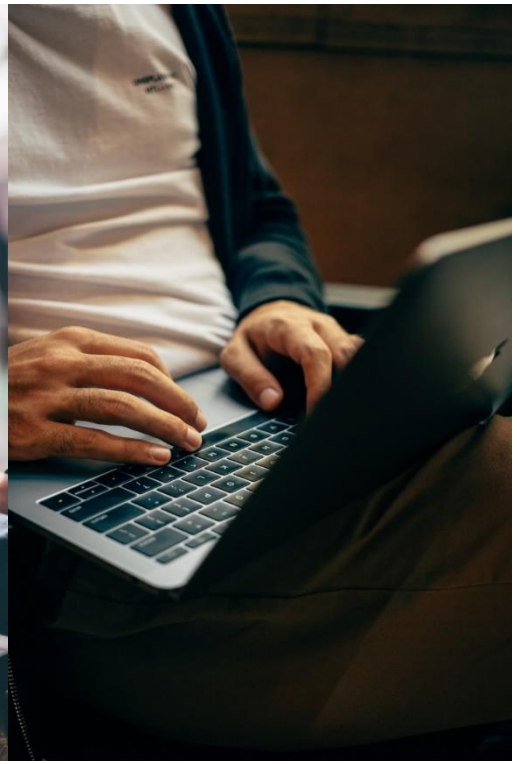
➔ Not all users are able to do that.

Not everything that could be done technically can be used / perceived by humans.

Humans – Excurse: Physiology

2. Relation to Computer Science

If we wouldn't take the human physiology and human factors in general into account, people might not be able to use a certain device or might come up with suboptimal performance.

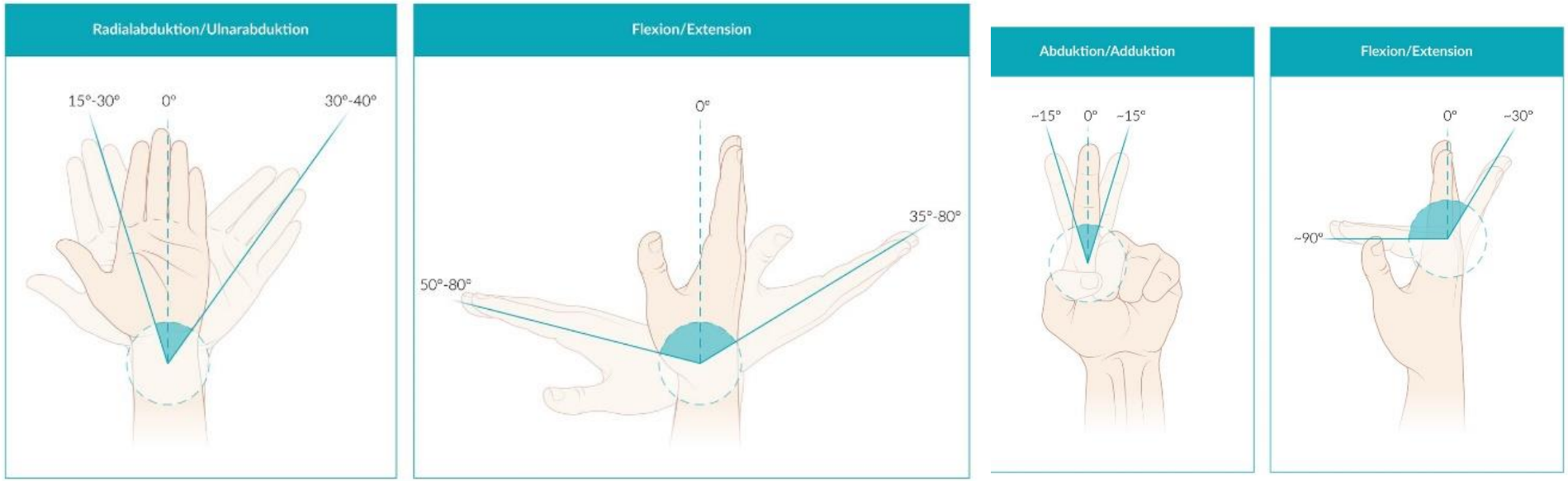


Humans – Excurse: Physiology

2. Relation to Computer Science

The human hand with its numerous bones, joints and muscles is an anatomically complex part of the human body.
It consists of 17 active joints that provide 23 degrees of freedom (DOF) in total.

DOF:



Human Processor, coegnitive abilities and memroy

Model Human Processor (1)

Very simple “model” of a **human interacting** with a computer

See Card, Moran and Newell 1983, and Dix Chapter 1

The model describes the human as **three sub-systems**

Perceptual system
(acquire input from the real world)

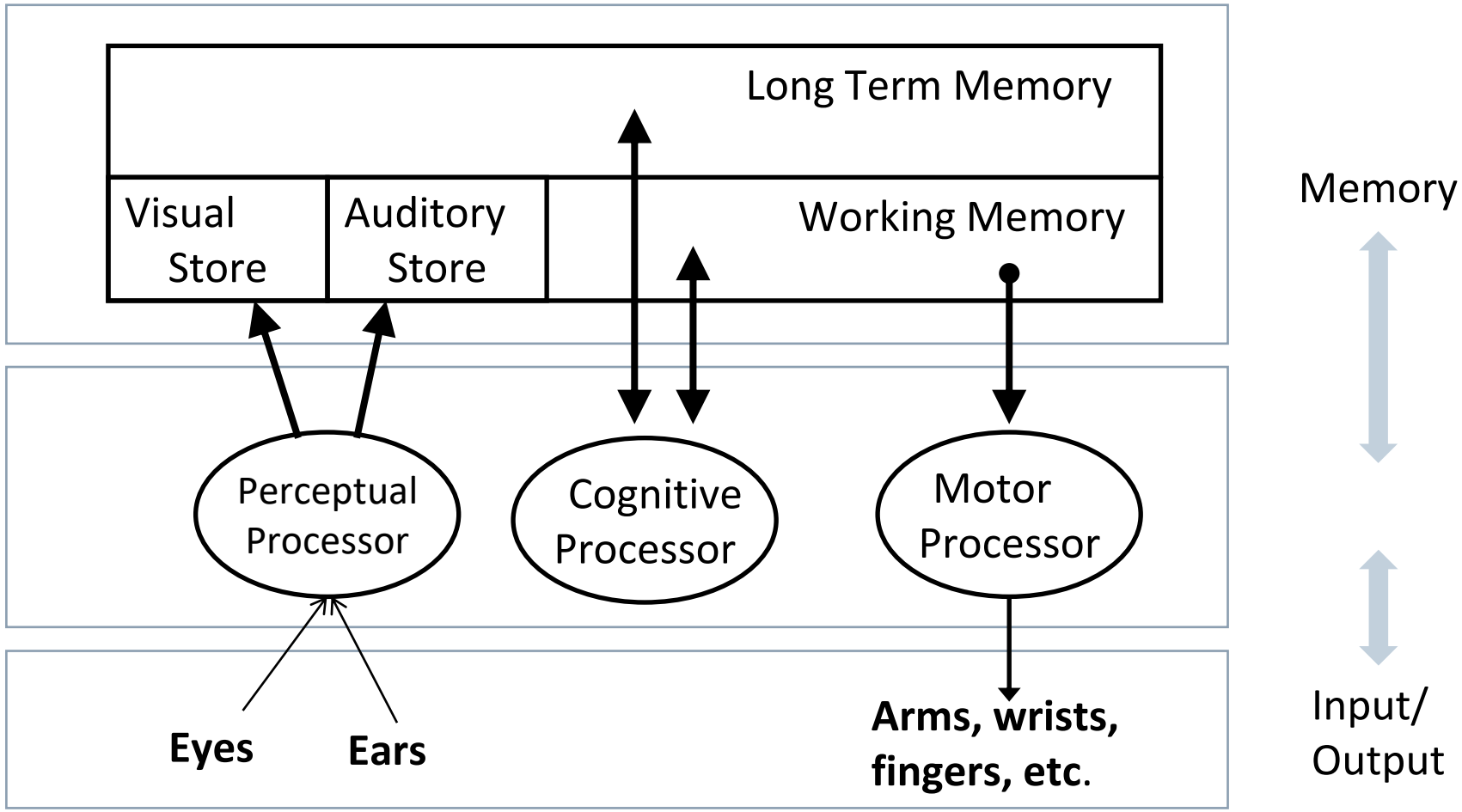
Motor system
(manipulate the real world)

Cognitive system
(connection between input and output, basic processing and memory)

Each subsystem includes:

- Processing
- Memory

Model Human Processor (2)



From Computer Science 498bpb, Psychology of HCI

Model Human Processor (3)

The model can explain how long certain tasks will take

Examples for Reaction/processing time:

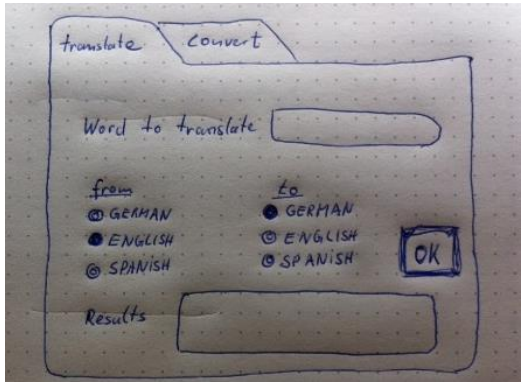
- Perception (stimulus); typical time: TP ~ 100ms
- Simple decision; typical time: TC ~ 70ms
- Minimal motion; typical time: TM ~ 70ms

Further example for complex motor action: see Fitts' law, KLM

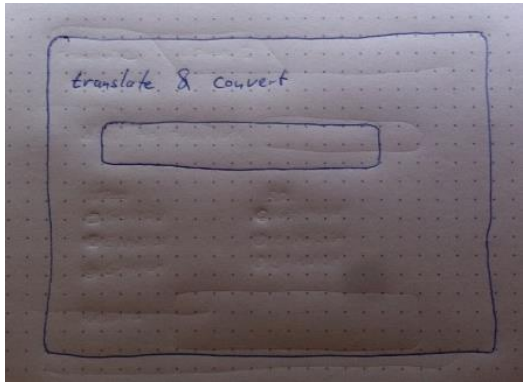
Model Human Processor (3)

Overall time for operation where there is a sequential processing

- Pressing a button when a light comes on ?
  - 240ms
  - T = TP + TC +TM
- Matching a symbol and then pressing one of the two buttons ?
  - 310ms (2TC because there is comparison and decision)
  - T = TP + 2TC + TM



VS.



Processing can also be “**parallel**”
(e.g., phoning while writing, talking while driving, …)

Movement

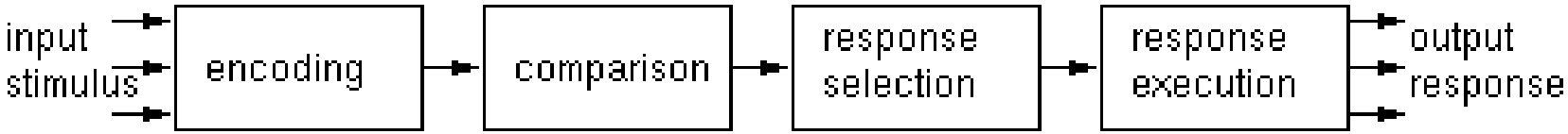
Time taken to respond to stimulus

- Reaction time + movement time
- Movement time dependent on age, fitness etc.
- Reaction time – dependent on stimulus type:
  - Visual ~ 200ms
  - Auditory ~ 150ms
  - Pain ~ 700ms

- Interesting for programming games
- $t = \sqrt{\frac{2d}{9.81\ m/s^2}}$
  - d = distance in meters
  - t = reaction time

Human Information Processing

Sequential four-stage process

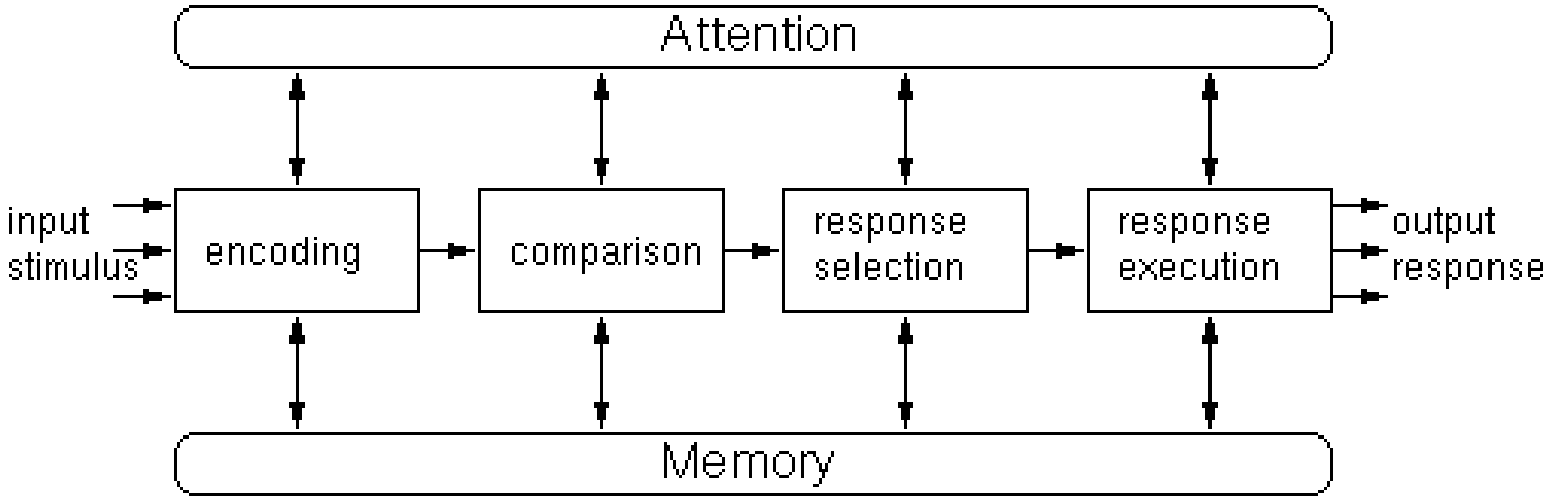


- Encode stimulus received from the environment into an internal representation
- Compare the encoded stimulus with stored / memorised representation
- Formulate / select a response to received and encoded stimulus
- Act on the stimulus and execute the response

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

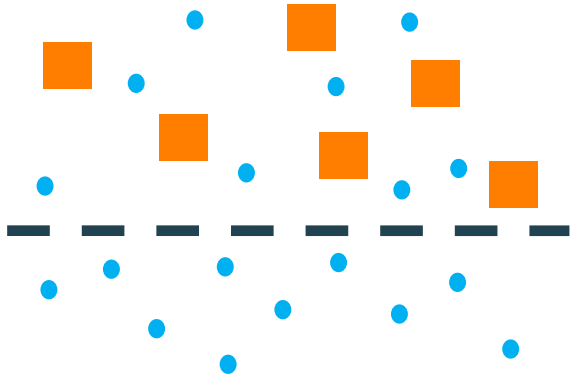


Barber, P (1988). Applied Cognitive Psychology. London: Methuen.
Source (text, image): http://web.cs.dal.ca/~jamie/teach/NickGibbins/psych.html

Excurse: Attention

Like a Filter?

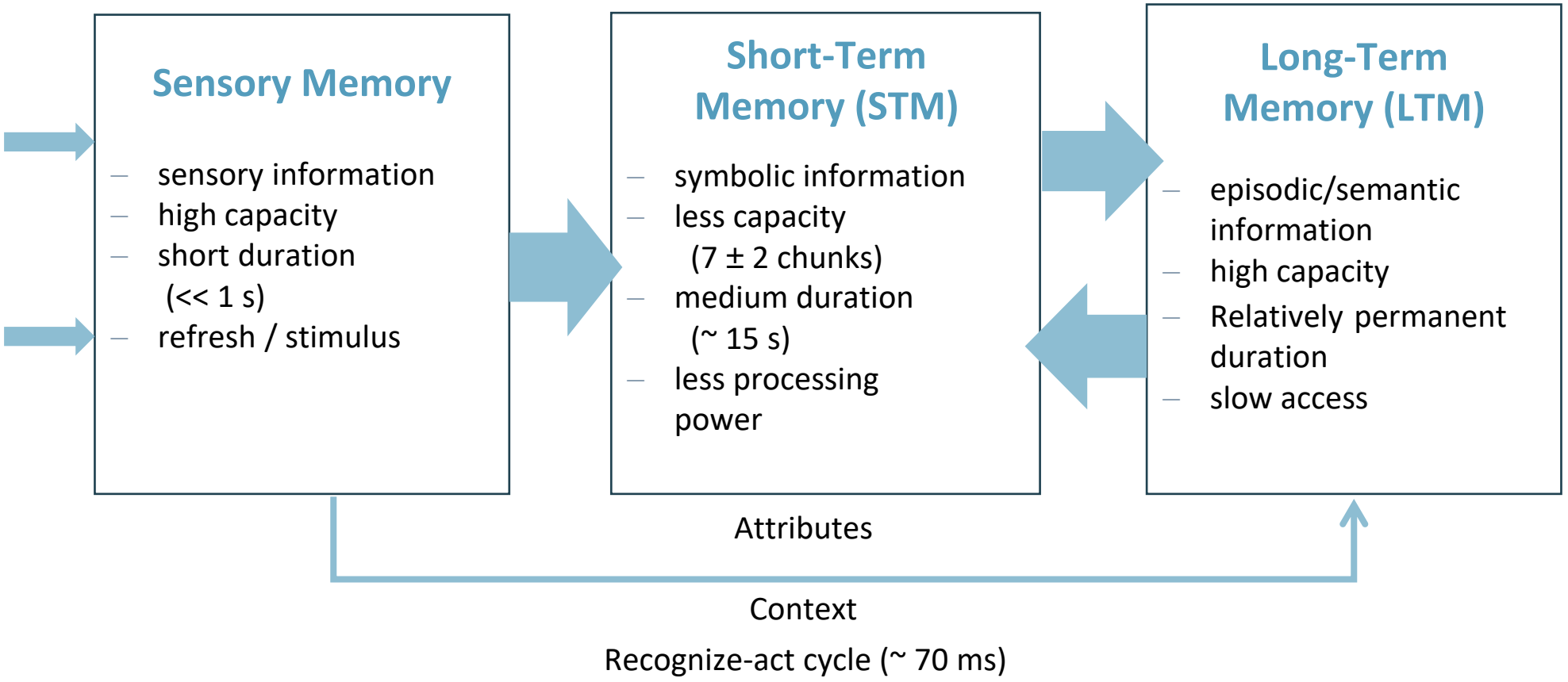
- Attention acts as filter
- “Relevant” stimuli are accepted
- Others are filtered out



Like a Bottleneck?

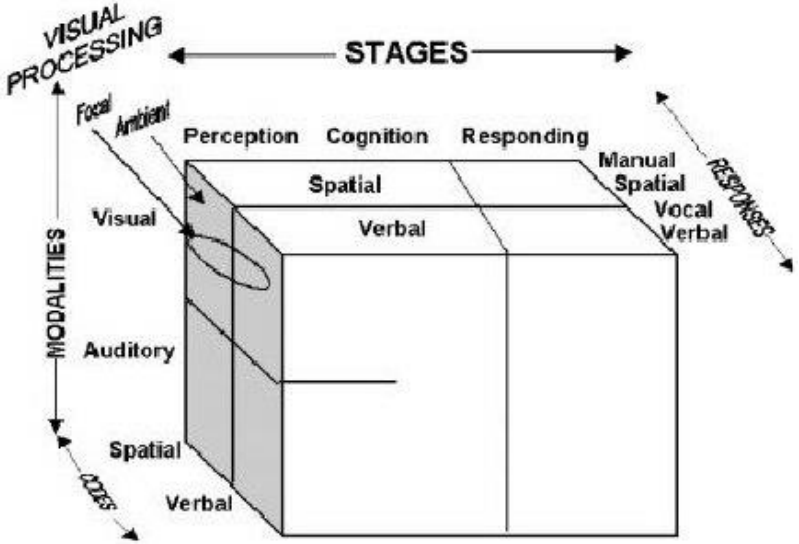
- Attention as a limited resource
- The capacity is limited
- Only parts “get through”
- Coding is relevant

Multi-Store Model for visual and oral perception



Wickens 4 - Dimensional Multiple Resource Model

- **Four** dimensions:
  - Processing stages
  - Perceptual modalities
  - Visual Channels
  - Processing codes
- Implications:
  - Tasks that use different resources are easier to do than tasks that require “more” of one resource
  - Listening to 2 conversations?
  - Searching a photo while listening?

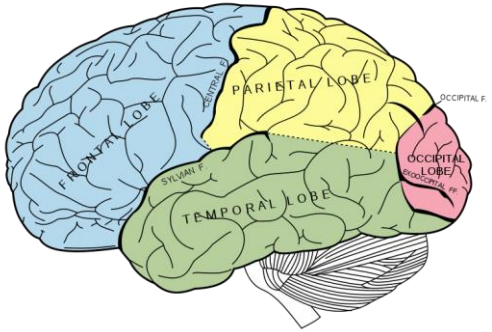


Source: Wickens, C. D.: Multiple resources and performance prediction. Theoretical Issues in Ergonomics Science. S.159–177, 2002.

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 GUI over command-based interfaces
- Better at **remembering images** than words
  - The use of icons rather than names



Reproduction of a lithograph plate from Gray's Anatomy by Mysid (public domain)
https://en.wikipedia.org/wiki/File:Gray728.svg

https://en.wikipedia.org/wiki/File:Luna_Park_Melbourne_scenic_railway.jpg

Short-term memory (STM)

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Guideline: Do not overload and over strain your STM

- Use **known symbols**
- Notes, menus, lists (**WYSIWYG**)
- **Grouping**, chunks (complex super symbols)
- **Short**, closed actions

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6B7C

www.mad.tf.fau.de
131.188.16.206

Guideline: Utilize STM properties

- Visualize **attributes** (icons, colors)
- Link illusion and keyword
- **Minimize distraction!**
- **Avoid inconsistent** similarity (e.g. get / set , delete / repeat)
- **Reduce Complexity**

Long-term memory (LTM)

- Context-based memory (associative links)
- Loss of access instead of erasing (forgetting)
- Duration depends on the intensity and the quality of memorizing
- Two types of LTM
  - **Episodic** : serial memory of events
  - **Semantic** : structured memory of facts, concepts, skills
- The following can train your LTM:
  - Learning by **repeated practicing**
  - **Active** learning (learning by doing)
  - **Rules** and **structures** increase the efficiency
  - Illustrate and **visualize** words

Motivation : Decision and long-term memory

Do dogs bark?

Yes | No

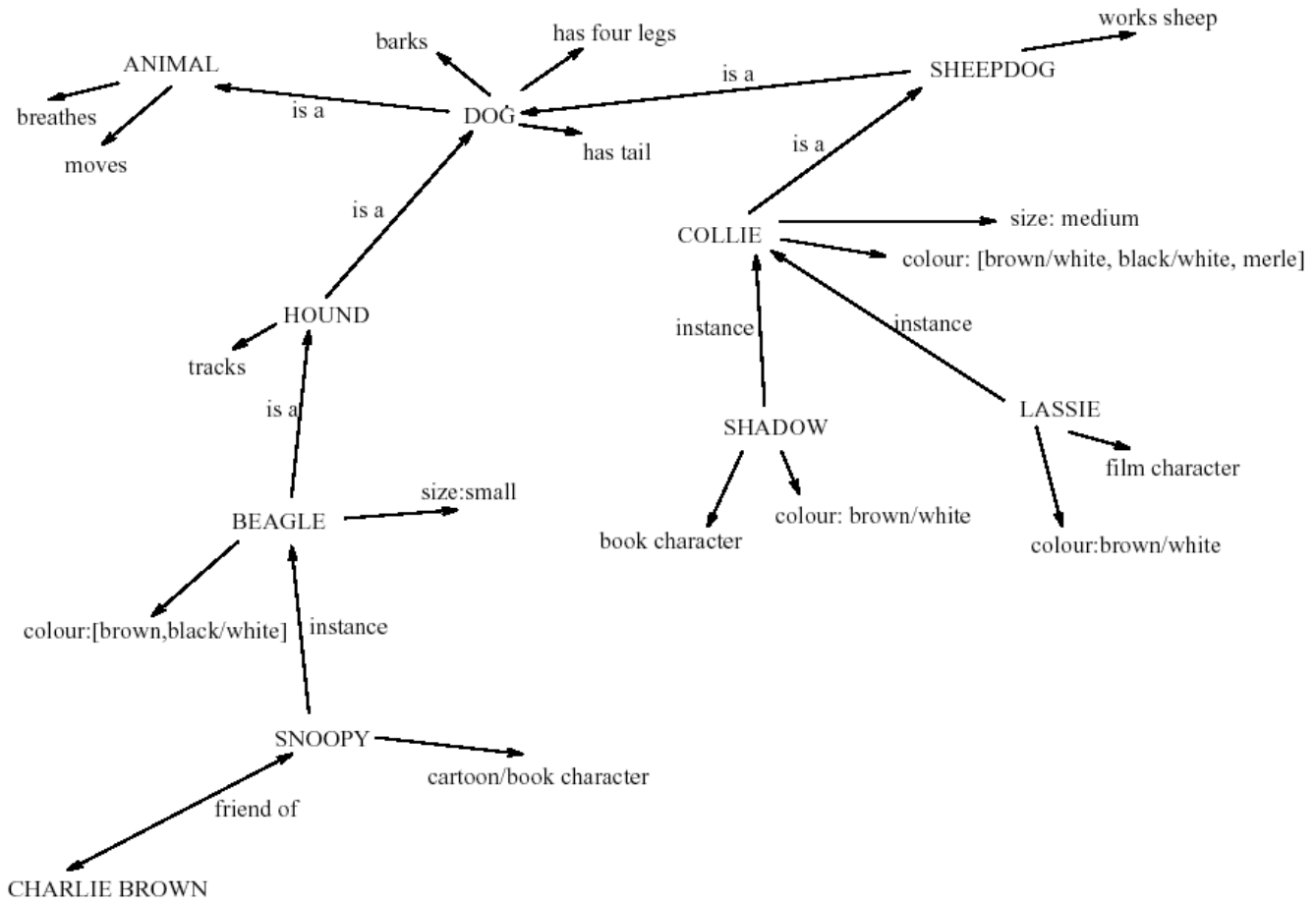
Do dogs breathe?

Yes | No

The second question takes longer to answer.

This indicates semantic coding.

LTM – semantic network



Visual Perception

Visual Perception

Visual perception is one of the most important sources of information.
Approximately 60-80% of all information is perceived visually.
We can define three terms that will clearly distinguish the processes in visual perception:

Reception describes the transformation of the stimulus (light) into electrical energy.
Cognition describes the *"Understanding"* in the brain.
Perception describes the sensors (receptors) and signal processing happening in the eyes and in brain.

Basic and first signal interpretation:

- Size and depth
- Brightness
- Color

Visual Perception – Gestalt Laws

Optical Illusions and Gestalt Laws

Gestalt Laws

Many different Gestalt Laws, but we will stick to just seven:

- Law of Similarity
- Law of Proximity
- Law of Continuity
- Law of Closure
- Law of Pragnanz
- Law of common fate
- Law of Symmetry

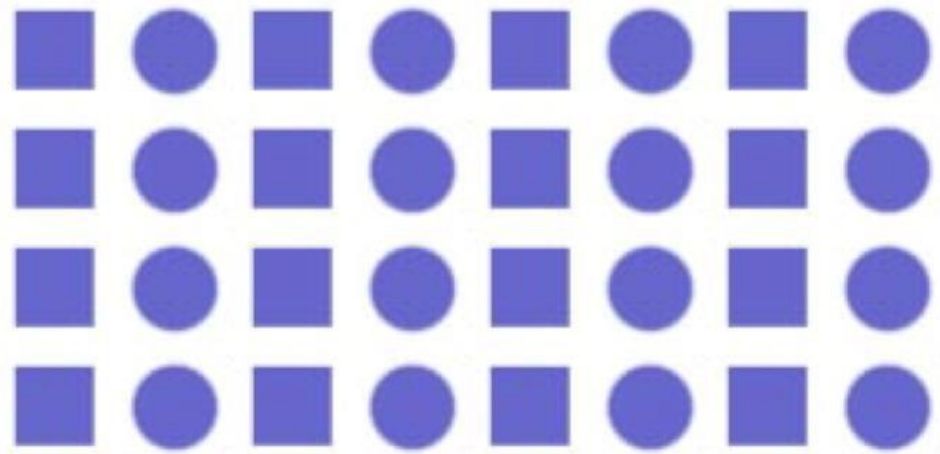
There are more Gestalt Laws like *Figure and Ground* or *Smallness Area*. However, we will only cover the seven Laws above.

Optical Illusions and Gestalt Laws

Gestalt Laws – Law of Similarity

Items that are similar tend to be grouped together.

In the image, most people see vertical columns of circles and squares.

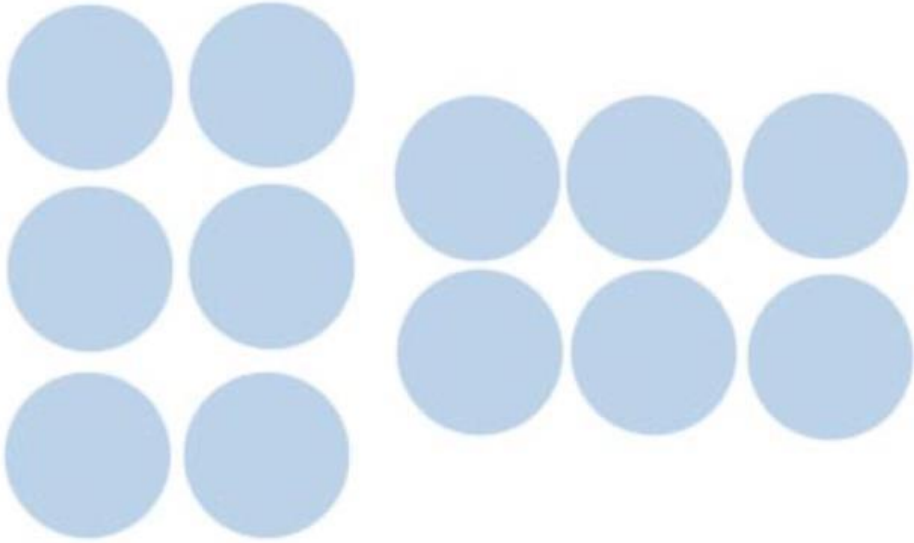


Optical Illusions and Gestalt Laws

Gestalt Laws – Law of Proximity

Objects near each other tend to be grouped together.

The circles on the left appear to be grouped in vertical columns, while those on the right appear to be grouped in horizontal rows.

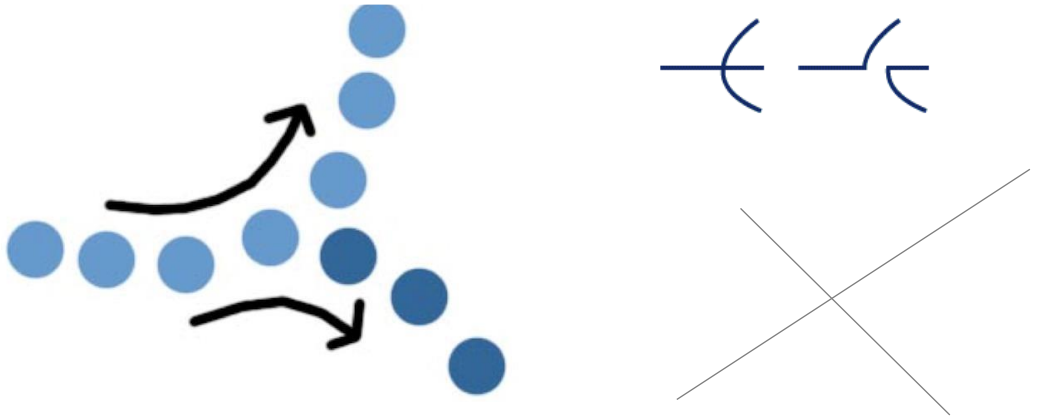


Optical Illusions and Gestalt Laws

Gestalt Laws – Law of Continuity

Lines are seen as following the smoothest path.

In the left image, the top branch is seen as continuing the first segment of the line. This allows us to see things as flowing smoothly without breaking lines up into multiple parts.

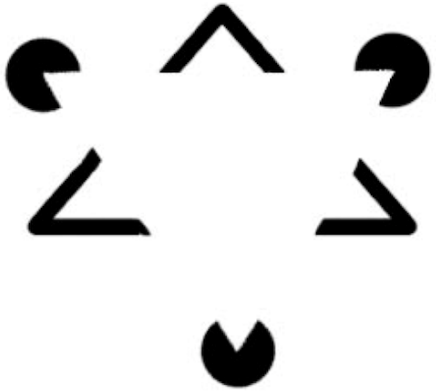


Optical Illusions and Gestalt Laws

Gestalt Laws – Law of Closure

Objects grouped together are seen as a whole

We tend to ignore gaps and complete contour lines. In the left image, there are no triangles or circles, but our minds fill in the missing information to create familiar shapes and images.

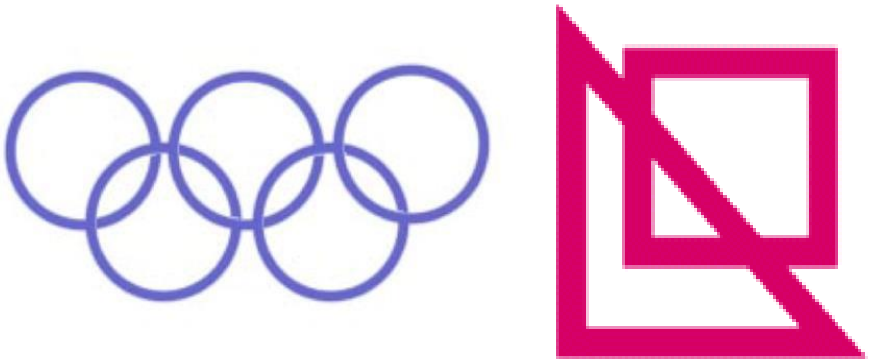


Optical Illusions and Gestalt Laws

Gestalt Laws – Law of Pragnanz (Simplicity/ good shape)

Reality is organized or reduced to the simplest form possible

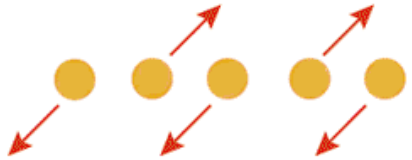
E.g., we see the left image as a series of circles rather than a much more complicated shape



Optical Illusions and Gestalt Laws

Gestalt Laws – Law of common fate

Elements with the same moving directions are perceived as a collective or unit.

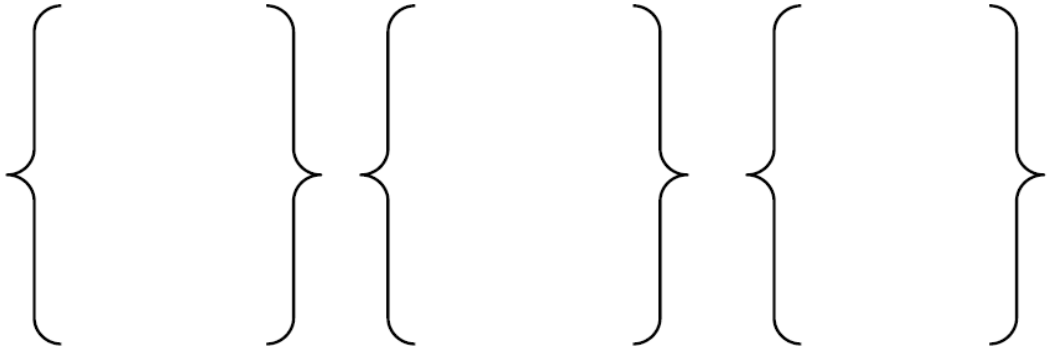


Video Link:
https://www.youtube.com/watch?v=LZMaTtPHBMk

Optical Illusions and Gestalt Laws

Gestalt Laws – Law of symmetry

Symmetrical images are perceived collectively, despite their distance to each other



Thank you for your attention!

Are there questions