

Psychology 101

Action – Perception – Cognition

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Action-perception coupling

« Classical » psychology (cognitivist approach)

Perception \Leftrightarrow Cognition \Leftrightarrow Action

Coupling between action and perception

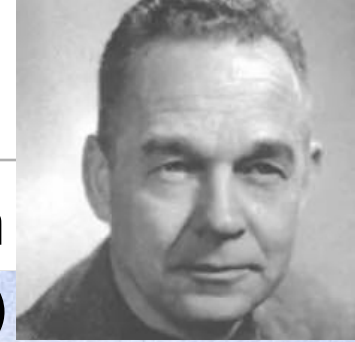
Action for perception

Move head to perceive depth

Manipulate object to perceive its shape

Perception for action

Adjust arm and hand motion to grasp an object



Ecological theory of perception - James Gibson (1966)

Co-evolution between the animal and its environment

Direct perception

« Information pick up »

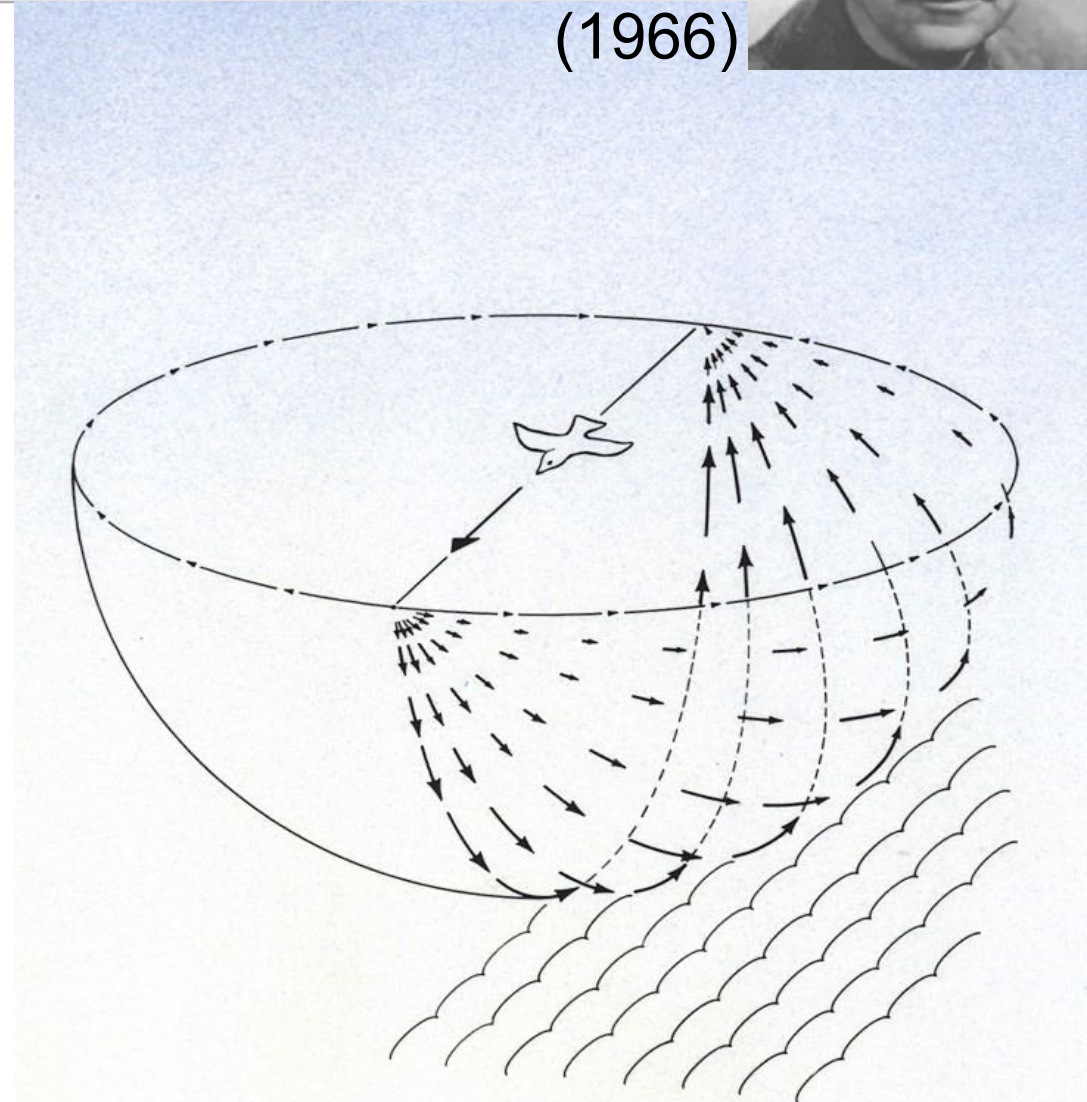
Visual perception

Perception of optical flow

Extract invariants

Example :

direction of motion =
fixed point in the optical flow



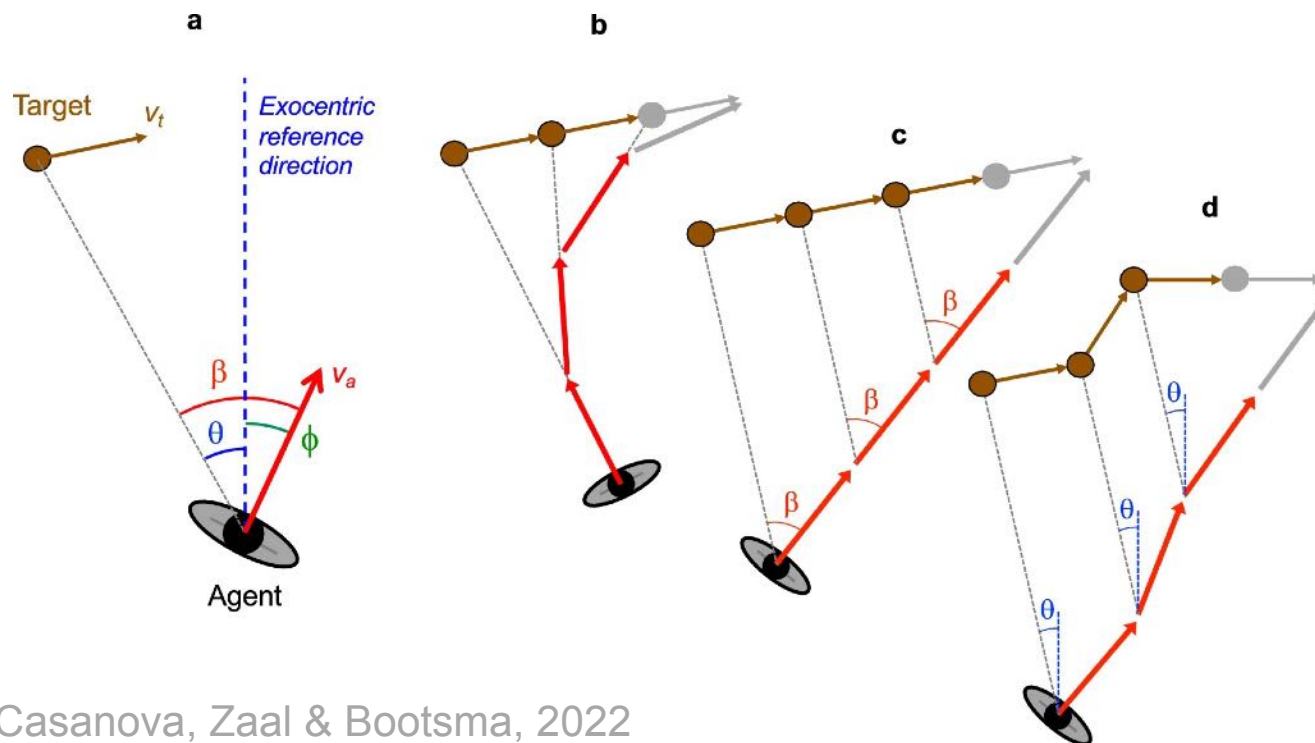
Maintaining invariants: intercepting a moving target

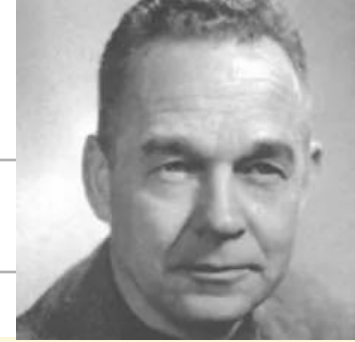
Maintain a constant angle between target and self motion

(b) Zero Target-Heading Angle (ZTHA) or classical pursuit,

(c) Constant Target-Heading Angle (CTHA) or classical interception

(d) Constant Bearing Angle (CBA).



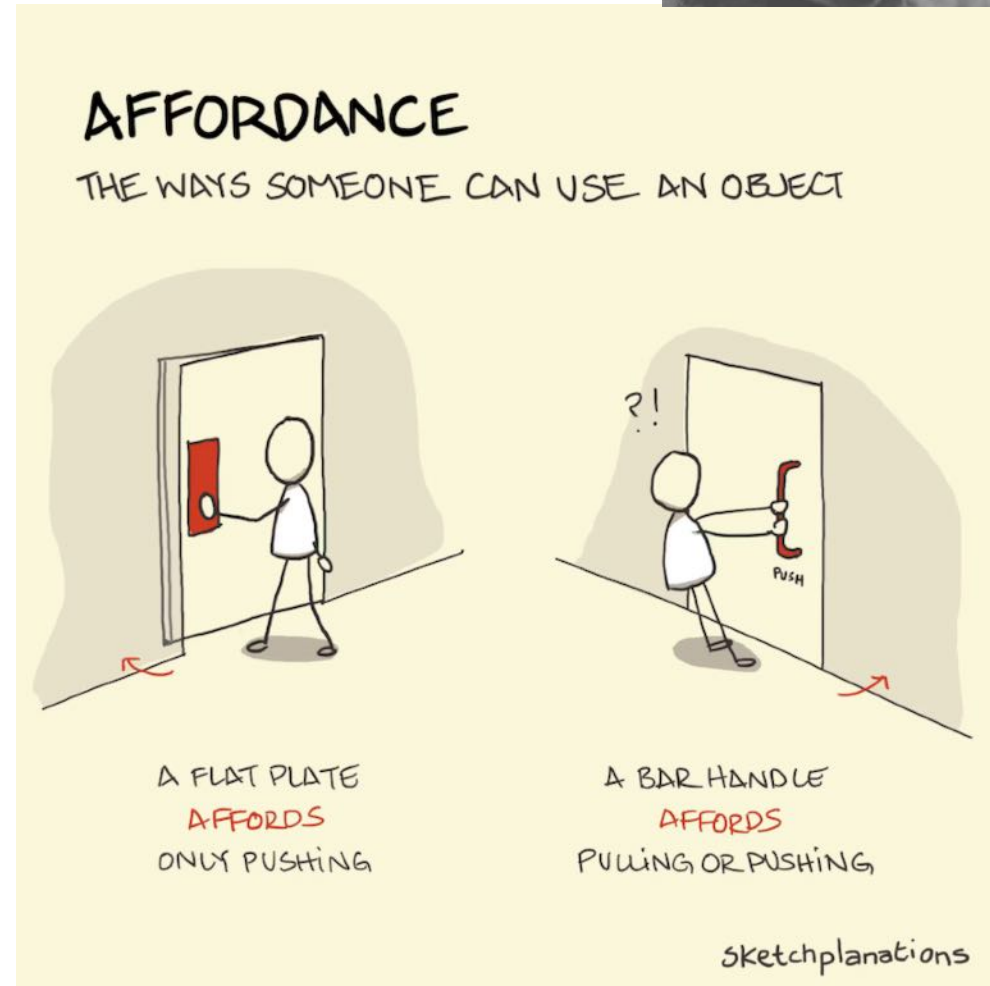


Affordances - James Gibson (1979)

The possibilities of the environment for action, in relation to the action capabilities of the animal

Independent of the actor's experience, knowledge, culture, or ability to perceive

(Incorrectly) introduced in HCI by Don Norman, who focused on *perceived* affordances, which he later renamed “signifiers”





Perceptual learning - Eleanor Gibson (1960s)

We learn to perceive

We perceive to learn

Visual cliff experiment

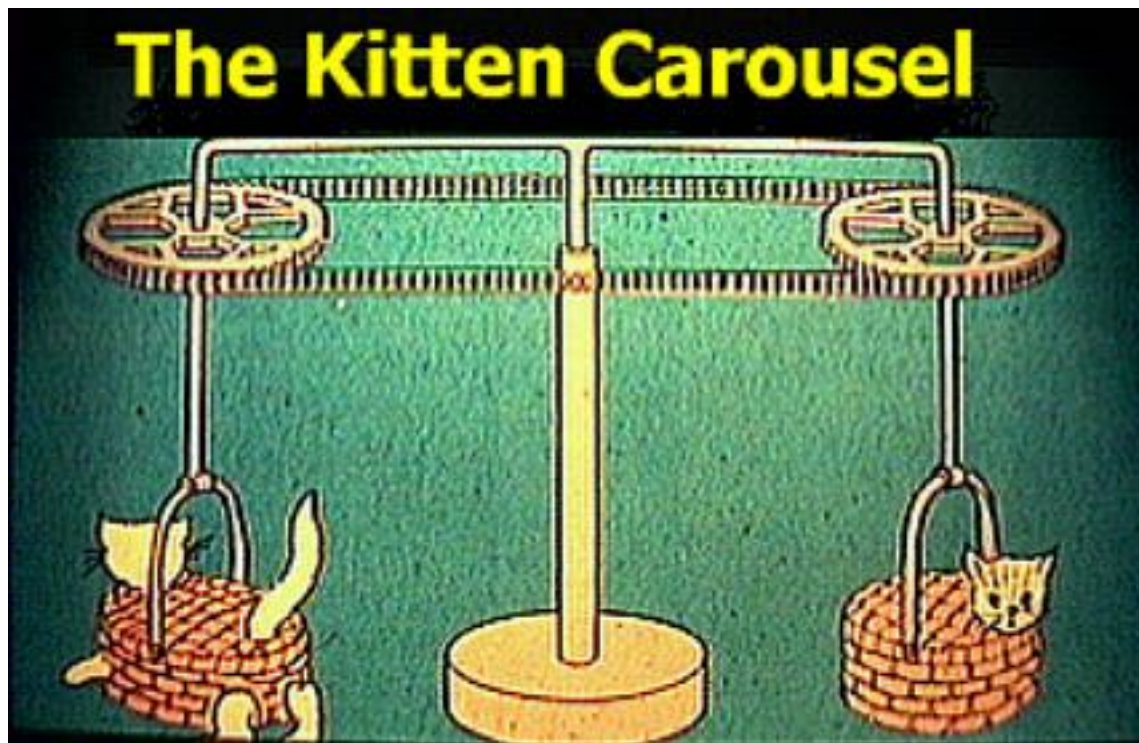
(Gibson & Walk, 1960)

92% of babies (6-14 months)
would not cross the visual cliff



Kitten Carousel - Richard Held & Alan Hein (1963)

The role of experience in perceptual-motor development



Self-produced movement and concurrent visual feedback are essential for the development of visually guided behavior

Kitten Carousel - Richard Held & Alan Hein (1963)

“Self-produced movement and concurrent visual feedback are essential for the development of visually guided behavior”

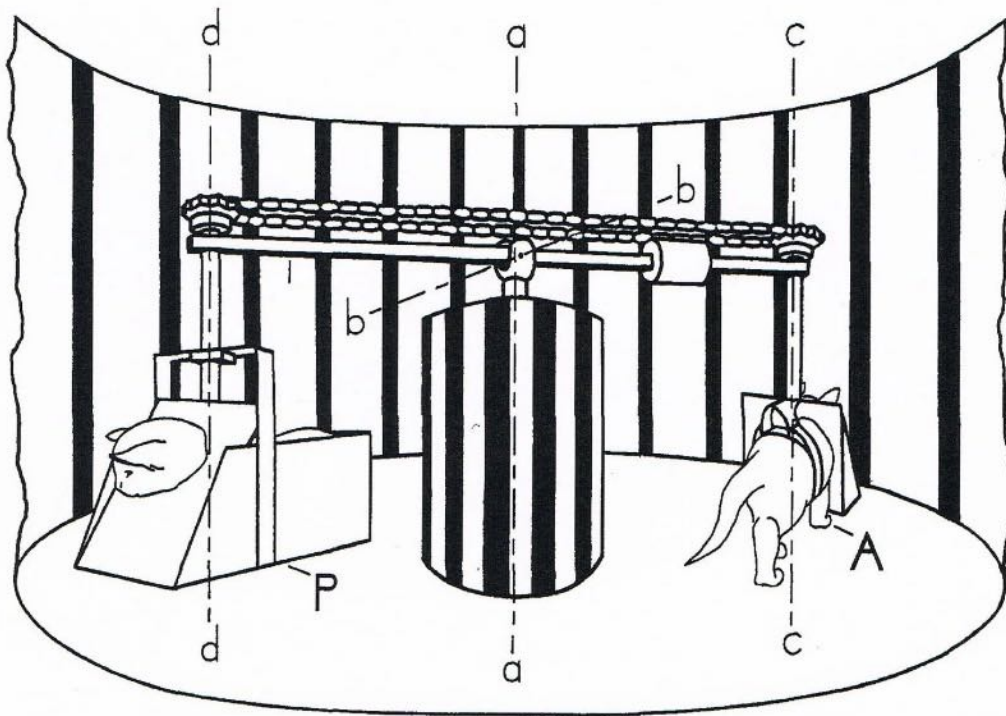


Table 1 Responses on the visual cliff

Active kittens		Passive kittens	
shallow	deep	shallow	deep
12	0	6	6
12	0	4	8
12	0	7	5
12	0	6	6
12	0	7	5
12	0	7	5
12	0	5	7
12	0	8	4
12	0	6	6
12	0	8	4

Visual channel: Sight

Visual field is about 180°

Focus of attention

Visual acuity: 0.04mm at 50cm

Peripheral perception

Less sensitive to colors,
More sensitive to motion

Perception of color, motion, depth

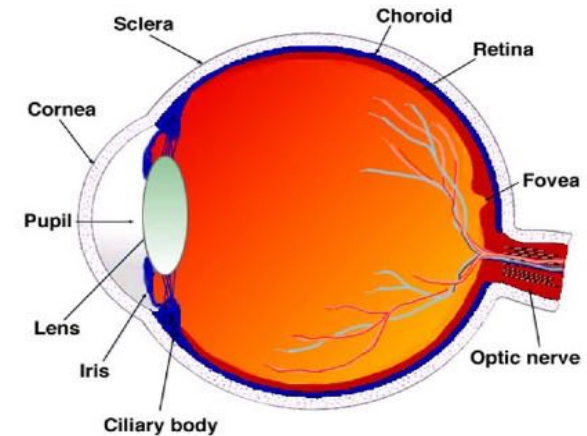
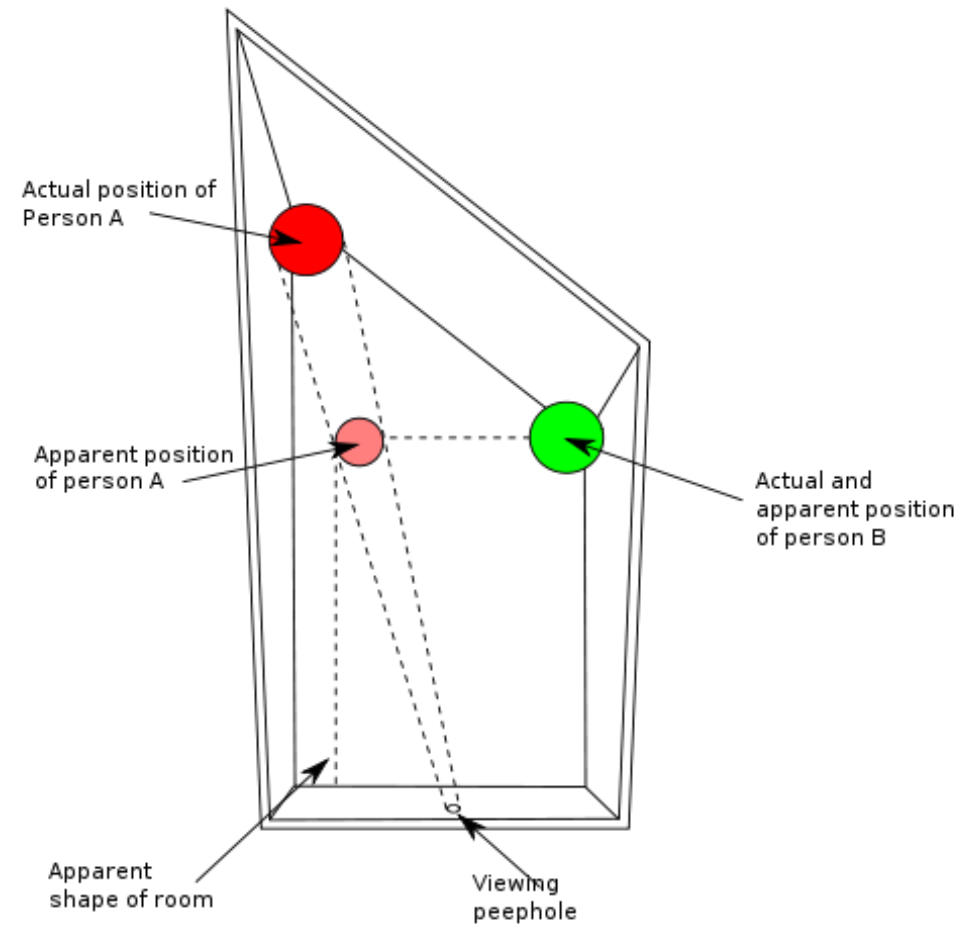


Fig. 6. Vertical sagittal section of the adult human eye.

Depth illusion: Ames room



The Monkey Business Illusion

Watch this video:

https://www.youtube.com/watch?v=IGQmdoK_ZfY



The Monkey Business Illusion

Daniel J. Simons



(c) 2010 Daniel J. Simons

Change blindness

We do not always notice changes in visual stimuli,
even when the change is dramatic

Attention is selective: notifications can go unnoticed



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Auditory channel: Hearing

Very large sensitivity range

Hearing without listening
« Cocktail-party » effect

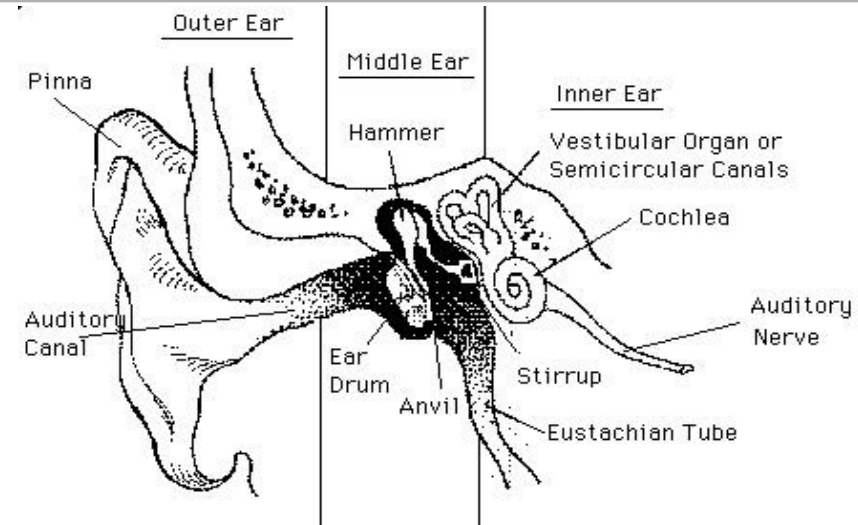
Masking effects

Distance between sources

Distance between peak frequencies

Localizing a source

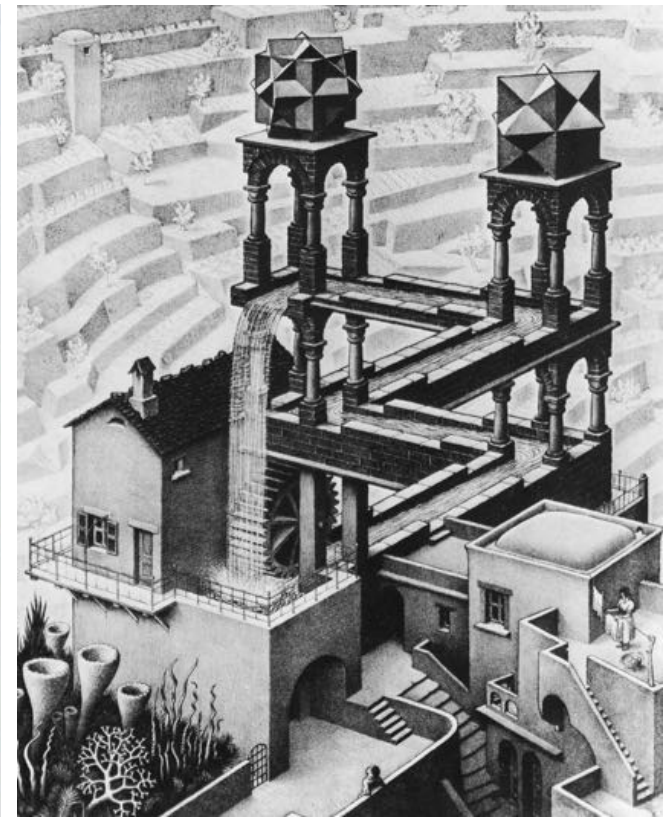
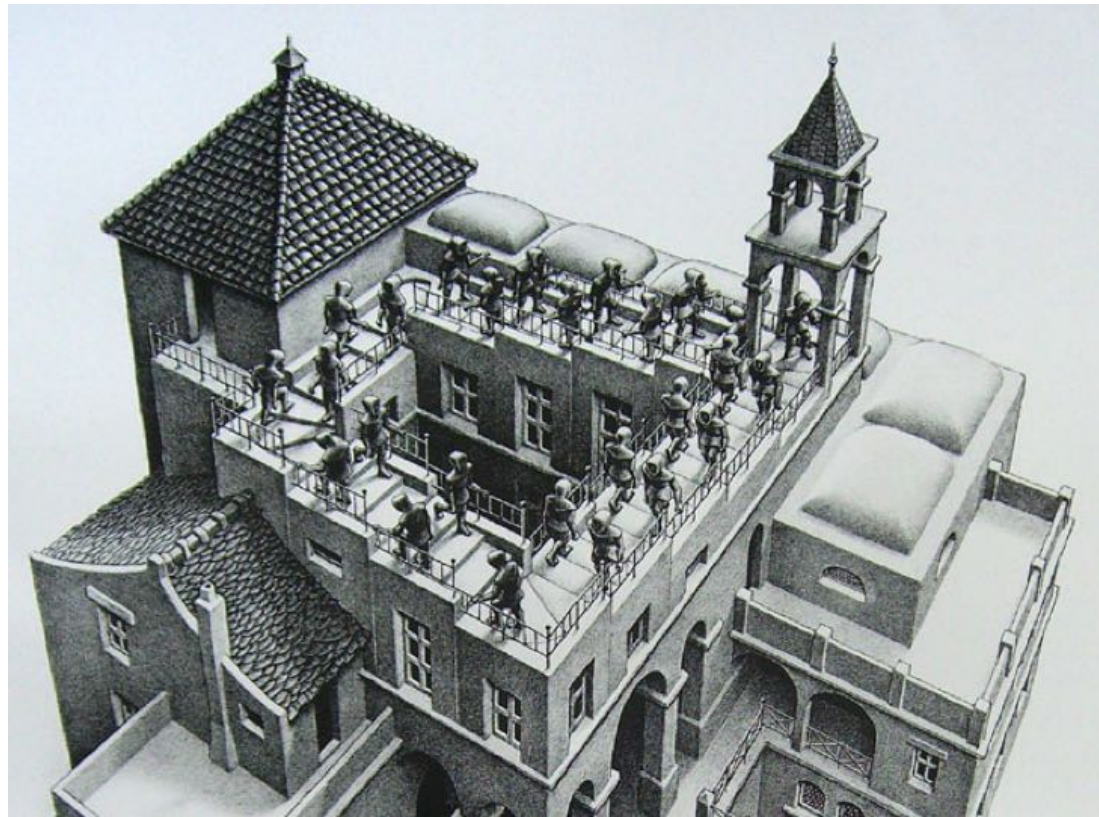
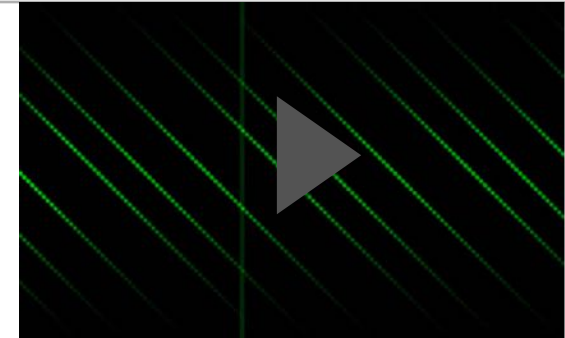
Correlation with visual localisation



Auditory illusion: Sheppard-Risset tones

A sound that (seems to) always go down

Audio equivalent to Escher's stairs or fountain

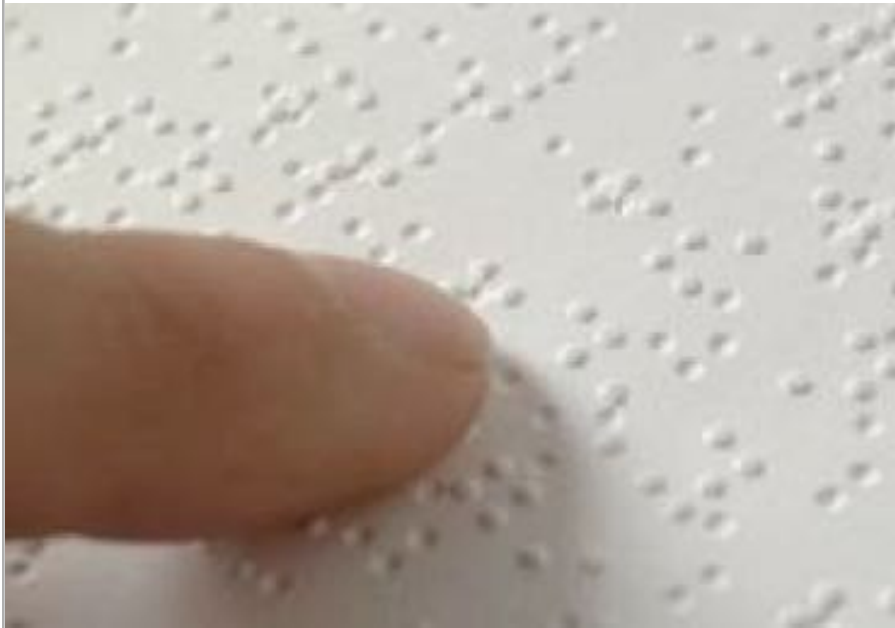
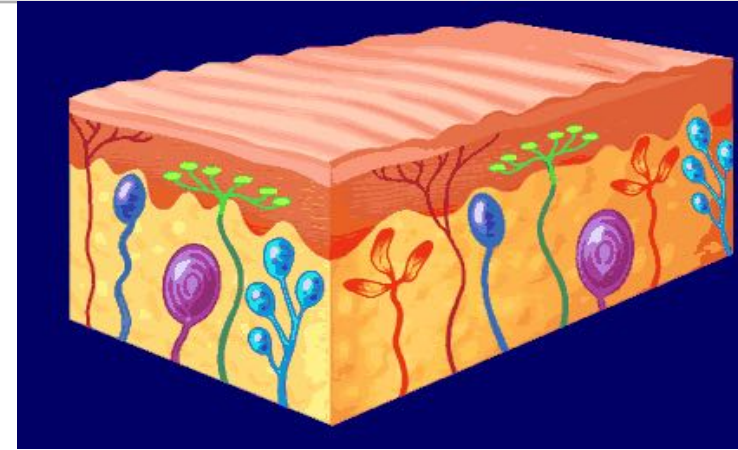


Haptic channel: TPK

Touch: 6 types of receptors

Heat, Cold, Pain

Pressure, Vibration, Texture



Haptic channel: TPK

Touch

Proprioception

Configuration of one's body in space,
used to perceive, e.g., the shape of an object



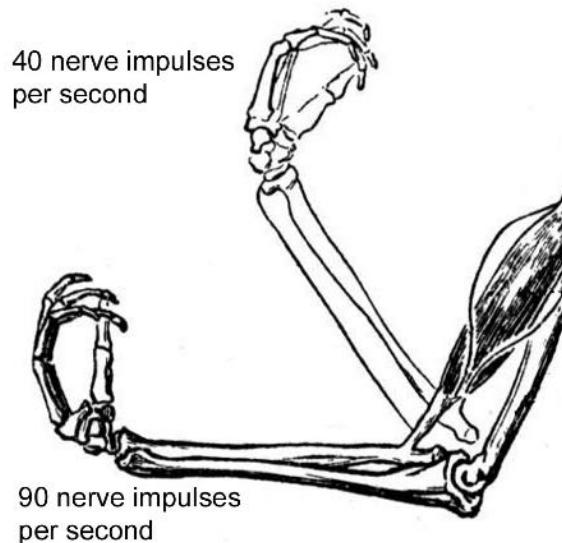
Haptic channel: TPK

Touch

Proprioception

Kinesthesia

Tension of one's muscles,
used to assess the weight or resistance of an object



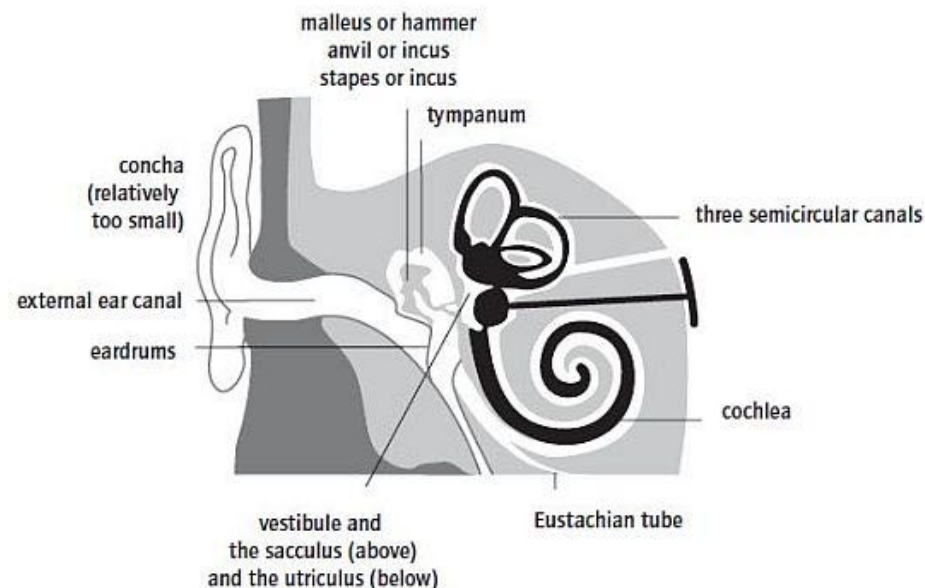
Vestibular sense

Sense of balance: relative orientation in space

Located in the inner ear

Multimodal perception: visual, kinesthetic, vestibular

Discrepancies cause nausea/dizziness



Motor system

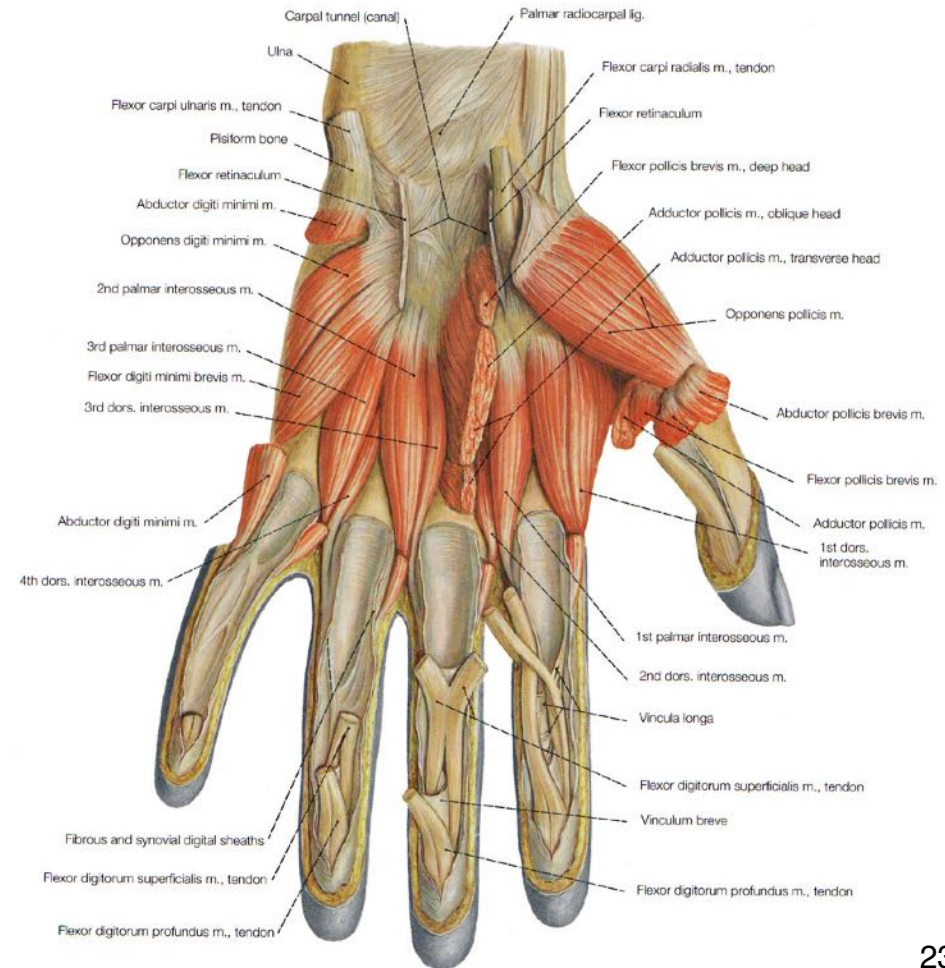
Control body movements

Locomotion

Physical action

Gesturing, hand movements

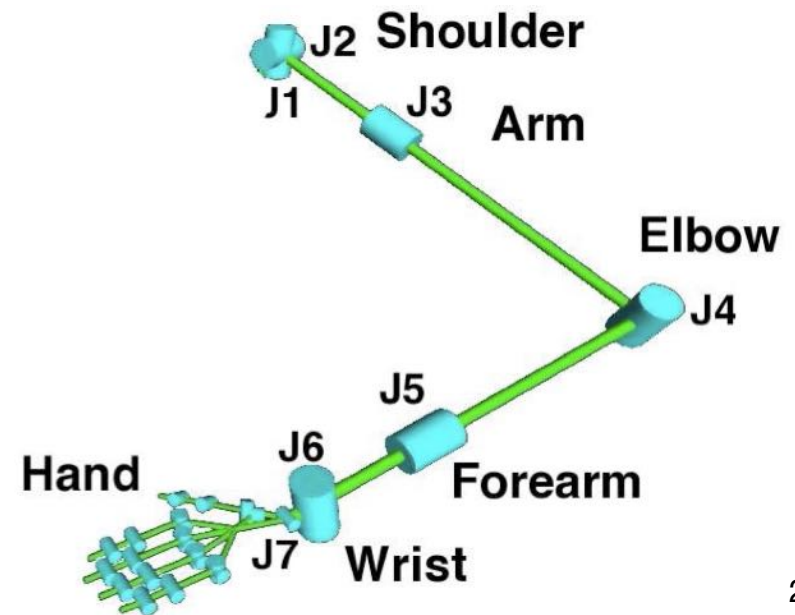
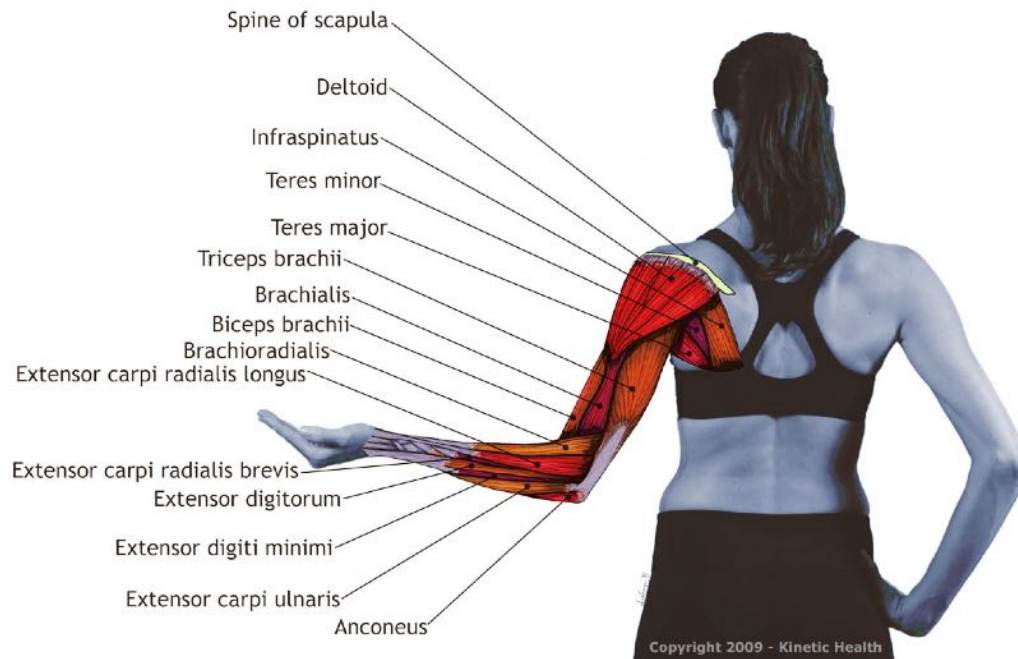
Voice



Motor system

Control body movements

Kinematic chain: articulated arrangement of the limbs
to combine large amplitude and precise movements



Motor system

Control body movements

Kinematic chain

Bi-manual control (Yves Guiard)

Non dominant hand: sets the context

Dominant hand: acts within that context



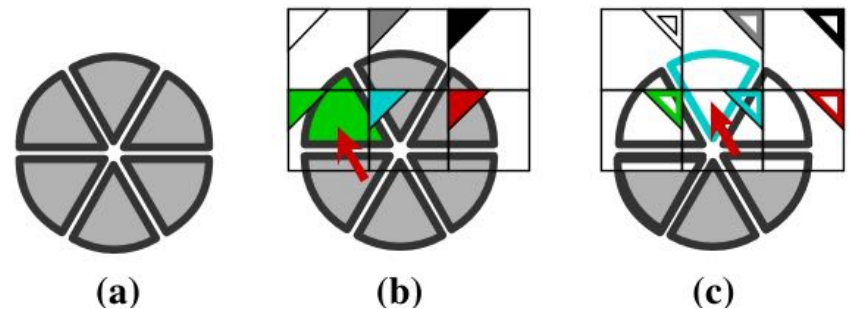
Motor system

Control body movements

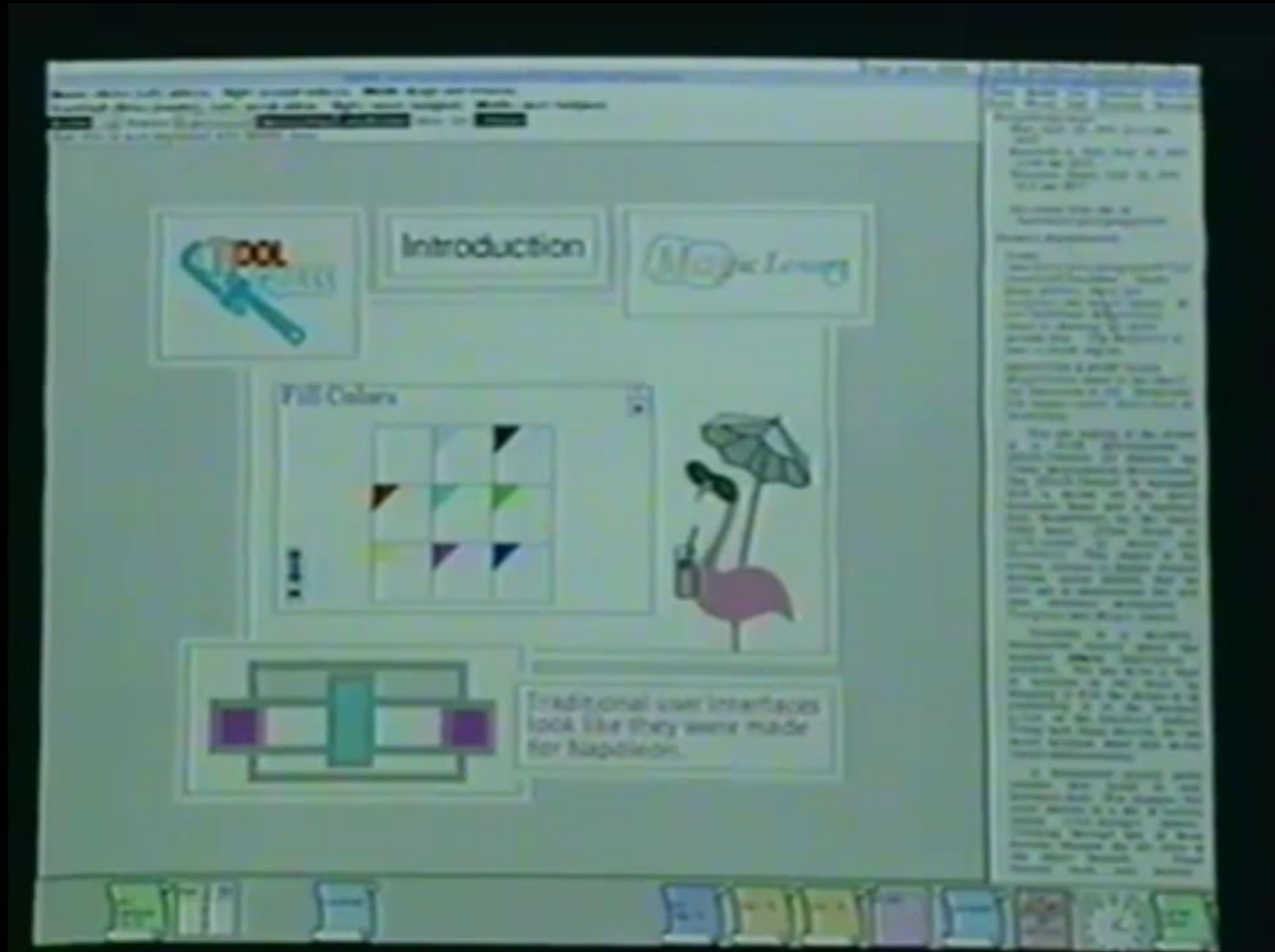
Kinematic chain

Bi-manual control (Yves Guiard)

Application to a drawing interface: Toolglasses



Toolglasses and Magic Lenses,
Bier et al., SIGGRAPH 1993





Motor system

Paul Fitts

Controlling a gesture: target pointing

Fitts' law

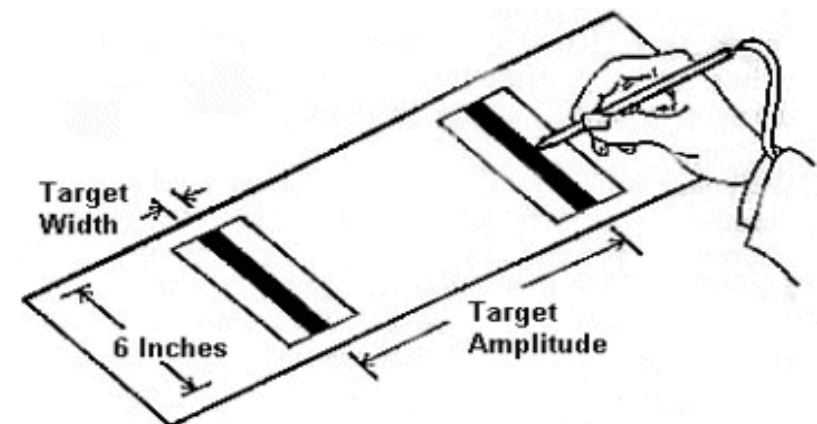
$$MT = a + b \log(1 + D/W)$$

MT, movement time

D , distance to target

W , width of target

a , b , empirically determined constants



Scale invariant:

pointing a target twice as large at a distance twice as long takes the same time

Functions of the gestural channel - Claude Cadoz

Epistemic:
acquire information



Ergotic:
transform through
physical action



Semiotic:
emit information



Memory

Short-term memory

Working memory

Low capacity (7 ± 2)

Short-lived (10-30s)

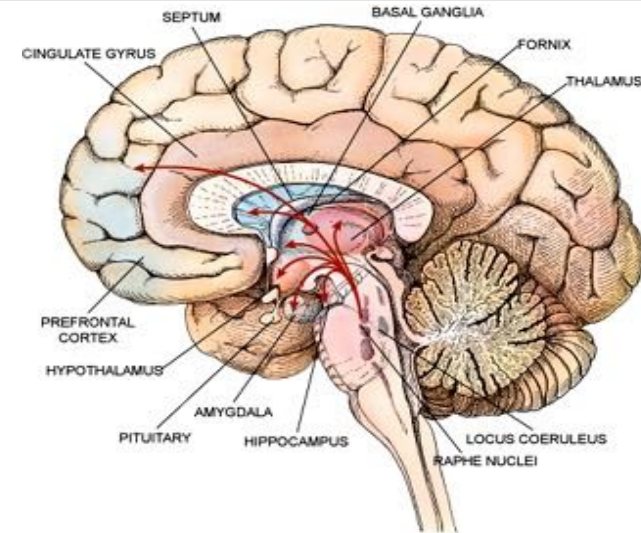
Long-term memory

Infinite capacity

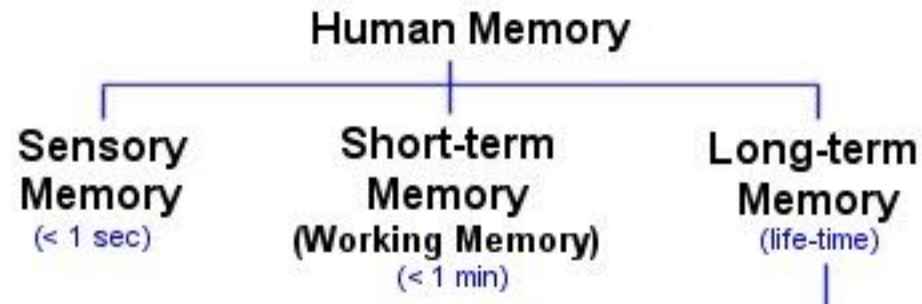
Unlimited duration

Associative access

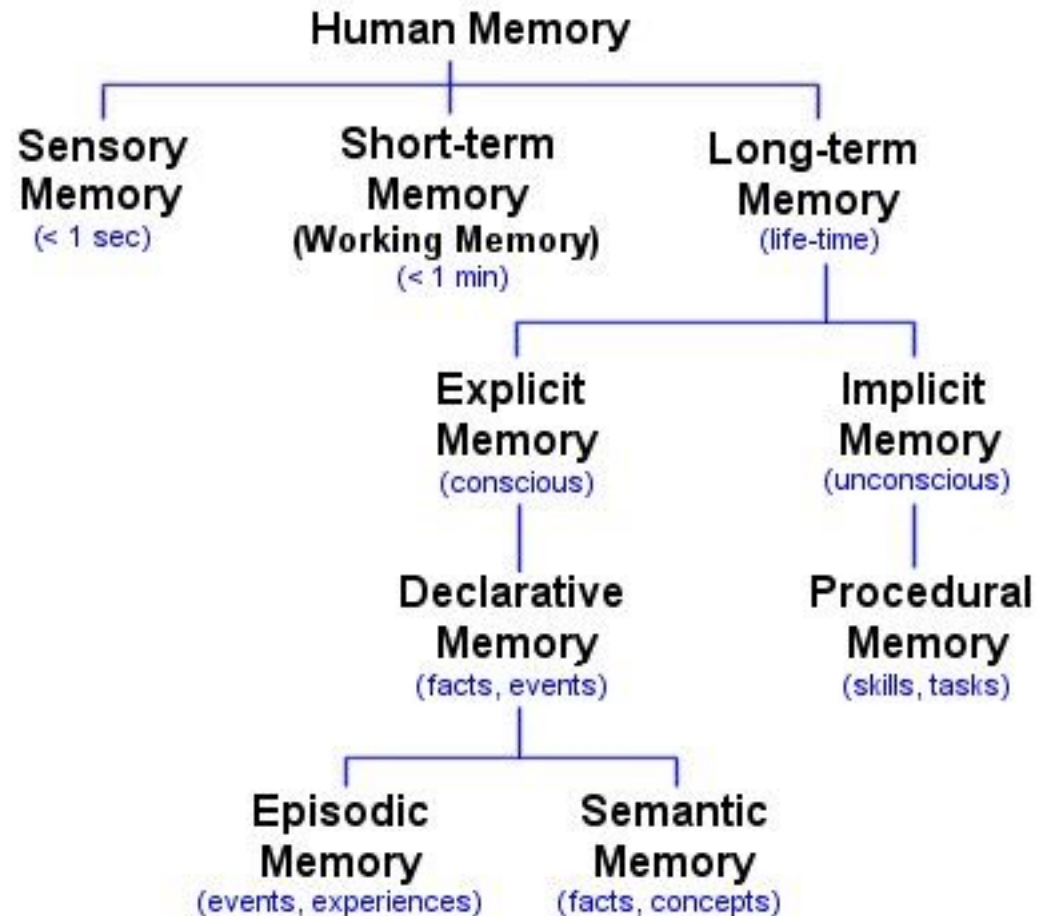
Memory tasks: Recognition (have you seen this before?)
vs Recall (what is your PIN number?)



Different types of memory



Different types of memory



Learning

Acquiring skills, knowledge, behaviors (and more: values, attitudes, ...)

Psychomotor (dance, swim, ride a bike, ...)

Cognitive (recall, calculate, analyze, ...)

Affective (like, fear, hate, ...)

Non-associative learning

Habituation (diminishing response to a repeated stimulus)

Sensitization (amplified response to a repeated stimulus)

Active learning

Explicit activity that involves metacognition (knowing what I know)

Learning

Associative learning

Classical conditioning:

Pairing a stimulus that evokes a reflex with another stimulus.

After conditioning, the response occurs for both stimuli (Pavlov's dog)

Operant conditioning:

Shaping a behavior according to the desires of the trainer through reinforcement and (positive or negative) punishment

=> Massively used by the Tech industry (social networks, chatbots, ...)

Play

Transfer of learning

Application of learned skills/knowledge to a new situation

Problem solving

Achieving a desired goal by overcoming obstacles

Many different strategies, including:

- Abstraction (solving the problem in a tractable model)

- Analogy (to a previous problem that was solved)

- Divide and conquer (breaking down into smaller problems)

- Help seeking (getting external assistance)

- Trial and error (testing possible solutions until one works)

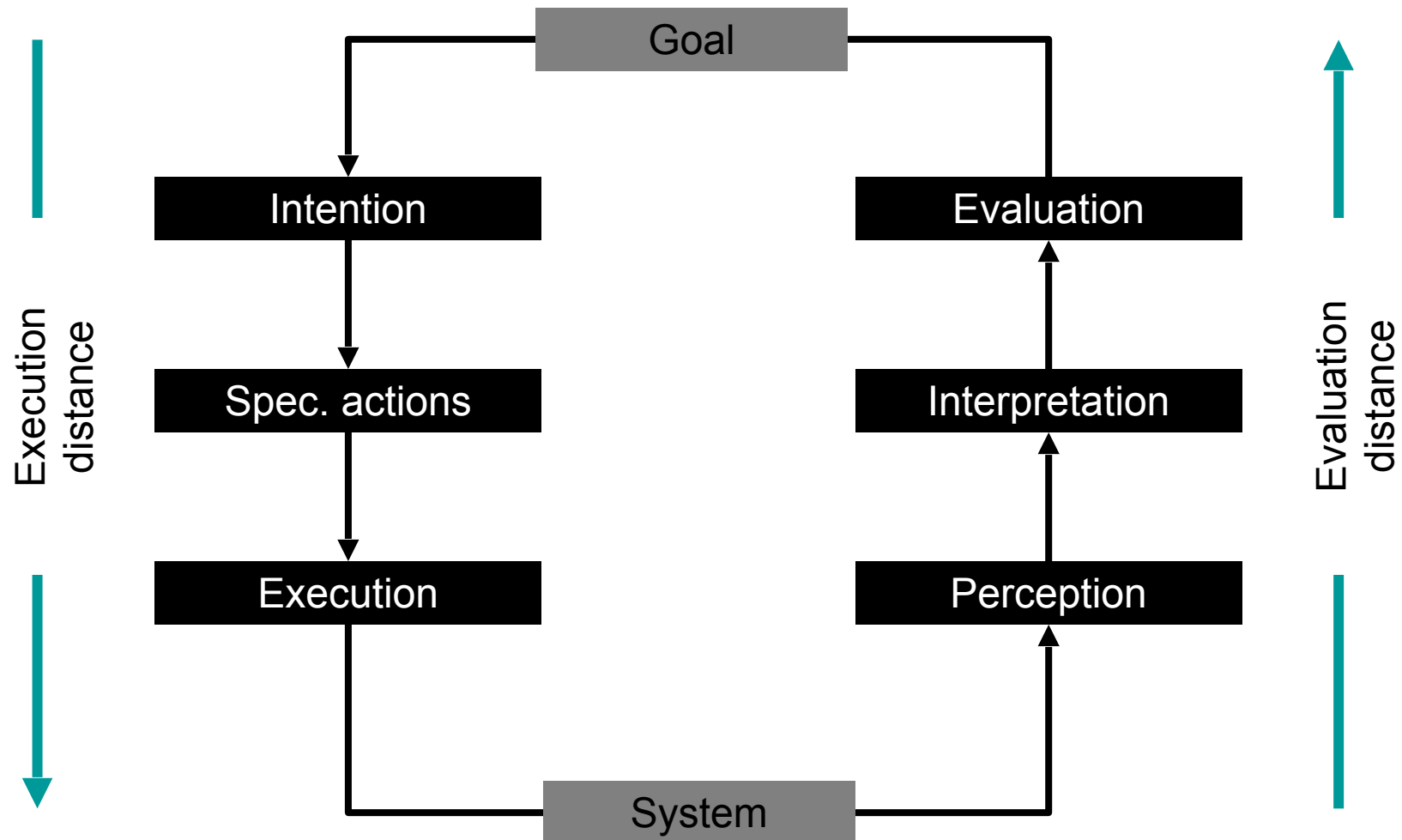
Common obstacles:

- Confirmation bias

- Functional fixedness



Seven stages of action - Don Norman



Plans and Situated Action - Lucy Suchman



Humans do not always act according to a pre-made plan

Action is *situated*

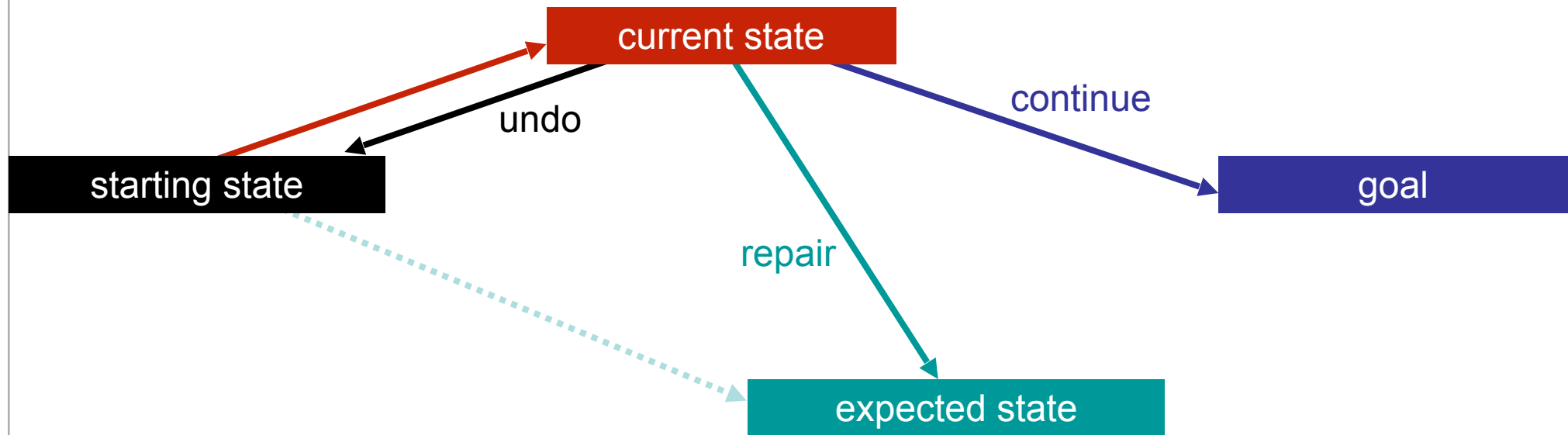
The plan is revised / adapted according to the local situation

Example: empty printer

- add paper
- print to another printer
- give up printing

Problem solving

Strategies in case of error



Mental models

Mental representations that help us reason and solve problems

Cognitive Biases

Systematic pattern of deviation from the norm or from rational judgement

Work by Tversky and Kahneman that challenges the “rational choice theory” in social and economic behavior

Example :

Do you prefer 150€ now or 180€ in 1 month?

Do you prefer 150€ in a year or 180€ in 13 months?

Wikipedia has a list of 185 cognitive biases!

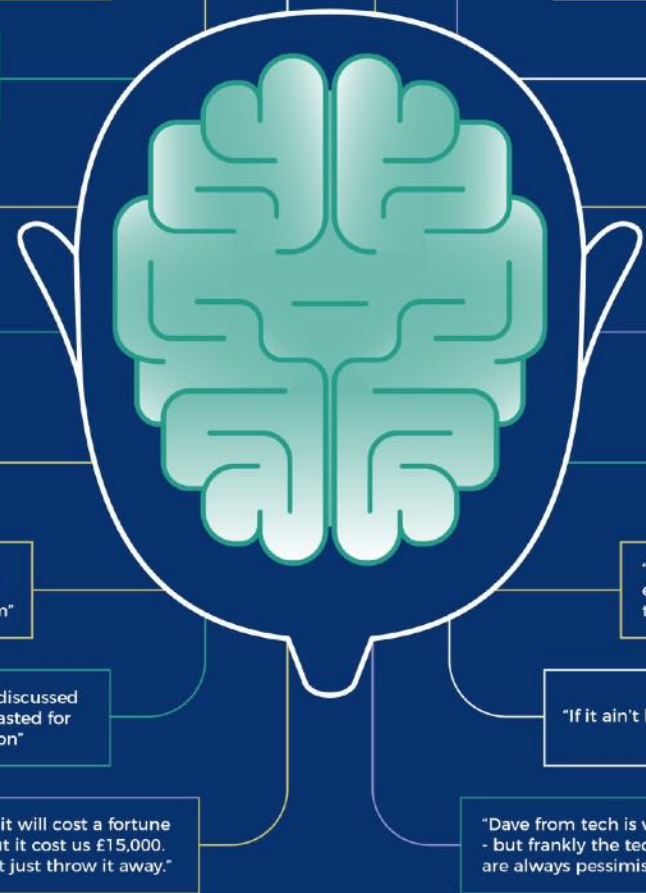
Cognitive bias

When it comes to assessing risk, humans often fail to make rational decisions because our brains take mental shortcuts that prevent us making the correct choice. Since the 1960s behavioural scientists and psychologists have been researching these failings, and have identified and labelled dozens of them. Here are some that can cause havoc when it comes to assessing risks in business

ORIGIN

The notion of cognitive biases was first introduced by psychologists Amos Tversky and Daniel Kahneman in the early-1970s. Their research paper, 'Judgment Under Uncertainty: Heuristics and Biases', in the Science journal has provided the basis of almost all current theories of decision-making and heuristics. Professor Kahneman was awarded a Nobel Prize in 2002 after further developing the ideas and applying them to economics.

- Social
- Financial
- Failure to estimate
- Short-termism



ANCHORING EFFECT
Relying too much on the initial piece of information offered when making decisions

"The first test seemed OK. Do we need to look any more?"

"The conveyor belt broke three times last month. It's pretty unlikely it'll happen again."

GAMBLER'S FALLACY
Believing that future probabilities are altered by past events, when in fact they are unchanged

AVAILABILITY HEURISTIC
Overestimating the importance and likelihood of events given the greater availability of information

"I saw something very similar to this on LinkedIn. We need to take it seriously"

"Let's just get the deal done ASAP"

HYPERBOLIC DISCOUNTING
Preferring a smaller, sooner payoff over a larger, later reward

BANDWAGON EFFECT
Uptake of beliefs and ideas increases the more that they have already been adopted by others

"The whole department knows there's no problem here"

"This worked fine in the factory in the Korea, it should work fine here"

ILLUSION OF VALIDITY
Overestimating our ability to make accurate predictions, especially when data appears to tell a coherent "story"

BELIEF BIAS
Basing the strength of an argument on the believability or plausibility of the conclusion

"I didn't quite follow your argument but the conclusion seems about right"

"Looks like we've run out of time to discuss this"

OSTRICH EFFECT
Avoiding negative financial information by pretending it doesn't exist

BLIND SPOT BIAS
Viewing oneself as less biased than others

"Let's ignore Sarah's views on this one. She's biased"

"We made a good call on that one"

POST-PURCHASE RATIONALISATION
Tendency to retroactively ascribe positive attributes to an option one has selected

CLUSTERING ILLUSION
Erroneously overestimating the importance of small clusters or patterns in large data

"This is the second week in a row that this has happened. There must be a problem"

"Our competitors are only doing well because their products are cheap"

REACTIVE DEVALUATION
Devaluing an idea because it originated from an adversary or opponent

CONFIRMATION BIAS
Focusing on information that only confirms existing preconceptions

"We did loads of simulations. Most of them showed there's no problem"

"Now we've got the new equipment we can cut the time spent on maintenance"

RISK COMPENSATION
Taking bigger risks when perceived safety increases; being more careful when perceived risks increases

COURTESY BIAS
Giving an opinion/conclusion that is viewed as more socially acceptable so as to avoid causing offence/controversy

"The last time we discussed this the meeting lasted for hours. Let's move on"

"If it ain't broke - don't fix it"

STATUS QUO BIAS
Preferring the current state of affairs over change

ENDOWMENT EFFECT
The tendency for people to ascribe more value to things merely because they already own/have them

"I know it will cost a fortune to fix but it cost us £15,000. We can't just throw it away."

"Dave from tech is worried - but frankly the tech team are always pessimists"

STEREOTYPING
Assuming a person has characteristics because they are a member of a group

Cognitive Biases

Problems that biases help us address :

Too much information: we need to filter it

Examples: Confirmation bias, Anchoring

Not enough meaning: we like to fill in missing pieces

Examples : Anecdotal fallacy, Halo effect

Not enough time: we need to act fast

Examples : Egocentric bias, IKEA effect

Too many things to remember:

we need to compress / omit information

Examples : Primacy / recency effects, Implicit stereotype

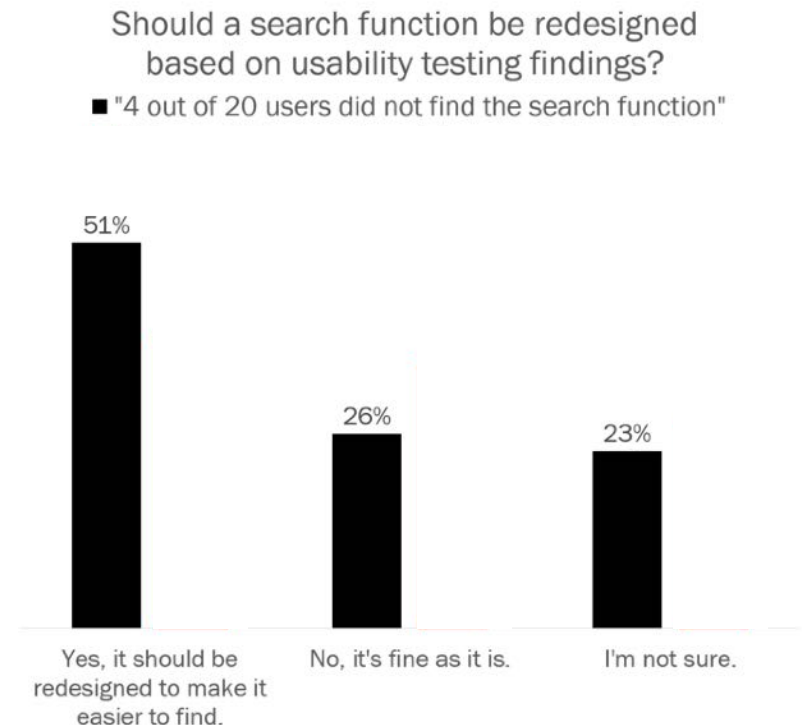
Cognitive Biases and HCI

Cognitive biases affect the design process

Confirmation bias: choose designs that support existing beliefs

Framing bias: presentation of results affect choice

“4 out of 20 users could not find the search function”



Cognitive Biases and HCI

Cognitive biases affect the design process

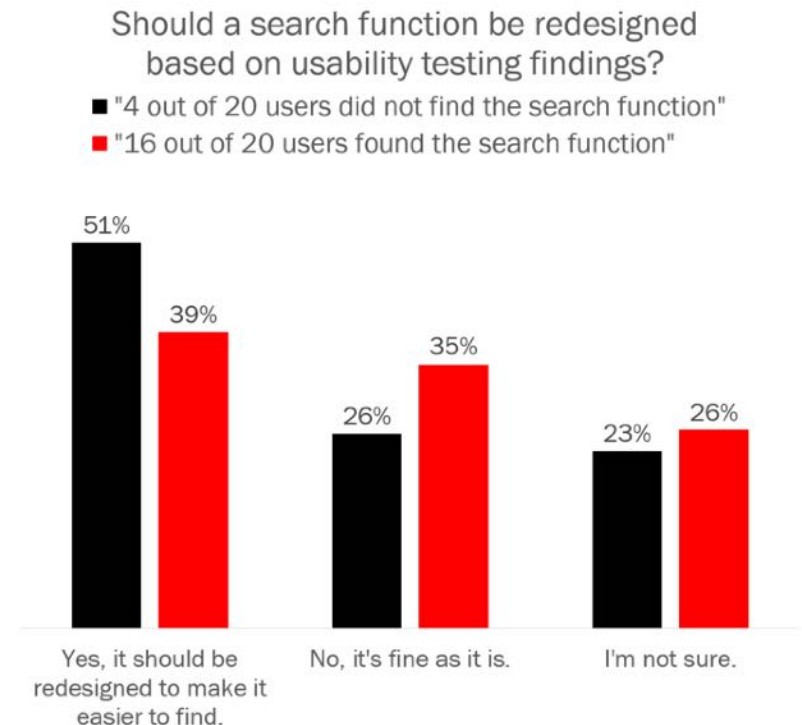
Confirmation bias: choose designs that support existing beliefs

Framing bias: presentation of results affect choice

“4 out of 20 users could not find the search function”

VS.

“16 out 20 users found the search function”

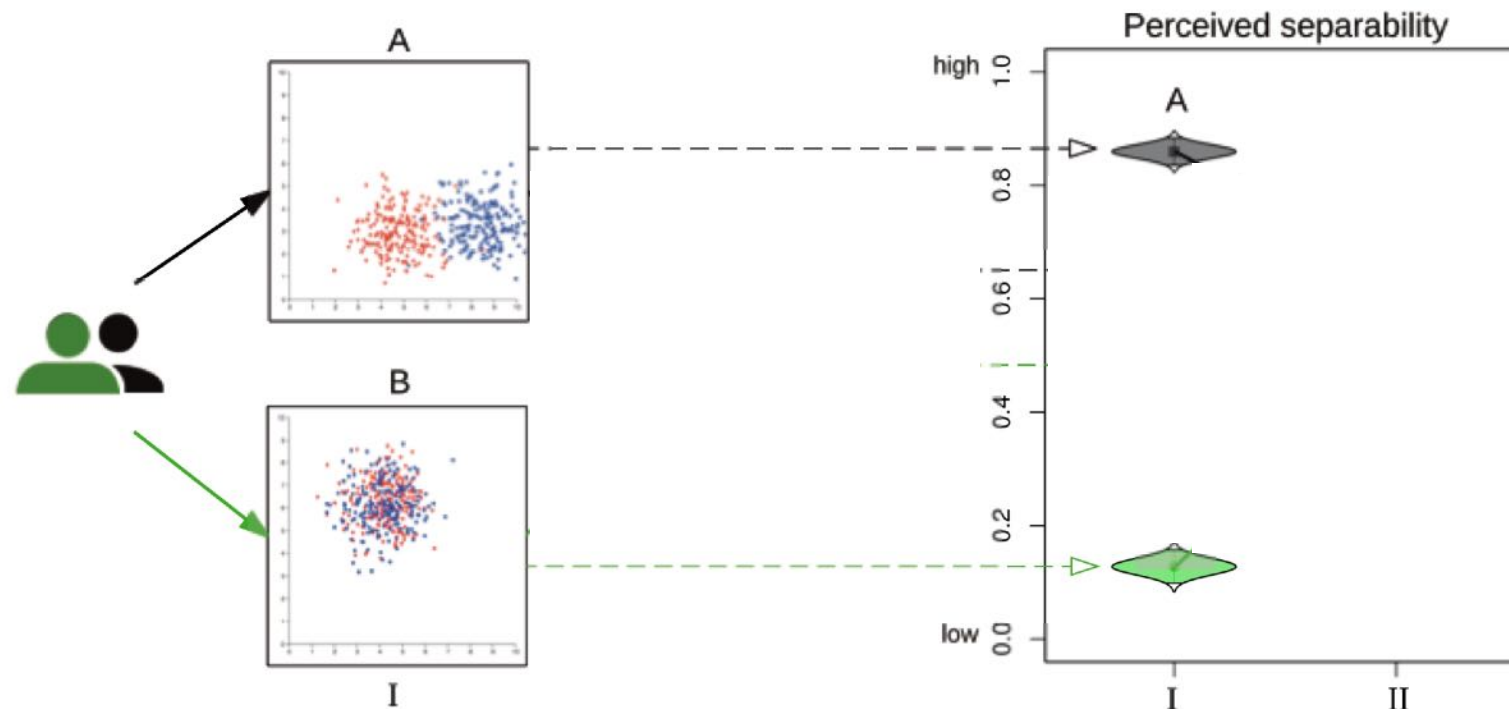


Cognitive Biases and HCI

Cognitive biases affect users' behavior

Confirmation bias: users focus on online reviews that support their pre-existing opinion of the product

Anchoring: decision depends on initial piece of information

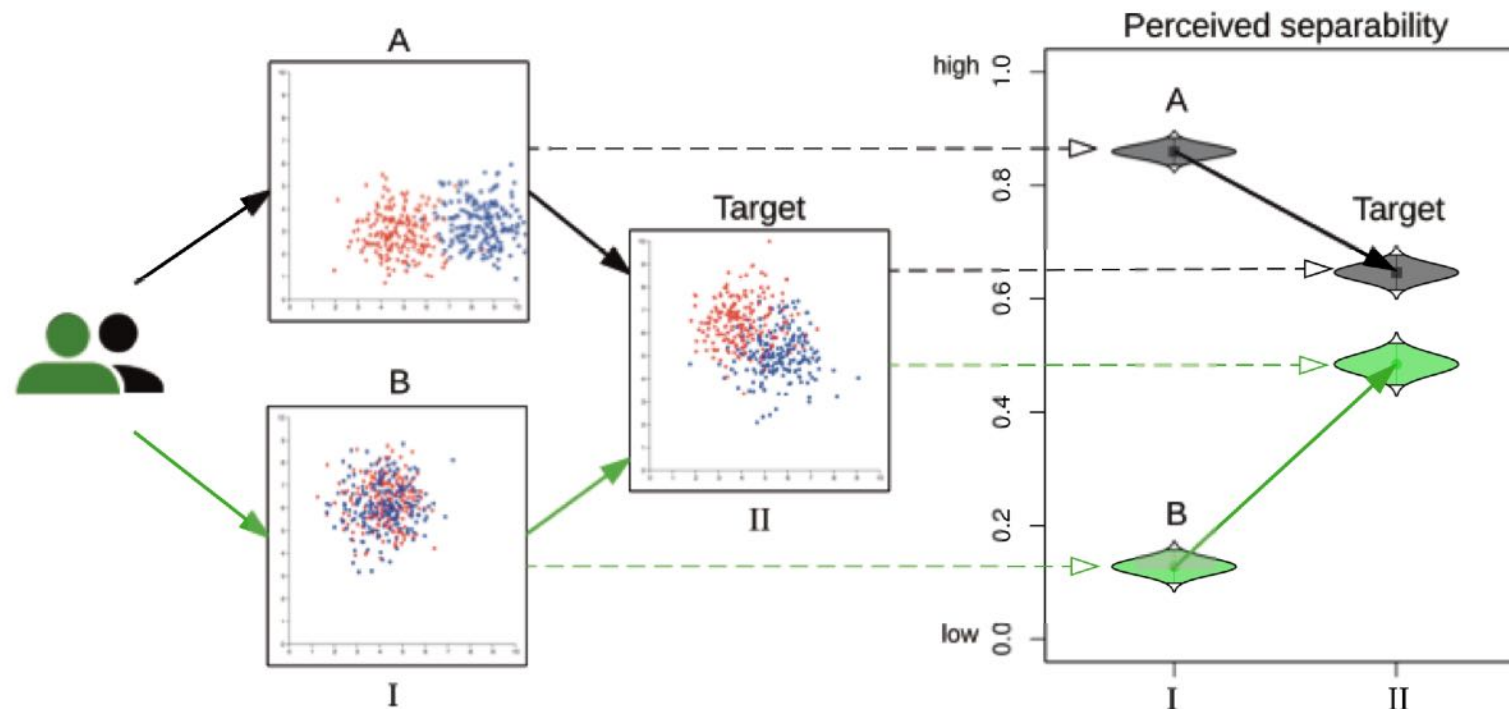


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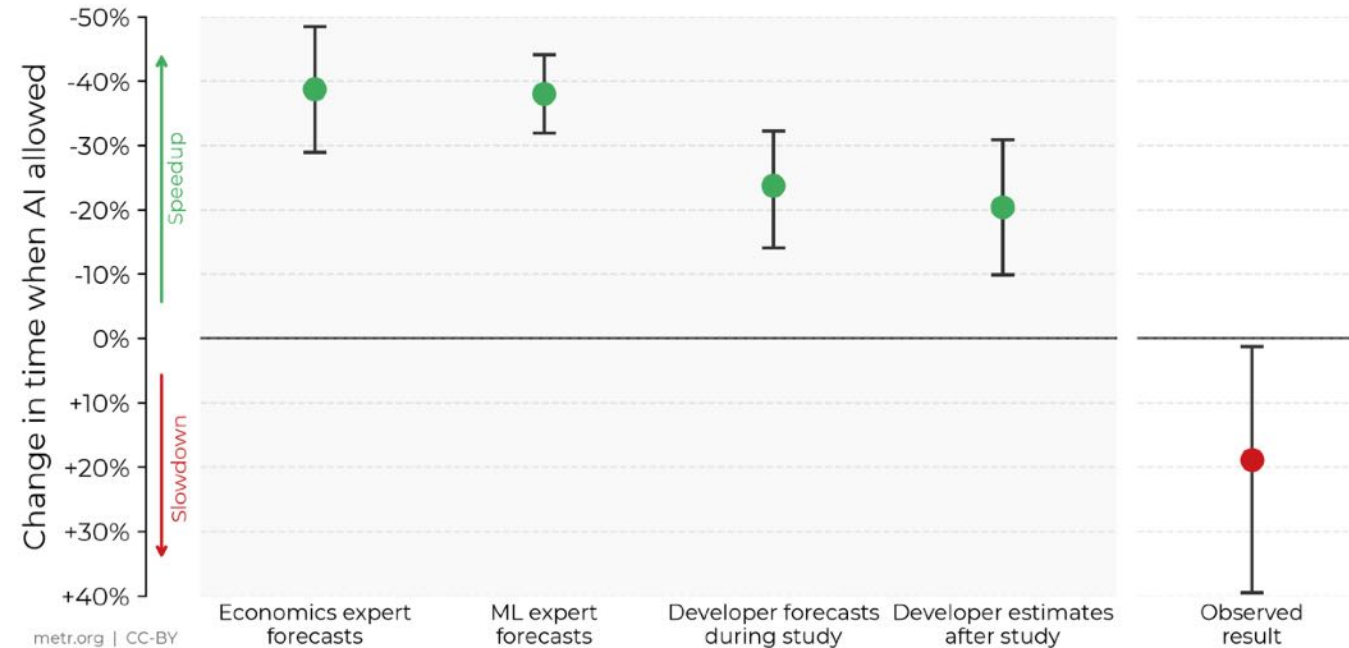
Automation bias: Effects of AI on human behavior

Programmers overestimate the benefit of using Generative AI:
They expect and believe that using AI saves time when it slows them down

Against Expert Forecasts and Developer Self-Reports, Early-2025 AI Slows Down Experienced Open-Source Developers



In this RCT, 16 developers with moderate AI experience complete 246 tasks in large and complex projects on which they have an average of 5 years of prior experience.



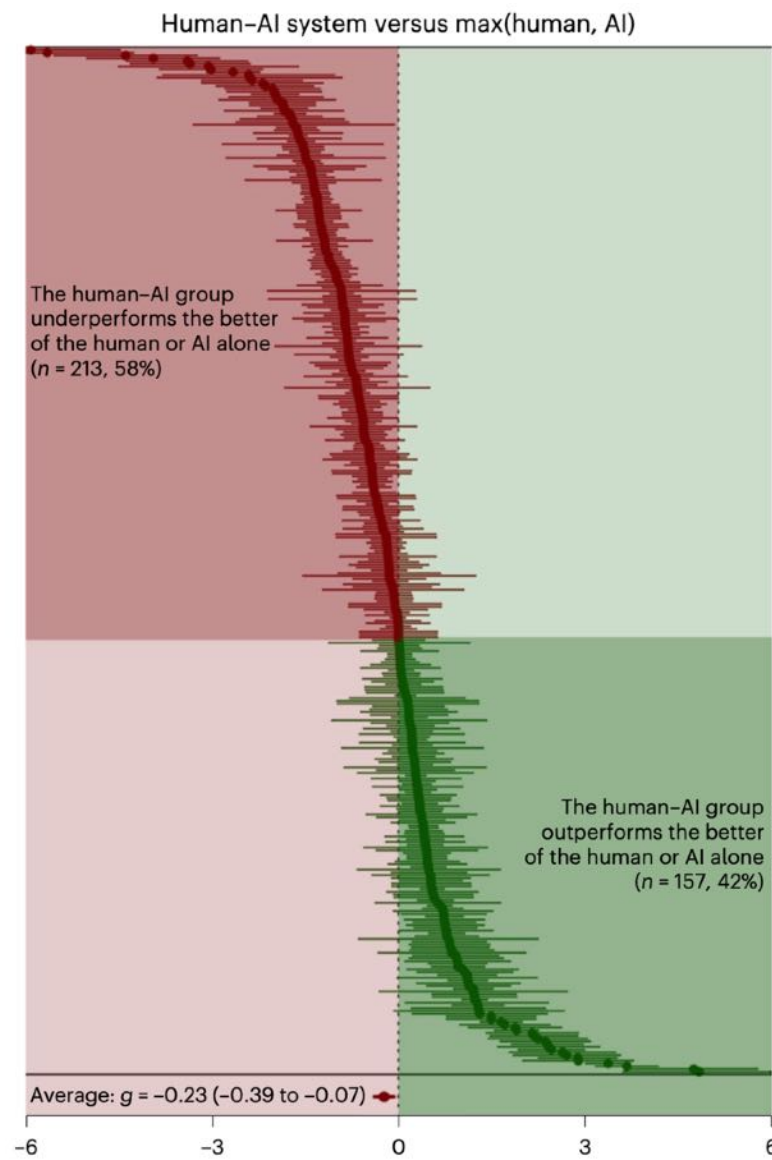
When is AI+Human better than AI or Human?

Performance **losses** in tasks that involve making **decisions**

Performance **gains** in tasks that involve **creating content**

When **humans** > **AI** alone, performance **gains** in **human+AI**

When **AI** > **humans** alone, performance **losses** in **human+AI**



Deskilling

Experts may become better with AI ...
but lose expertise when AI is taken away.

Automation leads to a loss of practical knowledge

Study of expert doctors before and after using an AI assistant
for analyzing medical images

=> 6% decrease in performance
when the AI assistant was taken away after 3 months

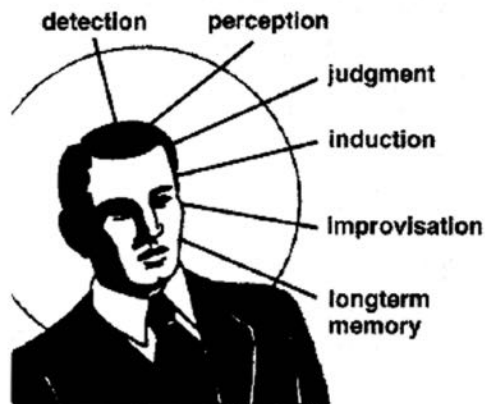
How to achieve upskilling rather than deskilling?



HABA-MABA list - Paul Fitts (1951)

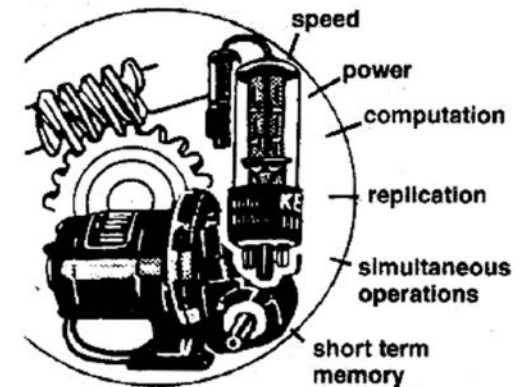
Humans Are Better At / Machines Are Better At

HUMANS SURPASS MACHINES IN THE:



- Ability to detect small amounts of visual or acoustic energy
- Ability to perceive patterns of light or sound
- Ability to improvise and use flexible procedures
- Ability to store very large amounts of information for long period and to recall relevant facts at the appropriate time
- Ability to reason inductively
- Ability to exercise judgment

MACHINES SURPASS HUMANS IN THE:



- Ability to respond quickly to control signals, and to apply great force smoothly and precisely
- Ability to perform repetitive, routine tasks
- Ability to store information briefly and then to erase it completely
- Ability to reason deductively, including computational ability
- Ability to handle highly complex operations, i.e., to do many different things at once.