Introduction to Cognitive Ergonomics
/Human Factors

Ergonomic principles of today were adhered to 25 centuries ago

Cutting tools used by Homo Sapiens were adapted both to the tasks to accomplish and to the characteristics of the hand

Archeological museum of Naples (Italy)

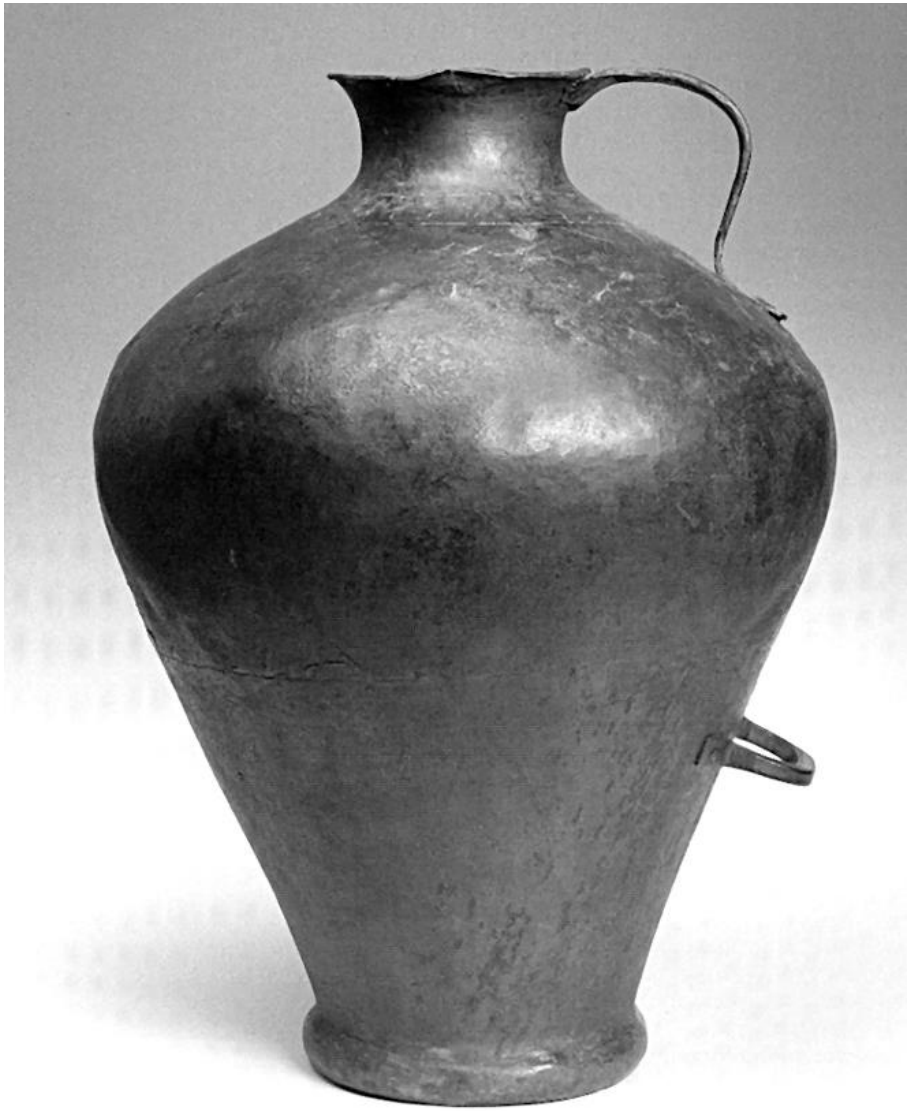
Ergonomic principles of today were applied by Ancient Greeks

"*πάντων χρημάτων μέτρον άνθρωπος*"

(man is the measure of all things)

Plato's Protagoras

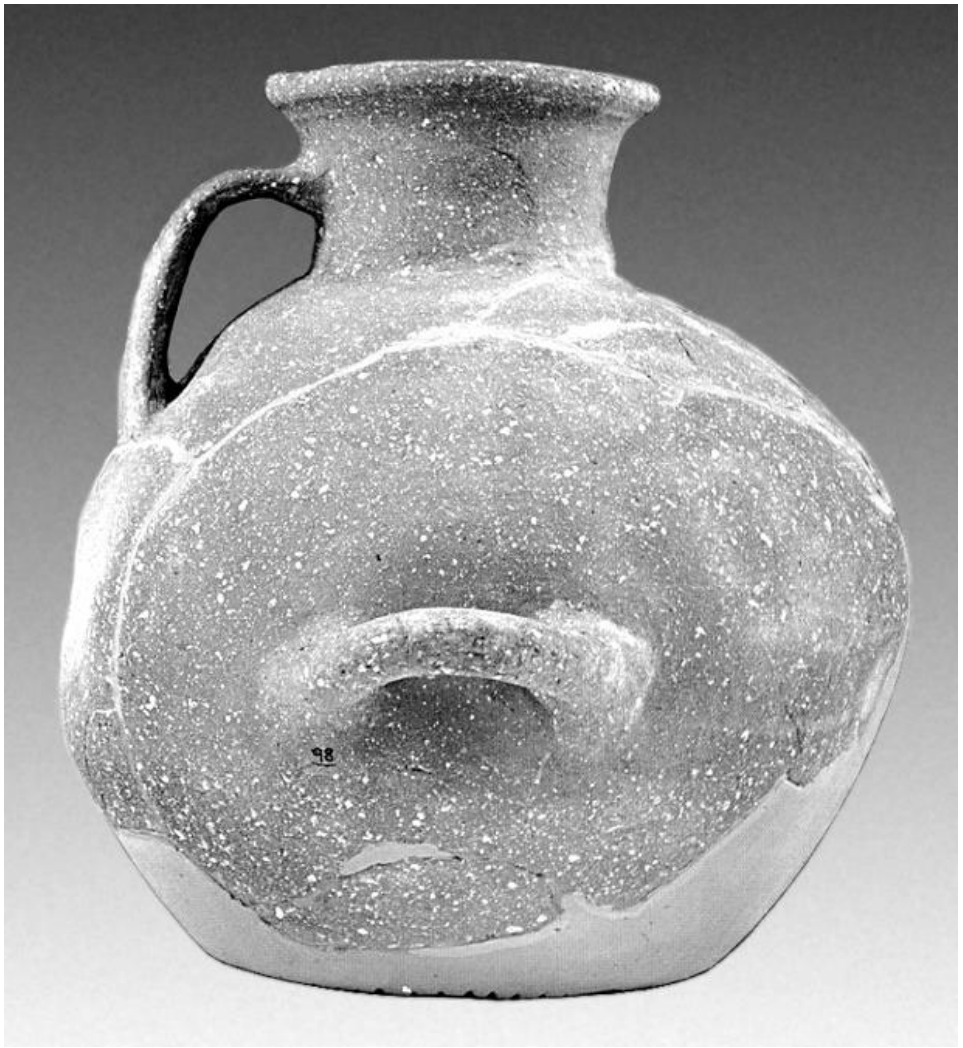
Ergonomic principles of today were applied by Ancient Greeks



Bi-handled bronze urn. The necessary force to lift the urn is applied to the lower handle, whilst the upper one is used to control the flow of the liquid

National Archaeological Museum of Athens

Ergonomic principles of today were applied by Ancient Greeks

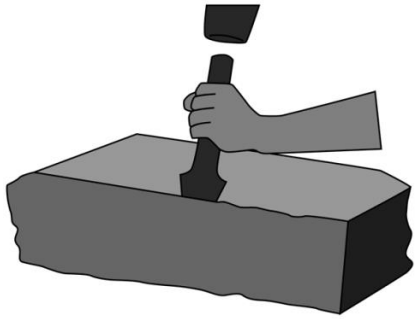


Tri-handled urn. The two horizontally opposed handles fit for carrying it when full. The third, neck-attached handle fits for carrying the urn when empty. It also facilitates a stabilising grip on the urn when carried on the shoulder

Archaeological Museum of Andros

As far as technology is evolving, cognitive components of work become more important

Direct treatment of materials with hands or/and with other materials



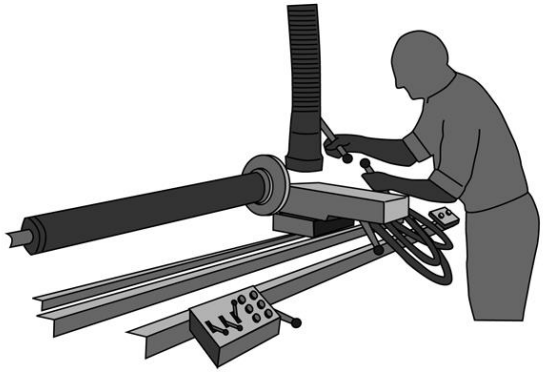
Treatment of materials using simple tools:

- Tool mediated manipulation

Treatment of materials using simple machines:

- Setting-up the machine
- Machine manipulation
- Repairing machine

As far as technology is evolving, cognitive components of work become more important



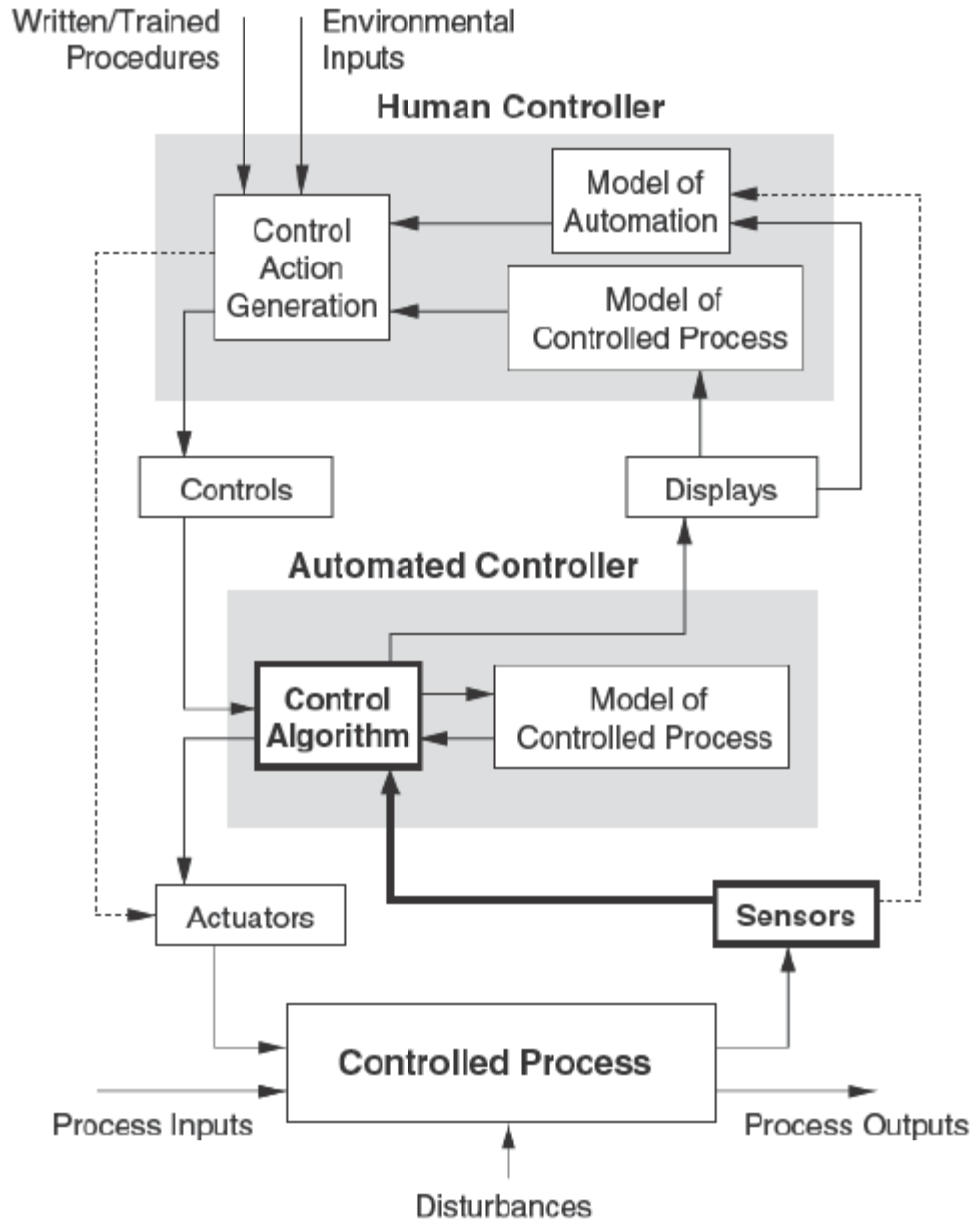
Treatment of materials using machines with simple automation:

- set up through analogue control panel
- supervision through the control panel and direct perception of physical signs
- decisions for intervention when something goes wrong

Treatment of materials using programmable machines and automatic control systems:

- programming production process in idle time (off line)
- control through predetermined (designed) scripts
- management of unexpected situations (not detectable by the automatic control systems)

Contemporary model of human-automation coupling



Cognitive Ergonomics / Human Factors

Studies the **behaviour of human problem solvers** who confront complexity in the course of their daily tasks.

It is **ecological**, because it studies behaviour in multidimensional, open worlds.

The cognitive ergonomist should consider what counts as effective **stimulus or signs** for the human agent, in a given situation. Thus, addresses the content and semantics of the studied domain.

The aim of C.E. is not merely to analyse a world; it is **to change behaviour** and, consequently, performance in that world.

C. E. is problem-driven and tool-constrained. This means that it aims to analyse human behaviour **in specific technological - social contexts** and to understand the sources of both good and poor performance, i.e., the cognitive problems to be solved or challenges to be met.

Cognitive Ergonomics / Human Factors

The cognitive ergonomist's problem is to analyse the world in question in order to:

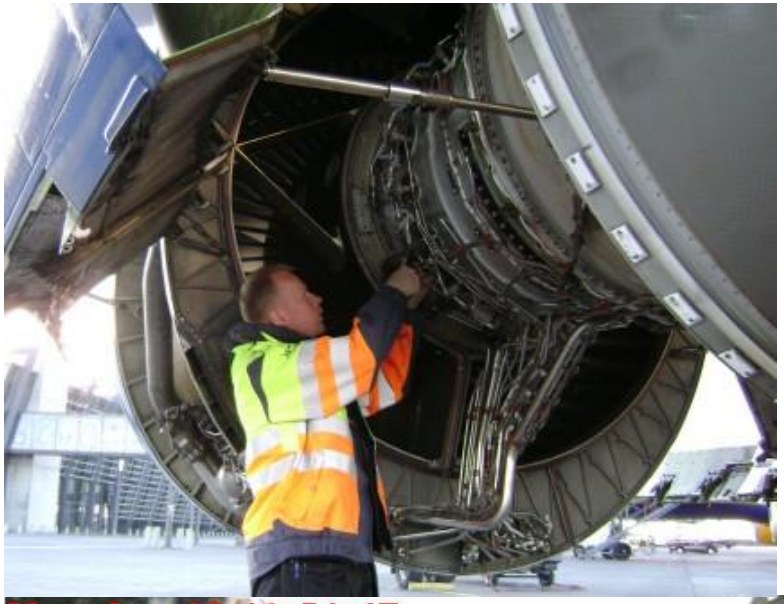
(i) identify mechanisms driving the dynamics of the cognitive agents' behaviour

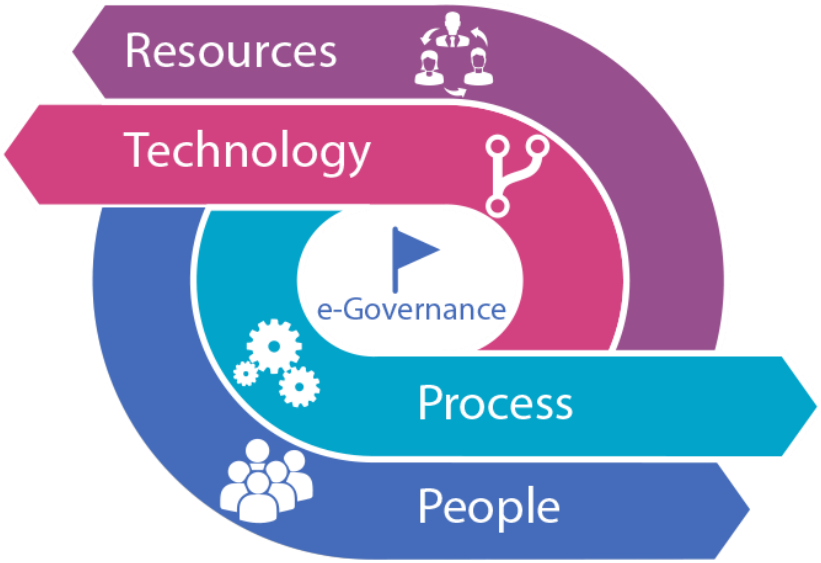
(ii) explain the desirable and undesirable work outputs,

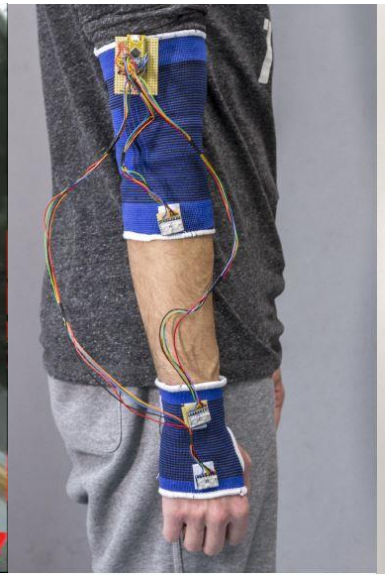
(iii) conceive an effective representation of the world, i.e. a model with predictive power, useful both for the design of future cognitive artefacts, and their evaluation when put in use.

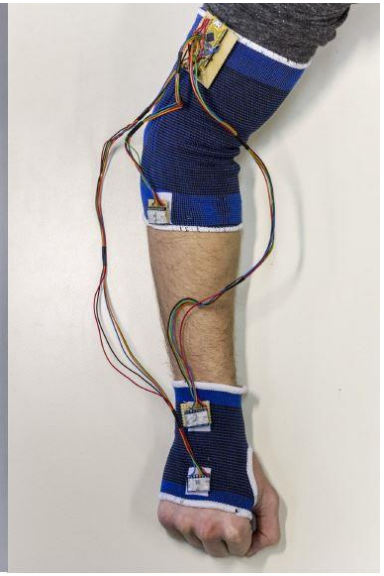
The term cognitive artefacts is used here in its broader sense, including both artefacts with a material manifestation as well as abstract artefacts.

Applications in ErgoU-NTUA

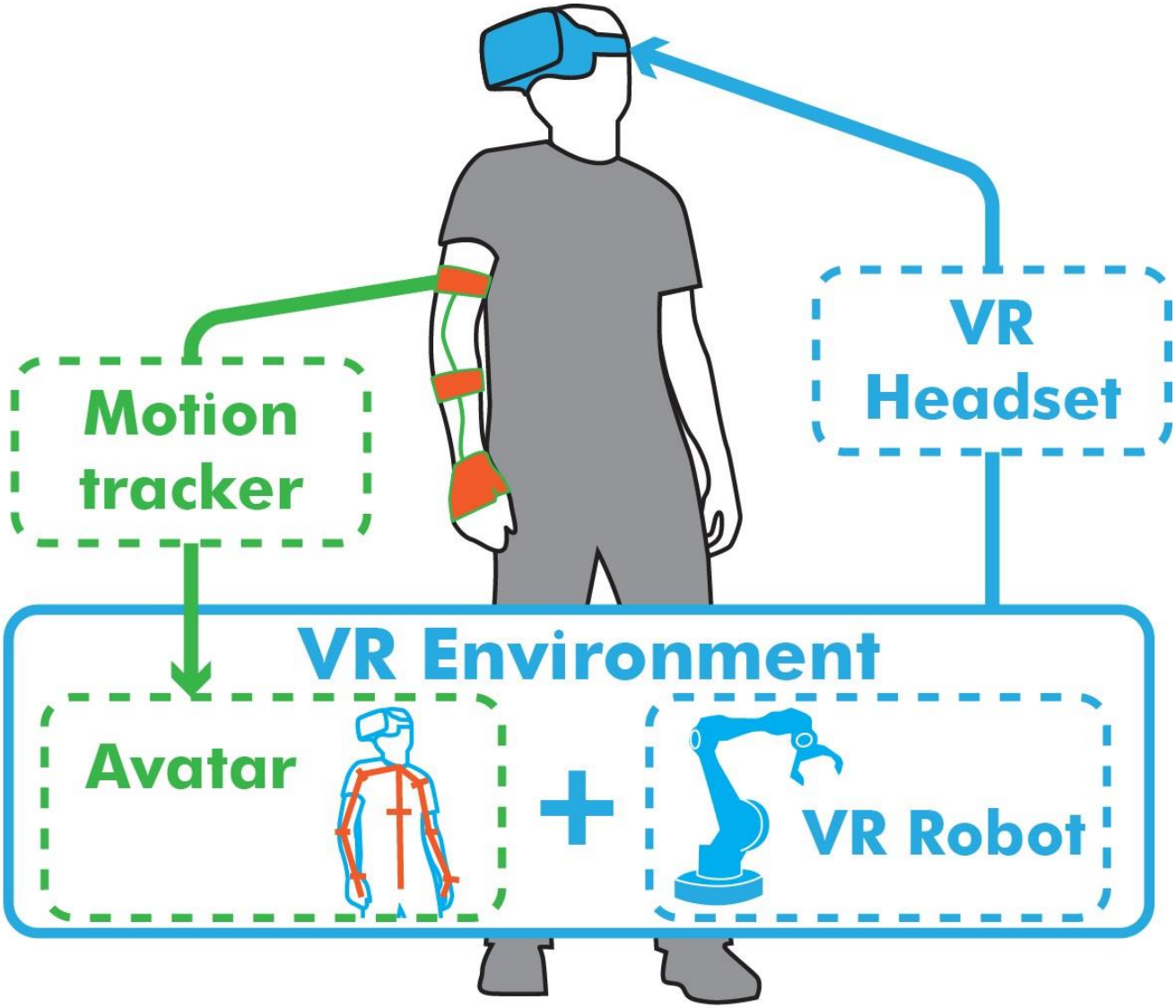






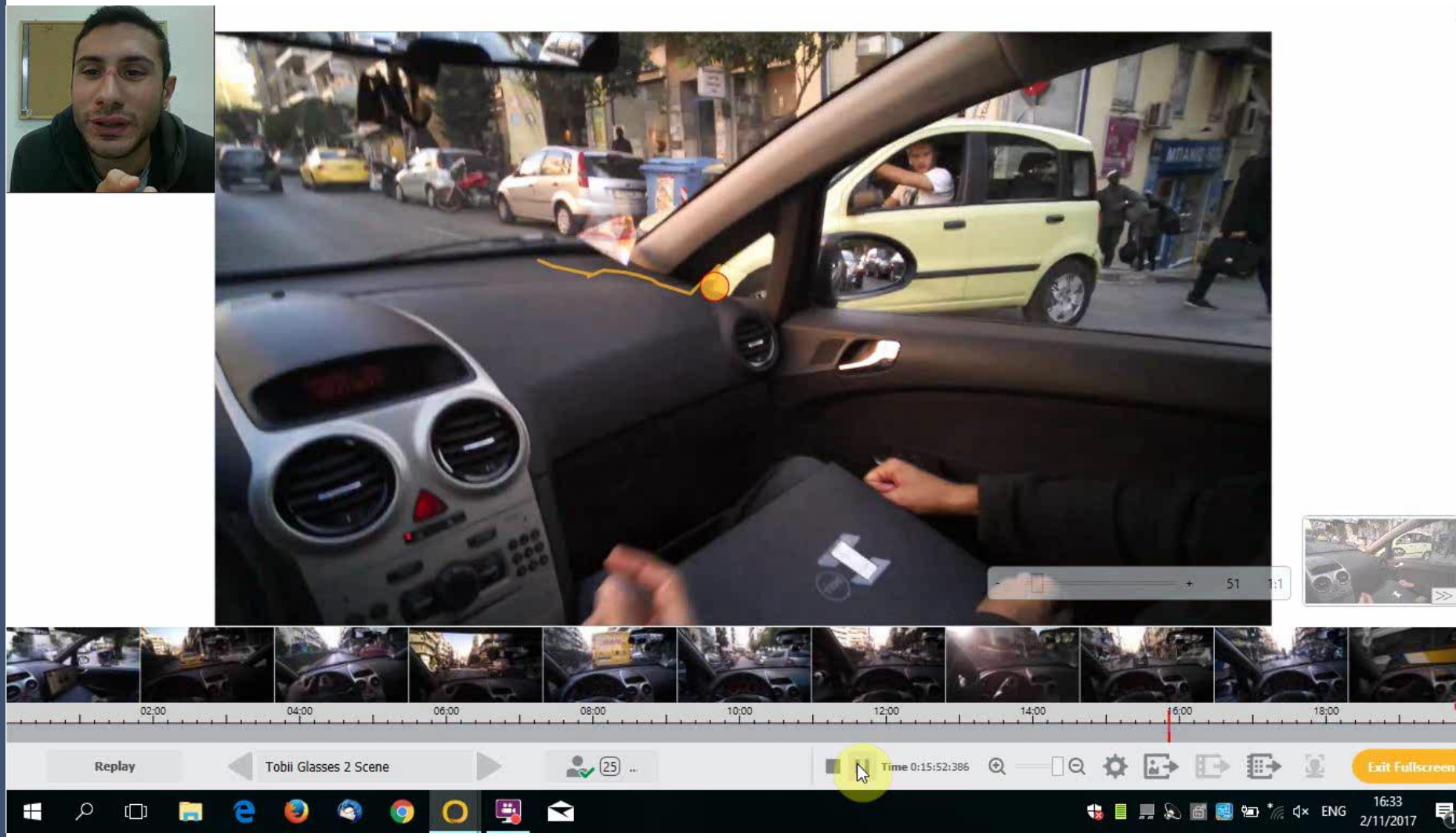


Experimental set-up for Human-Robot Interaction in VR

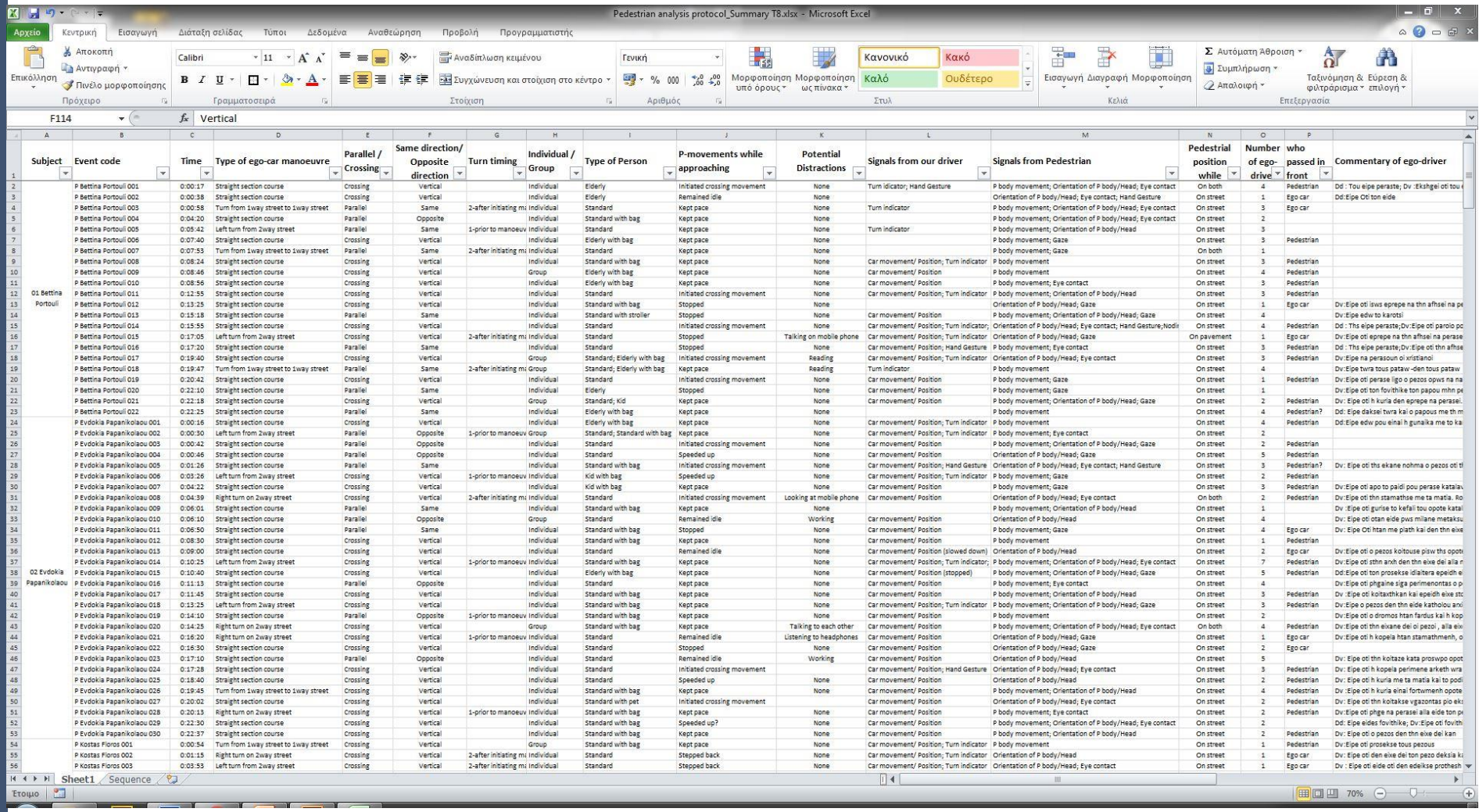


Testing Human-Robot collaboration schemes

Autonomous vehicles (AV) – Human Interaction
Recording eye-gaze coupled with retrospective Think-Aloud



Autonomous vehicles (AV) – Human Interaction
From field observation to compiled data

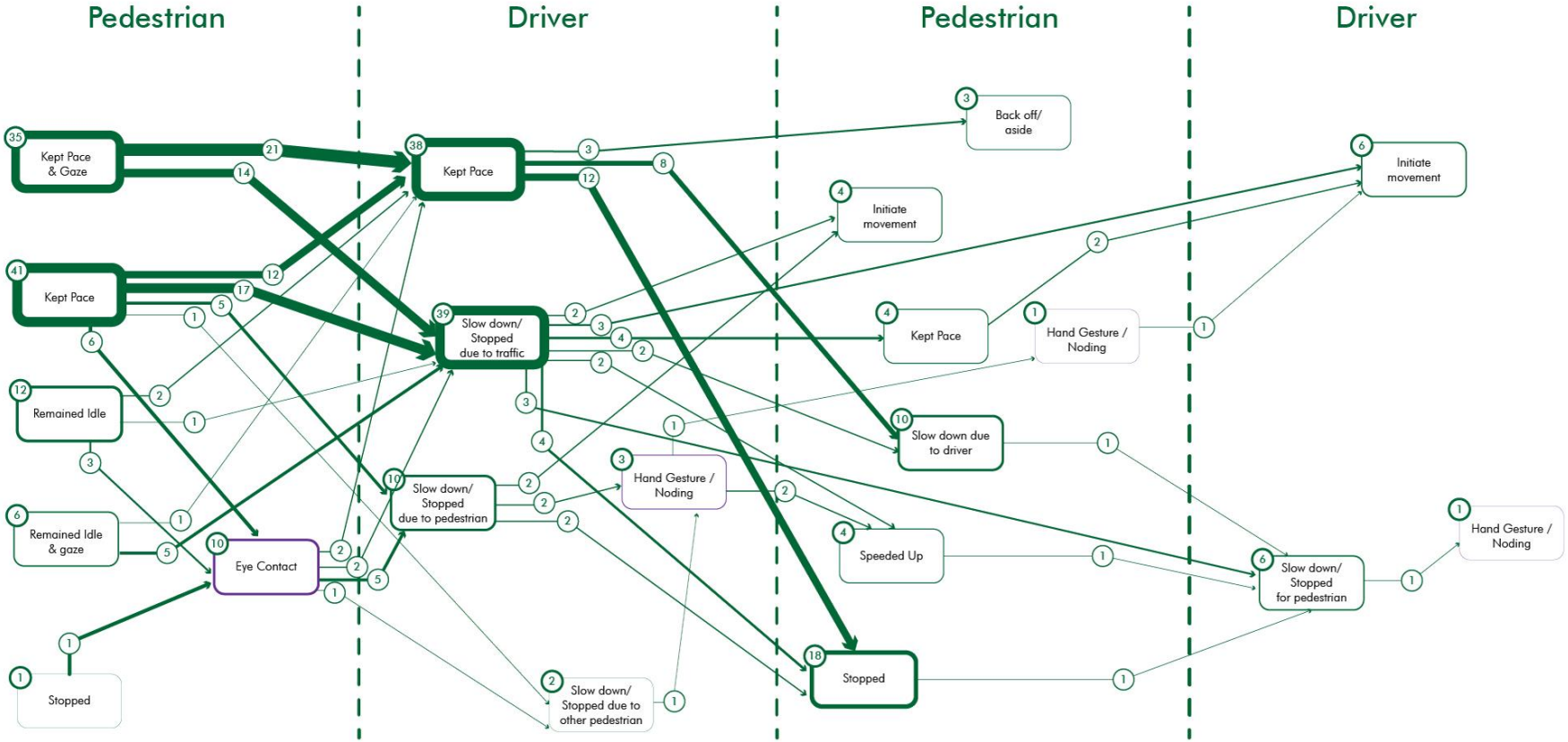


Pedestrian analysis protocol_Summary T8.xlsx - Microsoft Excel

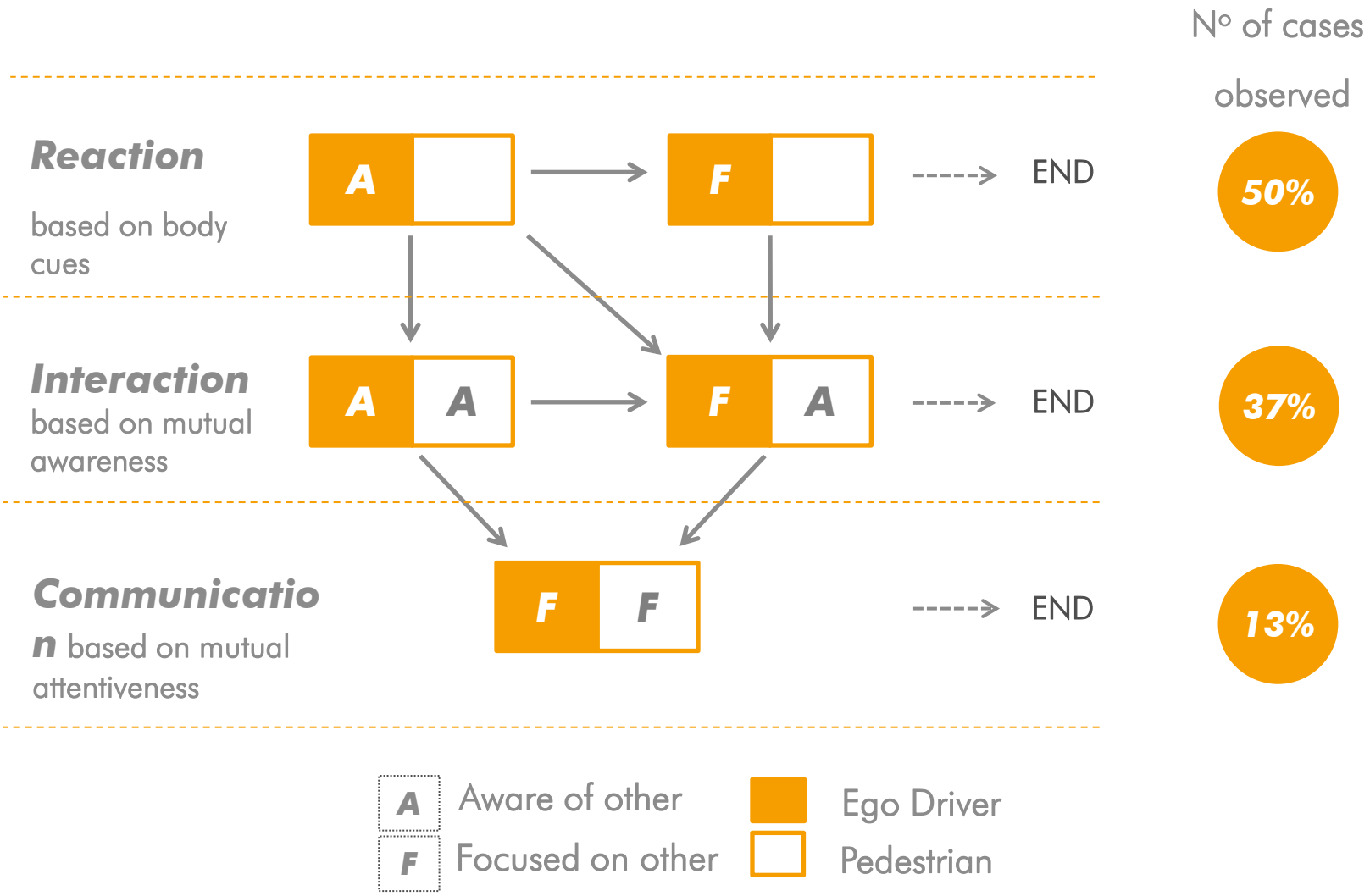
F114: Vertical

Subject	Event code	Time	Type of ego-car manoeuvre	Parallel / Crossing	Same direction/ Opposite direction	Turn timing	Individual / Group	Type of Person	P-movements while approaching	Potential Distractions	Signals from our driver	Signals from Pedestrian	Pedestrial position while	Number of ego-drive	who passed in front	Commentary of ego-driver
	P Bettina Portouli 001	0:00:17	Straight section course	Crossing	Vertical		Individual	Elderly	Initiated crossing movement	None	Turn idicator; Hand Gesture	P body movement; Orientation of P body/Head; Eye contact	On both	4	Pedestrian	Dd : Tou eipe peraste; Dv :Ekshgei oti tou
	P Bettina Portouli 002	0:00:38	Straight section course	Crossing	Vertical		Individual	Elderly	Remained idle	None		Orientation of P body/Head; Eye contact; Hand Gesture	On street	1	Ego car	Dd:Eipe Oti ton eide
	P Bettina Portouli 003	0:00:58	Turn from 1way street to 1way street	Parallel	Same	2-after initiating mi	Individual	Standard	Kept pace	None	Turn indicator	P body movement; Orientation of P body/Head; Eye contact	On street	3	Ego car	
	P Bettina Portouli 004	0:04:20	Straight section course	Parallel	Opposite		Individual	Standard with bag	Kept pace	None		P body movement; Orientation of P body/Head; Eye contact	On street	2		
	P Bettina Portouli 005	0:05:42	Left turn from 2way street	Parallel	Same	1-prior to manoeuv	Individual	Standard	Kept pace	None	Turn indicator	P body movement; Orientation of P body/Head	On street	3		
	P Bettina Portouli 006	0:07:40	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None		P body movement; Gaze	On street	3	Pedestrian	
	P Bettina Portouli 007	0:07:53	Turn from 1way street to 1way street	Parallel	Same	2-after initiating mi	Individual	Standard	Kept pace	None		P body movement; Gaze	On both	1		
	P Bettina Portouli 008	0:08:24	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement	On street	3	Pedestrian	
	P Bettina Portouli 009	0:08:46	Straight section course	Crossing	Vertical		Group	Elderly with bag	Kept pace	None	Car movement/ Position	P body movement	On street	4	Pedestrian	
	P Bettina Portouli 010	0:08:56	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	3	Pedestrian	
01 Bettina Portouli	P Bettina Portouli 011	0:12:55	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position; Turn indicator	P body movement; Orientation of P body/Head	On street	3	Pedestrian	
	P Bettina Portouli 012	0:13:25	Straight section course	Crossing	Vertical		Individual	Standard with bag	Stopped	None		Orientation of P body/Head; Gaze	On street	1	Ego car	Dv:Eipe oti isws eprepe na thn afhsei na pe
	P Bettina Portouli 013	0:15:18	Straight section course	Parallel	Same		Individual	Standard with stroller	Stopped	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	4		Dv:Eipe edw to karotsi
	P Bettina Portouli 014	0:15:55	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position; Turn indicator;	Orientation of P body/Head; Eye contact; Hand Gesture;Nodi	On street	4	Pedestrian	Dd : Ths eipe peraste;Dv:Eipe oti parolo po
	P Bettina Portouli 015	0:17:05	Left turn from 2way street	Crossing	Vertical	2-after initiating mi	Individual	Standard	Stopped	Talking on mobile phone	Car movement/ Position; Turn indicator	Orientation of P body/Head; Gaze	On pavement	1	Ego car	Dv:Eipe oti eprepe na thn afhsei na perase
	P Bettina Portouli 016	0:17:20	Straight section course	Parallel	Same		Individual	Standard	Stopped	None	Car movement/ Position; Hand Gesture	P body movement; Eye contact	On street	3	Pedestrian	Dd : Ths eipe peraste;Dv:Eipe oti thn afhse
	P Bettina Portouli 017	0:19:40	Straight section course	Crossing	Vertical		Group	Standard; Elderly with bag	Initiated crossing movement	Reading	Car movement/ Position; Turn indicator	Orientation of P body/Head; Eye contact	On street	3	Pedestrian	Dv:Eipe na perasoun oi xristianoi
	P Bettina Portouli 018	0:19:47	Turn from 1way street to 1way street	Parallel	Same	2-after initiating mi	Group	Standard; Elderly with bag	Kept pace	Reading	Turn indicator	P body movement	On street	4		Dv:Eipe twra tous pataw -den tous pataw
	P Bettina Portouli 019	0:20:42	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement	None	Car movement/ Position	P body movement; Gaze	On street	1	Pedestrian	Dv:Eipe oti perase ligo o pezos opws na na
	P Bettina Portouli 020	0:22:10	Straight section course	Parallel	Same		Individual	Elderly	Stopped	None	Car movement/ Position	P body movement; Gaze	On street	1		Dv:Eipe oti ton fovithike ton papou mhn pe
	P Bettina Portouli 021	0:22:18	Straight section course	Crossing	Vertical		Group	Standard; Kid	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	2	Pedestrian	Dv: Eipe oti h kuria den eprepe na perasei.
	P Bettina Portouli 022	0:22:25	Straight section course	Parallel	Same		Individual	Elderly with bag	Kept pace	None		P body movement	On street	4	Pedestrian?	Dd: Eipe daksei twra kai o papous me th m
	P Evdokia Papanikolaou 001	0:00:16	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement	On street	4	Pedestrian	Dd:Eipe edw pou einai h gunaika me to ka
	P Evdokia Papanikolaou 002	0:00:30	Left turn from 2way street	Parallel	Opposite	1-prior to manoeuv	Group	Standard; Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement; Eye contact	On street	2		
	P Evdokia Papanikolaou 003	0:00:42	Straight section course	Parallel	Opposite		Individual	Standard	Initiated crossing movement	None	Car movement/ Position	P body movement; Orientation of P body/Head; Gaze	On street	2	Pedestrian	
	P Evdokia Papanikolaou 004	0:00:46	Straight section course	Parallel	Opposite		Individual	Standard	Speeded up	None	Car movement/ Position	Orientation of P body/Head; Gaze	On street	5	Pedestrian	
	P Evdokia Papanikolaou 005	0:01:26	Straight section course	Parallel	Same		Individual	Standard with bag	Initiated crossing movement	None	Car movement/ Position; Hand Gesture	Orientation of P body/Head; Eye contact; Hand Gesture	On street	3	Pedestrian?	Dv: Eipe oti ths ekane nohma o pezos oti t
	P Evdokia Papanikolaou 006	0:03:26	Left turn from 2way street	Crossing	Vertical	1-prior to manoeuv	Individual	Kid with bag	Speeded up	None	Car movement/ Position; Turn indicator	P body movement; Gaze	On street	2	Pedestrian	
	P Evdokia Papanikolaou 007	0:04:22	Straight section course	Crossing	Vertical		Individual	Kid with bag	Kept pace	None	Car movement/ Position	P body movement; Gaze	On street	3	Pedestrian	Dv:Eipe oti apo to paidi pou perase katala
	P Evdokia Papanikolaou 008	0:04:39	Right turn on 2way street	Crossing	Vertical	2-after initiating mi	Individual	Standard	Initiated crossing movement	Looking at mobile phone	Car movement/ Position	Orientation of P body/Head; Eye contact	On both	2	Pedestrian	Dv:Eipe oti thn stamathse me ta matia. Ro
	P Evdokia Papanikolaou 009	0:06:01	Straight section course	Parallel	Same		Individual	Standard with bag	Kept pace	None		P body movement; Orientation of P body/Head	On street	1		Dv :Eipe oti gurise to kefali tou opote katal
	P Evdokia Papanikolaou 010	0:06:10	Straight section course	Parallel	Opposite		Group	Standard	Remained idle	Working	Car movement/ Position	Orientation of P body/Head	On street	4		Dv: Eipe oti otan eide pws milane metaksu
	P Evdokia Papanikolaou 011	0:06:50	Straight section course	Parallel	Same		Individual	Standard with bag	Stopped	None	Car movement/ Position	P body movement; Gaze	On street	4	Ego car	Dv: Eipe Oti htan me plath kai den thn eixe
	P Evdokia Papanikolaou 012	0:08:30	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement	On street	1	Pedestrian	
	P Evdokia Papanikolaou 013	0:09:00	Straight section course	Crossing	Vertical		Individual	Standard	Remained idle	None	Car movement/ Position (slowed down)	Orientation of P body/Head	On street	2	Ego car	Dv:Eipe oti o pezos koitouse plsw ths opote
	P Evdokia Papanikolaou 014	0:10:25	Left turn from 2way street	Crossing	Vertical	1-prior to manoeuv	Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator;	P body movement; Orientation of P body/Head; Eye contact	On street	7	Pedestrian	Dv:Eipe oti sthn arxh den thn eixe dei alla r
02 Evdokia Papanikolaou	P Evdokia Papanikolaou 015	0:10:40	Straight section course	Crossing	Vertical		Individual	Elderly with bag	Kept pace	None	Car movement/ Position (stopped)	P body movement; Orientation of P body/Head; Gaze	On street	5	Pedestrian	Dd:Eipe oti ton prosekse idiaitera epeidh e
	P Evdokia Papanikolaou 016	0:11:13	Straight section course	Parallel	Opposite		Individual	Standard	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	4		Dv:Eipe oti phgaine siga perimenontas o p
	P Evdokia Papanikolaou 017	0:11:45	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head	On street	3	Pedestrian	Dv :Eipe oti koitaxthkan kai epeidh eixe stc
	P Evdokia Papanikolaou 018	0:13:25	Left turn from 2way street	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement; Orientation of P body/Head; Gaze	On street	3	Pedestrian	Dv:Eipe o pezos den thn eide katholou ano
	P Evdokia Papanikolaou 019	0:14:10	Straight section course	Parallel	Opposite	1-prior to manoeuv	Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement	On street	2		Dv:Eipe oti o dromos htan fardus kai h kop
	P Evdokia Papanikolaou 020	0:14:25	Right turn on 2way street	Crossing	Vertical		Group	Standard with bag	Kept pace	Talking to each other	Car movement/ Position	P body movement; Orientation of P body/Head; Eye contact	On both	4	Pedestrian	Dv:Eipe oti thn eixane dei oi pezoi , alla eix
	P Evdokia Papanikolaou 021	0:16:20	Right turn on 2way street	Crossing	Vertical	1-prior to manoeuv	Individual	Standard	Remained idle	Listening to headphones	Car movement/ Position	Orientation of P body/Head; Gaze	On street	1	Ego car	Dv:Eipe oti h kopela htan stamathmenh, o
	P Evdokia Papanikolaou 022	0:16:30	Straight section course	Crossing	Vertical		Individual	Standard	Stopped	None	Car movement/ Position	Orientation of P body/Head; Gaze	On street	2	Ego car	
	P Evdokia Papanikolaou 023	0:17:10	Straight section course	Parallel	Opposite		Individual	Standard	Remained idle	Working	Car movement/ Position	Orientation of P body/Head	On street	5		Dv: Eipe oti thn koitaze kata proswpo opot
	P Evdokia Papanikolaou 024	0:17:28	Straight section course	Crossing	Vertical		Individual	Standard	Initiated crossing movement		Car movement/ Position; Hand Gesture	Orientation of P body/Head; Eye contact	On street	3	Pedestrian	Dv: Eipe oti h kopela perimene arketh wra
	P Evdokia Papanikolaou 025	0:18:40	Straight section course	Crossing	Vertical		Individual	Standard	Speeded up	None	Car movement/ Position	Orientation of P body/Head	On street	2	Pedestrian	Dv: Eipe oti h kuria me ta matia kai to podi
	P Evdokia Papanikolaou 026	0:19:45	Turn from 1way street to 1way street	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head	On street	4	Pedestrian	Dv :Eipe oti h kuria einai fortwmenh opote
	P Evdokia Papanikolaou 027	0:20:02	Straight section course	Crossing	Vertical		Individual	Standard with pet	Initiated crossing movement		Car movement/ Position	Orientation of P body/Head; Eye contact	On street	2	Pedestrian	Dv: Eipe oti thn koitakse vgazontas pio eks
	P Evdokia Papanikolaou 028	0:20:13	Right turn on 2way street	Crossing	Vertical	1-prior to manoeuv	Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Eye contact	On street	2	Pedestrian	Dv:Eipe oti phge na perasei alla eide ton pe
	P Evdokia Papanikolaou 029	0:22:30	Straight section course	Crossing	Vertical		Individual	Standard with bag	Speeded up?	None	Car movement/ Position	P body movement; Orientation of P body/Head; Eye contact	On street	2		Dd: Eipe eides fovithike; Dv:Eipe oti fovith
	P Evdokia Papanikolaou 030	0:22:37	Straight section course	Crossing	Vertical		Individual	Standard with bag	Kept pace	None	Car movement/ Position	P body movement; Orientation of P body/Head	On street	2	Pedestrian	Dv: Eipe oti o pezos den thn eixe dei kan
	P Kostas Floros 001	0:00:54	Turn from 1way street to 1way street	Crossing	Vertical		Group	Standard with bag	Kept pace	None	Car movement/ Position; Turn indicator	P body movement	On street	1	Pedestrian	Dv:Eipe oti prosekse tous pezous
	P Kostas Floros 002	0:01:15	Right turn on 2way street	Crossing	Vertical	2-after initiating mi	Individual	Standard	Stepped back	None	Car movement/ Position; Turn indicator	Orientation of P body/Head	On street	1	Ego car	Dv: Eipe oti den eixe dei ton pezo deksia k
	P Kostas Floros 003	0:03:53	Left turn from 2way street	Crossing	Vertical	2-after initiating mi	Individual	Standard	Stepped back	None	Car movement/ Position; Turn indicator	Orientation of P body/Head; Eye contact	On street	1	Ego car	Dv : Eipe oti eide oti den edeikse prothesh

Autonomous vehicles (AV) – Human Interaction
From data to as-is modeling

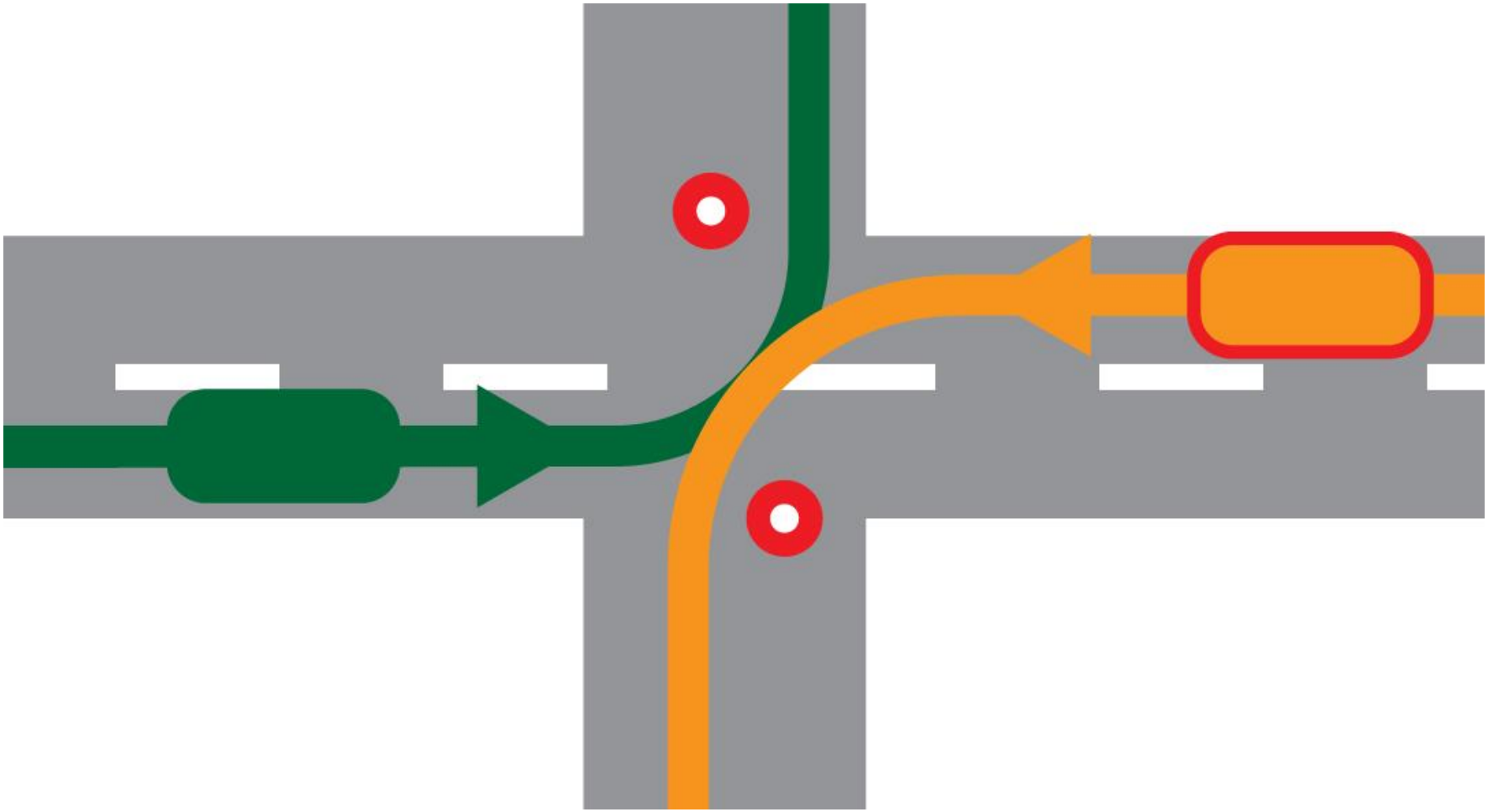


Autonomous vehicles (AV) – Human Interaction
From as-is modeling to conceptual models

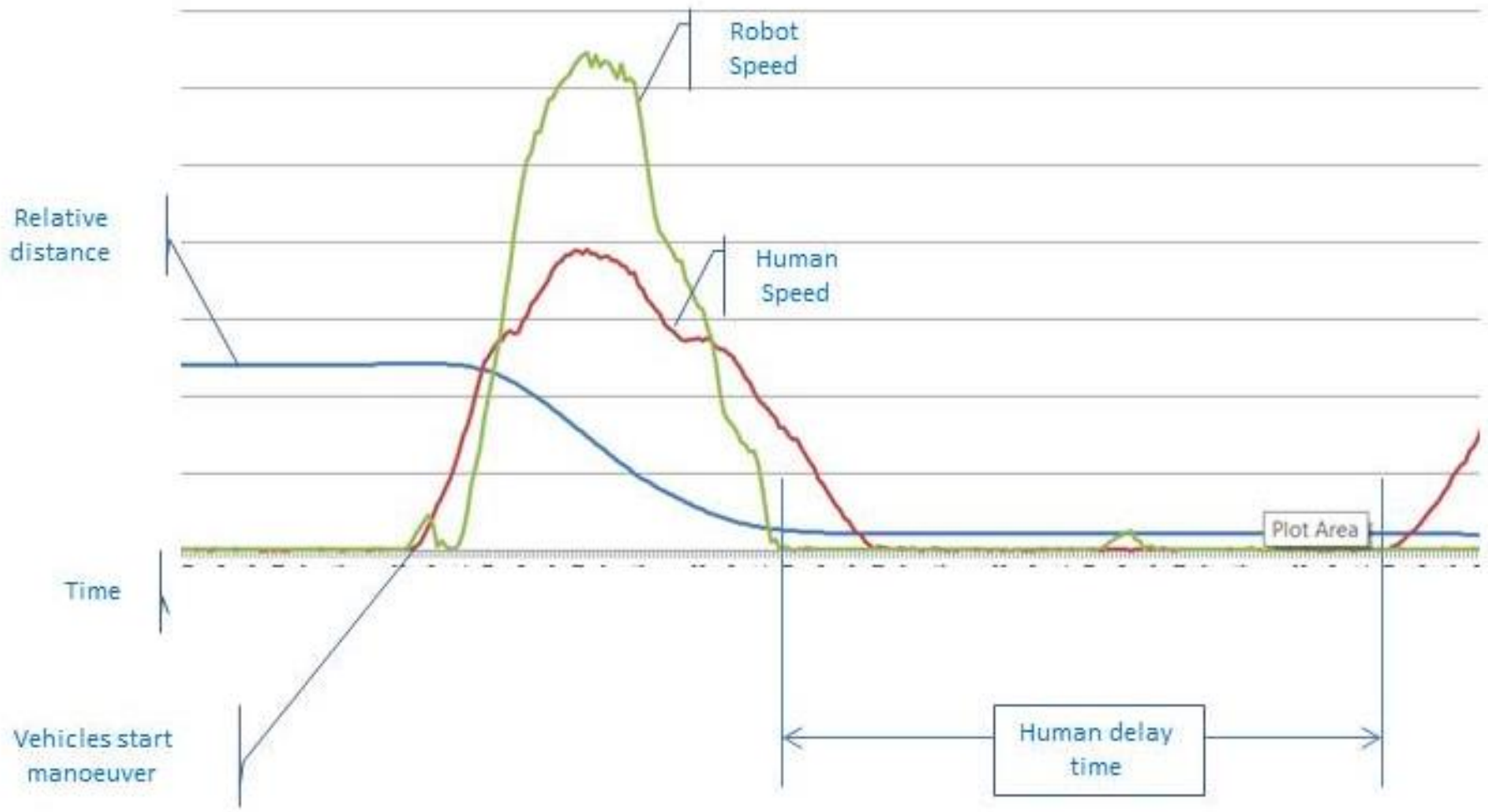


Autonomous vehicles (AV) – Human Interaction from field observations to naturalistic experiments

Autonomous vehicles (AV) – Human Interaction
Naturalistic experiments – Scenario building



Autonomous vehicles (AV) – Human Interaction
Naturalistic experiments – Data gathering



Reconstruction of the interface

A historical example

Define the interface in these machines

The evolution

1905

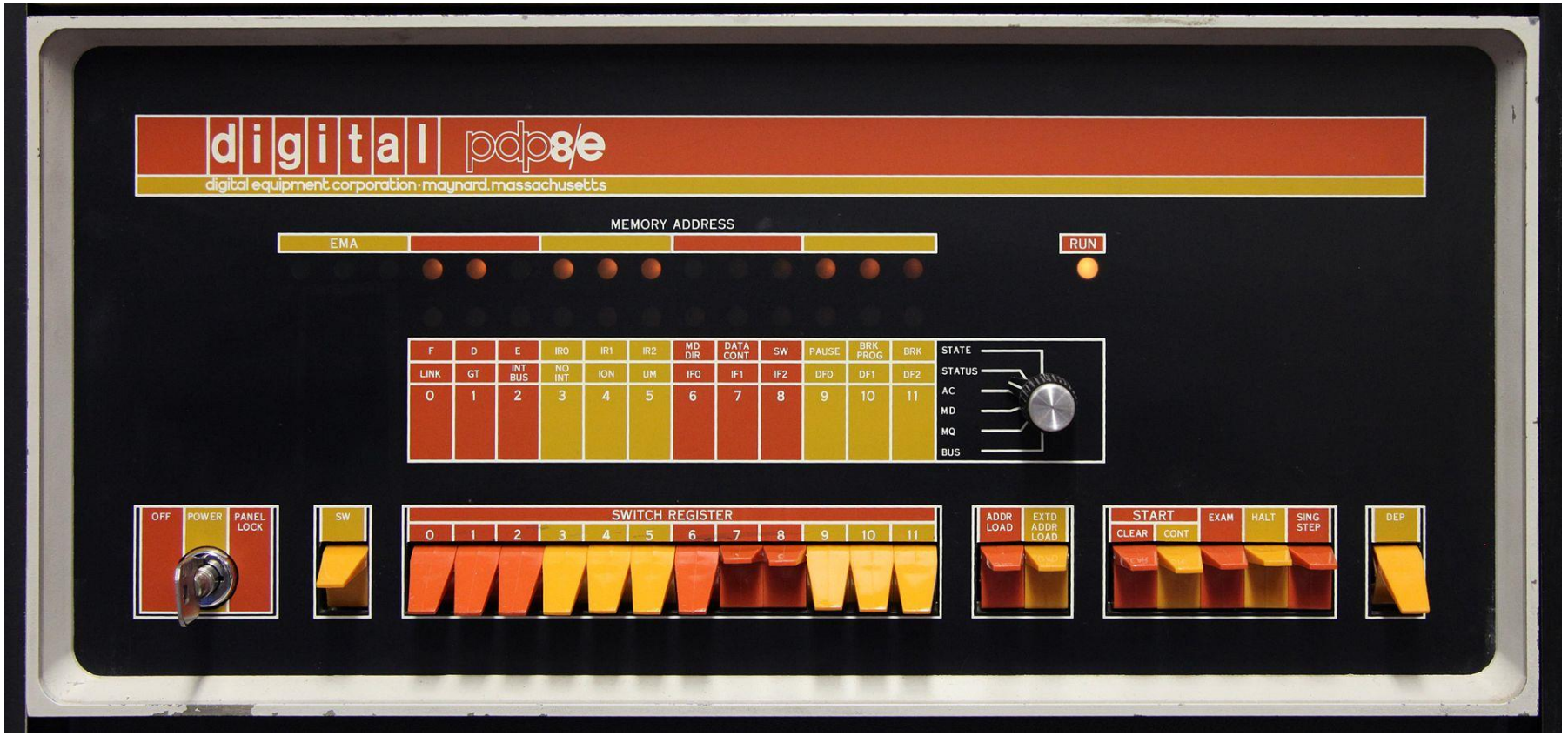
Today… find the drawbacks of this design

Ease of use is not always the primary criterion!

What is wrong with this specific interface?

How I put it?

Interfaces: means of informing the human + means of manipulating the machine



Command interface of PDP-8/E minicomputer. The actuator array at the bottom is used to enter lines of machine code into the computer (1970)

Interfaces: Communication language

Natural speech

Human

High level scripting

```
class Triangle {
  ...
  float surface()
    return b*h/2;
  }
```

Low level programming

```
LOAD r1,b
LOAD r2,h
MUL r1,r2
DIV r1,#2
RET
```

Machine code

```
0001001001000101
0010010011101100
10101101001...
```

Electrical pulses

Machine

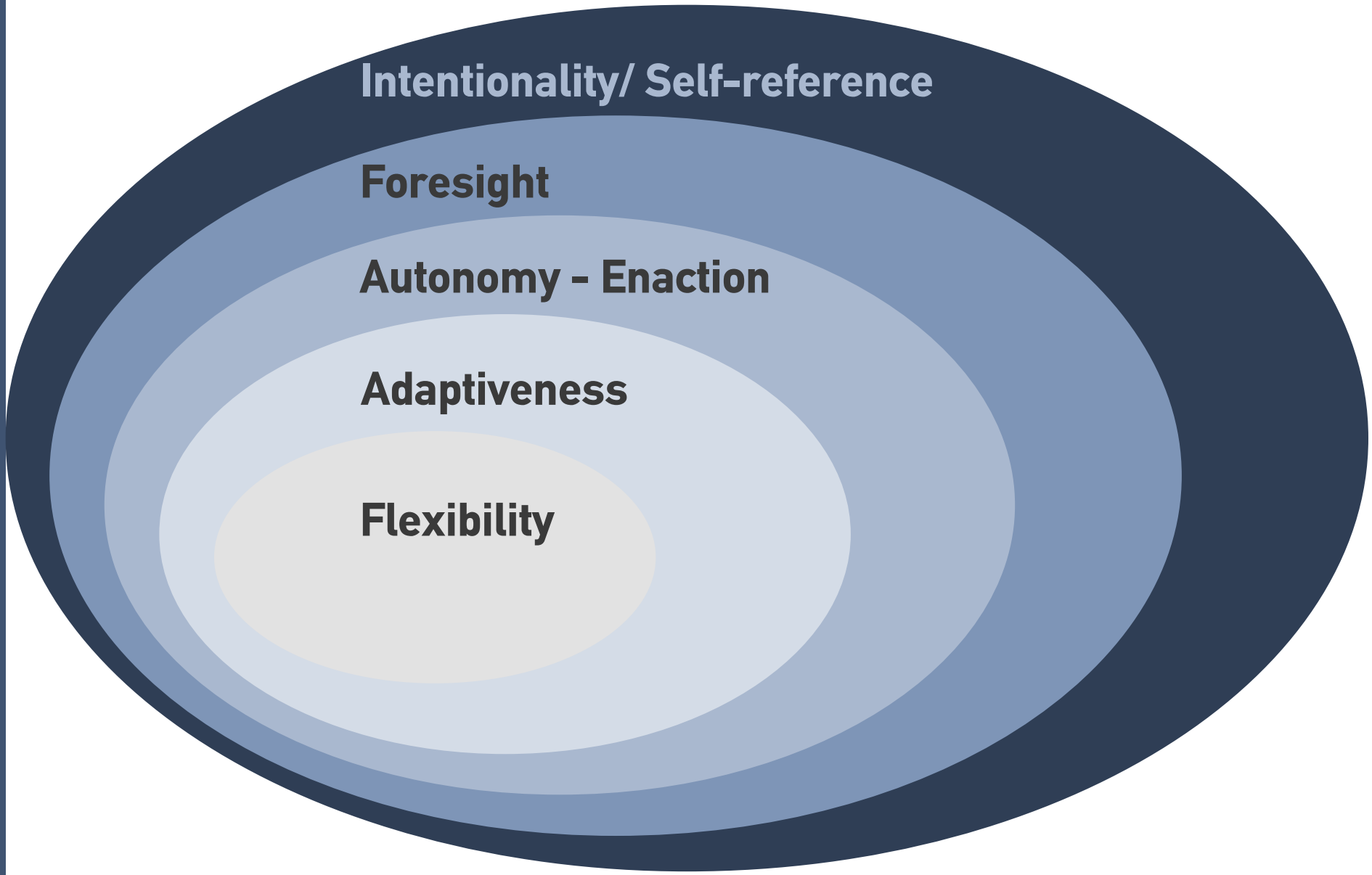
On cognition

All forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imagining, and problem solving*. (American Psychological Association)*

- Perceiving (not sensing)
- Remembering (not retrieving inf.)
- Learning
- Problem-solving – calculating - reasoning
- Judging
- Anticipating
- Imagining - Conceiving

Along with **Affect** (feelings-Emotion) and **Connation** (Will / Intentionality) they are "traditionally" identified as the 3 basic faculties of the mind

Evolution of intelligence



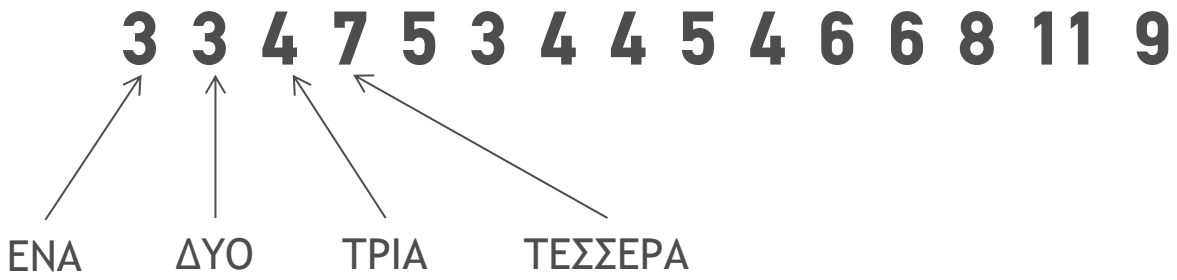
- A simple exercise for the human working memory capacity

4 7 3 1 9 4 0 5 1 6 2 8 2 4 1 8 3 7 2 4 6 5 2 9

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37

1 2 4 8 16 32 64 128 256 512 1024 2048 4096 8192


3 3 4 7 5 3 4 4 5 4 6 6 8 11 9
ΕΝΑ
ΔΥΟ
ΤΡΙΑ
ΤΕΣΣΕΡΑ

4 7 3 1 9 4 0 5 1 6 2 8 2 …	Memorizing
1 3 5 7 9 11 13 15 17 19 21 …	Identifying + remembering
1 2 4 8 16 32 64 128 256 512 …	Identifying + remembering and/or Calculating
3 3 4 7 5 3 4 4 5 4 6 6 8 11 9 …	Imagining + remembering + calculating

Cognitive analysis in everyday life

Change

Theoretical or novice approach:

- Mental or paper aided subtraction of amount owed (e.g. 8,35€) and amount given (e.g. 20€ bill)

$$20 - 8{,}35 = 11{,}65$$

- Retention in memory of resulting amount to return and adding up coins and bills up to a sum equating the amount to return

$$11{,}65 \rightarrow 10 + 1 + 0.50 + 0{,}10 + 0.05$$

Starting from larger notes to progressively smaller coins

Cognitive actions: 1. Mental subtraction 2. memorizing amount, 3. Computation of notes and coins up to the memorized amount

Expert way: a cognitive artifact

Change

Practical or expert approach:

- Addition («or building-up») of amount to return starting from the amount owed (8,35) upto the amount given (20)

8,35 0,05 + 0,10 + 0,50 + 1 + 10 20

- Starting from small coins to greater ones in order to ease memorizing burden

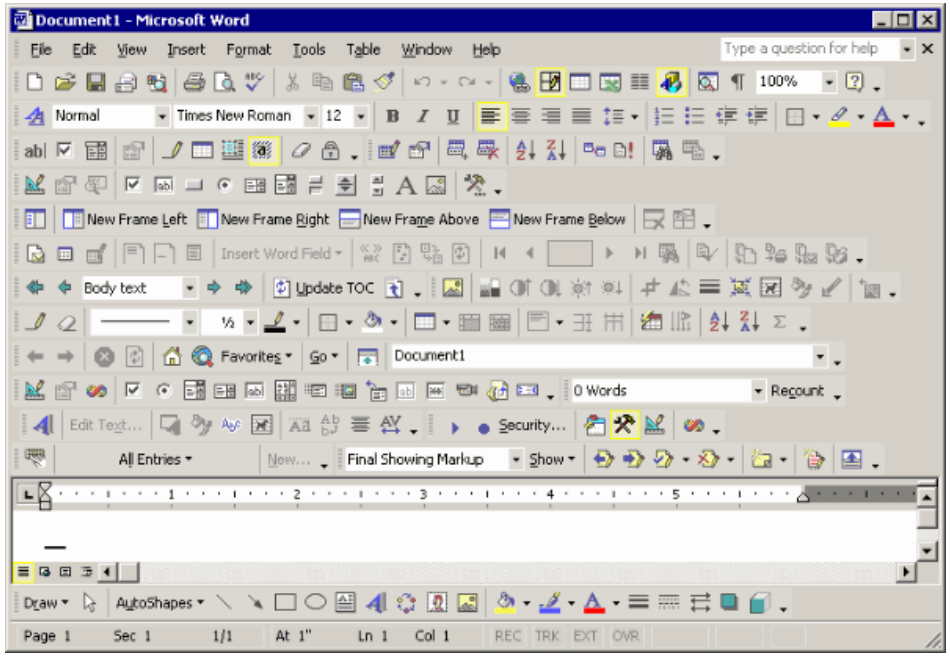
The materiality of the “tokens” aids the process

Addition is less cognitively demanding than abstraction

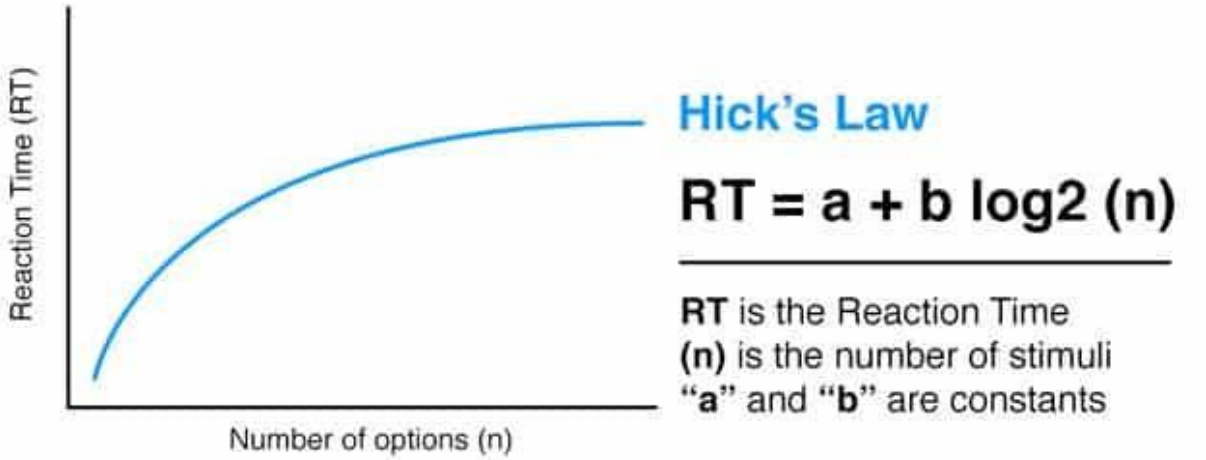
Cognitive actions: 1. addition with material traces up to standard amount given 2. memorizing remaining amount at each step *(note that the amount to memorize gets less demanding in each step)*

Hick's law

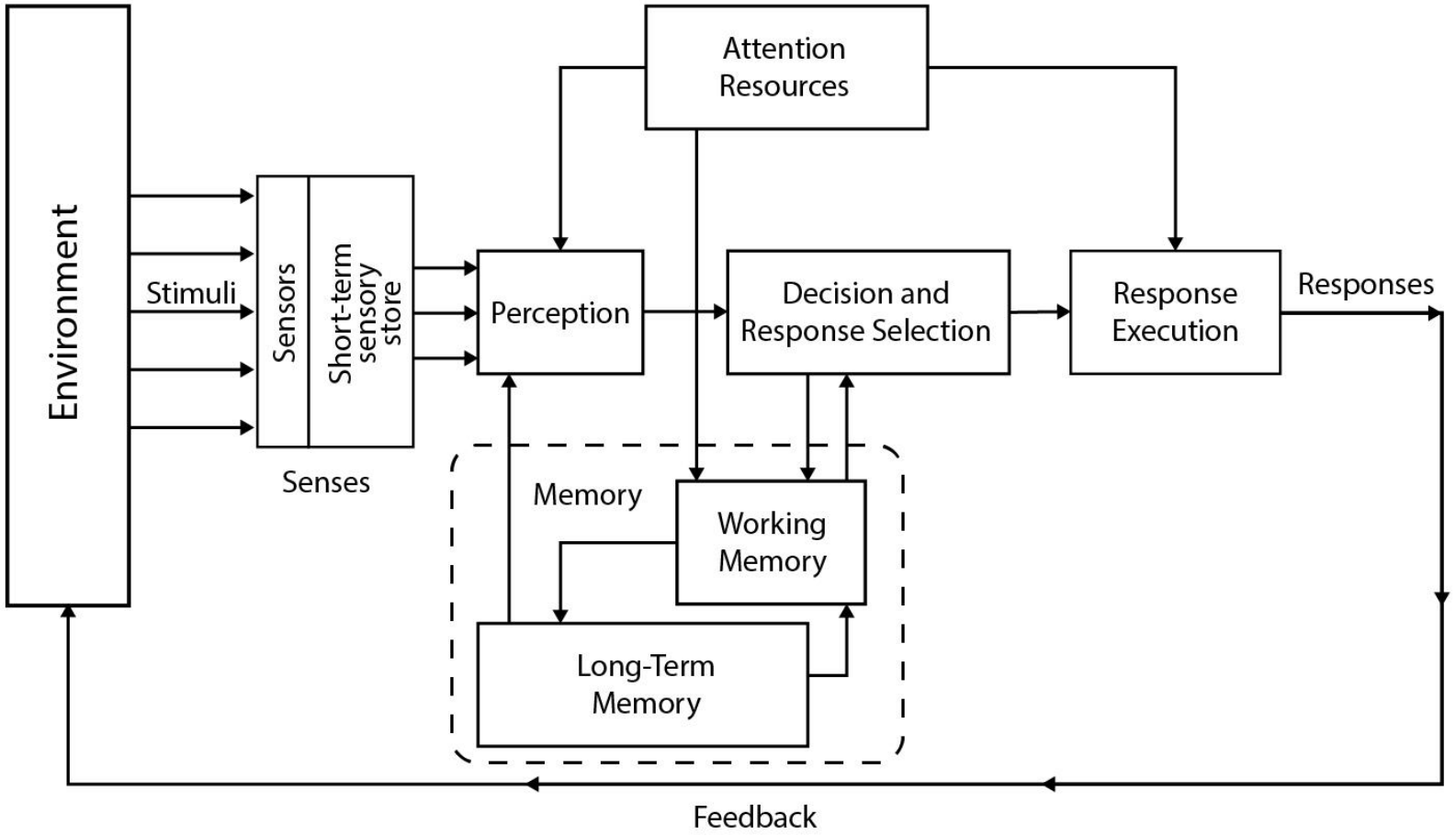
Hick's law



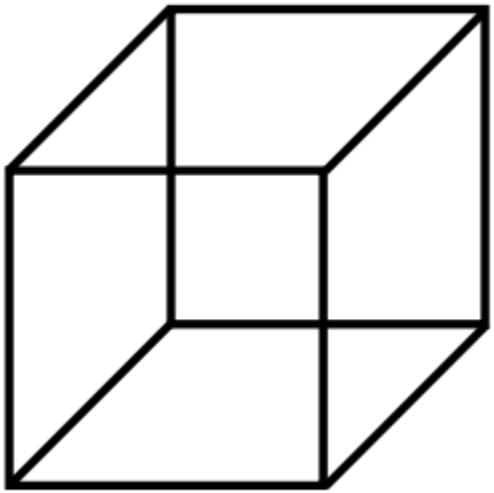
Increasing the options, increases the decision time logarithmically.

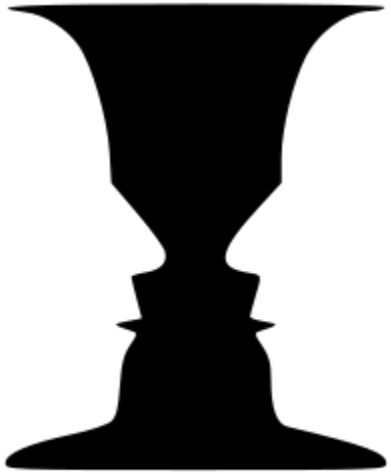


The model of Human Information Processing (Wickens 1992)

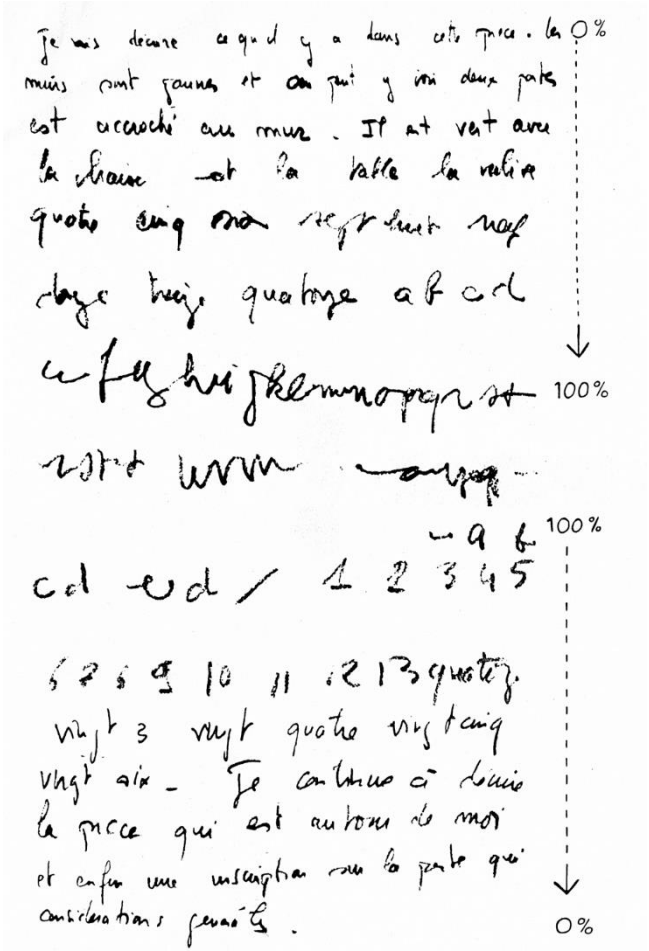


Sensing vs Perception

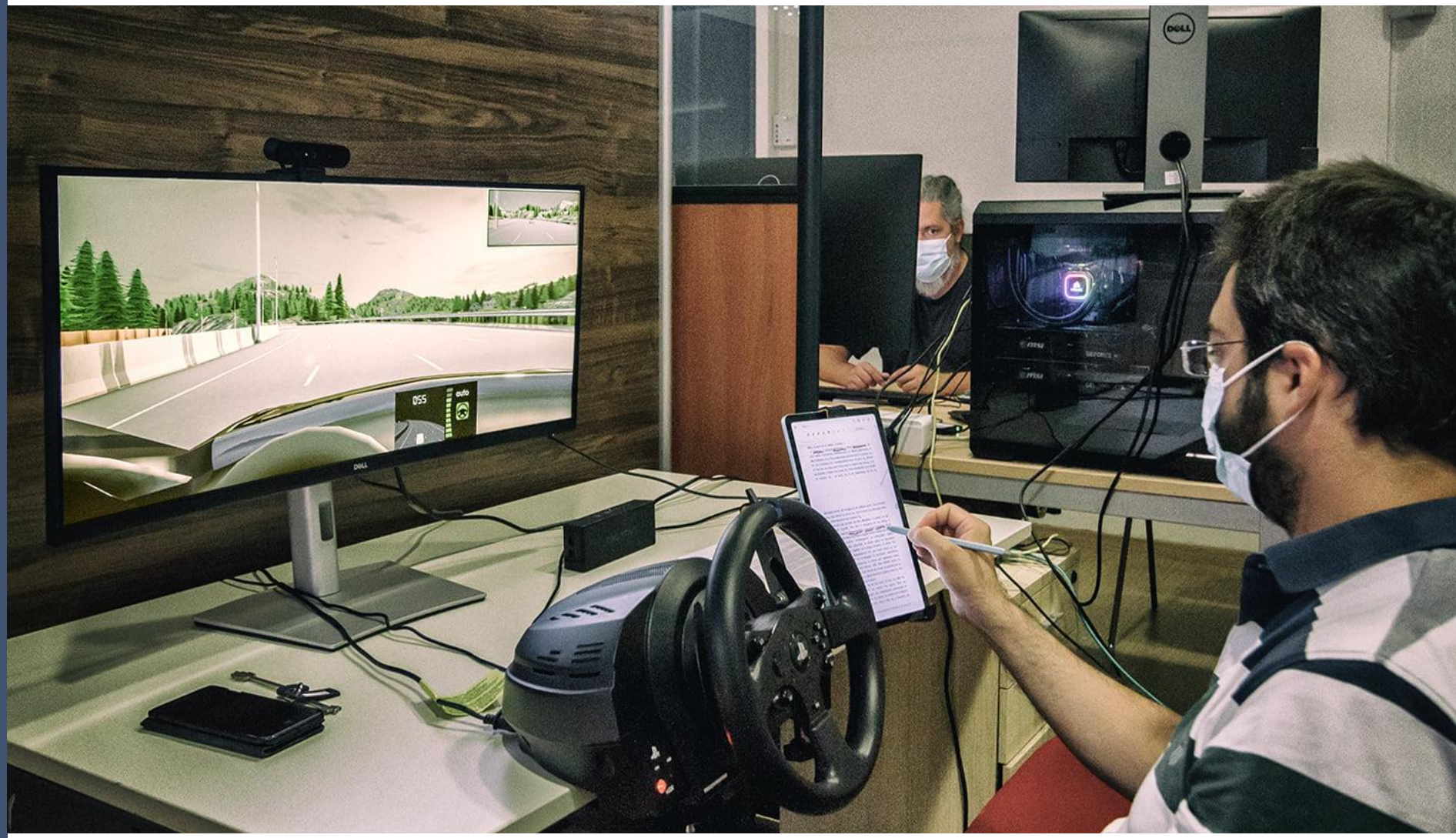




Single-channel hypothesis



Single-channel hypothesis



Types of memory

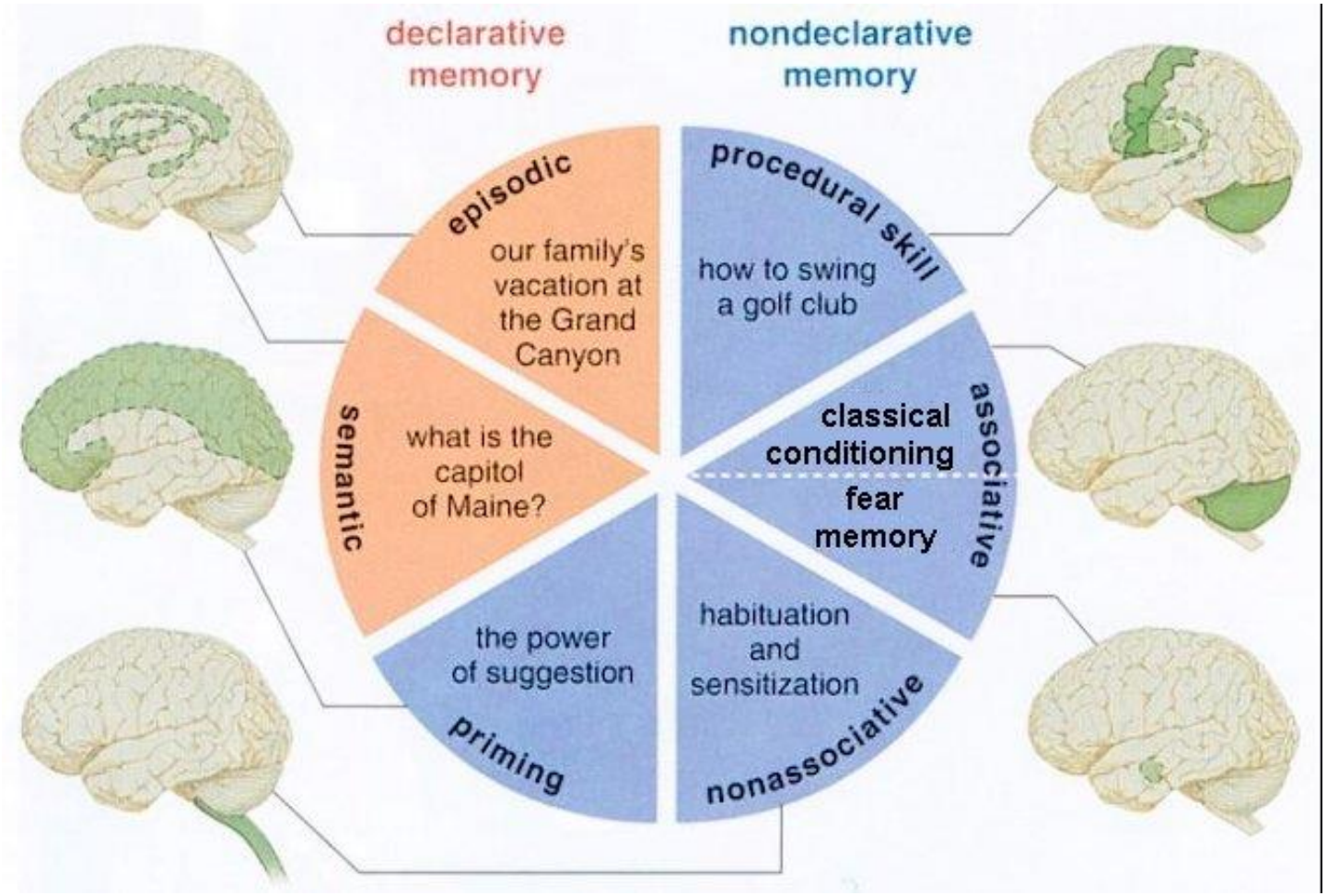
Declarative:

- They can be communicated to third parties
- It is considered conscious as it involves deliberate recall of factual information
- This type of memory appears to be controlled by the hippocampus which is a complex brain structure embedded deep in the temporal lobe.

Procedural

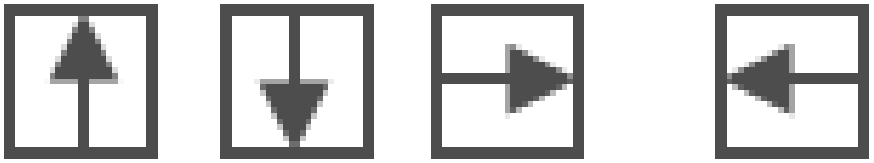
- It implies knowledge manifested while performing a familiar task.
- It is better understood as skill (perceptual / motor / cognitive).
- It is not easy to verbalize this kind of knowledge.
- The cerebellum, basal nuclei, and motor cortex are involved in procedural memory, which is generally supervised by the cerebral cortex.

Parts of the brain associated with different types of memory

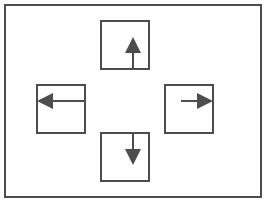


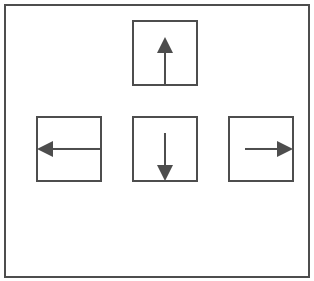
a first exercise in user centered design

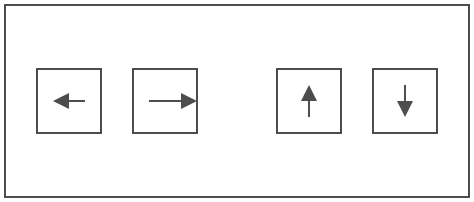
design a configuration for the four “cursor” keys below

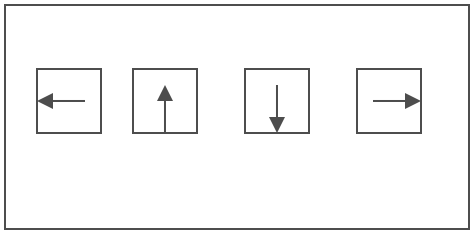


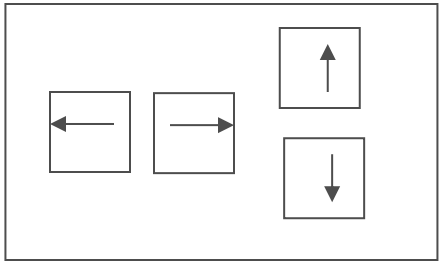
Possible solutions – no one is optimal for all applications and people











Reasons for solutions

- **Functionality - relation to task**
- **Representation (mapping) - ease of use**
- **learning - investing learning time**
- **physiology – comfort, speed of movements**

(and perception etc.)