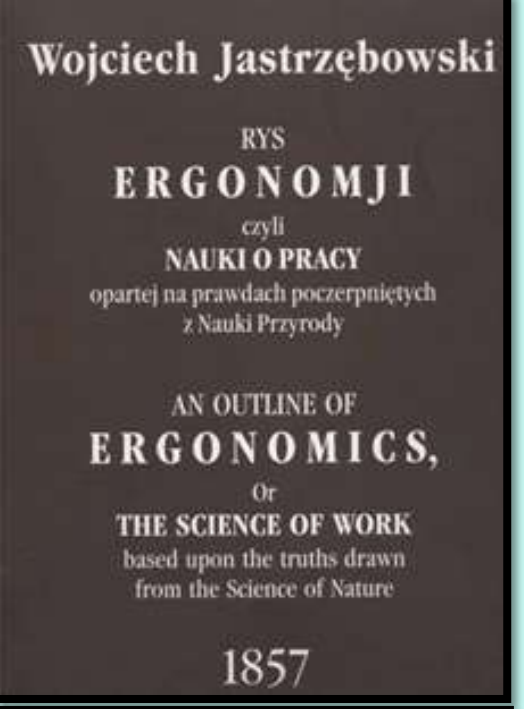
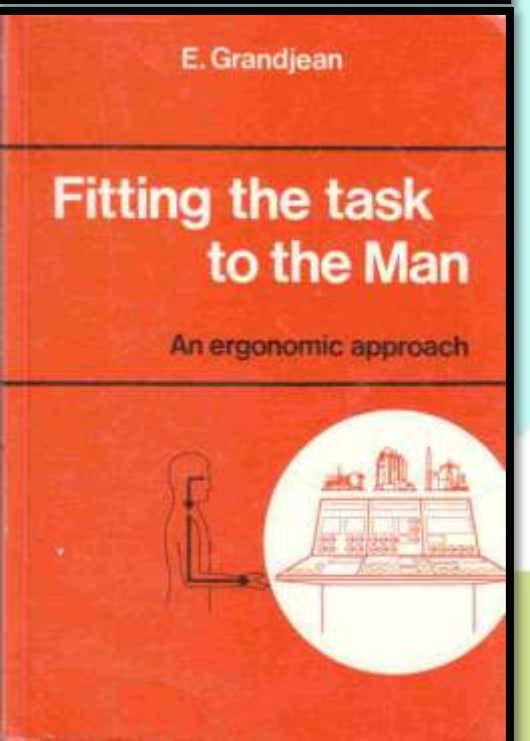
Ergonomics and Human Factor Engineering

Dewi Hardiningtyas, ST., MT., MBA.

Picture of life





Ergonomics (Human Factors)

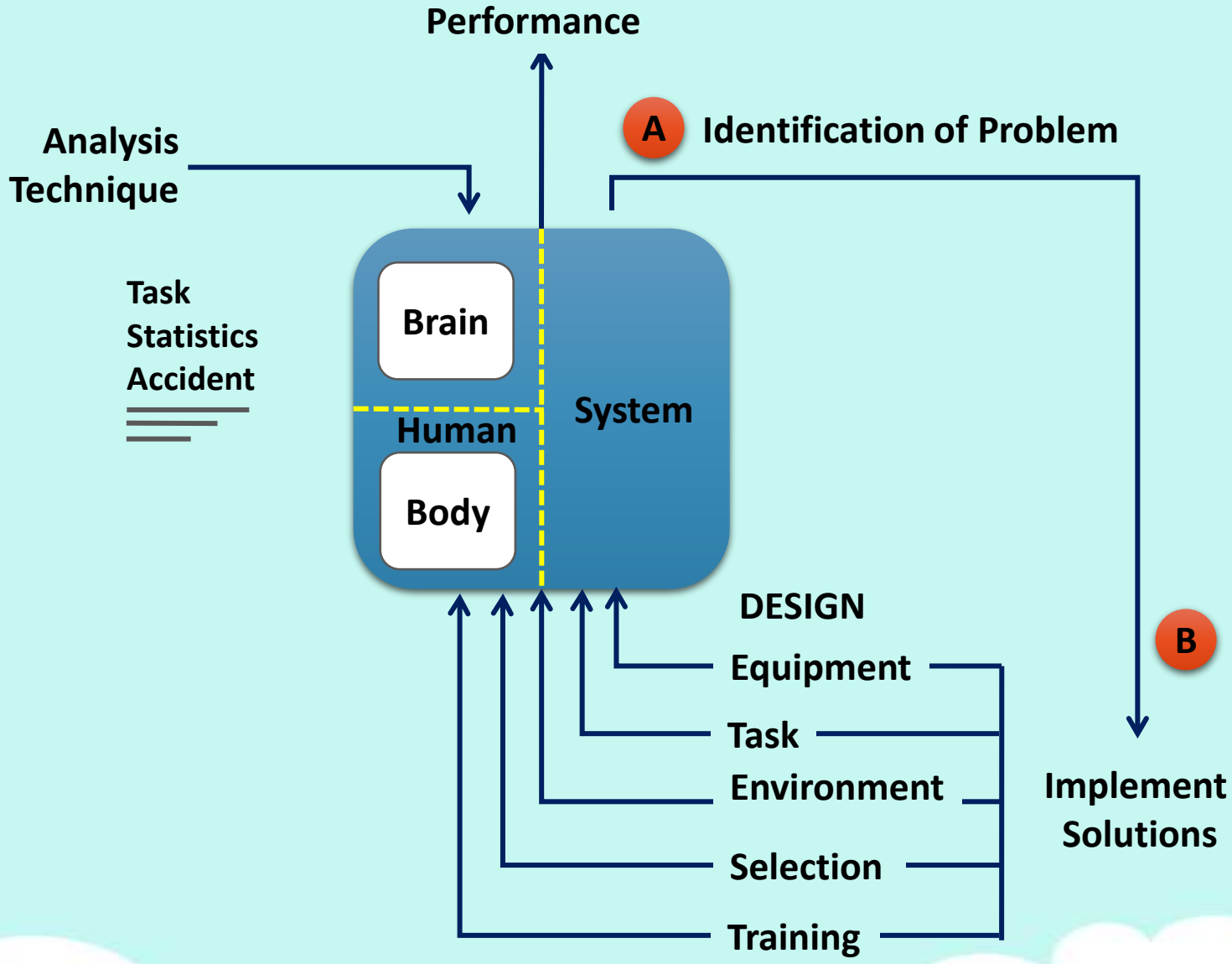
ergon **= work**
nomos **= laws**

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system performance. (International Ergonomics Association, www.iea.cc)

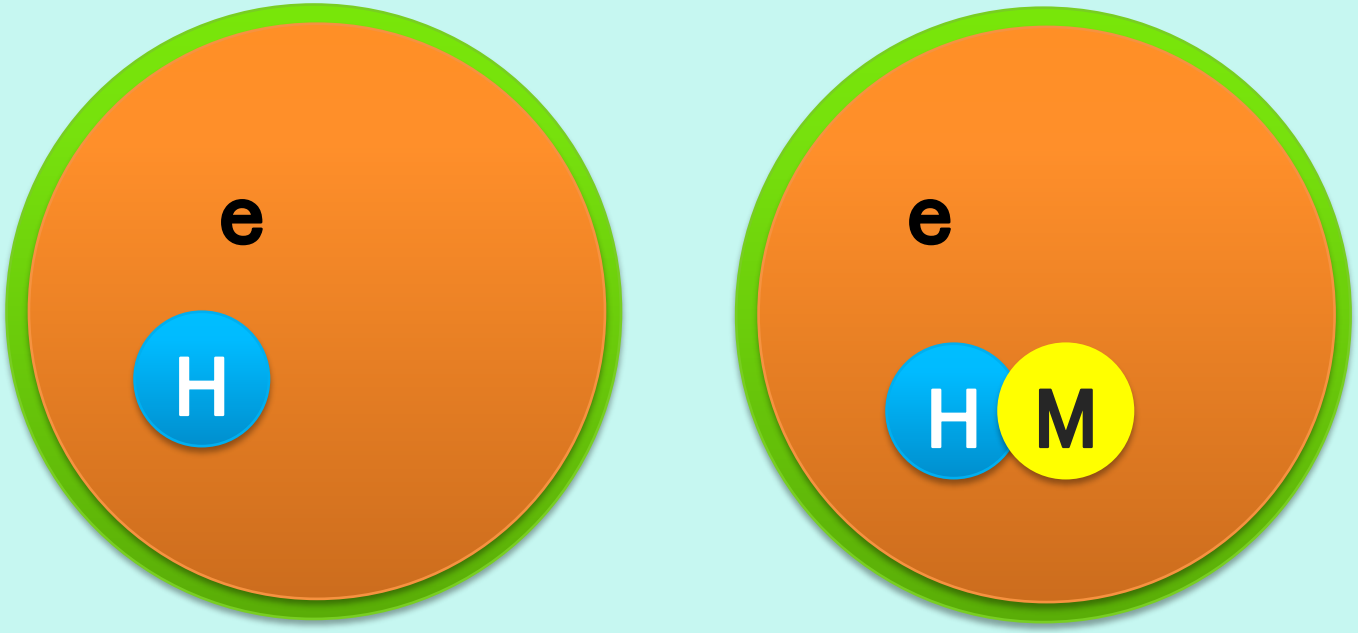
- ☑ The study of man's relationship with his or her workplace.
- ☑ Fitting the task to the person rather than forcing him/her to adapt to the work environment.
- ☑ Designing the workplace to prevent occupational injury and illness.
- ☑ Discovering the capabilities and limitations of the human body.
- ☑ The art and science that addresses workers' job performance and well-being in relation to their job tasks, tools, equipment and environment.
- ☑ The study of the relationship between people and machines or between employees and their environment.
- ☑ The study of the interaction between the worker and the process at the workplace.

The Cycle of Human Factors

- Point A identifies a cycle when human factors solutions are sought because a problem (e.g. accident or incident) has been observed in the human-system interaction.
- Point B identifies a point where good human factors are applied at the beginning of a design cycle.



Simple Ergo System

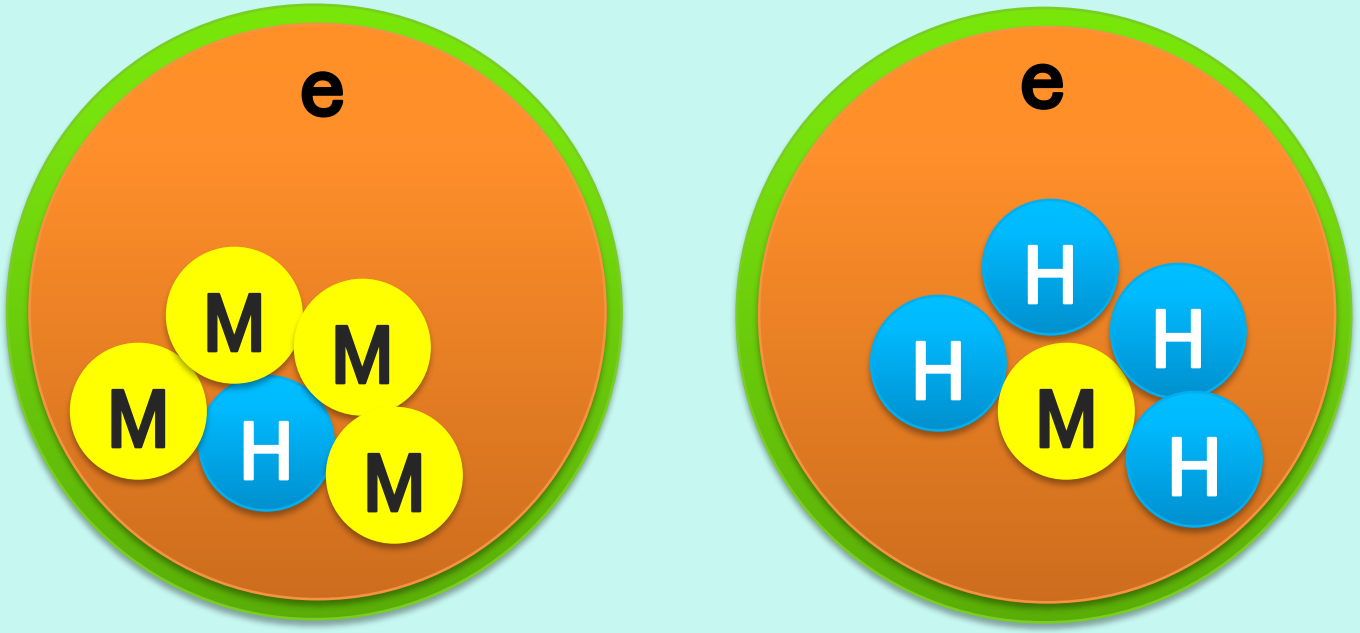


H = Human

M = Machine

e = Environment

Complex Ergo System



H = Human

M = Machine

e = Environment

ERGONOMICS IS IMPORTANT !!

ERGONOMICS PLAYS A ROLE IN APPROXIMATELY 50% OF ALL WORKPLACE INJURIES.

ERGONOMICS WILL HELP :

- ☑ Improve quality.
- ☑ Improve absenteeism.
- ☑ Maintain a healthier work force.
- ☑ Reduce injury and illness rates.
- ☑ Acceptance of high-turnover jobs.
- ☑ Workers feel good about their work.
- ☑ Reduce workers' compensation costs.
- ☑ Elevate OSHA compliance to a higher level of awareness.

Cognitive Task

+

Physical Task

→

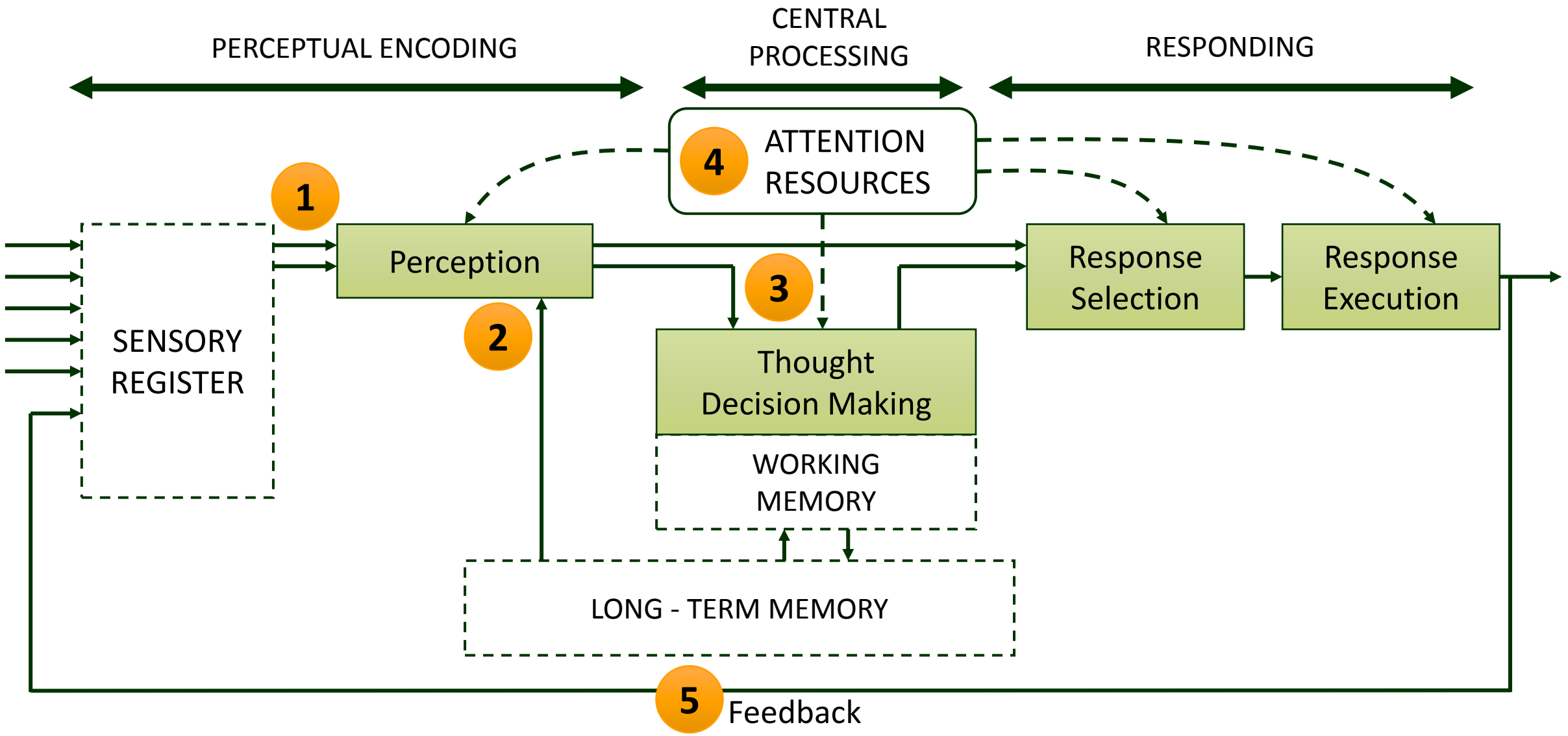
Ergonomics Assessment

COGNITIVE TASK

What is Cognitive Task?

- Design, managerial and production planning, computer programming, medical diagnosis, process control, air traffic control, and fault diagnosis in technological systems are typical examples of cognitive tasks.
- Cognitive ergonomics or cognitive engineering is an emerging branch of ergonomics that places particular emphasis on the analysis of cognitive required of operators in modern industries.
- Cognitive ergonomics aims to enhance performance of cognitive tasks by means of several interventions, including:
  - User-centered design of human–machine interaction
  - Design of information technology systems that support cognitive tasks (e.g., cognitive aids)
  - Development of training programs
  - Work redesign to manage cognitive workload and increase human reliability

Human Information Processing Model



Explanation

1. The senses (**vision, audition, smell, taste, and touch**) gather information from the environment, which is then perceived, providing meaningful interpretation of what is sensed.
2. Perception which is influenced by prior knowledge , comes through a mechanism called top-down processing. This prior knowledge is stored in long-term memory.
3. Sometimes, perception leads directly to the selection and execution of response. This condition requires temporary effort demanding-store, called working memory.
4. Mental or cognitive resources, a sort of pool of attention or mental effort that is limited availability and can be allocated to process as required.
5. Our actions often generate new information to be sensed and perceived, noted with the feedback loop.

Top-Down vs Bottom-Up Processing

EXPERIENCE

Top – Down Processing

- Knowledge
- Expectations
- Desires

Perception

- The 5 senses

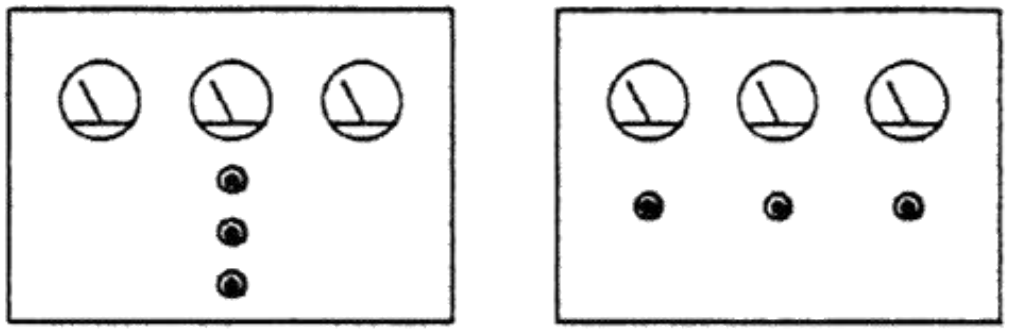
STIMULUS WORLD

Bottom – Up Processing

GOOD EXAMPLE OF A BRAIN STUDY. IF YOU CAN READ THIS YOU HAVE A STRONG MIND.

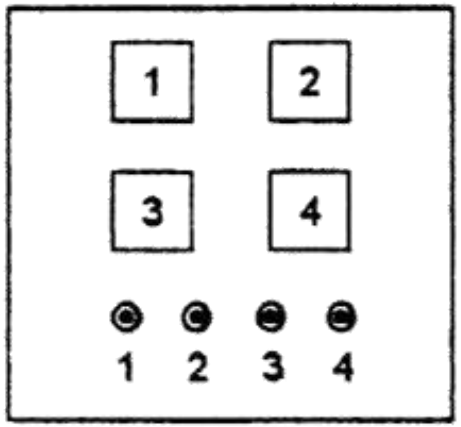
7H15 M3554G3
53RV35 7O PR0V3
H0W 0UR M1ND5 C4N
D0 4M4Z1NG 7H1NG5!
1MPR3551V3 7H1NG5!
1N 7H3 B3G1NN1NG
17 WA5 H4RD BU7
N0W, 0N 7H15 LIN3
Y0UR M1ND 1S
R34D1NG 17
4U70M471C4LLY
W17H 0U7 3V3N
7H1NK1NG 4B0U7 17,
B3 PROUD! 0NLY
C3R741N P30PL3 C4N
R3AD 7H15.
PL3453 5H4R3 1F
U C4N R34D 7H15.

I cxn rxplxce xvexy txirx lextex of x sextexce xitx an x, anx yox stxll xan xanxge xo rxad xt – ix wixh sxme xifxicxltx.

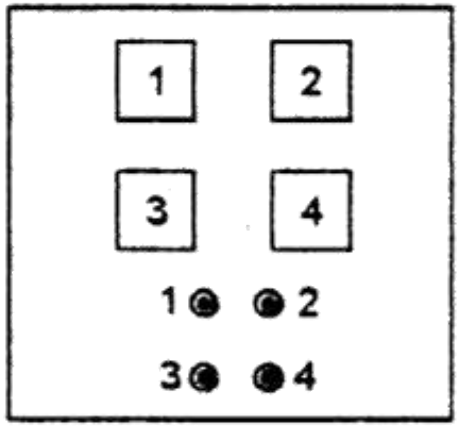


POOR (a)

GOOD (b)

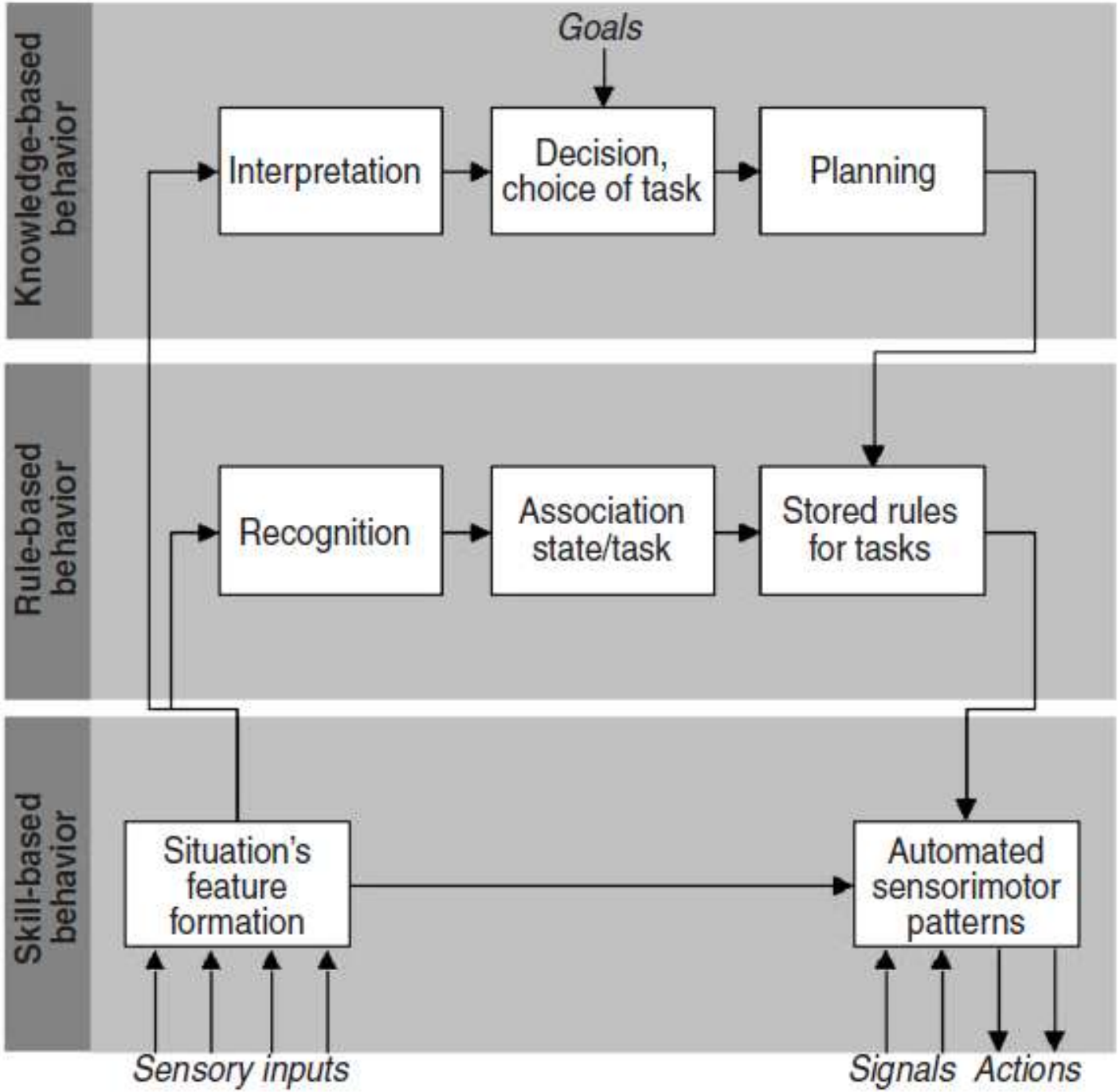


POOR (c)



GOOD (d)

Example : Alternative Layouts of Stove Burner Controls



The Skill-, Rule-, and Knowledge-Based Performance Model (Rasmussen 1986)

Evolution of the iOS Home Screens

PHYSICAL TASK

Ergonomics for Physical Task

- Ergonomic design is the application of this body of knowledge to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.
- The underlying philosophy of ergonomics is to design work systems where job demands are within the capacities of the workforce.
- Ergonomic job design focuses on fitting the job to capabilities of workers by, for example, eliminating occurrence of non natural postures at work, reduction of excessive strength requirements, improvements in work layout, design of hand tools, or optimizing work / rest requirements (Karwowski 1992; Karwowski and Salvendy 1998; Karwowski and Marras 1999).

Anthropometry

Anthropos = human

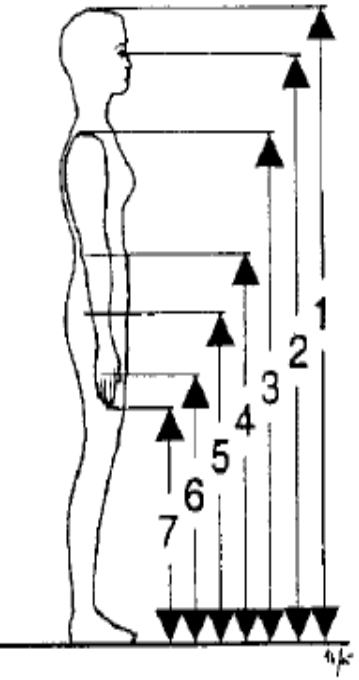
Metron = measure

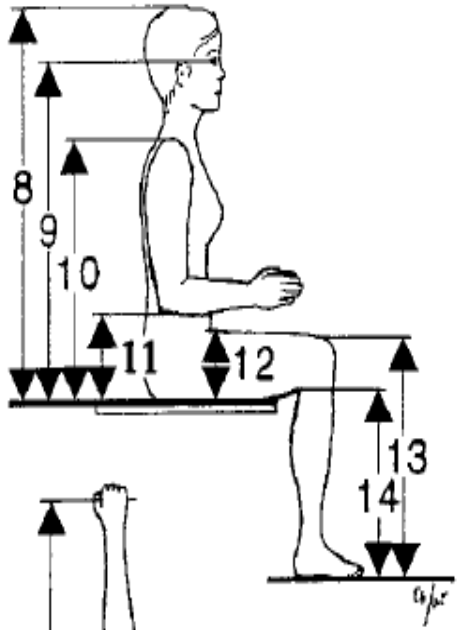
- The part of anthropology (study of humans) having to do with **measurements of the human body** to determine differences in races, individuals, etc… **(Webster's New 20th Century Dictionary, 1970).**
- Anthropometry is a science that deals with **the measurement of size, weight, and proportions of the human body**. It is empirical (experimentally derived) in nature and has developed quantitative methods to measure various physical dimensions. **(Chaffin, 1984)**

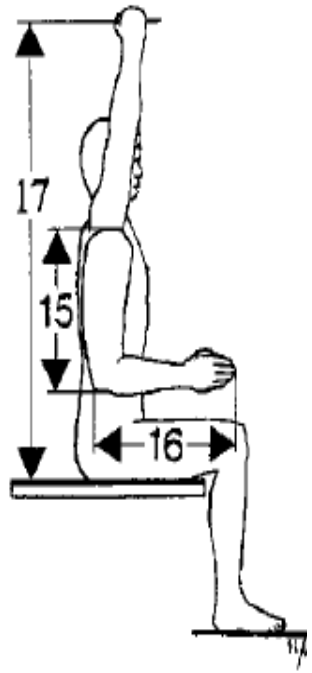
Factors affecting anthropometry data

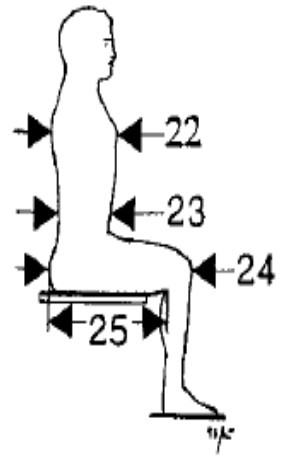
- Age
- Sex
- Jobs
- Body Position
- Clothing
- Daily changes
- Generational changes
- Ethnicity
- Pregnancy
- Disability

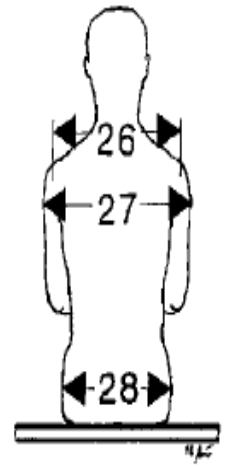
Body Dimension (Kroemer 1997)

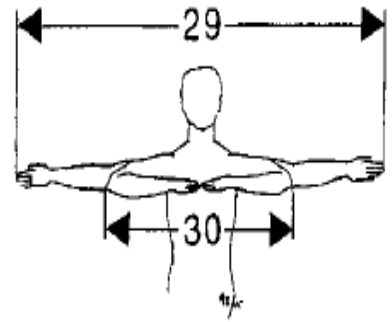


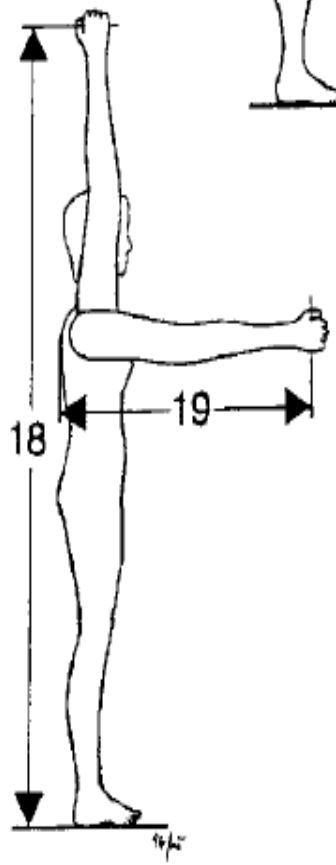


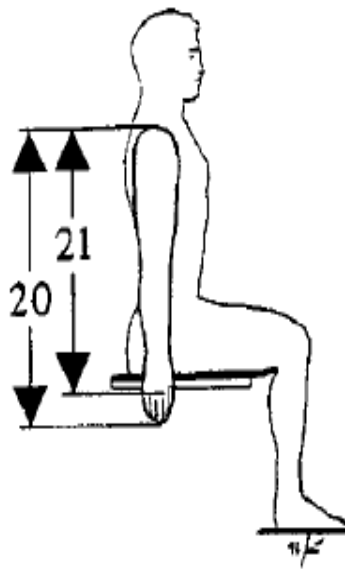


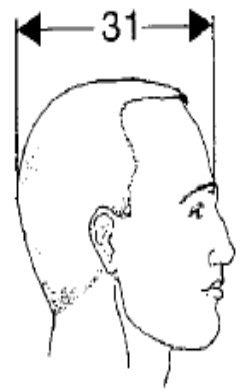


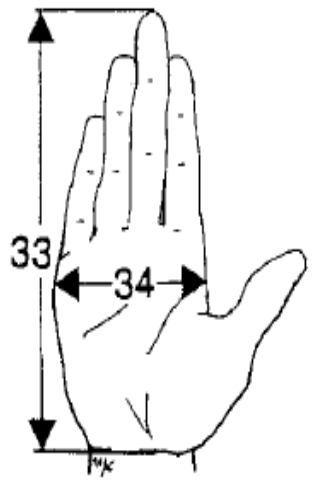


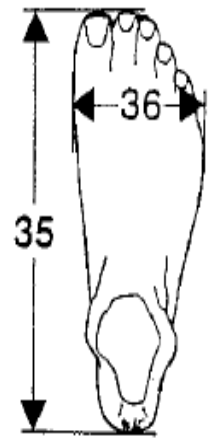






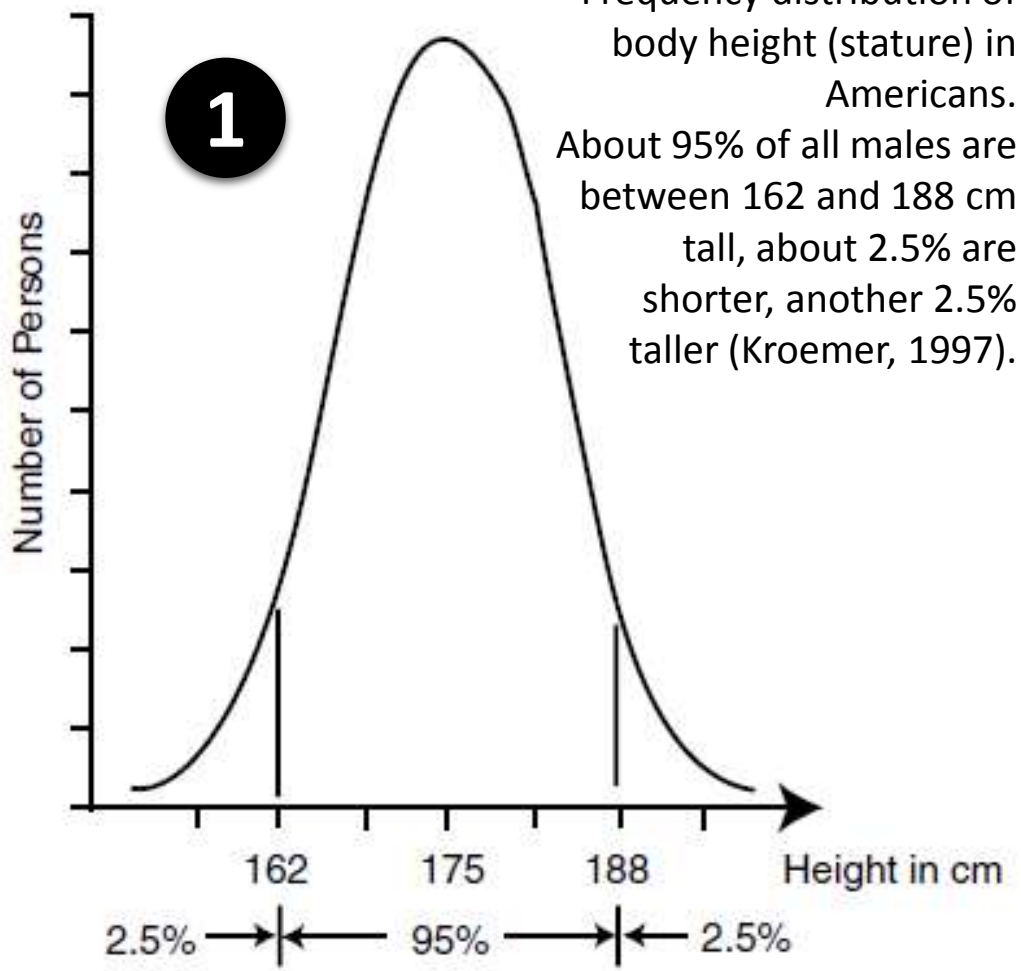






Develop Anthropometry Data

1



Frequency distribution of body height (stature) in Americans. About 95% of all males are between 162 and 188 cm tall, about 2.5% are shorter, another 2.5% taller (Kroemer, 1997).

2

$$\text{mean} = \bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} \qquad SD = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

3

Percentile is a value that indicate the percentage of a group who have the same value or under.
Percentile <50th : lower percentile
Percentile >50th : upper percentile

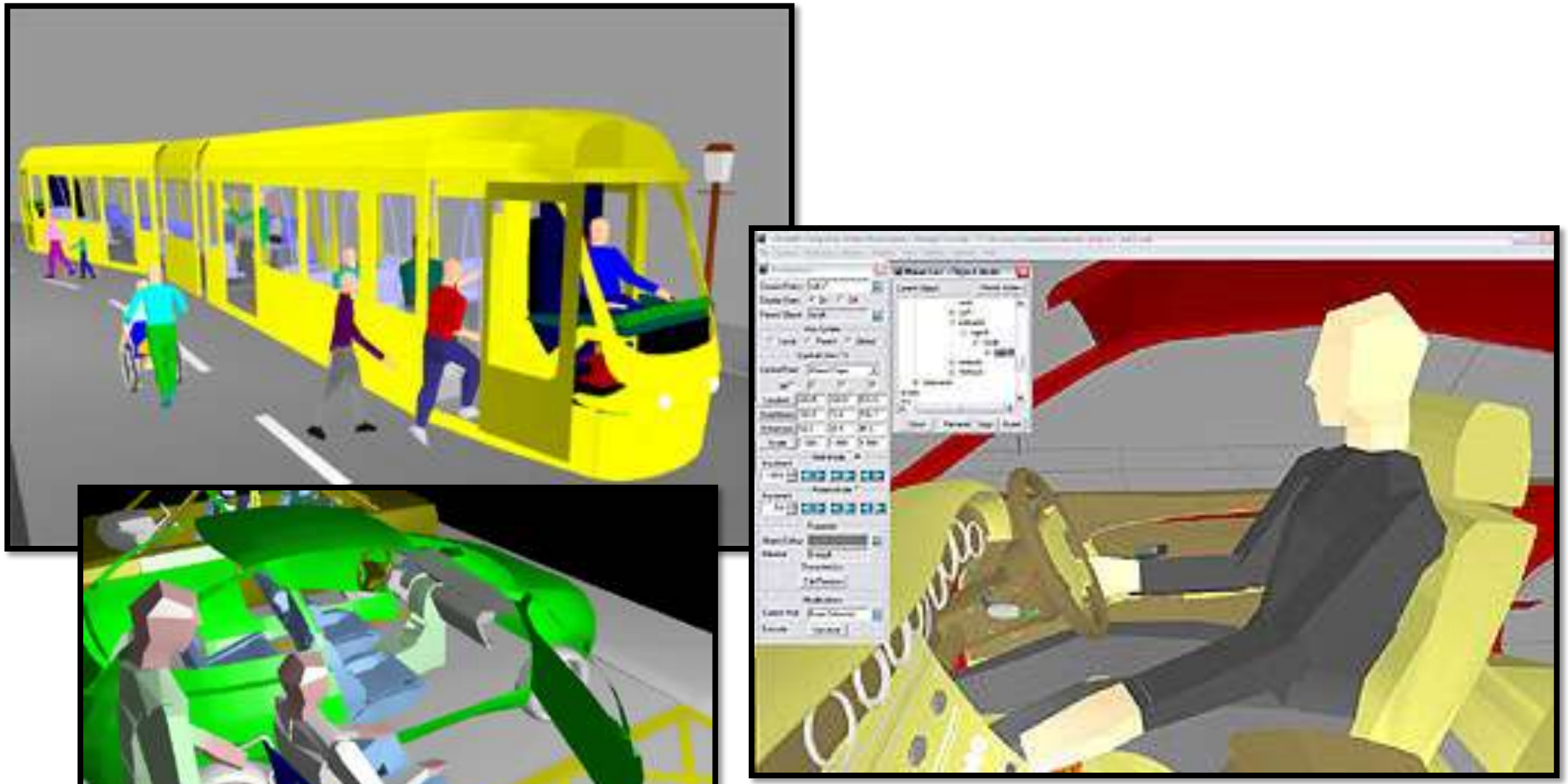
Percentile	Factor	Tabulation
1st	- 2,32	X – 2,32 SD
2,5th	- 1,96	X –1,96 SD
5th	- 1,64	X – 1,64 SD
10th	- 1,28	X – 1,28 SD
50th	0	X
90th	1,28	X + 1,28 SD
95th	1,64	X + 1,64 SD
97,5th	1,96	X + 1,96 SD
99th	2,32	X + 2,32 SD

Case Study :

Dari hasil pengukuran tubuh manusia Indonesia (dewasa, laki-laki, usia 19 – 40 tahun) diperoleh data yang berdistribusi normal dengan tinggi rata-rata 170 cm dgn standar deviasi 7 cm.
Berapakah ukuran 95^{th} dan 5^{th} percentile?

95^{th} percentile :
= X + 1,64 SD
= 170 + 1,64 (7)
= 182 cm

5^{th} percentile
= X – 1,64 SD
= 170 – 1,645 (7)
= 159 cm

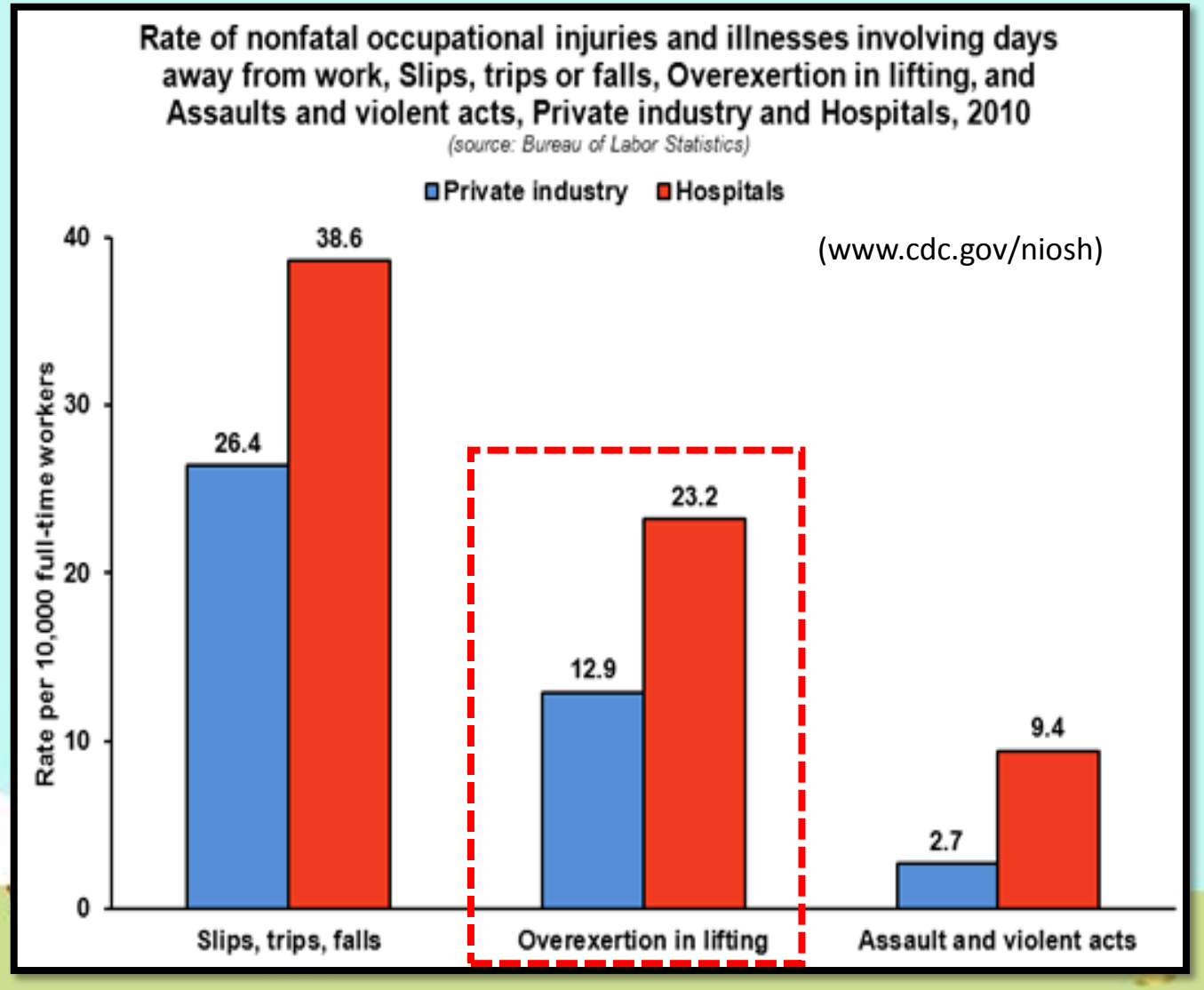


Occupational Biomechanics

Occupational biomechanics is a science concerned with the mechanical behavior of musculoskeletal system and component tissues when physical work is performed (Chaffin et.al, 1999).

Biomechanics analyzes the human **musculoskeletal system as a mechanical system** that obeys laws of physics (Wickens et.al, 2004).

Why Biomechanics is Important ?



The two most prevalent musculoskeletal problems are :

- **LOW BACK PAIN**
- **UPPER-EXTRIMITY** (fingers, hands, wrists, arms, and shoulders)

CUMULATIVE TRAUMA DISORDERS

Biomechanics Evaluation

Moore-Garg Strain Index

- The Strain Index was proposed by Moore and Garg as a means to assess jobs for risk of work-related musculoskeletal disorders (WRMSDs) of the distal upper extremities (hand, wrist, elbow).

Divide a job into tasks.

(For each task and for each hand) Assess the 6 job risk factors by assigning it to a category.

For each category, note the rating.

The Strain Index is the product of the six ratings.

Strain index (SI) = (intensity of exertion multiplier) x (duration of exertion multiplier) x (exertions per minute multiplier) x (posture multiplier) x (speed of work multiplier) x (duration per day multiplier)

TABLE 23 Rating Criteria for Strain Index

Rating	Intensity of Exertion	Duration of Exertion (% of Cycle)	Efforts/Minute	Hand–Wrist Posture	Speed of Work	Duration per Day (h)
1	Light	<10	<4	Very good	Very slow	≥1
2	Somewhat hard	10–29	4–8	Good	Slow	1–2
3	Hard	30–49	9–14	Fair	Fair	2–4
4	Very hard	50–79	15–19	Bad	Fast	2–8
5	Near maximal	≤80	≤20	Very bad	Very fast	≤8

Adapted from Moore and Garg 1995.

TABLE 24 Multiplier Table for Strain Index

Rating	Intensity of Exertion	Duration of Exertion (% of Cycle)	Efforts/Minute	Hand–Wrist Posture	Speed of Work	Duration per Day (h)
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.50
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.00
5	13	3.0[a]	3.0	3.0	2.0	1.50

Adapted from Moore and Garg 1995.
[a] If duration of exertion is 100%, then the efforts/minute multiplier should be set to 3.0.

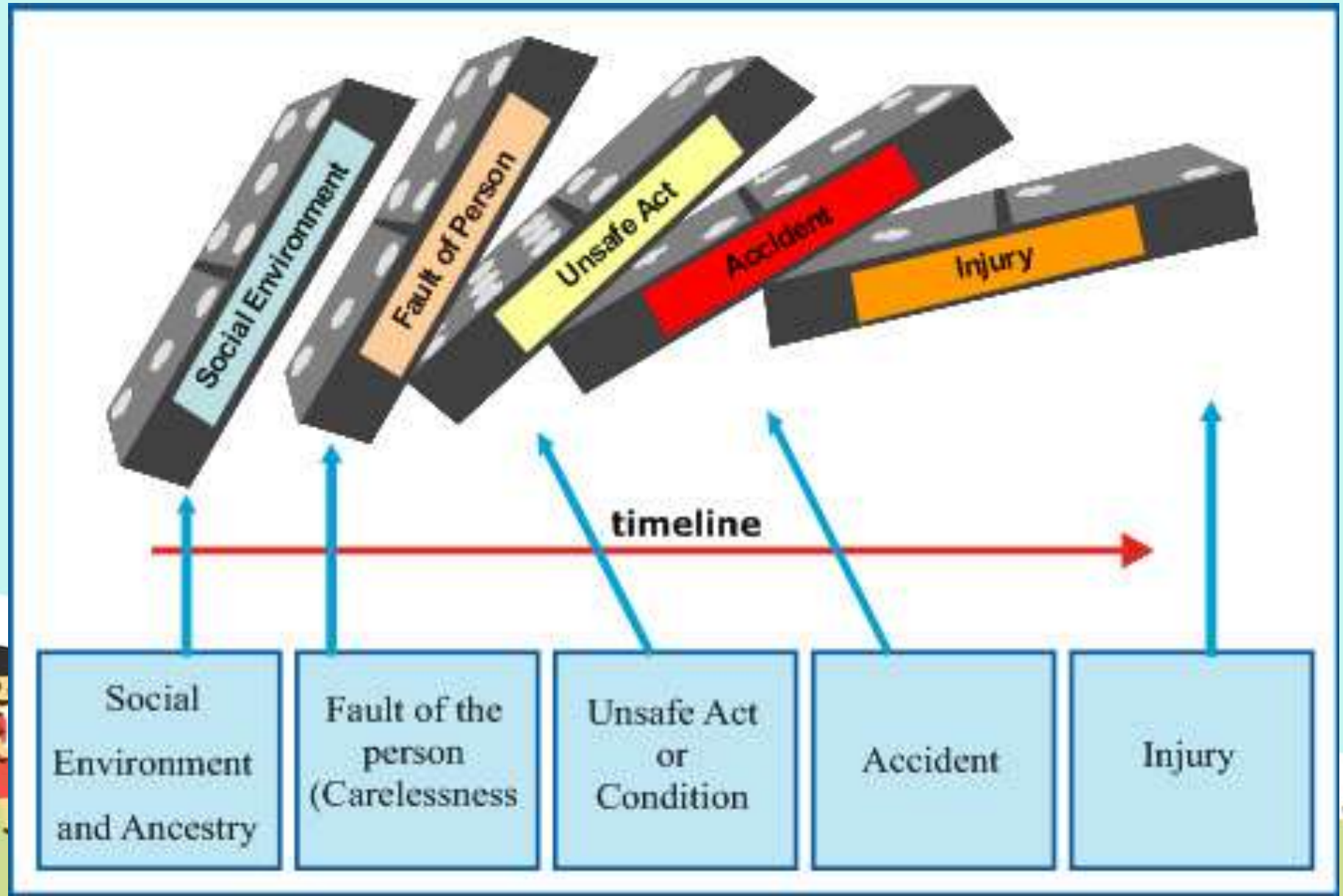
SI < 3 → Safe
SI 3-5 → Uncertain
SI 5-7 → Some Risk
SI > 7 → Hazardous

INDUSTRIAL SAFETY

"Human beings by their very nature make mistakes; therefore, it is unreasonable to expect error-free human performance." (Shappell & Wiegmann, 1997)

- *It is not surprising then, that human error has been implicated in 60-90% of all accidents.*
- *However, the rate of human error accidents has remained relatively stable over the past 20 years, whereas accidents associated with mechanical failures have been virtually eliminated.*

The Domino Theory (Heinrich, 1931)




systems
Industrial
Engineers
Engineering
Business
processes
operations
design
control
knowledge
planning
system
scheduling
program
production
manufacturing
analyze
engineering
pursue
Offered
complex
individual
allows
quality
skills
college
large
flexibility
disciplines
inventory
particular
statistical
realm
personnel
safety
infrasstructures
equipment
elective
solving
meet
work
field
need
integrations
improve
career
computer
study
analysis
science
restricted
option
degree
etc
if
flexible
material
easily
includes
communication
choose
tailor
broad
perspective
ability
number
information
apply
one
simulation
customize
assignment
allocation
handling
workplaces
integrators
problem
methods
degrees
buildings
group
resource
Minor
wide
mathematics
well
management
facilities
rooms
Entrepreneuership
assurance
credits
interpersonal
variety
people
add
processess-service
systematic
option
manage
interest
goals
use


KEEP
CALM
YOU'RE AN
INDUSTRIAL
ENGINEER