

Haptics, Human factors, Ergonomy, Shisa Kanko

...and what it means for engineering, safety, biomedical technology

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EPFL

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Human Factors & Ergonomics*

Wikipedia & ISO 6385 :

Application of **psychological and physiological** principles to the engineering and design of products, processes, and systems.

Goals: **reduce human error**, increase productivity, enhance **safety**

Focus on the **interaction** between the human & "system"

Combines psychology, physiology,
engineering, biomechanics,
user interface, design

Designing equipment, devices and processes that fit the **human body** and its **cognitive abilities**

*1857, Wojciech Jastrzębowski

- Basics of human perception → **haptics!**
- «**Embodiement**»
- All 5 (?) senses contribute
- Haptics: The least known and the most basic (life without it is impossible)



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Haptics (touch)

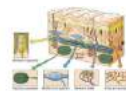
- Basics of human perception → **haptics!**
- One of the (aristotelian) 5 senses; Ibn Sina (Avicenna)
- You can live without any of 4 them
- You **cannot live without the haptic sense**



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Haptics (touch)

Cutaneous Mechanoreceptors



Receptor	Merkel corpuscles	Merkel discs	Ruffini corpuscles	Pacinian corpuscles
Stimuli	changes in texture, low-frequency vibrations	sustained touch and pressure	sustained pressure, skin stretch, slip	deep pressure, high-frequency vibrations
Frequency response	3/10-50 Hz	0.4-10 Hz	0.4-10/100 Hz	10/100-1000 Hz
Receptive field	small, well defined	small, well defined	large, indistinct	large, indistinct
Rate of adaptation	R&I	S&I	S&I	R&I
Percentage (hand)	43 %	35 %	19 %	13 %

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And don't forget

- Temperature
- Texture
- Dry, wet, slippery, metal, wood, sand, grass,...
- Force, pressure, proprioception
- Vestibular system, an accelerometer & inclinometer
- ...



Human Factors Science/Technology

Multidisciplinary field incorporating contribution from:

- Anthropometry
- Psychology
- Statistics
- Engineering
- Industrial design

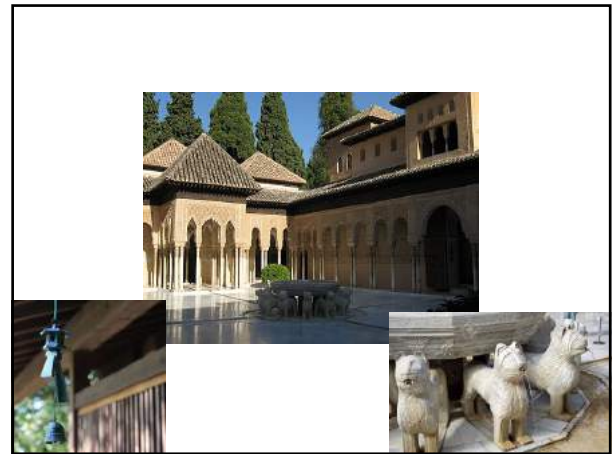


Physical Ergonomics

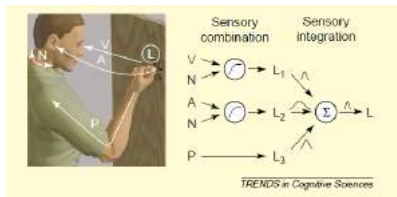
Cognitive Ergonomics



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Multisensory combination and integration

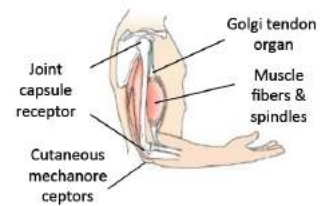


Sensory combination: interaction between sensory signals that are not redundant
Multisensory integration: interaction between redundant signals

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Linking Perception and action (sensors and actuators)

Movement and proprioception

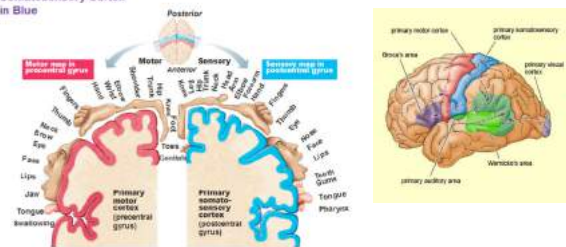


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Sensori-Motor System

Homunculus of Primary Somatosensory Cortex in Blue

Able that each hemisphere receives info from the opposite side of the body



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Cognitive Neuroscience

- One of the fundamental brain functions is **body representation**.
- What brain mechanisms are involved?
- Two central concepts:
 - 1) Body Ownership or «**Embodiment**»
 - 2) **Sense of Agency**



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Human Factors

- the «dirty dozen»
- Commercial Air-traffic
- B-7 at origin of **checklists**
- The “red nurse”



versus Health-care System

Atul Gawande: The Checklist Manifesto



The red nurse

- Visit at Clinica Hildebrand, Brissago

Critical action:
Preparing medication



Example: Principles of machine->human interface design

Christopher Wickens et al. *Introduction to Human Factors Engineering*

4) Redundancy

Present alternative physical forms (e.g. colour & shape, voice & print,), **redundancy ≠ repetition.**

A traffic light **colour and position** are redundant. Or: **Date & week-day!**

5) Similarity causes confusion: Use distinguishable elem

Signals that appear to be similar will likely be confused.

e.g. , A423B9 is more similar to A423B8 than 92 is to 93.



Implications for Safety

Cognitive and physical ergonomics **ARE CLOSELY LINKED**, should not be separated!

Pointing and Calling 指差喚呼 **Shisa kanko**

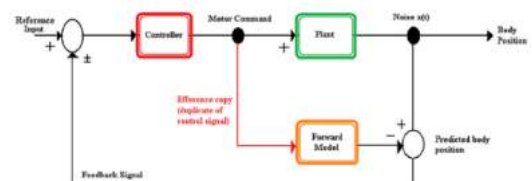


co-action & co-reaction among brain, eyes, hands, mouth, ears

<https://www.youtube.com/watch?v=etUeiYb48BE>

What does Shisa Kanko teach us?

- Importance of multimodal sensori-motor experience!
- Combine visual, haptics, audio, passive sensing (force feedback) and active gestures for confirmation.



Back to medical robotics: Four Armed Surgical robot



Control of two arms with the feet: Haptic & visual feedback

Jacob Fernandez, Mohamed Bouri, Aude Billard



Force feedback on feet, haptic sensation on hands



Jacob Fernandez, Mohamed Bouri, Aude Billard



It is already done



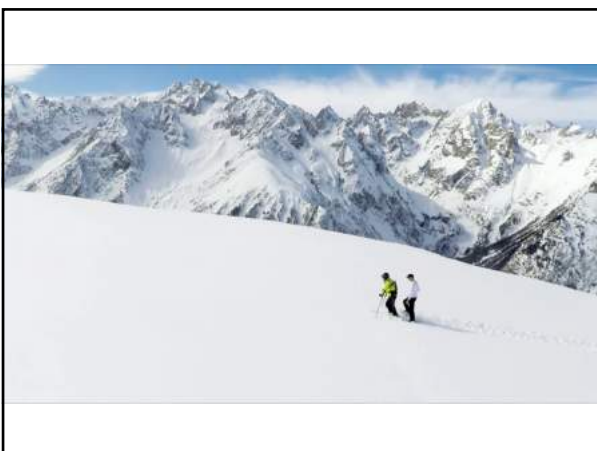
Car (manual shift), excavator, pipe organ ... How many d.o.f ?

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To close:

Our self-consciousness derives from the combination of all our sensorial signals, incl. **Haptics**

The complete sensorimotor feedback confirms our internal model of the physical world

This insight leads to highly efficient and safe design of industrial systems

It is especially needed in medical technology



Thank you for your attention!