Affordances

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What you should get out of this session

- What is the principle of the ecological approach to visual perception and how is it manifested in the control of actions?
- What is the benefit of thinking about questions using this principle?

On the Objects of Perception

"Idea is the object of thinking. Every man being conscious to himself, that he thinks, and that which his mind is employed about whilst thinking being the ideas that are there, 'tis past doubt, that men have in their minds several ideas, such as are those expressed by the words, *whiteness, hardness, sweetness, thinking, motion, man, elephant, army, drunkenness,* and others: it is in the first place then to be inquired, how he comes by them? …

"To this I answer, in one word, from *experience*: in that, all our knowledge is founded; and from that it ultimately derives itself."

John Locke

Book II, Chap. I, 1-2

An Essay Concerning Human Understanding (1690)

On the Objects of Perception

- Locke, along with a lot of others, thinks the object of perception can be found in the dictionary, using nouns, adjectives, adverbs, etc.
- But this confounds two great problems in behavioral science:
  - What are the objects of perception?
  - What is the relation between perception and language?
- What do you think come first, language or visual perception?

Ask the right question

- What do we need from visual perception to perform everyday actions?
- The scaling problem
  - Optical information is angular (solid visual angles).
  - It does not provide metric information (meters, centimeters, etc.).
  - Texture and optic flow specify relative scale.
- How do we scale our actions?
  - How do we know how wide we should open our hand to grab a mug on the desk?
  - How do we know when we should turn our shoulders to pass through a doorway?

Affordances

- James Gibson – “Afford-ances”
  - Afford – “To make available, give forth, or provide naturally or inevitably”.
- What are affordances?
  - <u>Properties</u> of surfaces, objects, and events
  - <u>Relational</u> – relationship between properties of the environment and properties of animals.
  - <u>Functional</u> – about action capabilities, what actions are afforded
  - <u>Perceptible</u> – one can directly perceive visual information that specifies affordances. They are not something to be found in the dictionary. They must be discovered.
  - <u>Real</u> – affordances are always there. They are not phenomenal (i.e. only exist when you see the environment).

Measuring Affordances

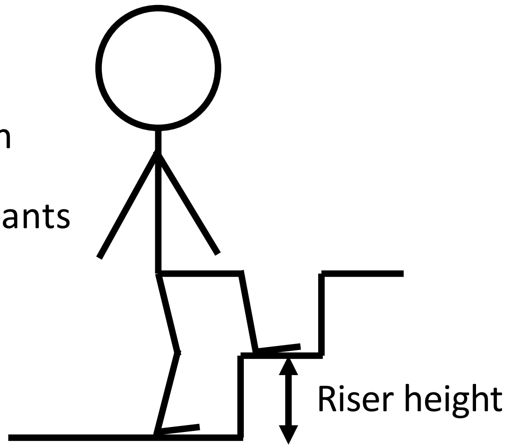
- Measures the **intrinsic** animal/environment relationship (body or action scaled environment property) using **extrinsic** units (e.g. centimeters, grams, etc.).

Stair-climbing (Warren, 1984)

- π – the intrinsic scaling between the environment's property and animal's property.

$$\pi = \frac{riser\ height}{leg\ length}$$

- Optimal π – preferred scaling
  - Action: measured participants' energy use while they climb an escalator with adjusted risers
  - Perception: given a series of stairs with different riser heights, asked participants to choose
- Critical π – action boundary, scaling at which people need to switch actions.
  - Action: measured maximum climbable riser height
  - Perception: judge the maximum climbable riser
- Because these are intrinsic relations, optimal π and critical π are the <u>same</u> for tall and short people.



Stair-climbing (Warren, 1984)

Optimal π - Action
Measured through action and energy expenditure

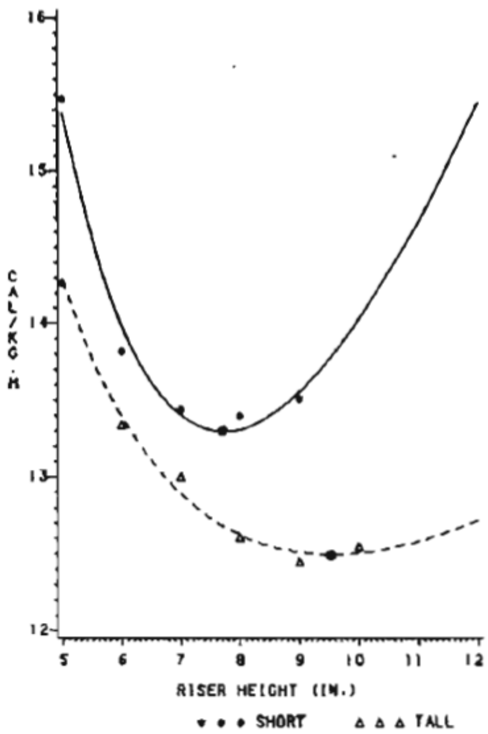


Figure 8. Mean energy expenditure (in calories per kilogram of body weight per vertical meter) as a function of riser height for each group. (The data and fitting curves are transformed from Figure 7. Minima are indicated by solid circles.)

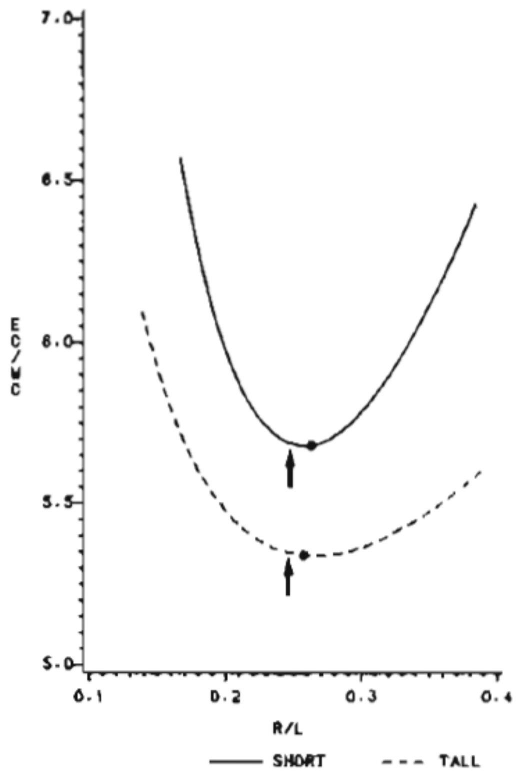


Figure 9. Intrinsic plot: inverse efficiency (energy expended per step cycle/work done per step cycle) as a function of *R/L*. (The fitting curves are transformed from Figure 8. Minima are indicated by solid circles; the arrows indicate visual riser preference as determined in Experiment 3.)

Stair-climbing (Warren, 1984)

Critical π - Perception
Measured through verbal judgment

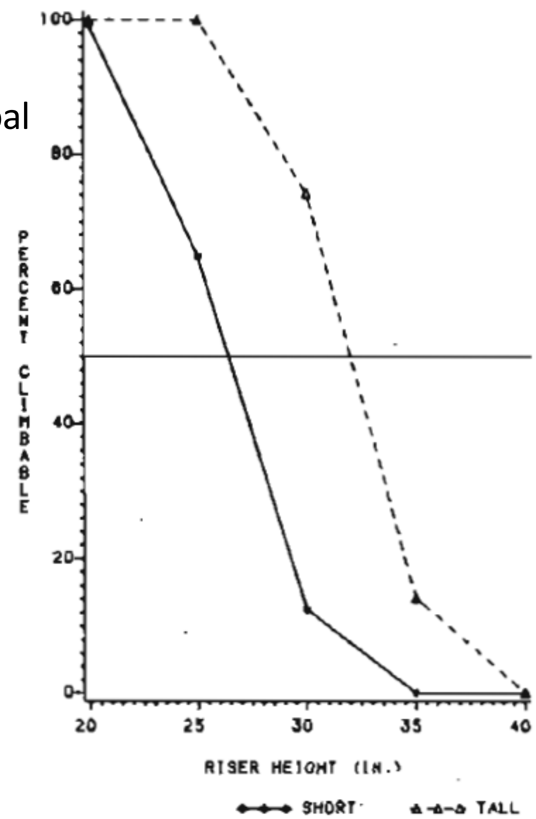


Figure 3. Mean percentage of "climbable" judgments as a function of riser height for each group.

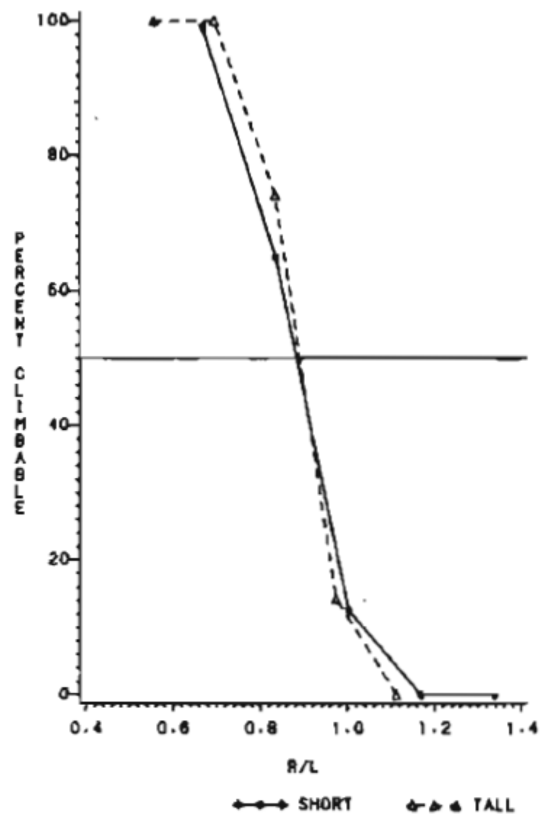


Figure 4. Intrinsic plot: mean percentage of "climbable" judgments as a function of *R/L* for each group.

Walking through an aperture (Warren & Whang, 1987)

- Critical π for walking through an aperture (when shoulders rotate)

$$\pi_c = \frac{aperture\ width}{shoulder\ width} > 1$$

Allowing for a safety margin.

- Three experiments
  - Experiment 1: measured π_c in action
  - Experiment 2: measured π_c in perception
  - Experiment 3: investigated information – eye height scaling.

Exp. 1: Action Measurement

- Asked participants to walk through apertures of different sizes
  - Either walk at a normal speed or a fast speed.
- Two groups of participants
  - Small group (height < 168 cm, mean shoulder width = 40.4 cm)
  - Large group (height > 202 cm, mean shoulder width = 48.4 cm)
- Used videotape to measure when and by how much participants would turn their shoulders when walking through an aperture (a door).

Exp. 1: Action Measurement

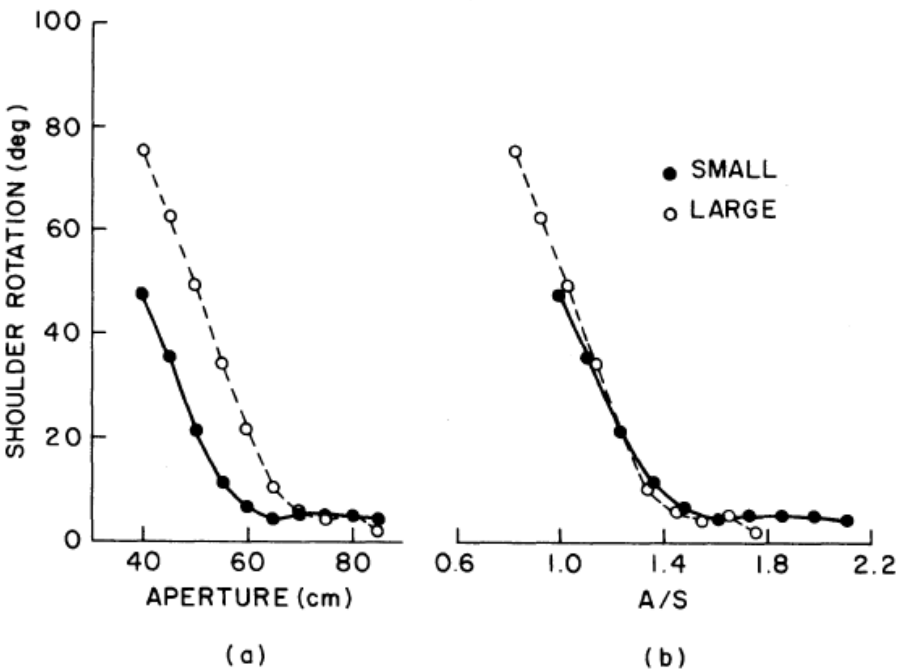


Figure 1. Mean absolute angle of shoulder rotation at normal walking speed as a function of aperture width (Panel a) and aperture width normalized for shoulder width (*A/S*) (Panel b) for each group. (Each data point represents the mean of approximately 30 trials.)

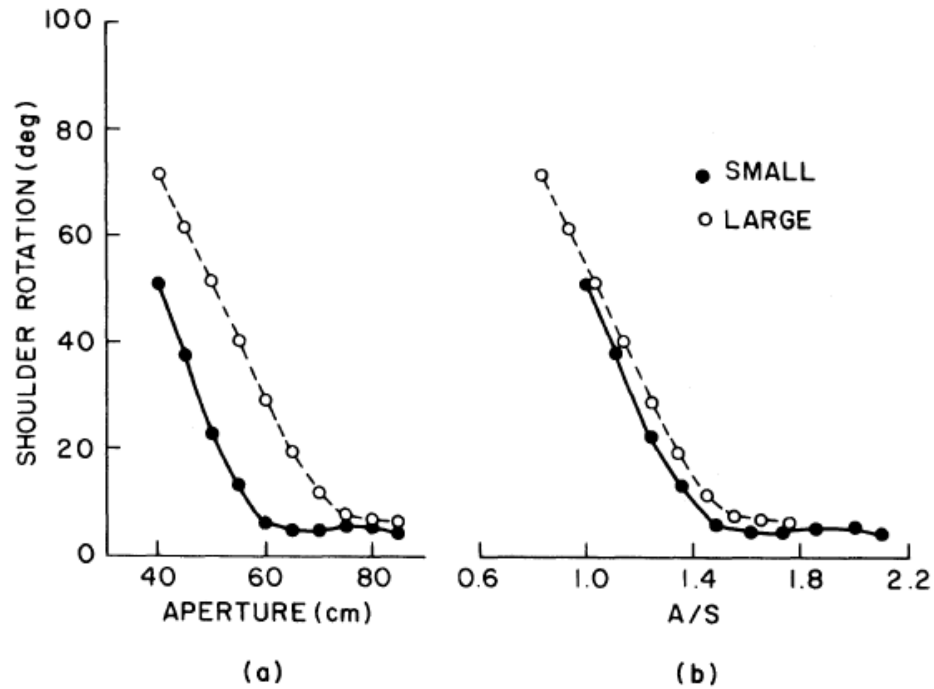


Figure 2. Mean absolute angle of shoulder rotation at fast walking speed as a function of aperture width (Panel a) and aperture width normalized for shoulder width (*A/S*) (Panel b). (Each data point represents the mean of approximately 30 trials.)

Exp. 1: Action Measurement

- Normal speed:
  - Small group: mean aperture width = 53 cm, mean π_c = 1.31
  - Large group: mean aperture width = 62 cm, mean π_c = 1.28
- Fast speed:
  - Small group: mean aperture width = 54 cm, mean π_c = 1.34
  - Large group: mean aperture width = 66 cm, mean π_c = 1.36
- Intrinsic scaling for walking through an aperture

$$\pi_{max} = \frac{aperture\ width}{should\ width} \approx 1.30$$

Exp. 2: Perception Measurement

- Asked participants to judge the passability of apertures of different sizes at a distance.
- Two groups of participants (small vs. large groups)
- Two viewing conditions
  - Static – viewed the aperture with one eye through a reduction screen (a rectangular hole, approx. 90° FOV), 5 m in front of the aperture
  - Moving – participants walked in a straight line from 7 m to 5 m in front of the aperture
- Asked participants to verbally judge if they can pass through the aperture without turning shoulders

Exp. 2: Perception Measurement

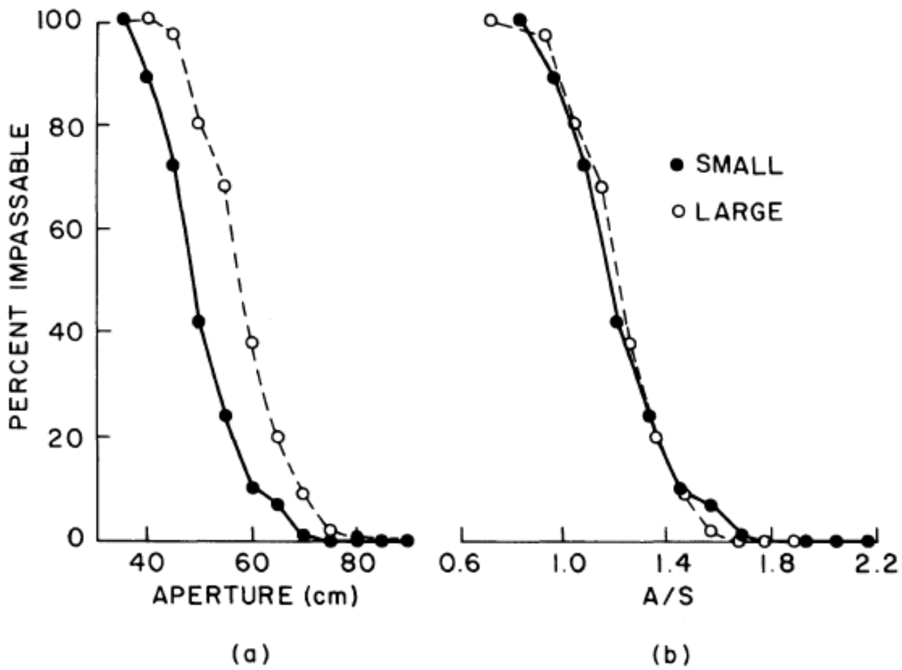


Figure 3. Mean percentage of "impassable" judgments in the static viewing condition as a function of aperture width (Panel a) and aperture width normalized for shoulder width (*A/S*) (Panel b). (Each data point represents the mean of approximately 100 trials.)

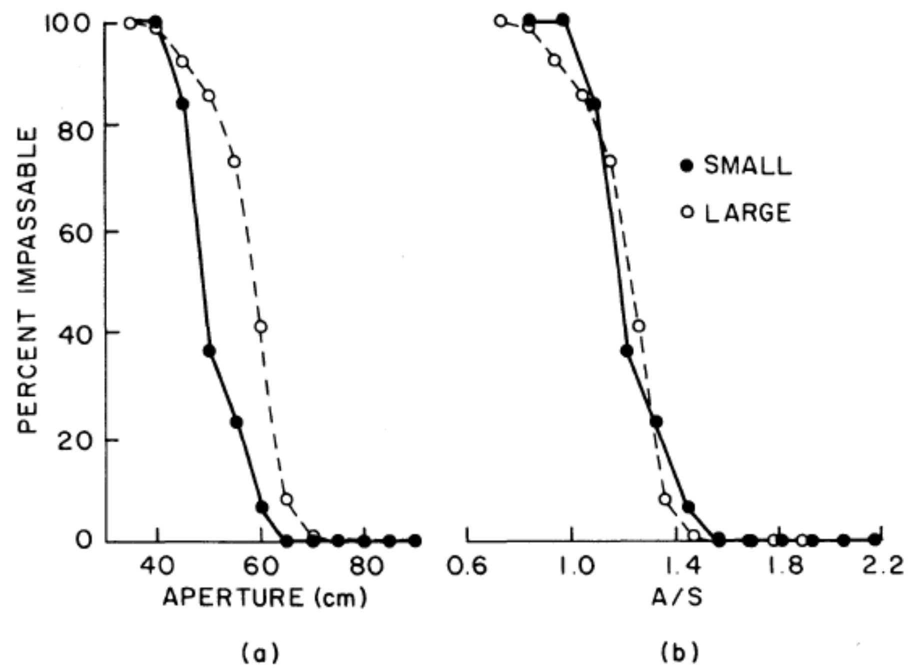


Figure 4. Mean percentage of "impassable" judgments in the moving viewing condition as a function of aperture width (Panel a) and aperture width normalized for shoulder width (*A/S*) (Panel b). (Each data point represents the mean of approximately 100 trials.)

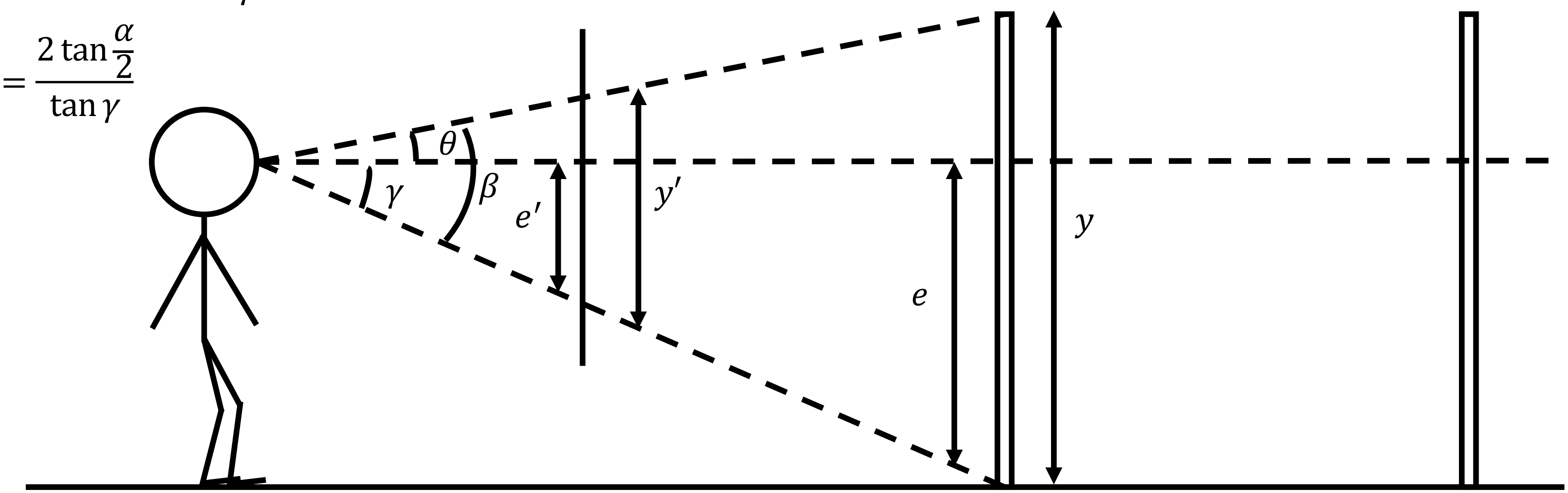
Exp. 2: Perception Measurement

- Static viewing:
  - Small group: mean aperture width = 47 cm, mean π_c = 1.14
  - Large group: mean aperture width = 56 cm, mean π_c = 1.17
- Moving viewing:
  - Small group: mean aperture width = 48 cm, mean π_c = 1.15
  - Large group: mean aperture width = 55 cm, mean π_c = 1.16

Exp 3: Optic Information – Eye Height Scaling

$$\frac{y}{e} = \frac{y'}{e'} = \frac{(\tan\gamma + \tan\theta)}{\tan\gamma}$$

$$\frac{x}{e} = \frac{2\tan\frac{\alpha}{2}}{\tan\gamma}$$



Exp 3: Optic Information – Eye Height Scaling

- Constant relationship between standing eye height (e) and shoulder width (S):

$$\frac{A}{e} = 0.25\frac{A}{S}$$

- Participants judged passability when looking through a reduction screen.
- The ground beyond the reduction screen was either flat or raised.

Exp 3: Optic Information – Eye Height Scaling

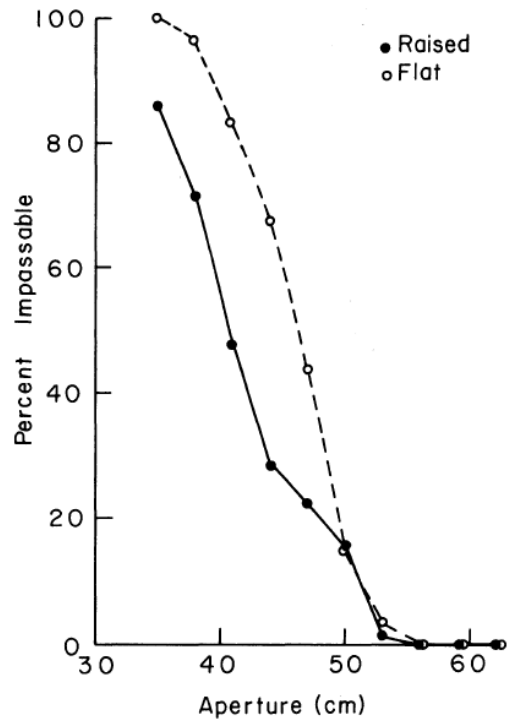


Figure 6. Mean percentage of "impassable" judgments as a function of aperture width, in the flat and raised floor conditions. (Each data point represents the mean of approximately 300 trials.)

Affordances are:

- Properties
- Relational
- Functional
- Perceptible
- Real

Why does it matter?

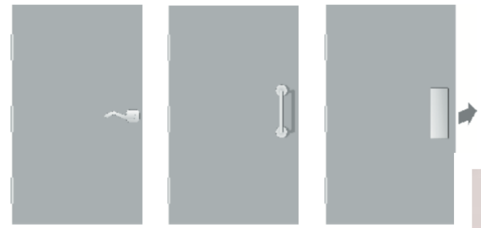
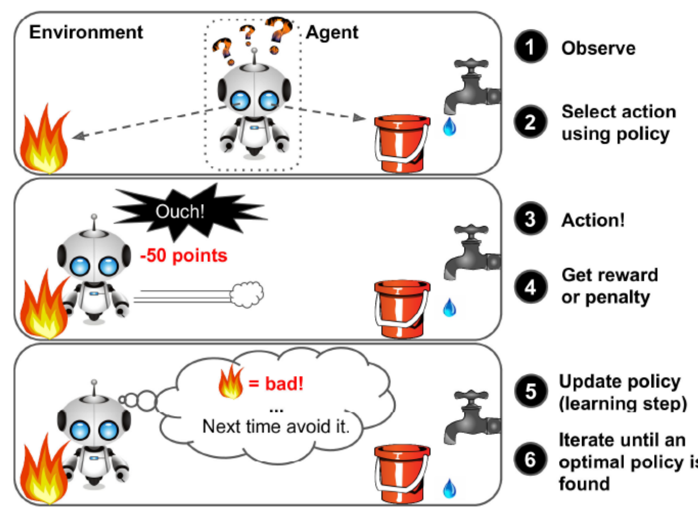


Figure 2. Affordances of door handles: lever, pull and push, (source: www.infovis.net).
Koutamanis , 2006

Figure 3. Flat vs. vertical keyboards
Mafiseh et al. 2019

- Reinforcement learning
  - Agent-Environment-Rewards(Penalties)-Policy
- Ergonomics
  - Affordance-based design and usability
- Architecture
  - Building design
- UI/UX design
- And so many more
- See reading on Google Drive if interested



Géron, 2019

What you should get out of this session

- What is the principle of the ecological approach to visual perception and how is it manifested in the control of actions?
  - The principle is identifying the organism-environment relationship and invariant over transformation.
  - When performing a certain action, human actors necessarily interact with an object in the environment.
  - One can identify the constant scaling relationship between the human actor and the environment to describe the action.
- What is the benefit of thinking about questions using this principle?
  - It simplifies things.
  - It allows you to think about things that you have never thought about before.

See you next time!