Direct perception: Ecological realism and perception-action

Jack Treffner

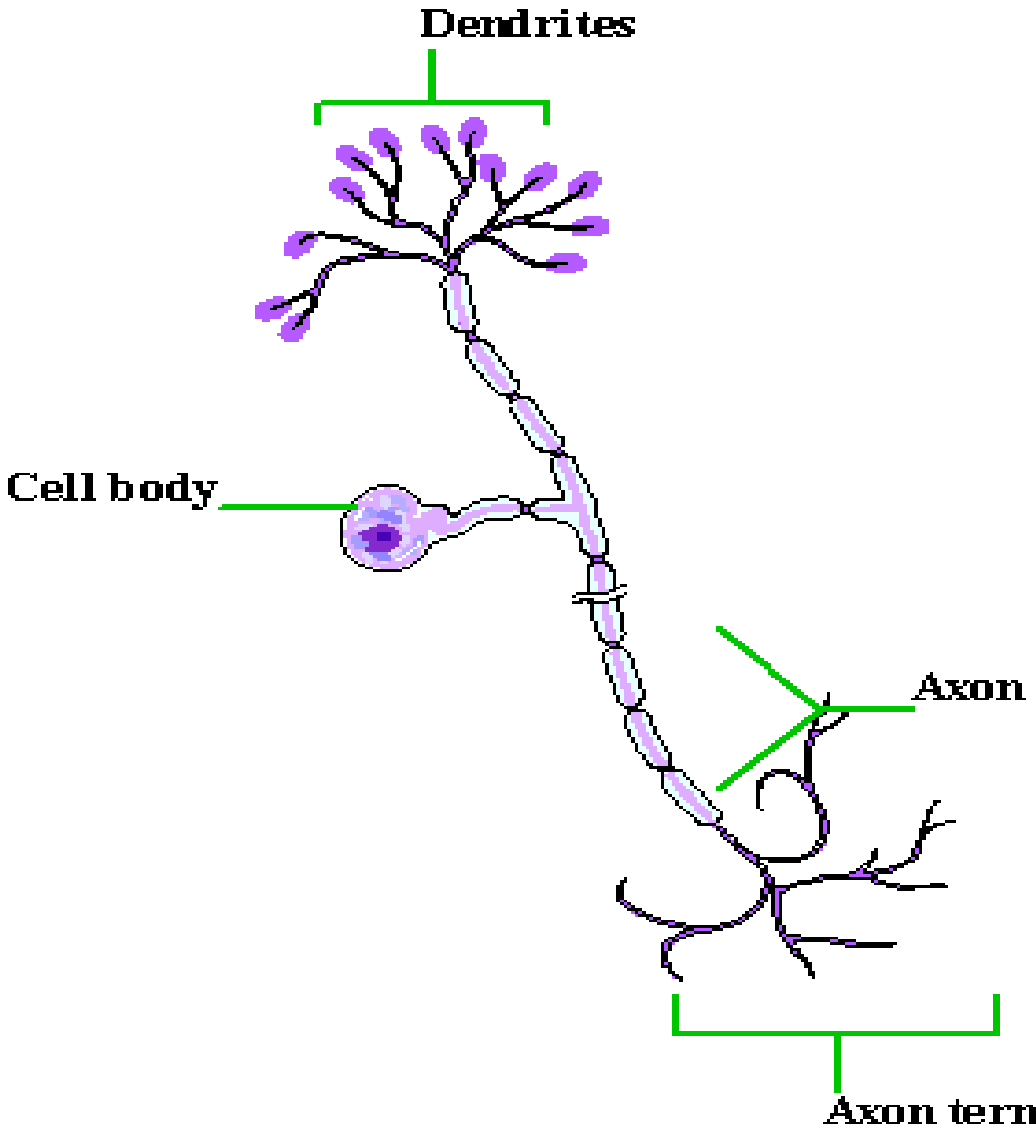
metaffordance.com

click

Descartes' dualism lives on: sensation vs. perception

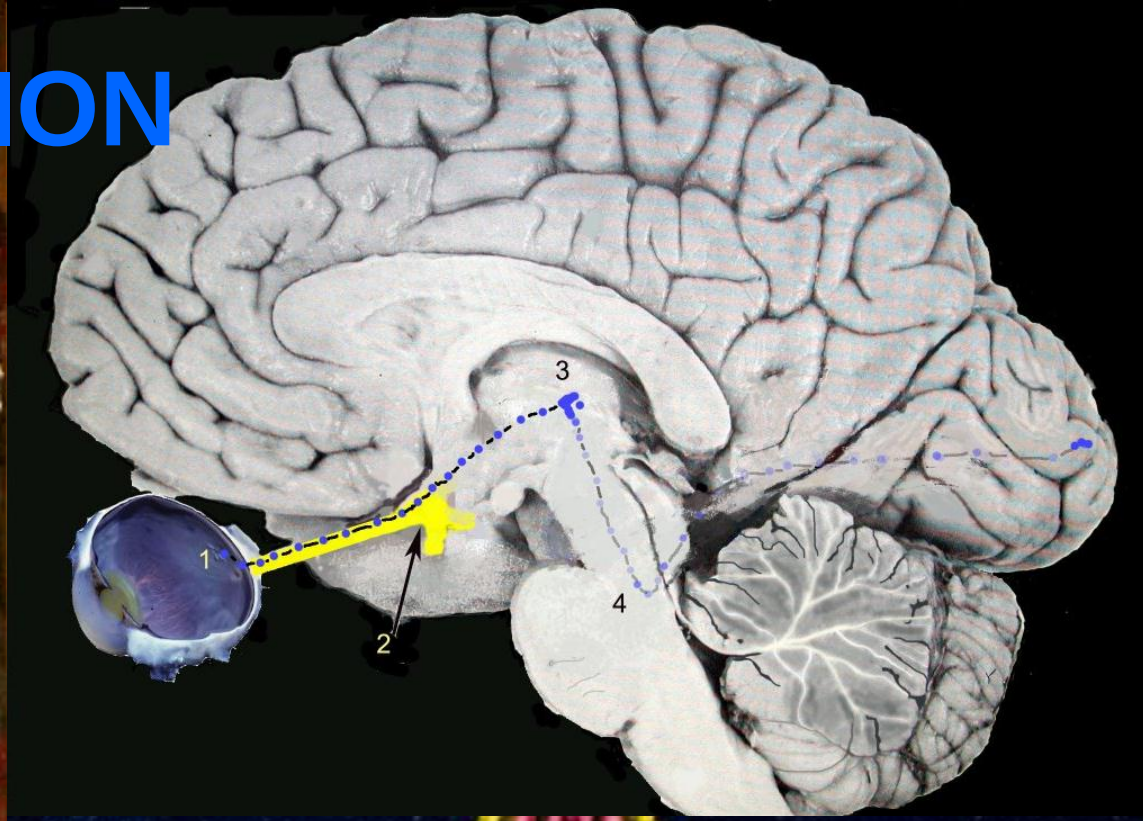
- Perception follows sensation…
- The brain *organises* the signals…
- *translates* them…
- into something *meaningful*…
- and we become *aware* of the meaning…
- somehow…producing… "*consciousness*"!

Sensory neurons



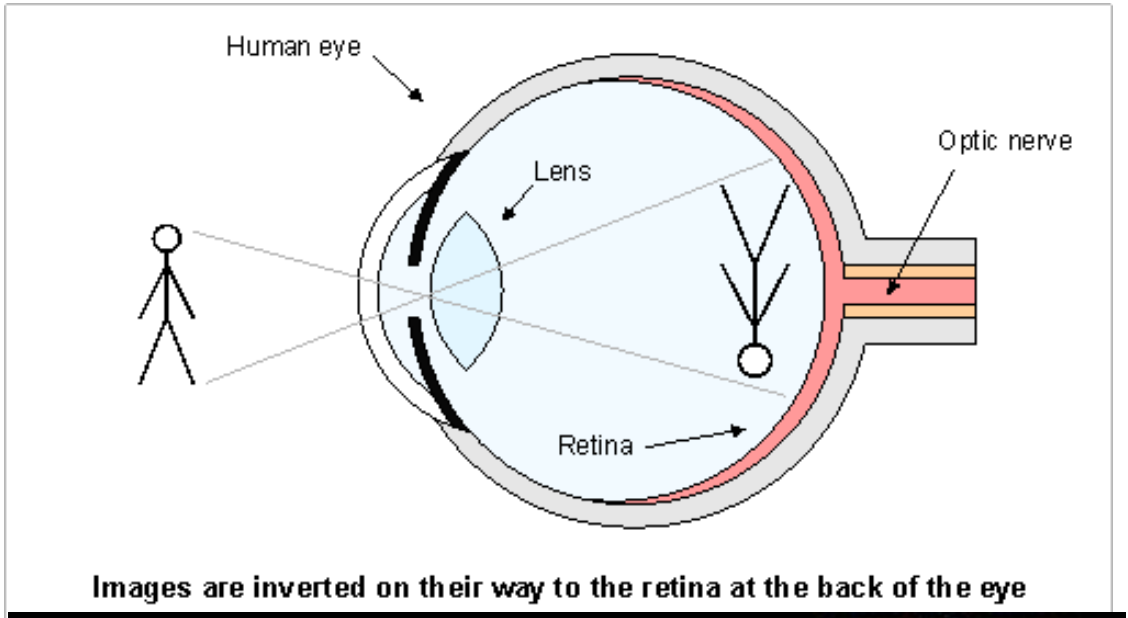
Descartes (1600)
“cogito ergo sum”

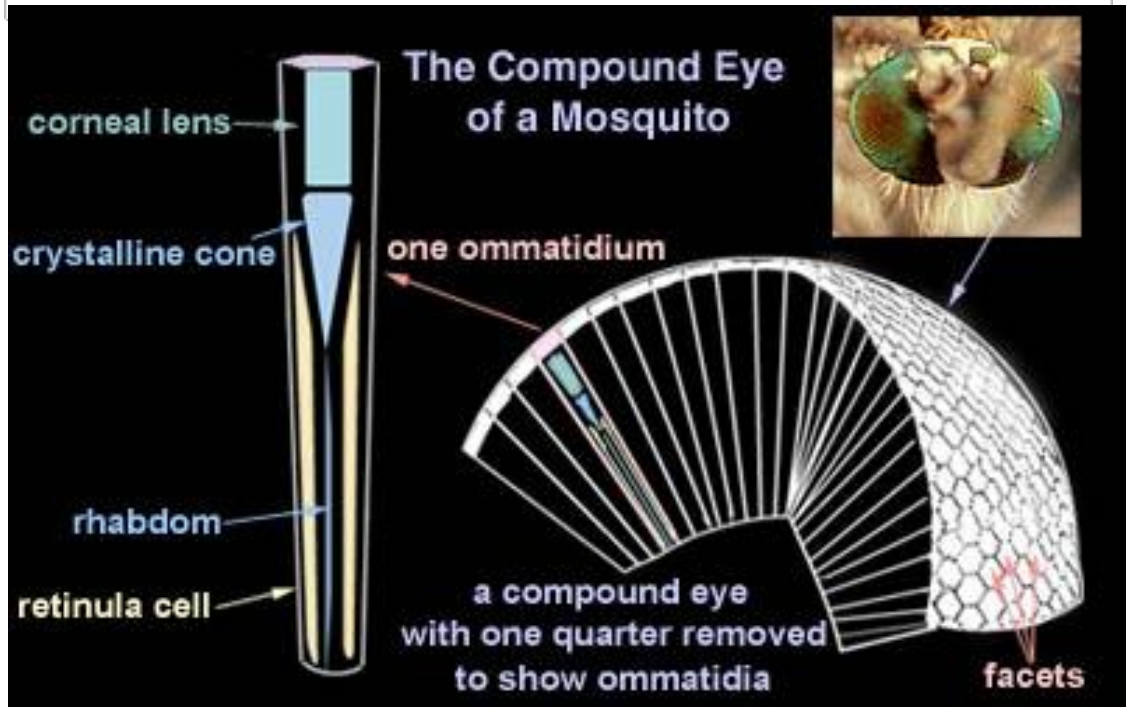
VISION

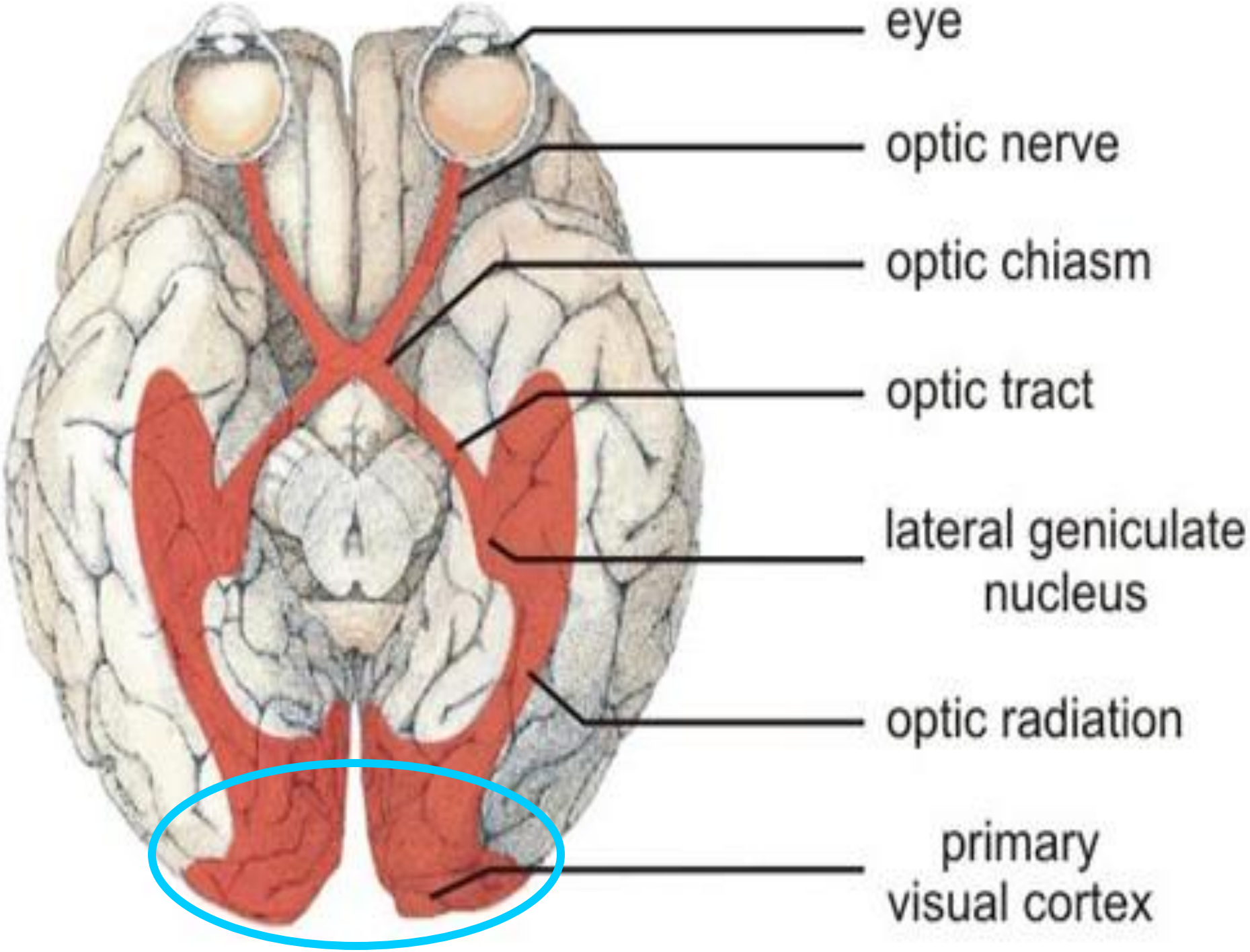


“Images”

- Light passes through the lens:
- focuses the light rays to fall on the **retina**
- An “upside-down image” is formed on the retina
- But the eye is not a camera!
- Compound eyes: animals do not need an image to see!!

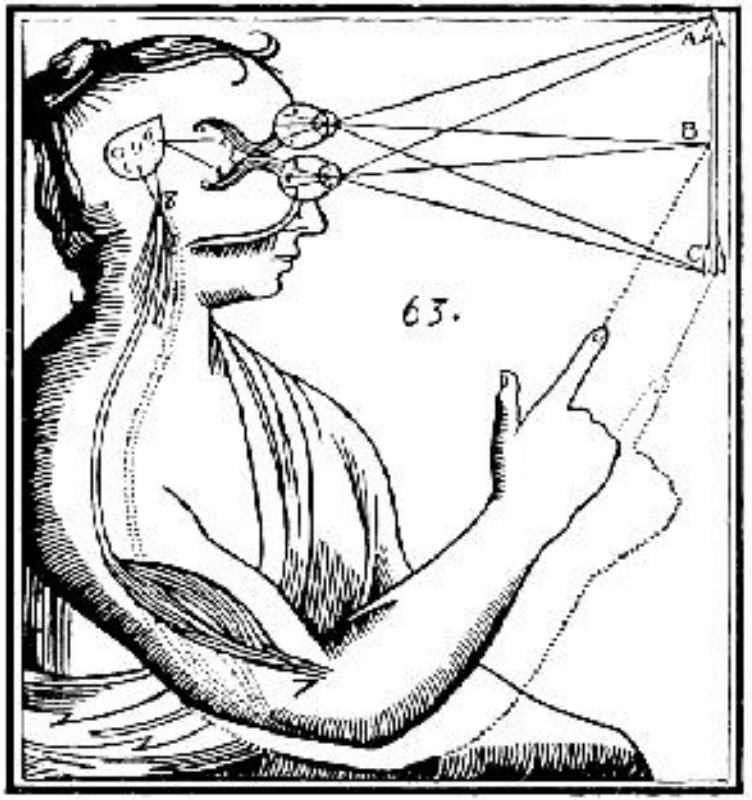





eye
optic nerve
optic chiasm
optic tract
lateral geniculate nucleus
optic radiation
primary visual cortex

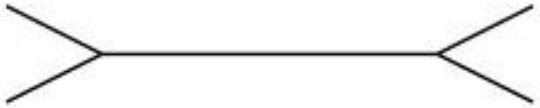
Current assumed theory of perception

Descartes (1649)

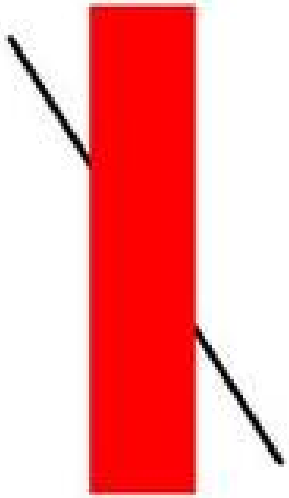


- Sensation
  - Passive, physical, meaningless
  - “Body”
- Perception
  - Active, intelligent, meaningful
  - “Mind” (Descartes’ “soul”)
- Knowledge
  - Needed to interpret (meaningless) sensations and tursn them into (meaningful) perceptions.
- Tries to avoid “Naïve Realism” using:
  - Argument from science (“material reductionism works so well”)
  - Argument from illusion (“you can’t trust the senses”)

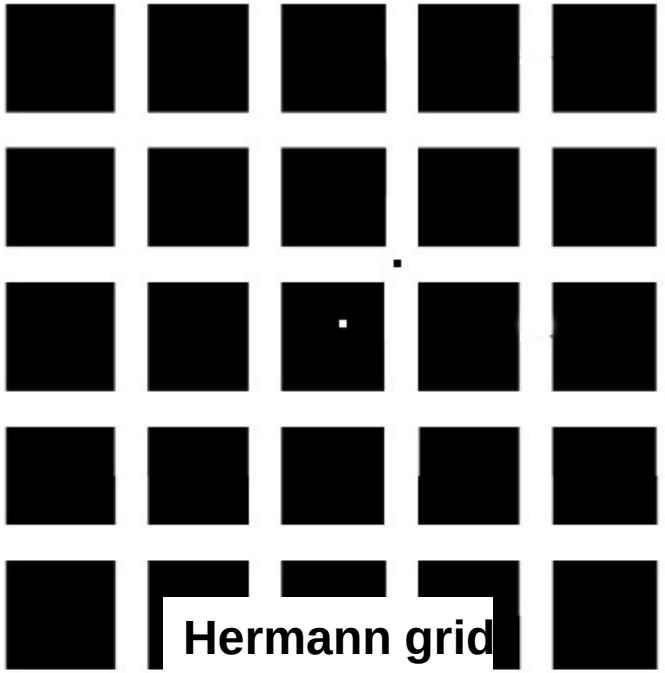
Illusions & ambiguous figures



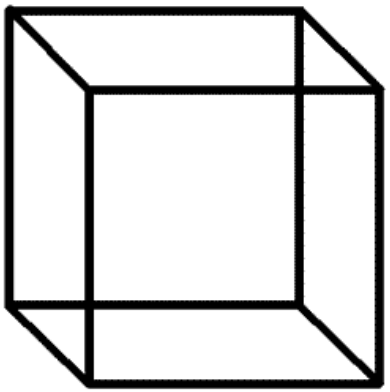
Muller-Lyer



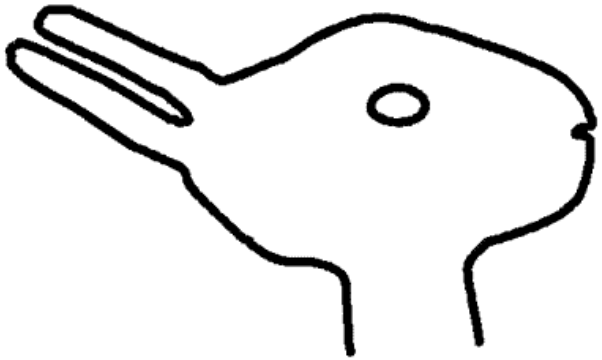
Poggendorf



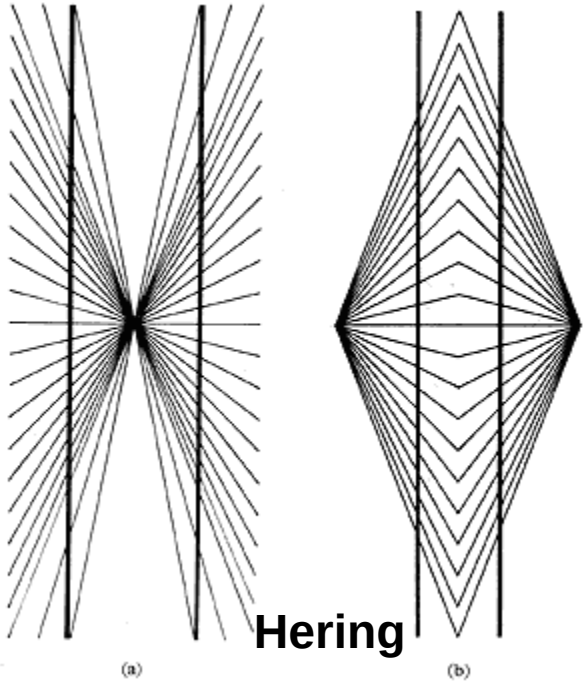
Hermann grid



Necker cube



Duck-rabbit

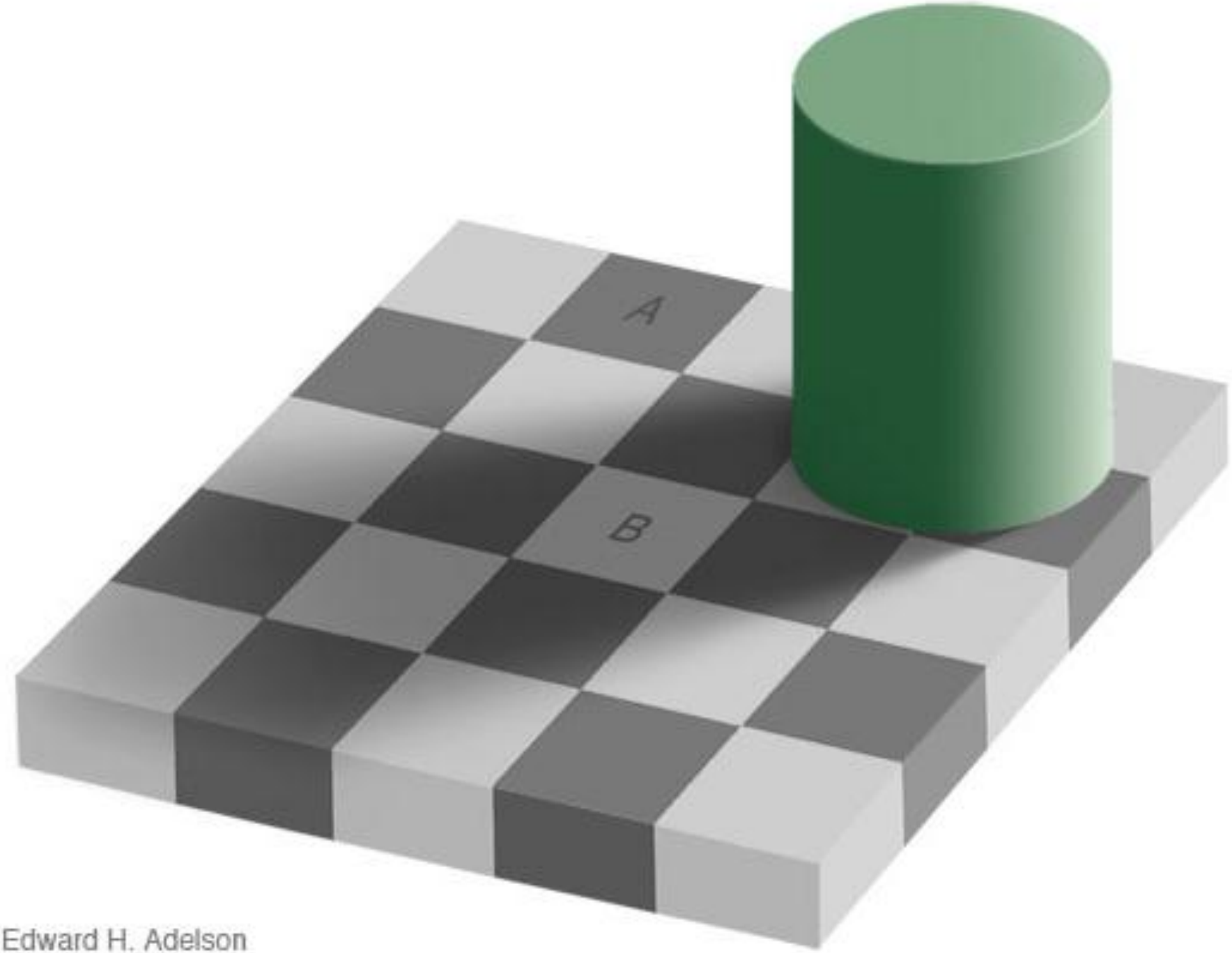


Hering

click

Importance of context

lightness constancy



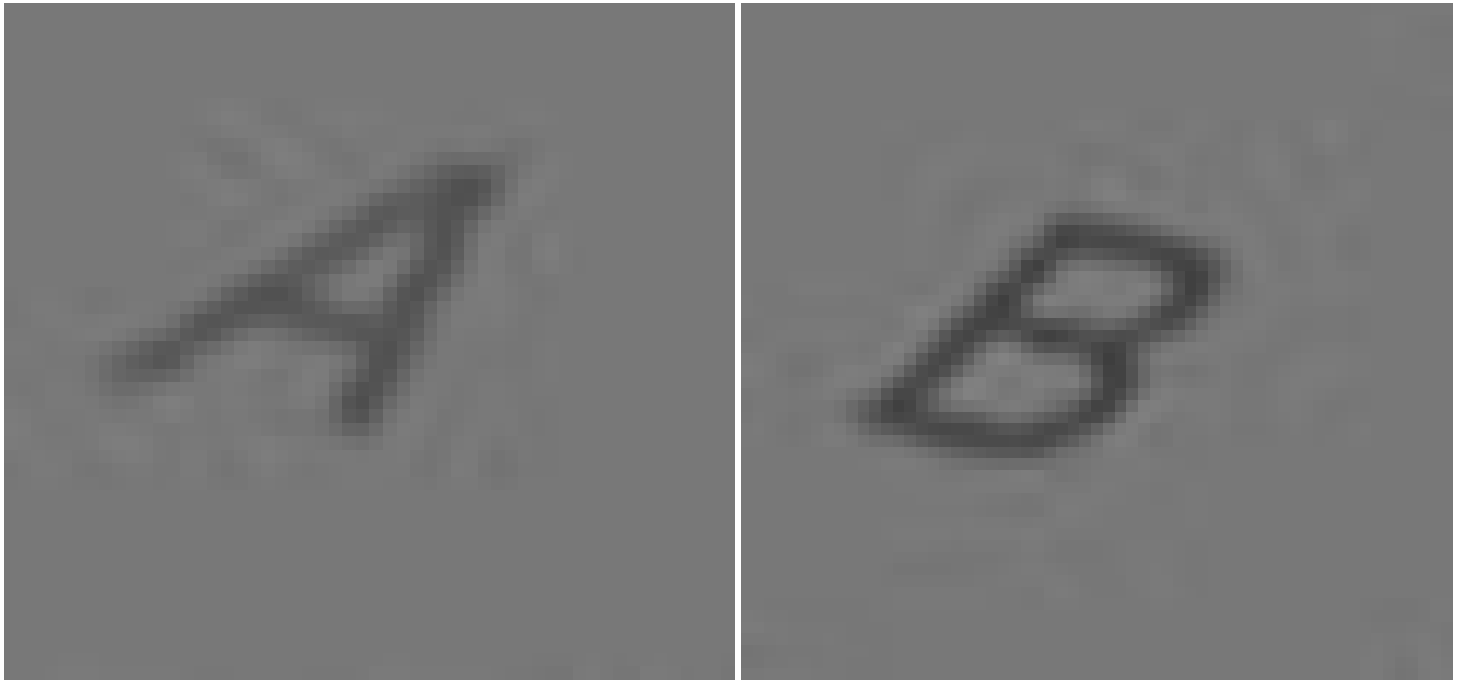
Edward H. Adelson

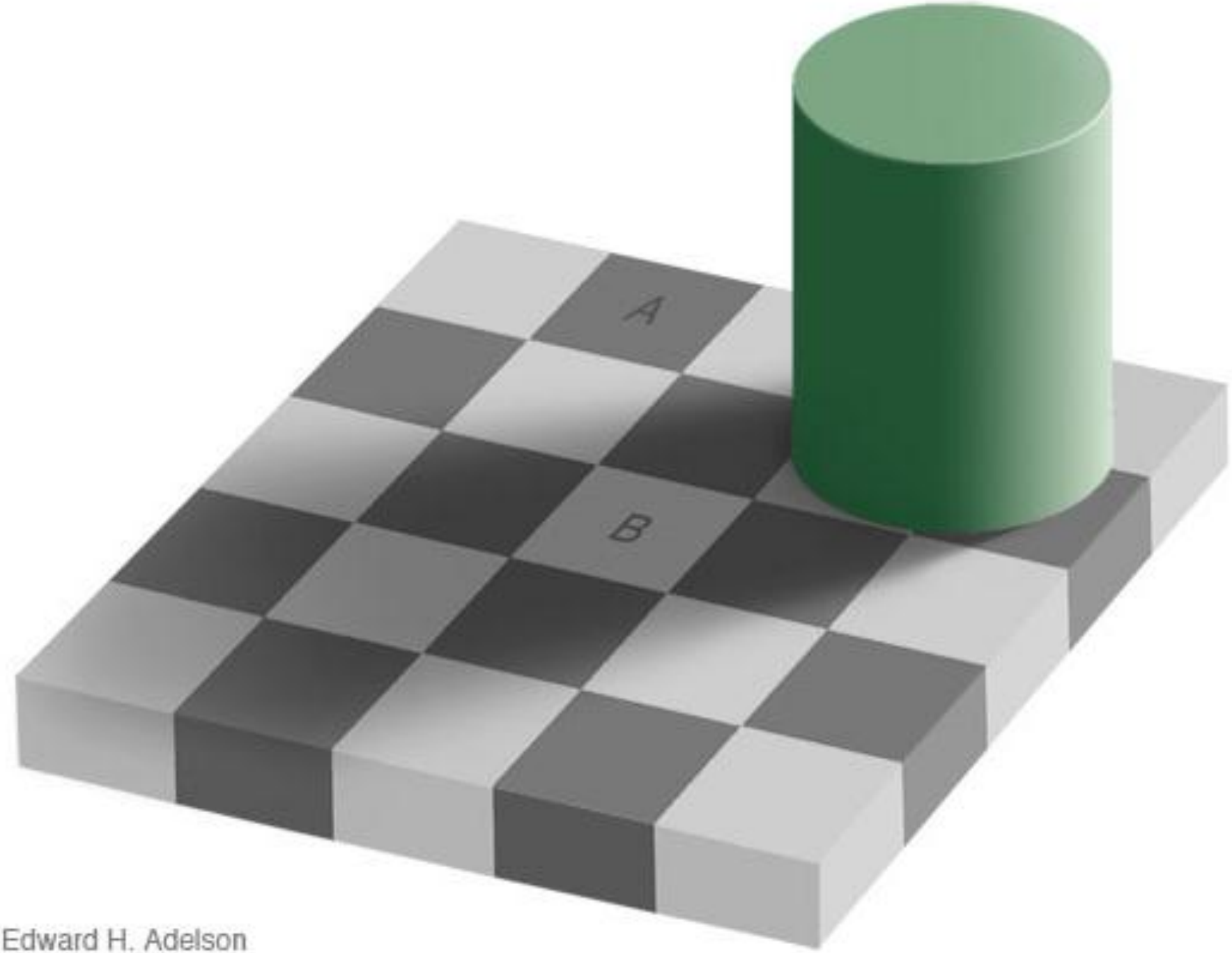

A


B


A


B





Edward H. Adelson

Size constancy

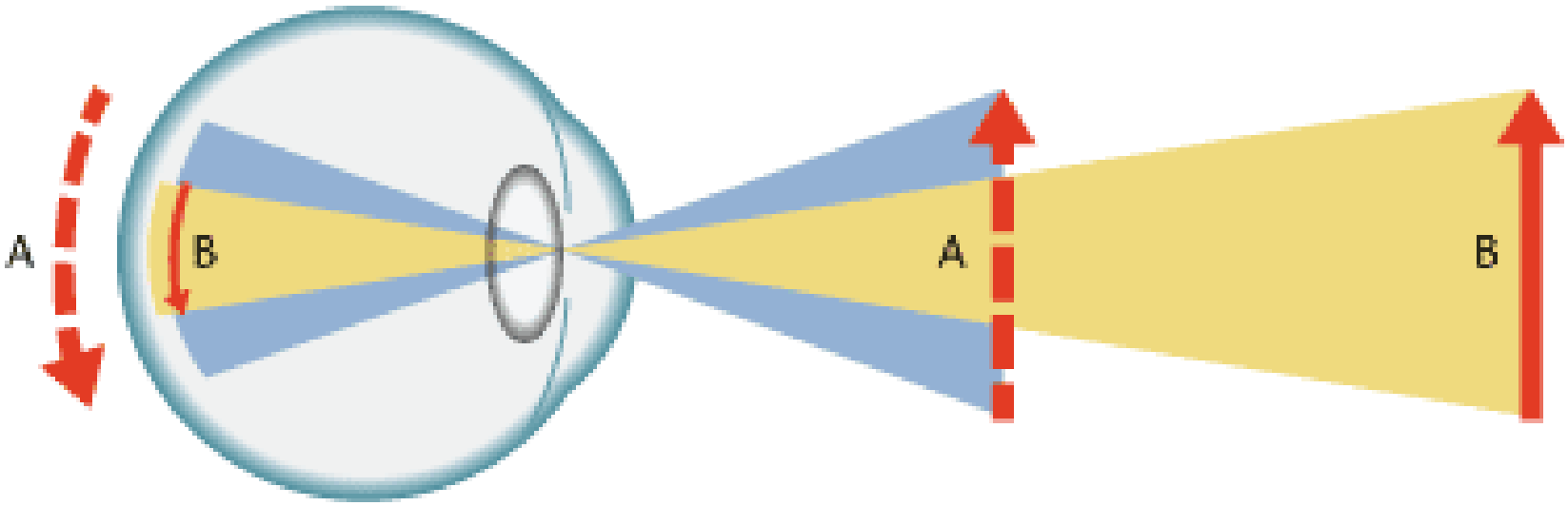
Different size of retinal sensations or “images”

Same size of perceived object!

Different sensations – size of retinal images, but…

Same perception – same sized object is perceived.

"AMBIGUOUS RETINAL IMAGES"
So "can not trust sensations". Therefore, "we can not know the world using sensations alone"



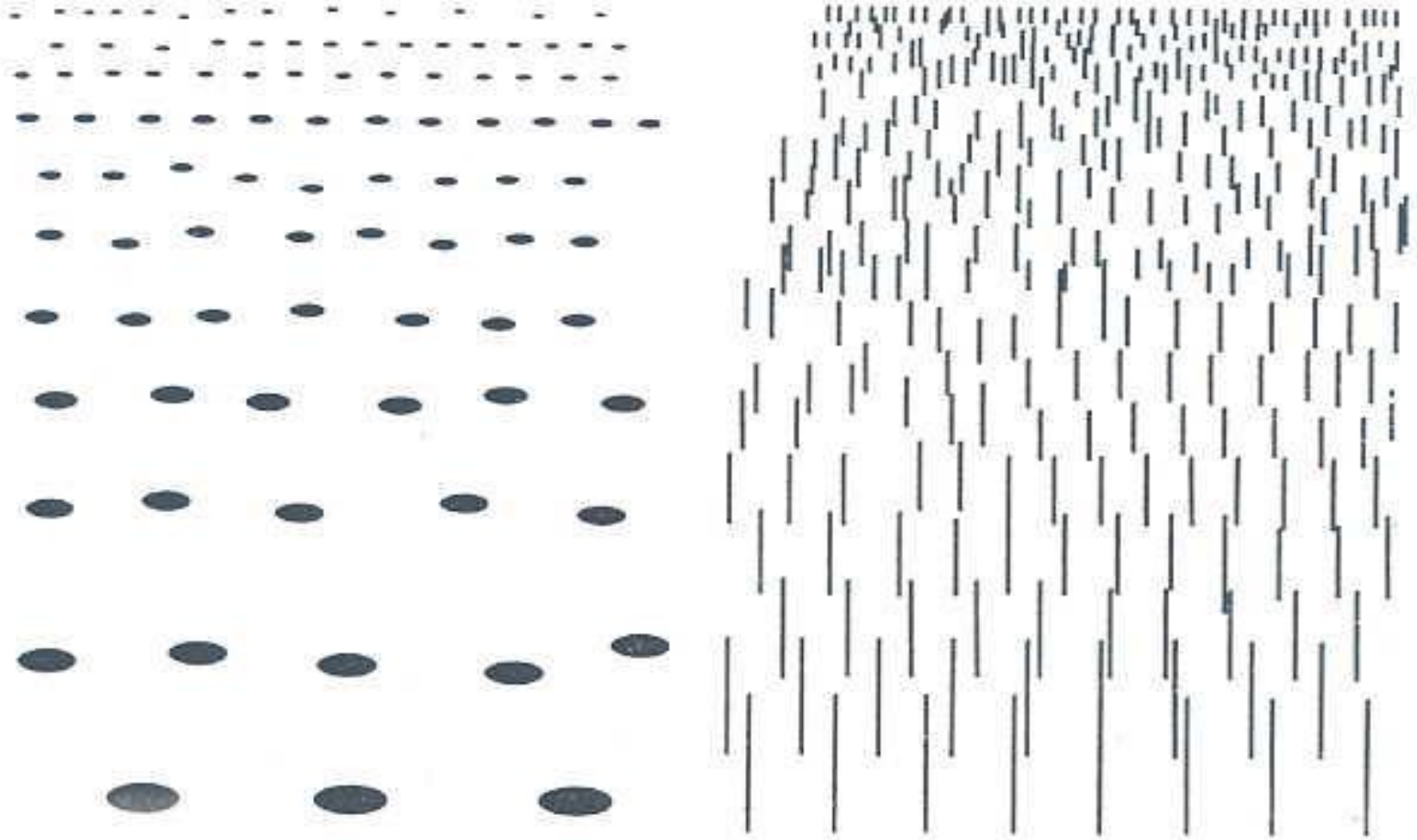


FIGURE 2.8: Examples of texture gradient. (From Gibson, 1950.)

Texture gradient

Gibson (1950)

A *ground theory* of size perception

Not an *air theory*

Context matters!

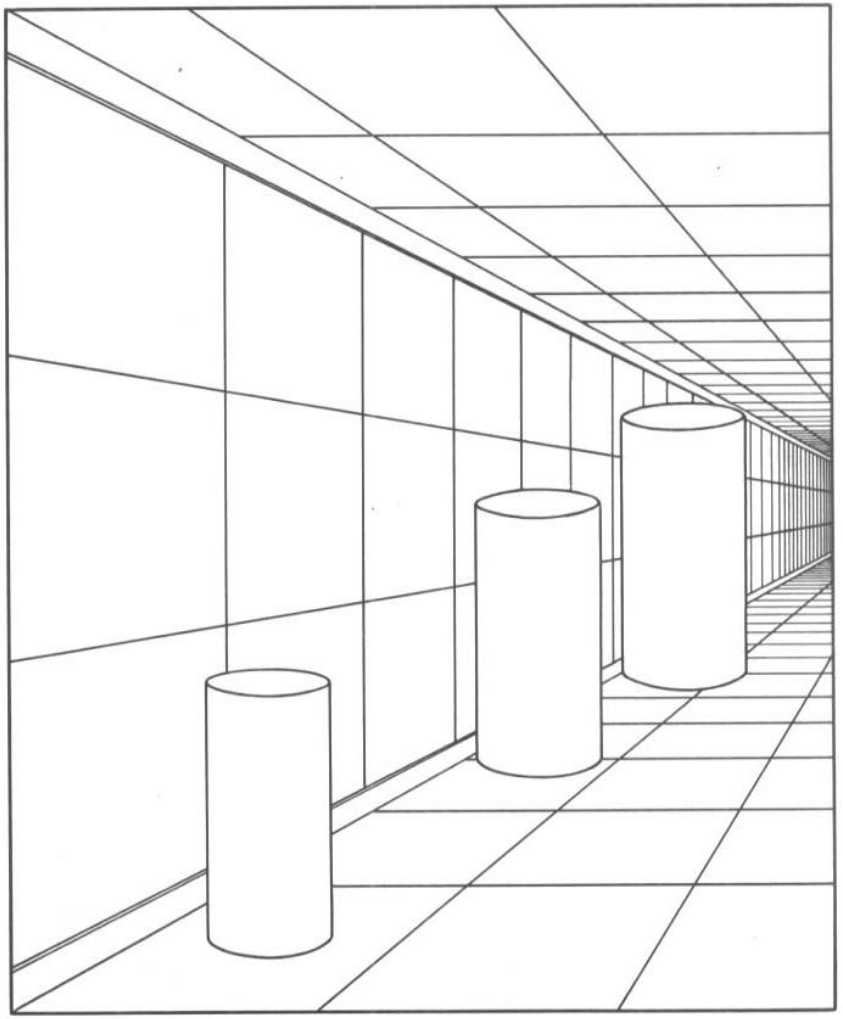
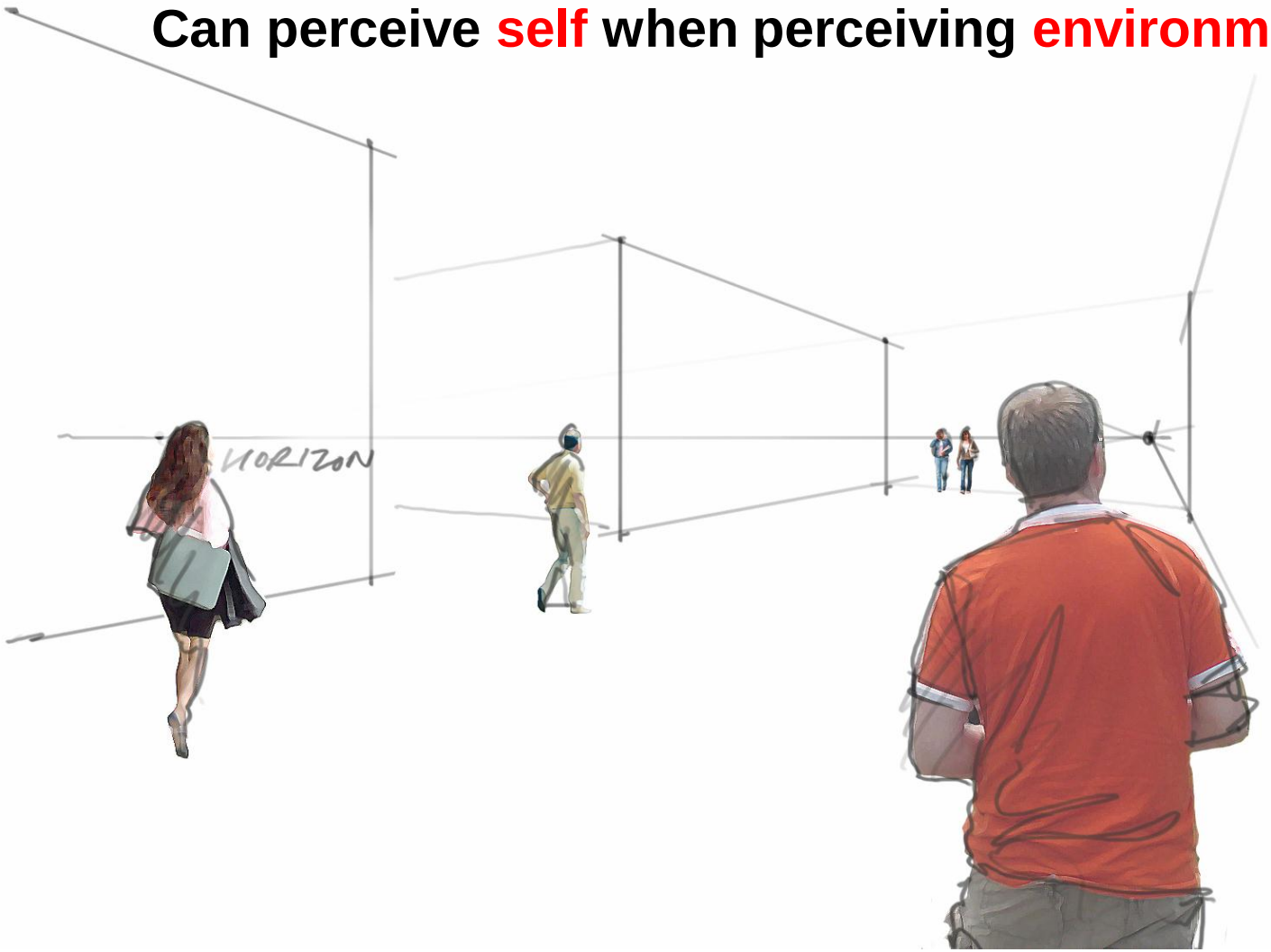


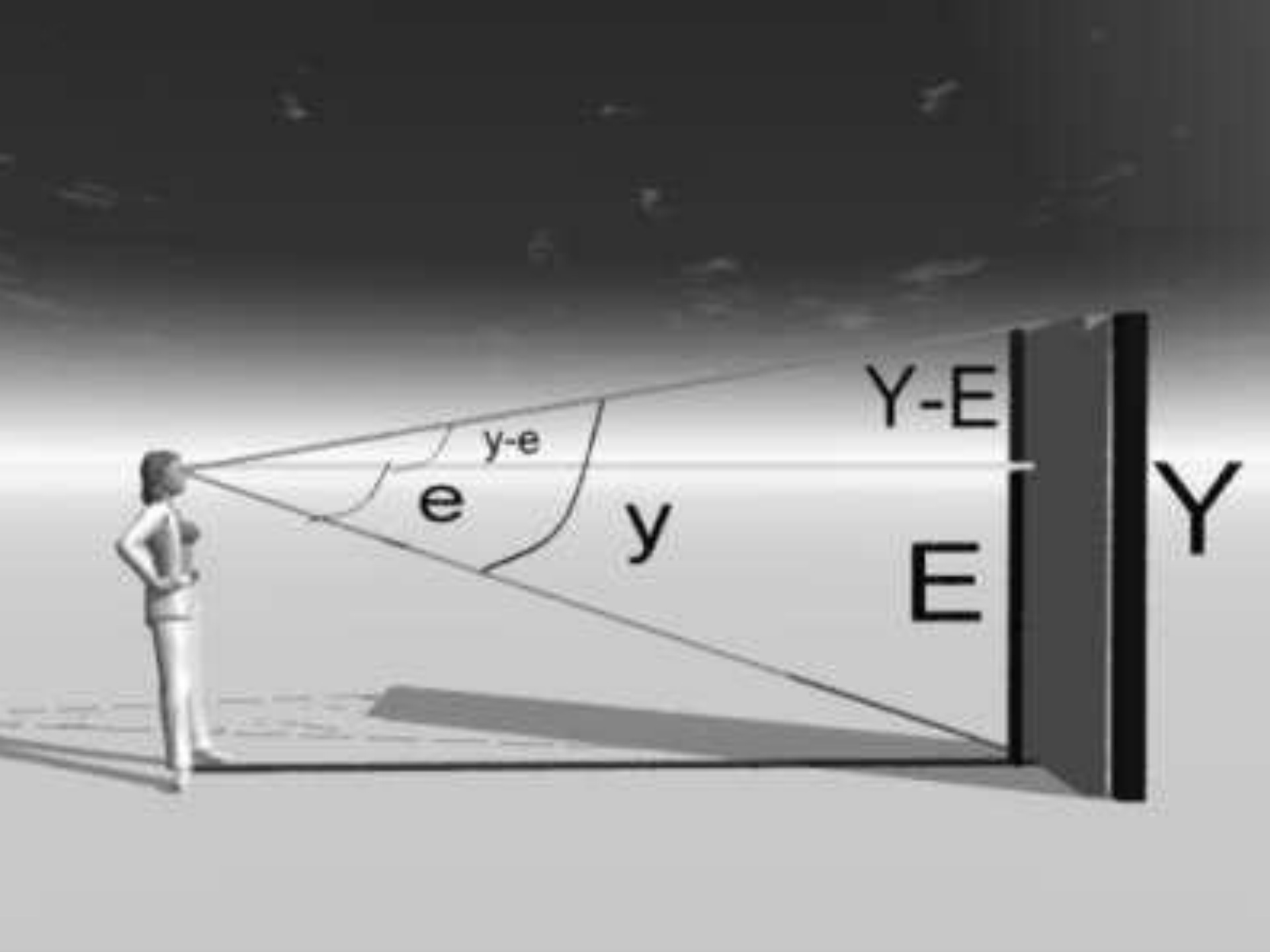
Figure 14.9 The principle of the perception of size-at-a-distance. One kind of information for detecting the size of an object that is part of a terrestrial environment consists of the amount of environmental texture the object intercepts or hides. The far cylinder in this scene is more than twice as large as the near one because it intercepts more than twice as many units of texture. Hence, in a pictorial array, the length of a line on the picture-plane can scarcely be seen as such; there is a strong tendency for it to be perceived as the length of the object it represents in the virtual space of the picture. (From Gibson, 1950.)

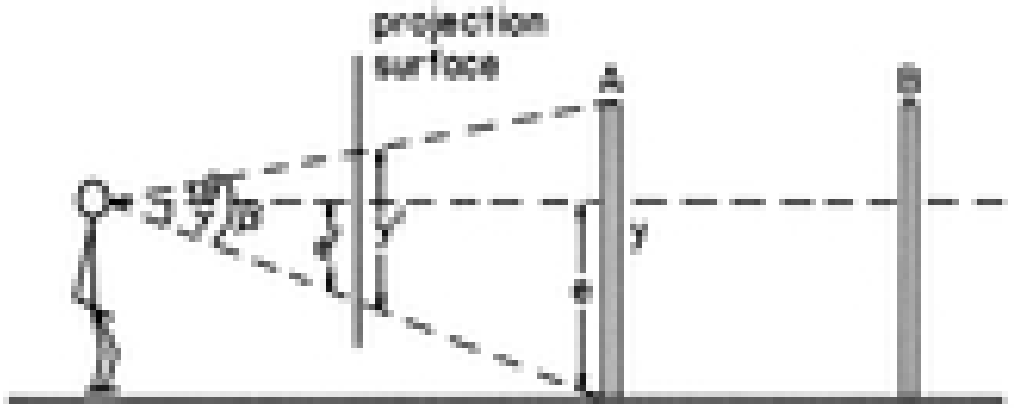
Horizon line

Horizon (or vanishing point):
intersects objects at viewer's own eye-height

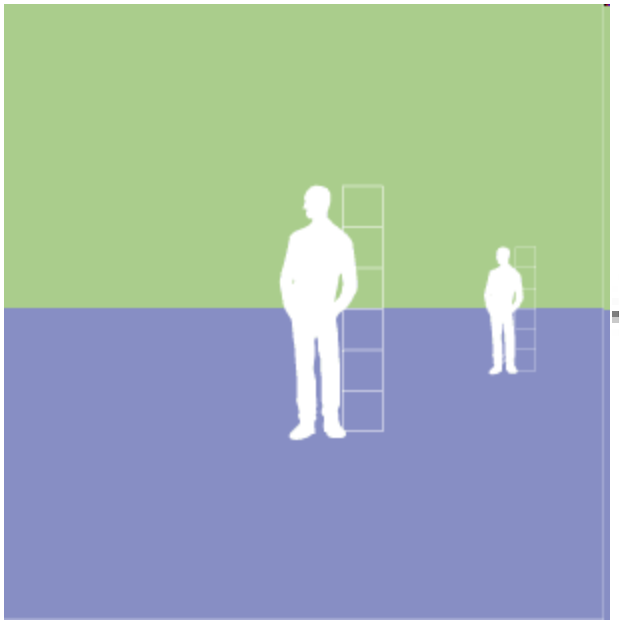
Can perceive self when perceiving environment

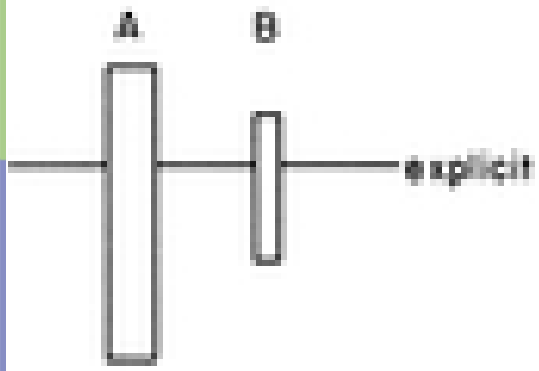



Y-E
y-e
e
y
E
Y

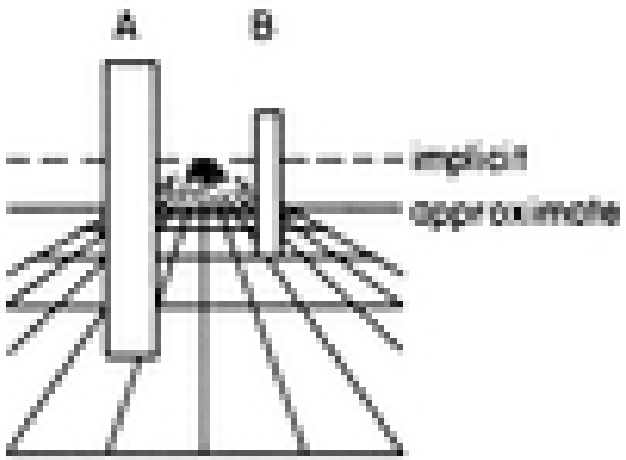

projection
surface
A
B
y
e

(a)




A
B
explicit

(b)


A
B
implicit
approximate

(c)

20th C attempts to banish mind-body dualism

1. **Phenomenology – irreducible *experience***
2. **Behaviourism – no mental states, just output behaviour caused by stimulus**
3. **Type-type identity reduction - any type of mental state "just is" a *specific type* of brain state (eg. pain)**
4. **Token-token identity reduction - *different* brain states can be the *same* mental state *by their function…***
5. **Functionalist reduction – mental states just are the *causal relations* of inputs, brain states, and outputs**
6. **Computer functionalism - Turing reductionism: same mental states = same program; different brains = different hardware**

Problems remain:

Intentionality and "mental content" (the "aboutness" of mental states)

- Searle's biological naturalism – consciousness as just "higher-level features" of matter
- Externalist approaches
  direct perception, affordances
  complex systems, embodied/situated cognition

Self and self-awareness

egomotion
ecological self

Subjectivity of experience

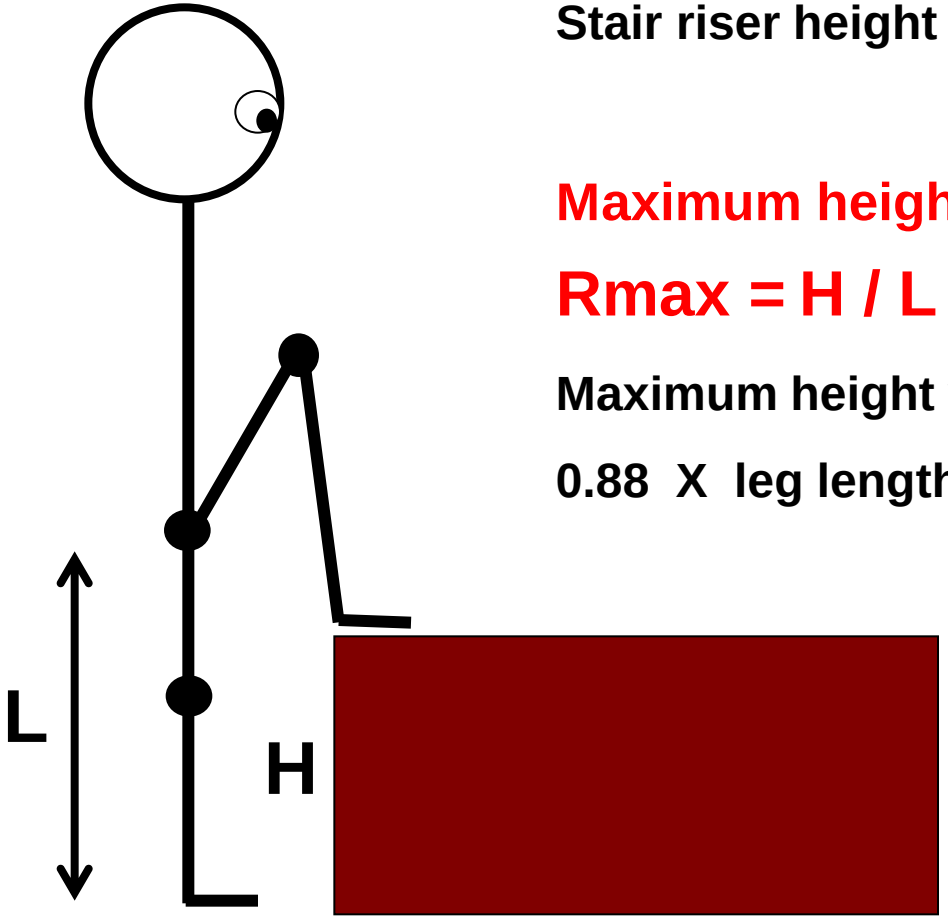
- qualitative first person "feel" of mental states (aka "consciousness")
- Chalmers (the "hard problem" of feel)
  information specifies resources (food)

What is the *maximum* height of stair you can step up on?

How do you *know* this?

Link: [Tree-climbing goats]

What is the maximum stair height of any stair you can step on? Does it *afford* stepping on?



Total leg length = L

Stair riser height = H

Maximum height, Rmax:

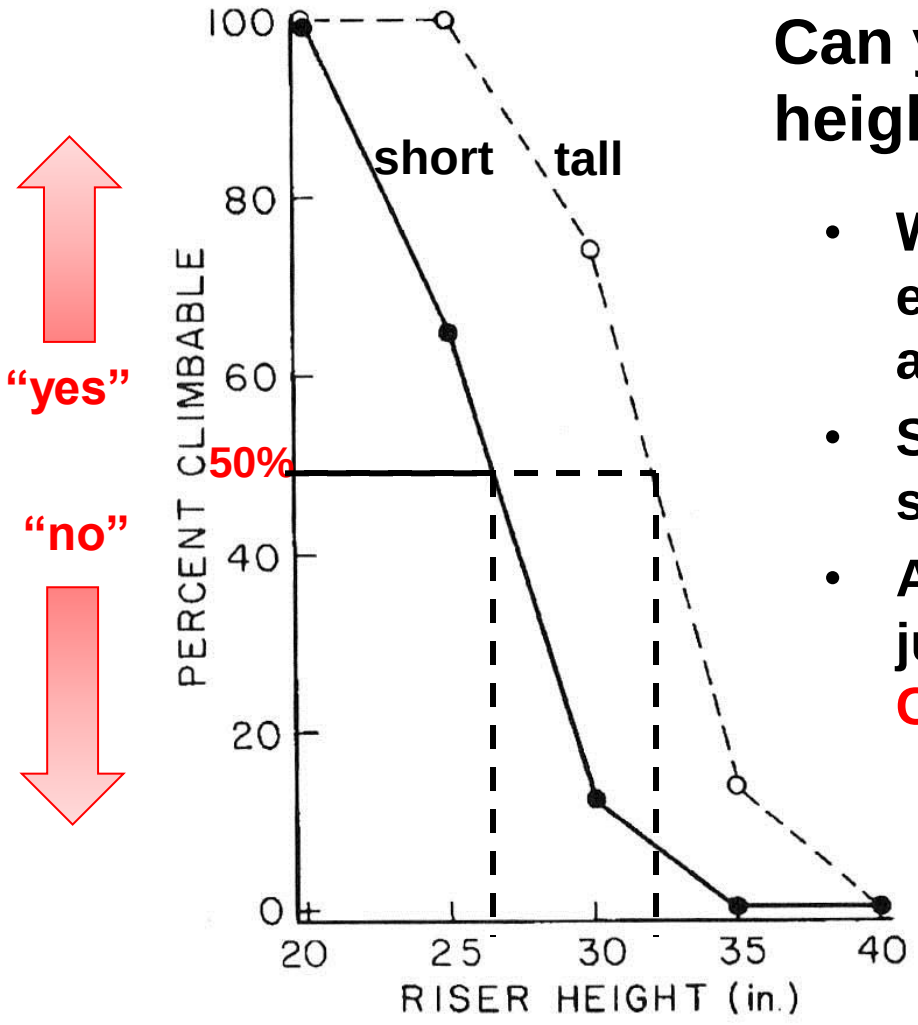
Rmax = H / L = 0.88

Maximum height you can step on is equal to

0.88 X leg length

e.g.,
leg length = 85 cm
Rmax = 0.88 x 85

Rmax = 75 cm



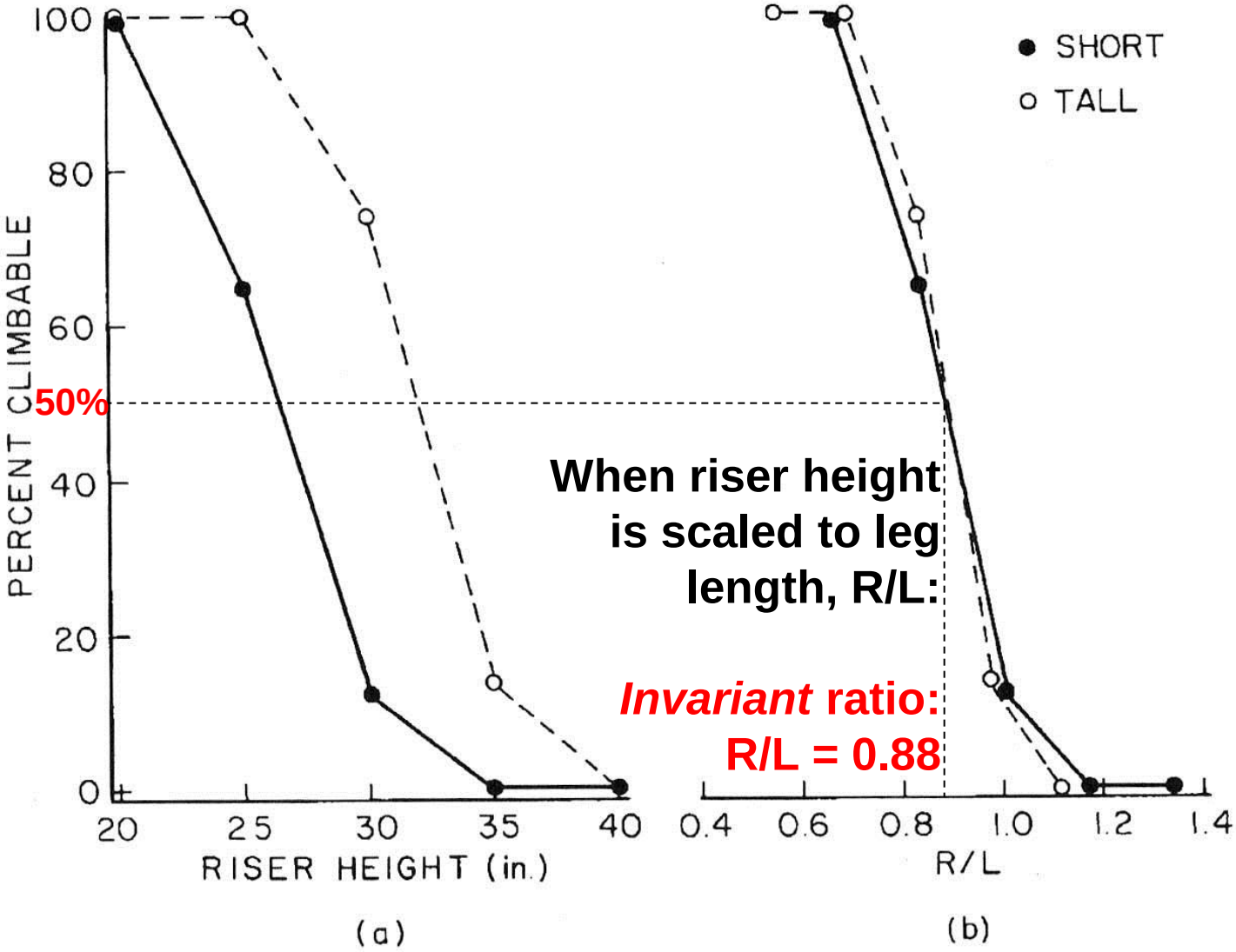
Can you *perceive* the *maximum* height of stair to step on?

- Warren's (1984) stair-climbing experiment on perceiving affordances
- Showed large photos of different stair heights to two groups
- Asked *short* and *tall* people to make judgments of
  CAN YOU CLIMB? Yes or No?

Short people: 26 in (66 cm)
Tall people: 32 in (81 cm)

Two *different* critical heights!

igure 8.4. *Judgments of critical riser height: (a) Mean percentage of climbable" judgments for each riser height,*



igure 8.4. *Judgments of critical riser height: (a) Mean percentage of climbable" judgments for each riser height, and (b) Intrinsic plot of climbable" judgments as a function of the riser height to leg length ratio (R/L).*

Preferred stair height

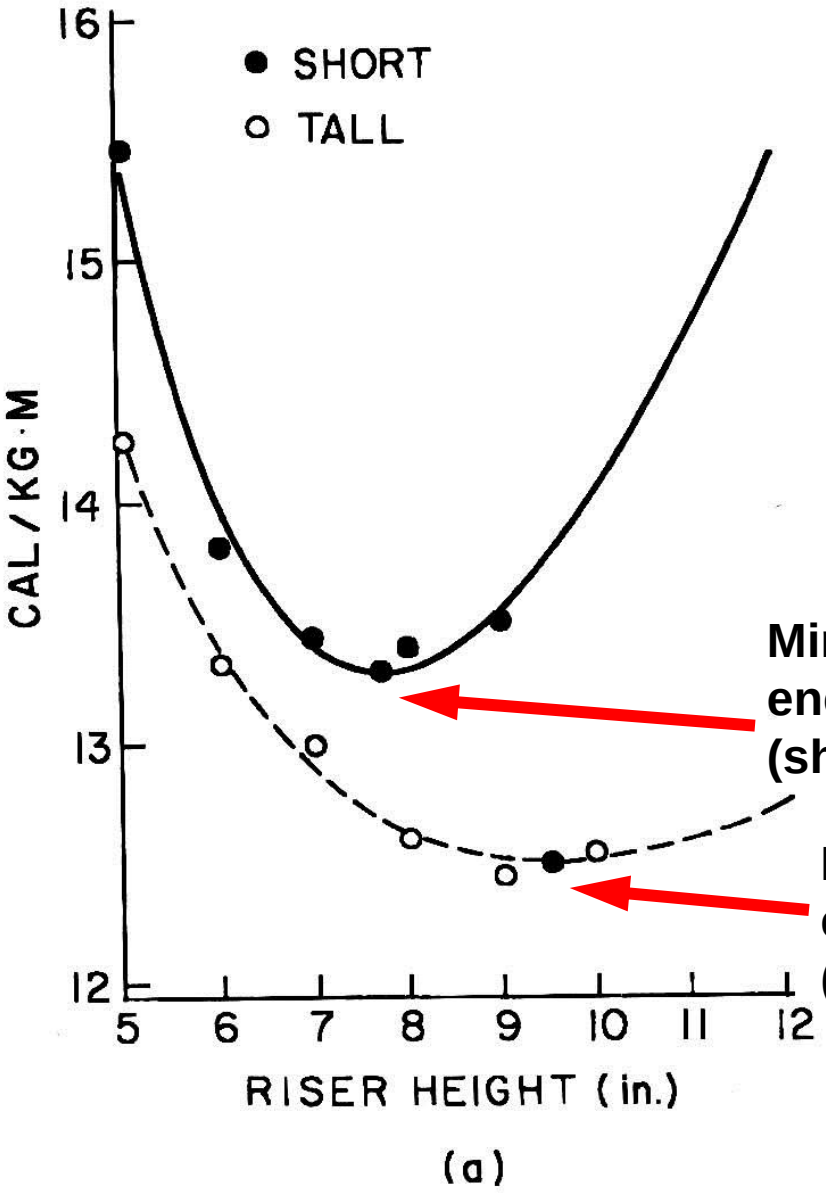
- Warren then asked:

  What is the *preferred* stair height that people could maintain comfortably for a continued amount of time

- Big? Small? Just right?

- Used a stairmill (like a treadmill) with different stair heights

- Tested them biomechanically in terms of energy expenditure to see **optimal** height (**least energy** expended) for different riser heights



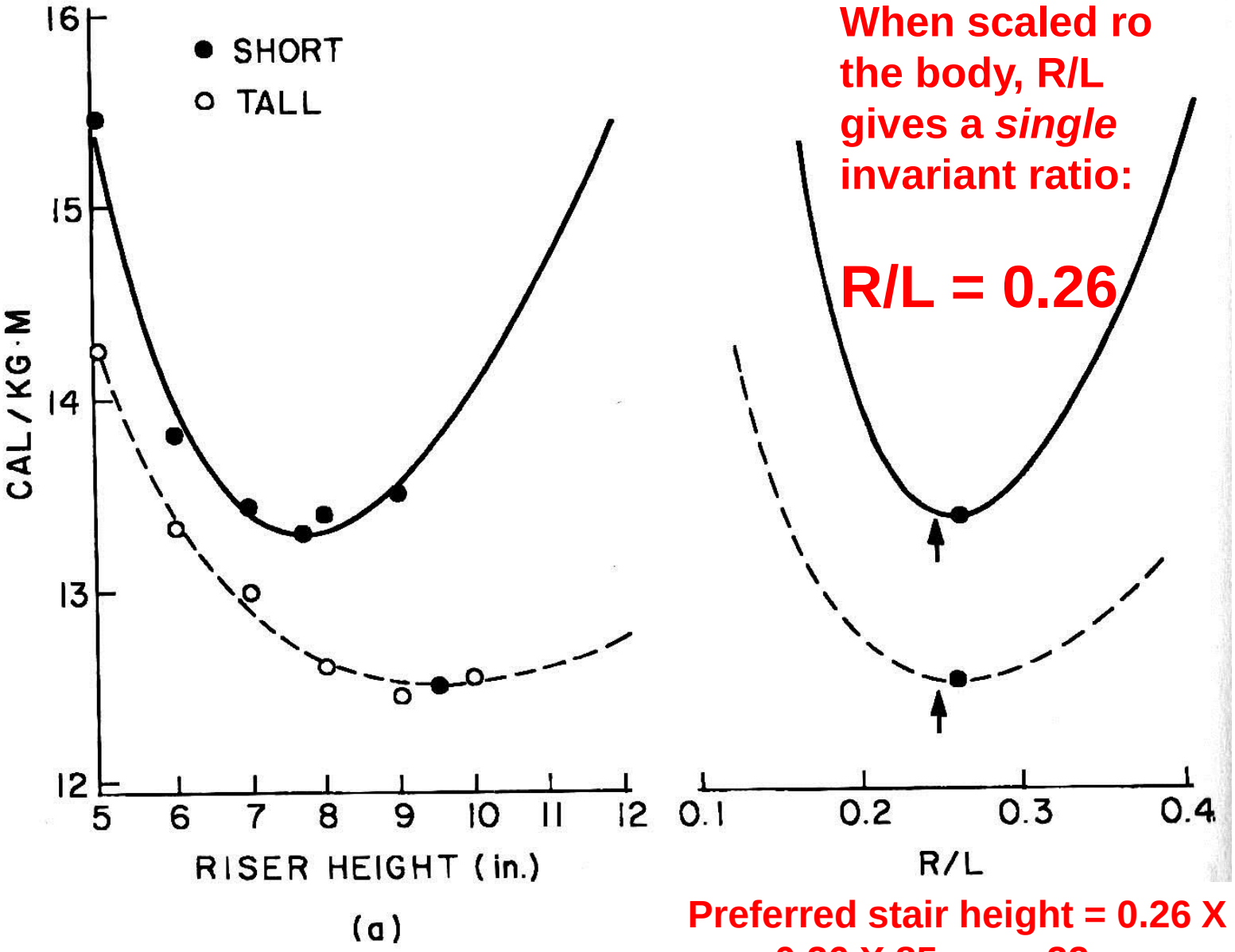
Preferred or *optimal* riser height (U-shaped functions)

Short people:
7.8 in (20 cm)

Tall people:
9.5 in (24 cm)

Two *different* preferred heights!

Figure. 8.5. *Optimal riser height. Energy expenditure as a function of (a) riser height,*

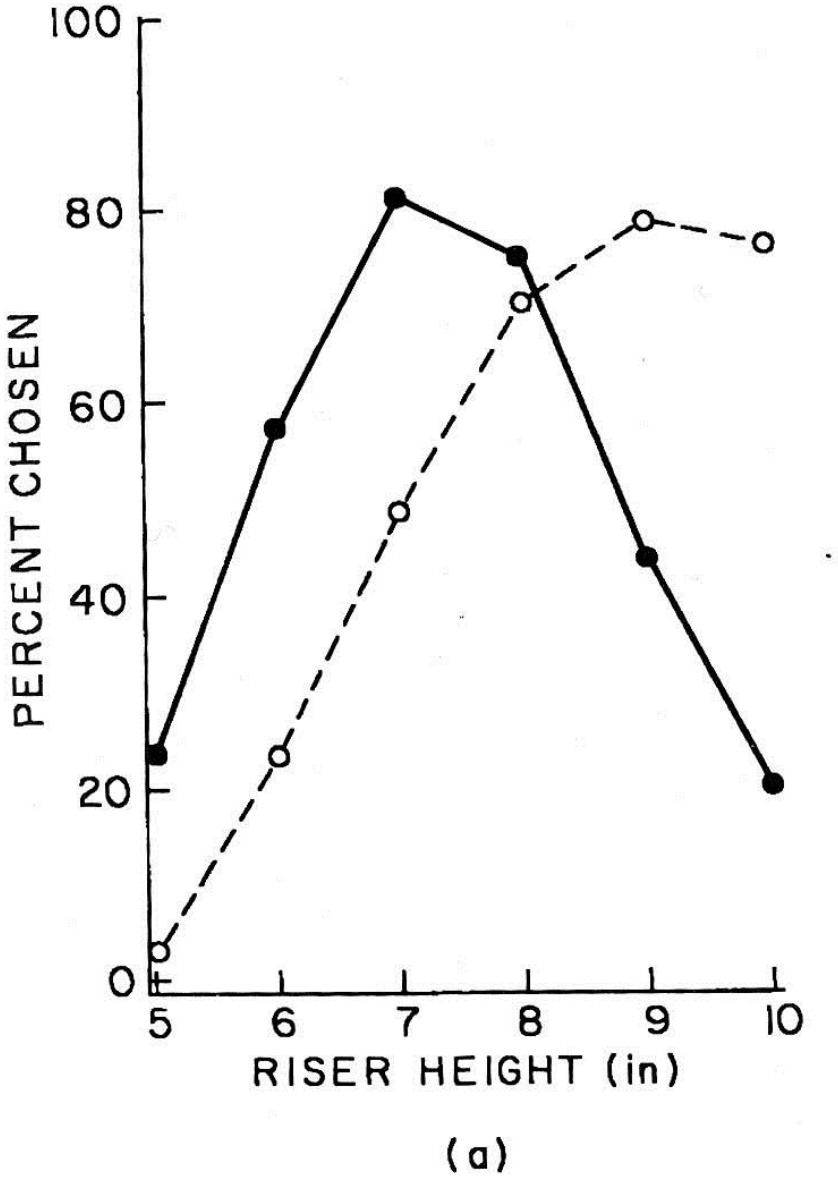


When scaled ro the body, R/L gives a *single* invariant ratio:

R/L = 0.26

Preferred stair height = 0.26 X Leg
e.g., 0.26 X 85 cm = 22 cm

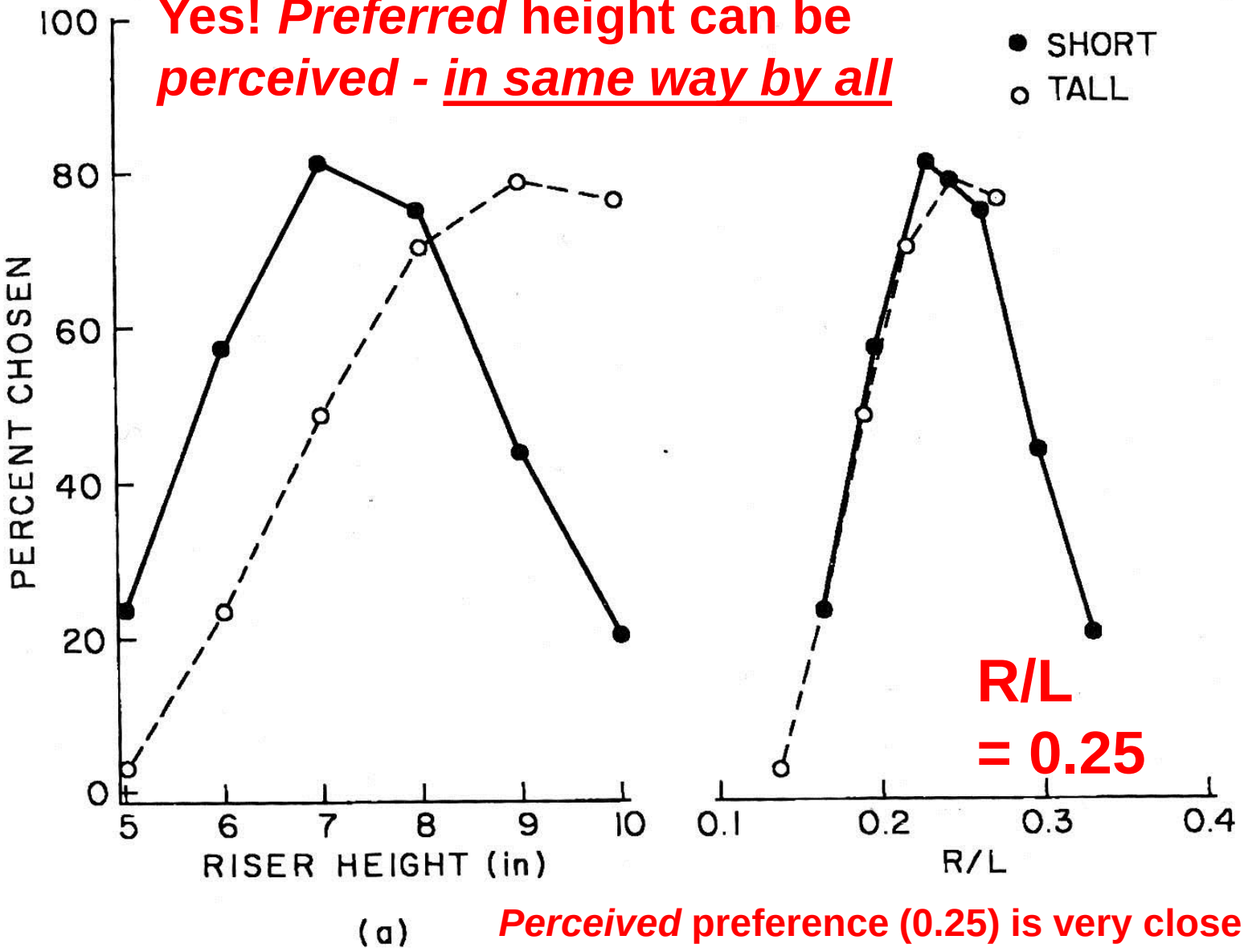
Figure. 8.5. *Optimal riser height. Energy expenditure as a function of (a) riser height, and (b) the R/L ratio.*



But can *preferred* height be *perceived?*

Figure 8.6. *Preferred riser height. Mean percentage chosen as a function of (a) riser height*

Yes! *Preferred* height can be *perceived - in same way by all*



***Perceived* preference (0.25) is very close to the optimal height (0.26) found biomechanically**

Figure 8.6. *Preferred riser height. Mean percentage chosen as a function of (a) riser height and (b) the R/L ratio.*

Why are monument steps so difficult to walk on?

Affordances: stair climbing

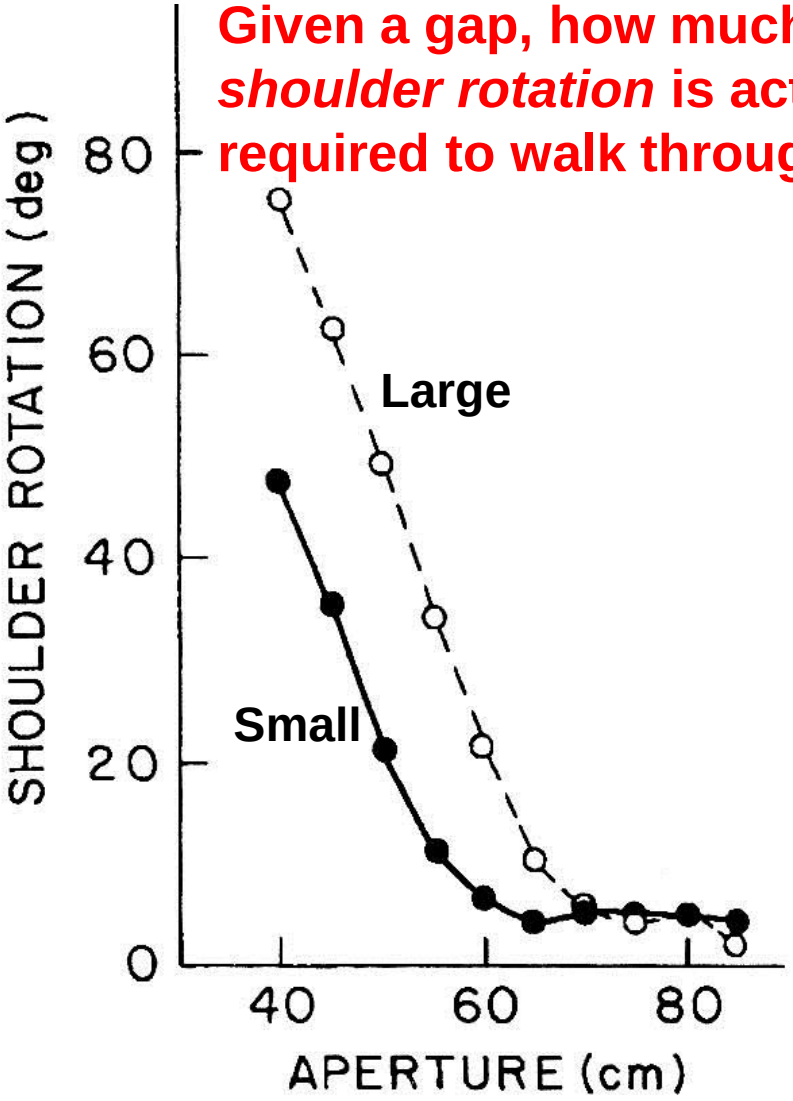
- Affordances are the *real possibilities for action* in the environment; direct realism, ecological realism (James Gibson; 1966, 1979)
- Affordances are the *perceivable properties* of the environment
- Warren (1984): first experimental study of affordances
- Showed affordances are physical properties of the environment in relation to us (not just concepts “in the head”) and…
- Different people (with “different body states”) but *see the same* affordances (have “same mental states”)
- Crucial experimental move to study affordances: *scaling the environment to the body*
- Affordances are defined *reciprocally* – they require an environment and a perceiver, but they are considered *real*
- Gibson emphasised affordances are *both objective and subjective*

- **If they are *real*, and if *information* is available to be detected, then affordances can be *directly* perceived (minimal thought processes, internal hypotheses, etc.):**

theory of “direct perception”


Can you *see* if you can walk through this gap?

Given a gap, how much *shoulder rotation* is actually required to walk through it?



What is the critical doorway width when shoulder rotation begins?

Rotation is defined as more motion than normal sway

As gap size is reduced:
Rotation begins earlier (at larger gaps) for large people.
Rotation begins later (at smaller gaps) for small people.

Figure 8.7. *Critical aperture width. Shoulder rotation as a function of (a) aperture width,*

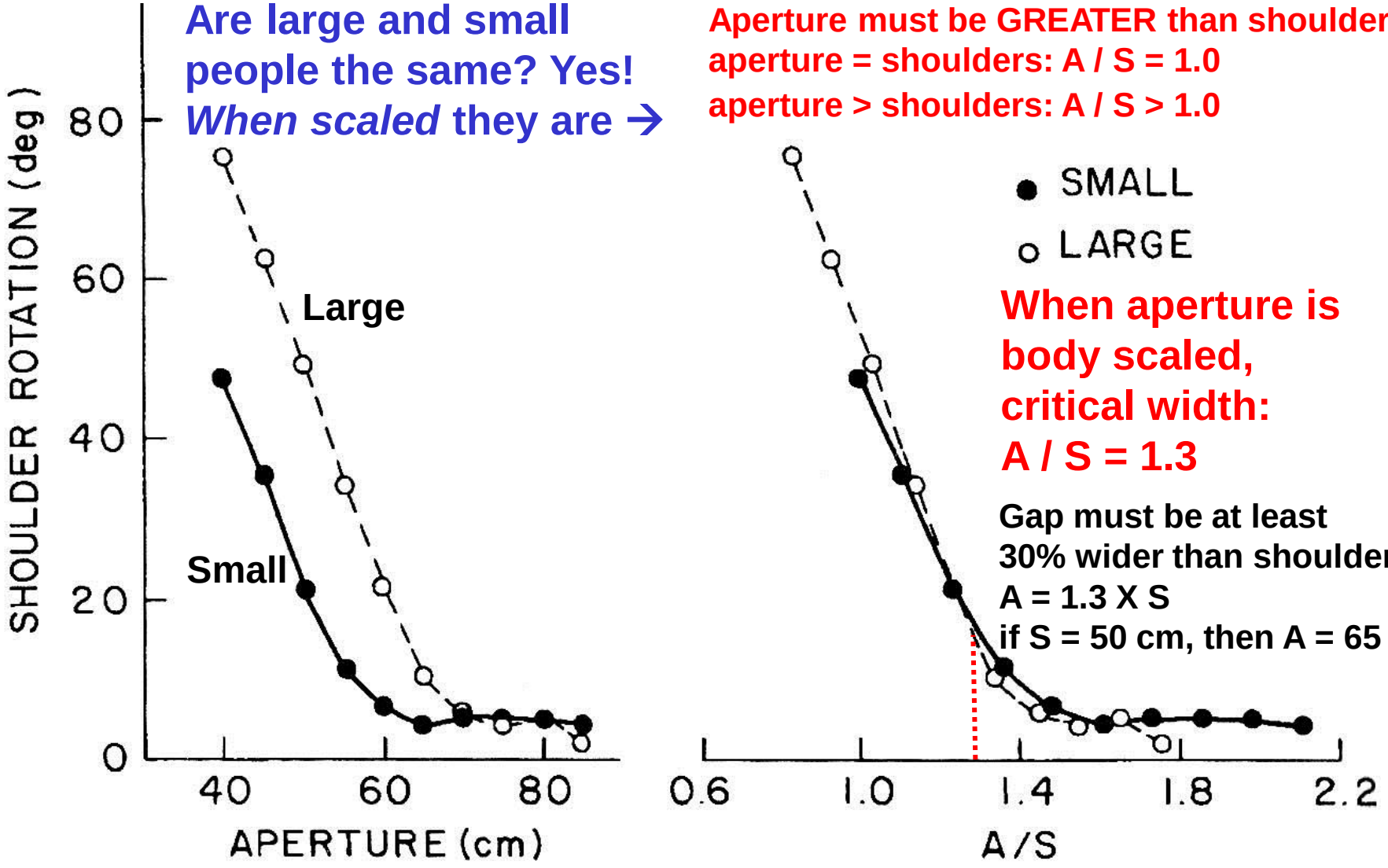
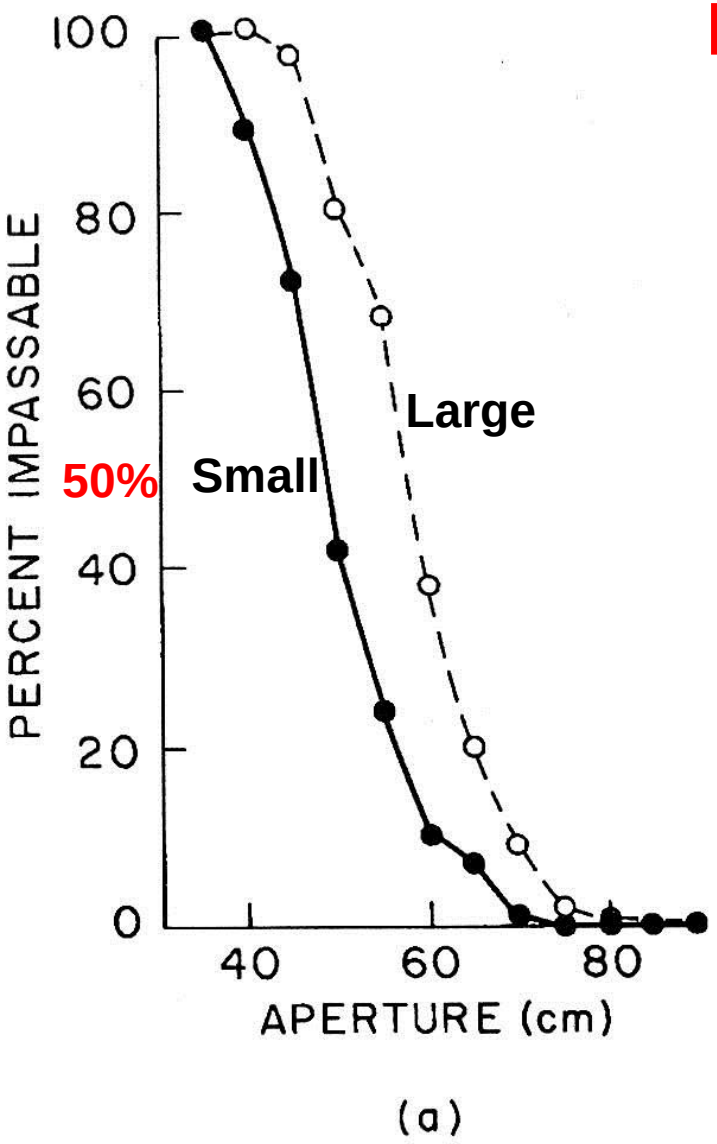


Figure 8.7. *Critical aperture width. Shoulder rotation as a function of (a) aperture width, and (b) the ratio of aperture width to shoulder width (A/S).*



But can a *passable gap* be *perceived?*

Judgments were made by small and large people of whether doorway was "passable" or "impassable" by looking at different doorways at a distance of 5 m

Figure 8.8. *Judgments of critical aperture width. Mean percentage of "impassable" judgments as a function of (a) aperture width,*

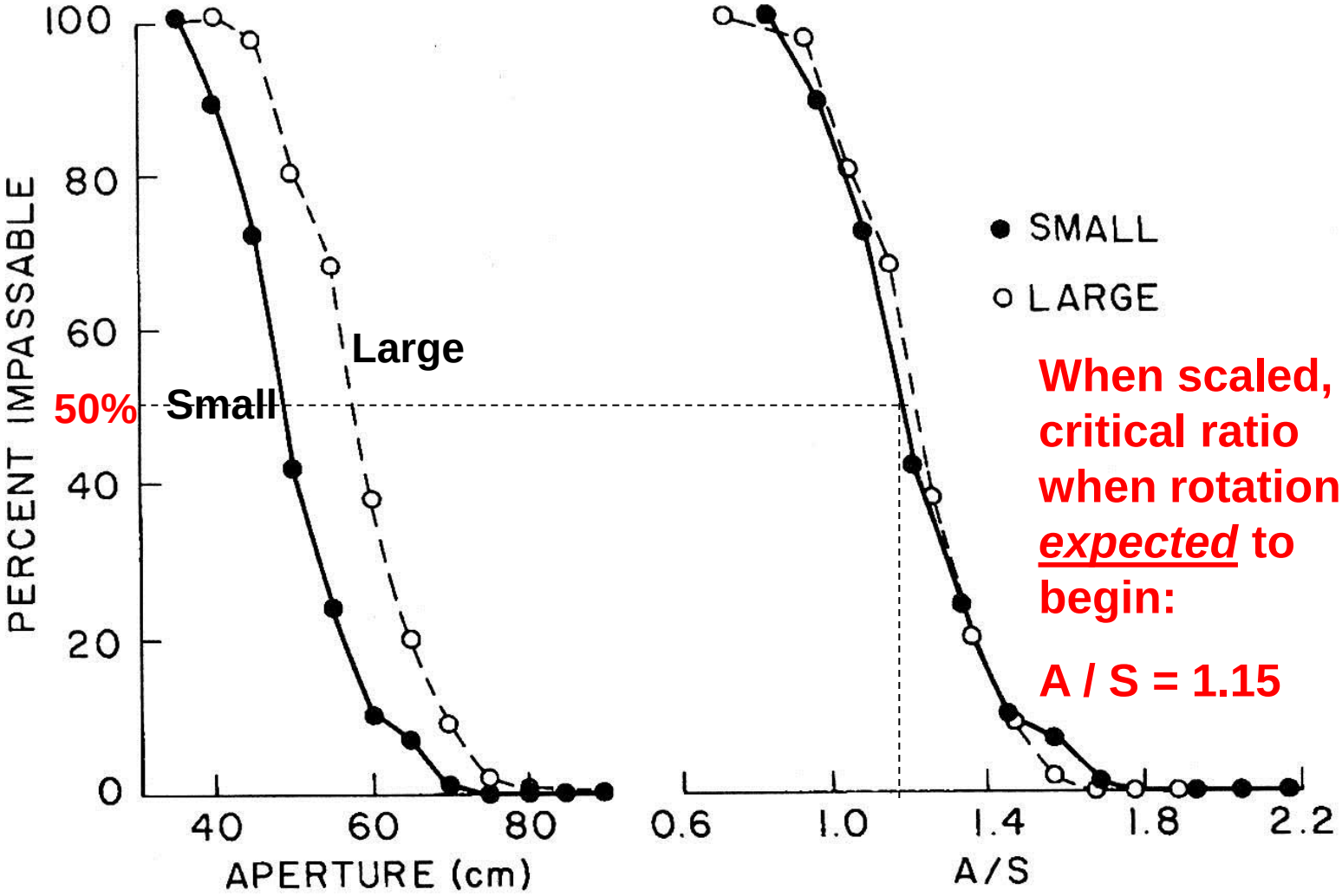
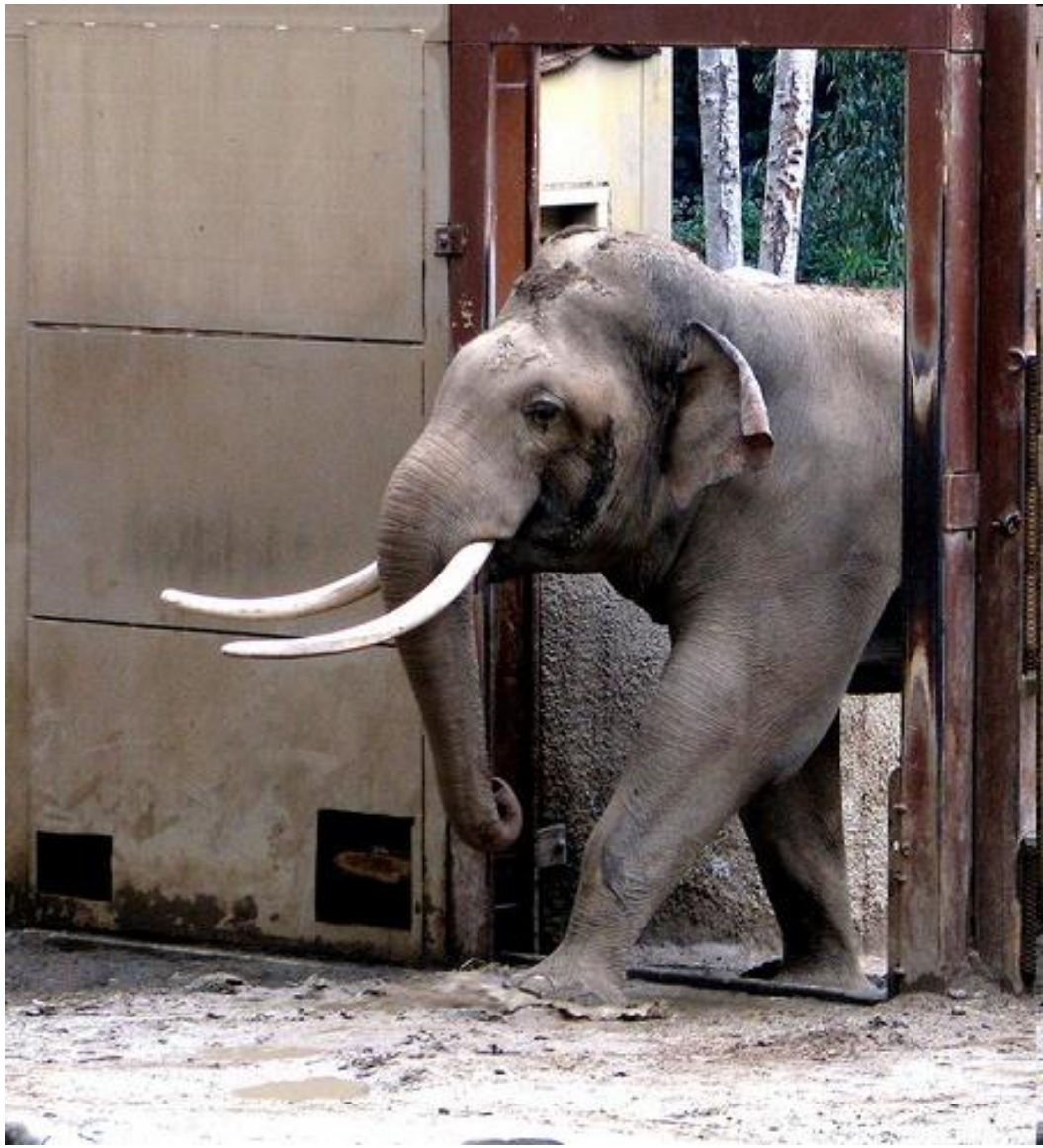


Figure 8.8. *Judgments of critical aperture width. Mean percentage of "impassable" judgments as a function of (a) aperture width, and (b) the A/S ratio.*

Other animals?

- Do other animals make perceptual judgments about in the same way as humans?
- If they do, then we might conclude that other animals perceive their environment in *the same way* as humans
- They would perceive the *meaningful affordances* of their environment

- Nagel:
  "What is it like to be a bat?"



Frogs

Jump or not jump through gaps

-Head width (H)
-Aperture (A)
-Same critical boundary!

A/H = 1.3

Ingle and Cook (1977)

KEA bird brain / high intelligence: affordances; http://www.youtube.com/watch?v=Twg4Yg4gFoo#t=04m20s

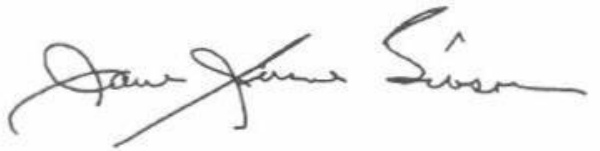
Table 8.1. *Architectural and ecological standards for several affordances*

Architectural and Ecological Standards for Several Affordances				
		Architectural Standard	Ecological Standard	π
Riser height	Opt	5-7 in	7.5in	.26L
Seat height	Opt Max	17.5 in 2 ft 6 in	14.5 - 17.5in 2ft 3in - 2ft 8in	.47L .87L
Passage width	Min	21 in	25in	1.3S
Graspable object diameter	Max	-	6in	.9G

Affordances

"The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment…"

(Gibson, 1979, *The ecological approach to visual perception*, p. 127).



“If a terrestrial surface is nearly horizontal (instead of slanted), nearly flat (instead of convex or concave), and sufficiently extended (relative to the size of the animal) and if its substance is rigid (relative to the weight of the animal), then the surface affords support...

Note that the four properties listed -- horizontal, flat, extended, and rigid -- would be physical properties of a surface if they were measured with the scales and standard units used in physics.

As an affordance of support for a species of animal, however, they have to be measured relative to the animal. They are unique for that animal.
They are not just abstract physical properties.”

(Gibson, 1979, p. 127, 129).

Summary

- **Affordances are the relevant, *perceivable* properties of the environment for an organism**
- **Affordances are about *action*: the *possibilities for action* in the environment**
- **If they are to be perceived, then there must be *information* about them**

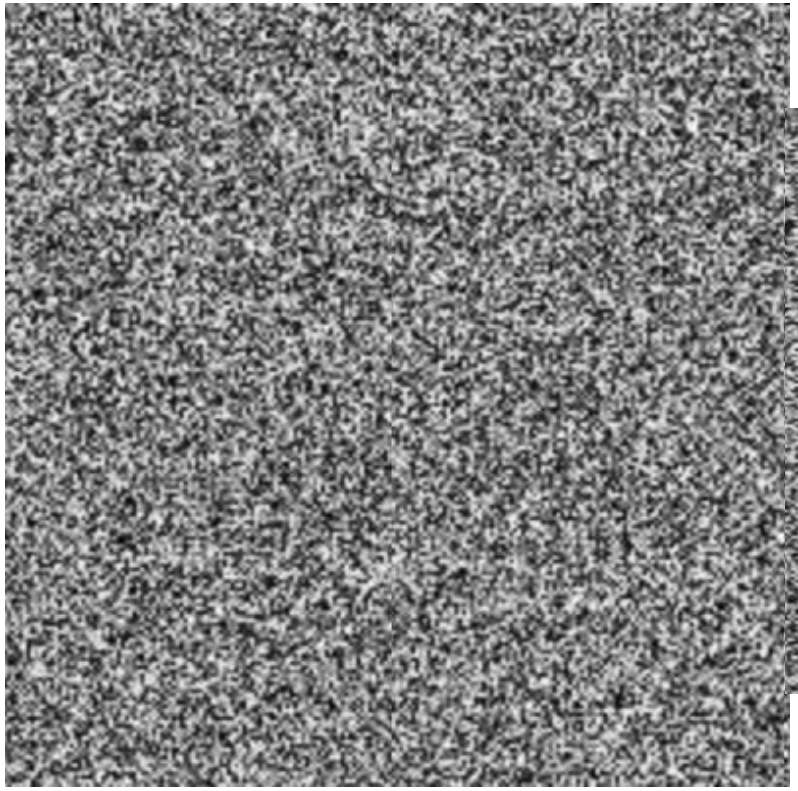
NOTE…

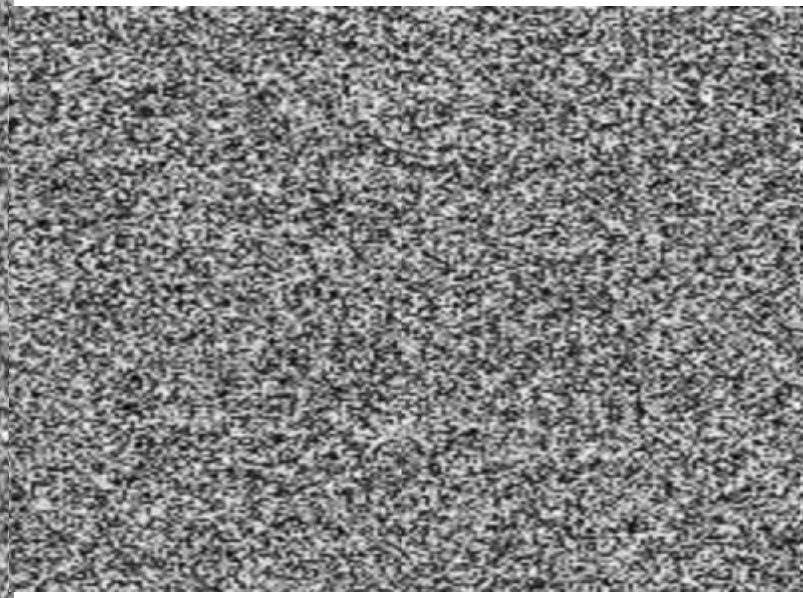
Information is *detected*…but

Affordances are *perceived*

Deletion & accretion of optical structure

(Download animations of following: HERE)



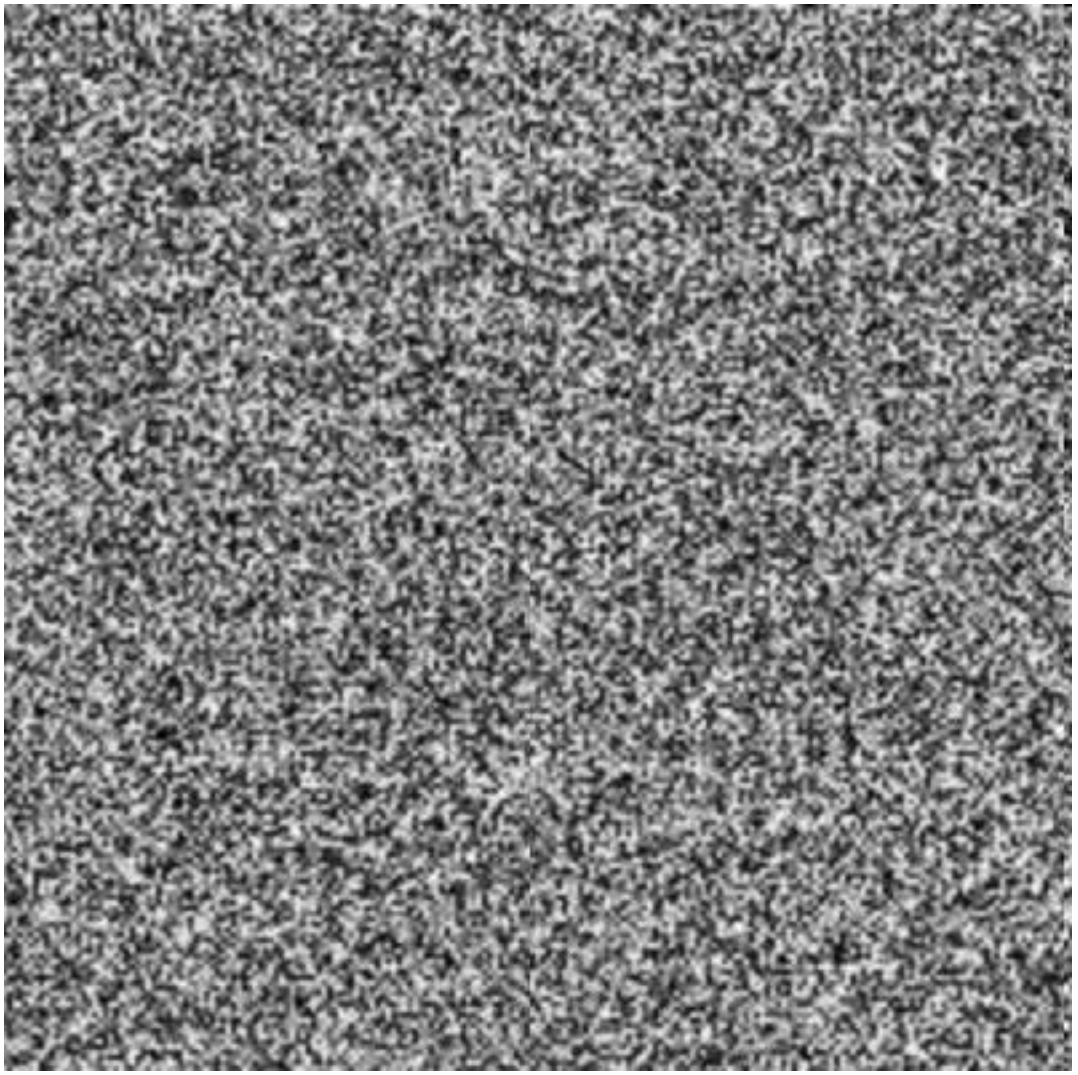


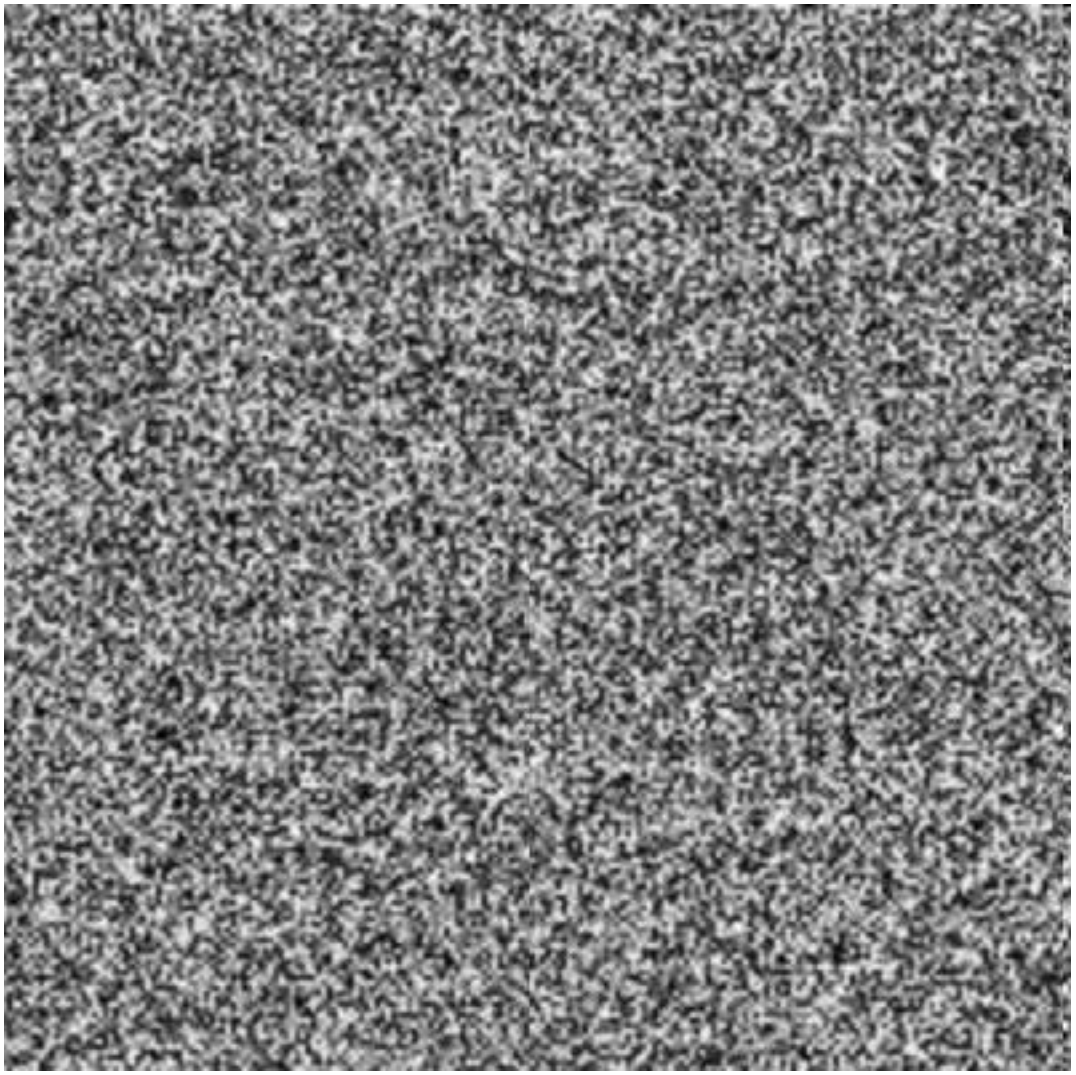
Deletion & accretion specifies:

1) edges

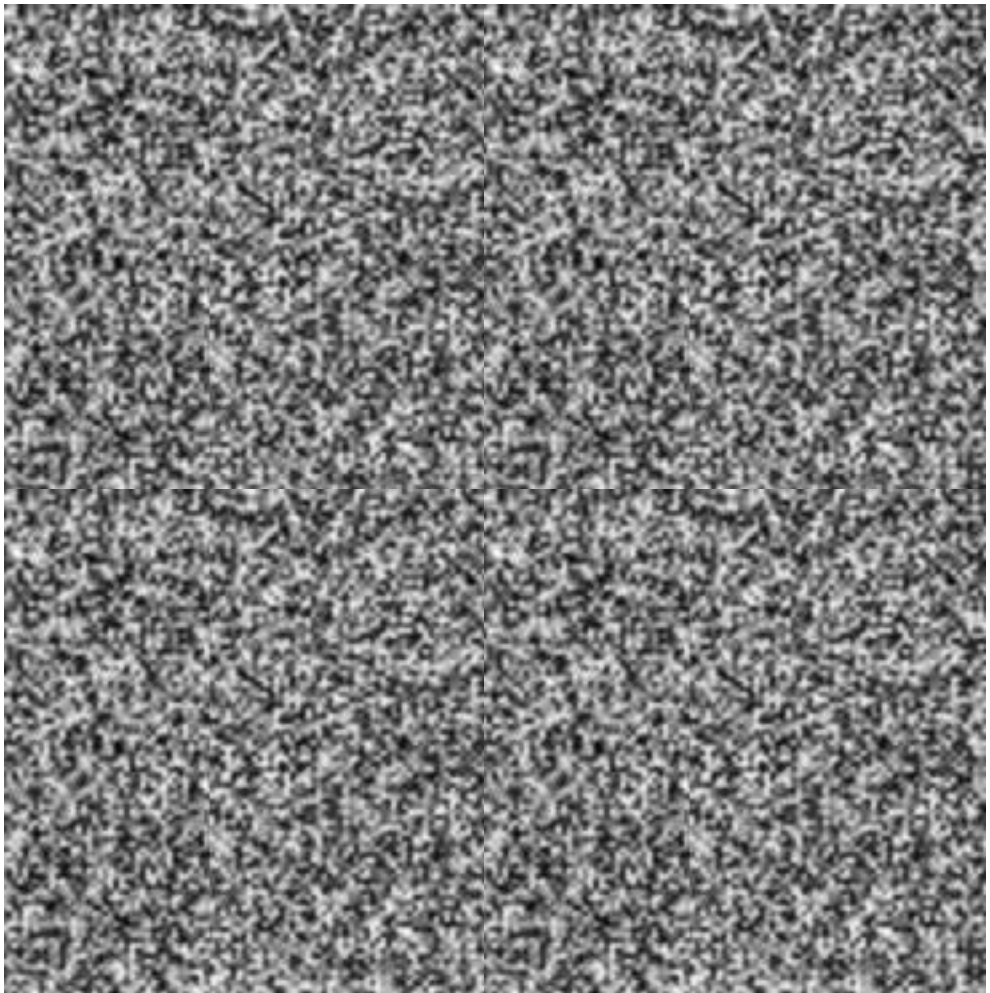
2) moving object is NEARER

3) enhanced “3D” effect

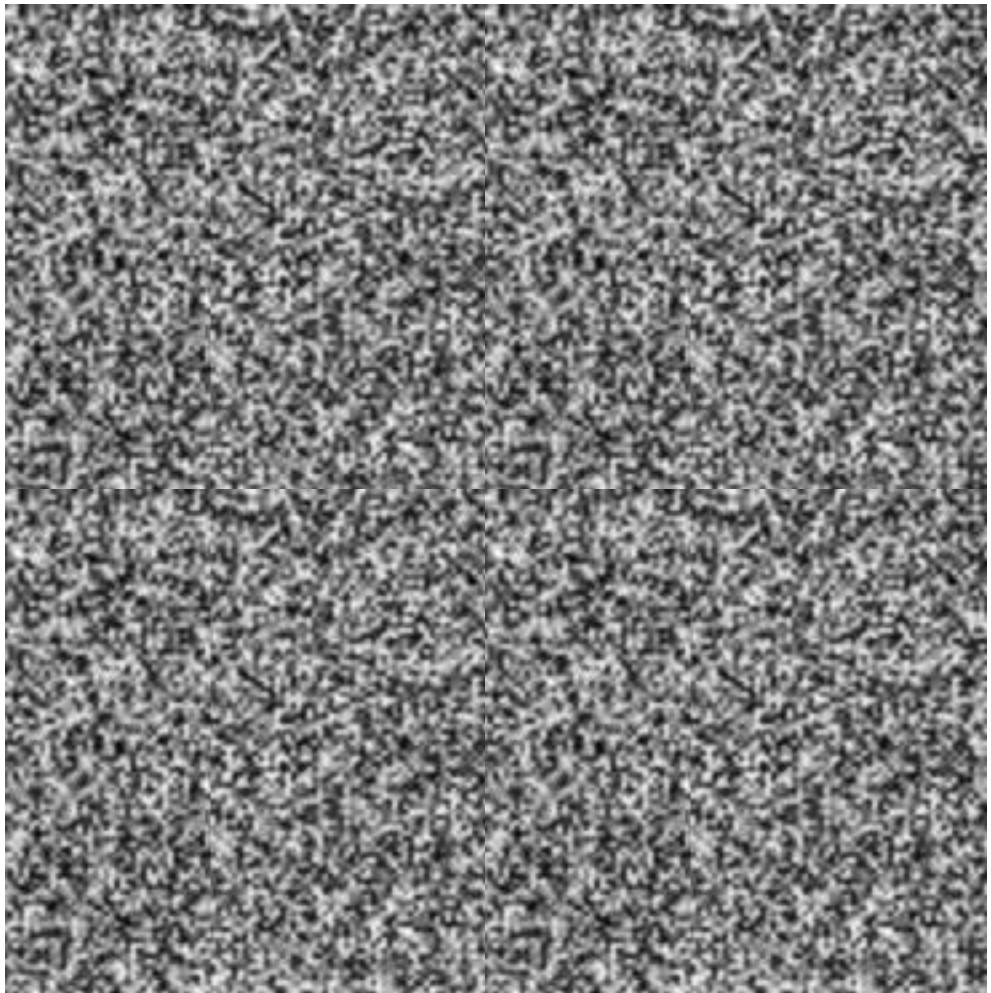




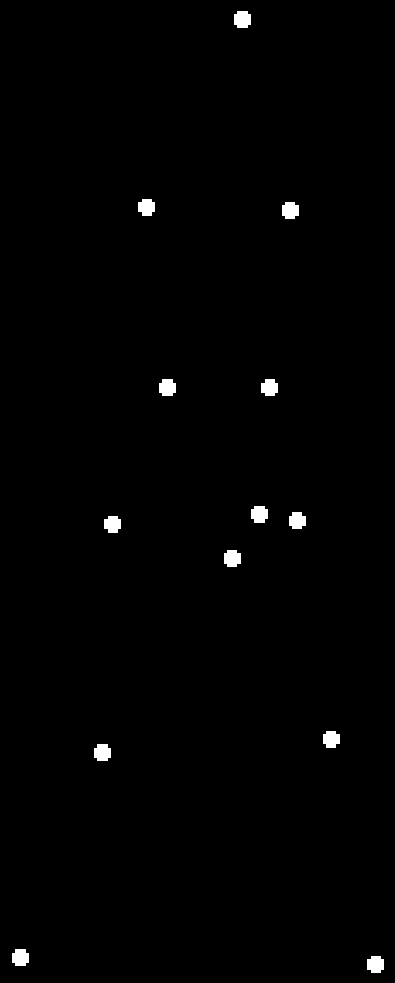
We do not need stimulation to perceive existence



Unusual conditions: *surprise & attention*



Point light displays



http://www.biomotionlab.ca/Demos/BMLwalker.html

Summary: Dynamic occlusion

We do not need a line to see a line
(the information for a line is not a line)

The information for a thing is not the thing

We do not need “continuous stimulation”
to *see* that something *exists*

Relative motion is sufficient to experience “depth”
(no need to have two eyes to create stereo 3D, etc)

The information specifying reality is a
higher-order relation in the optic array

The importance of self-motion

- Motion (change) is needed to reveal what is *invariant* (unchanging) = *information*

- *Self-generated* motion is essential for discovering the informational invariants for perception, behaviour, and awareness

- Kitten-carousel experiment (1963)
- Visual cliff experiment (Eleanor Gibson, 1960)

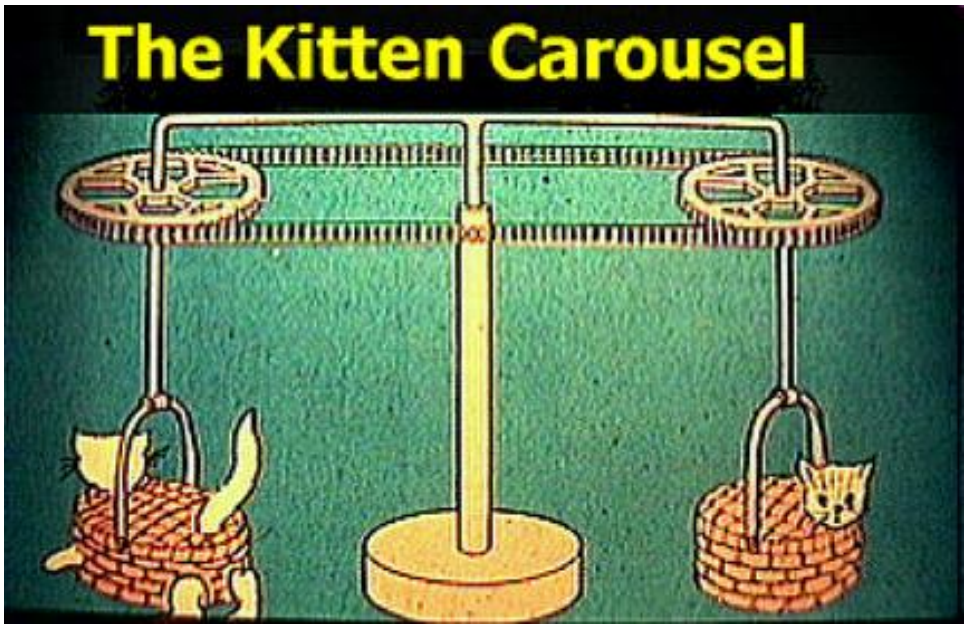
The "Kitten Carousel"

(Held & Hein, 1963)

- Raised in dark for 8 weeks
- 1 hr/day in carousel
- Active cat moves limbs
- Passive cat can’t move
- Both receive “same visual stimulation”

but…

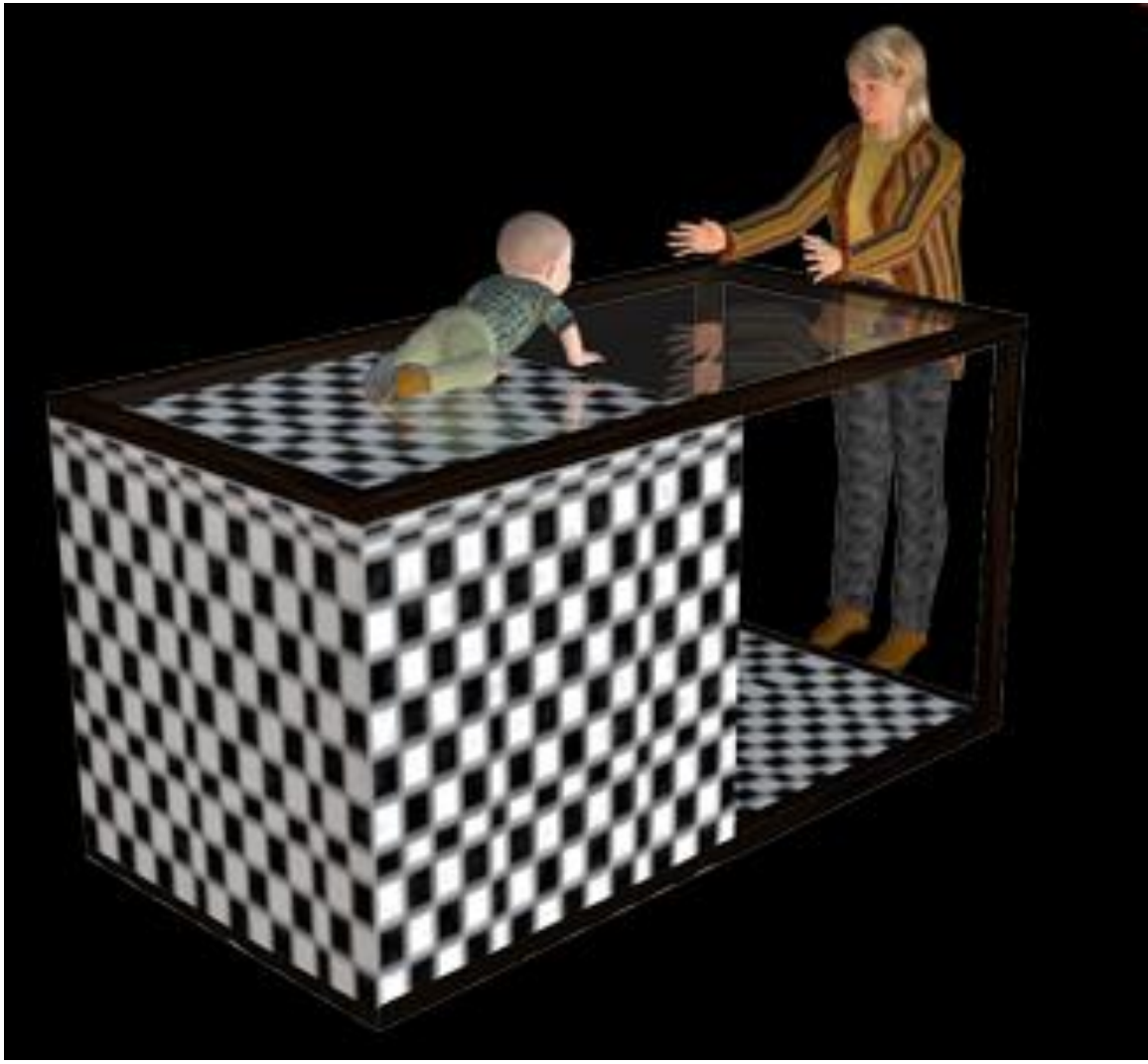
- Active kitten develops normal depth perception!



Active kitten **Passive kitten**

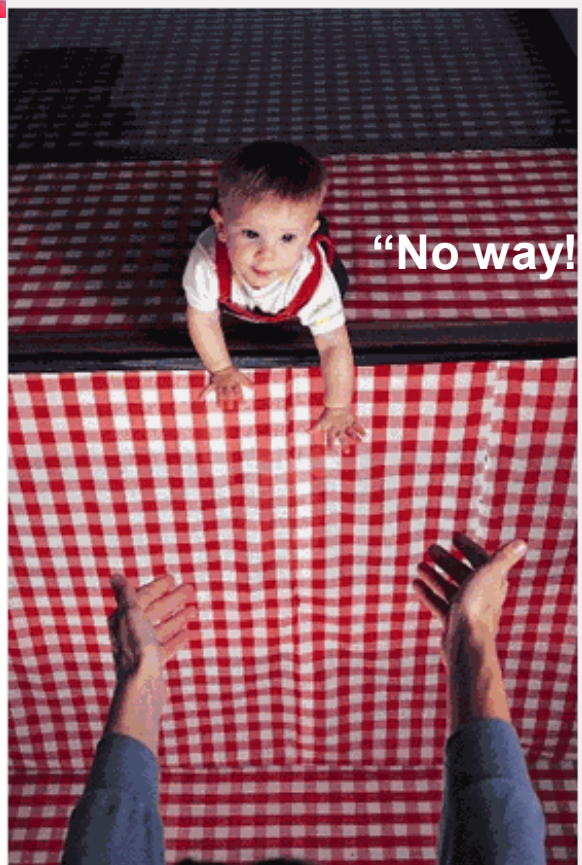
Gibson's "visual cliff"

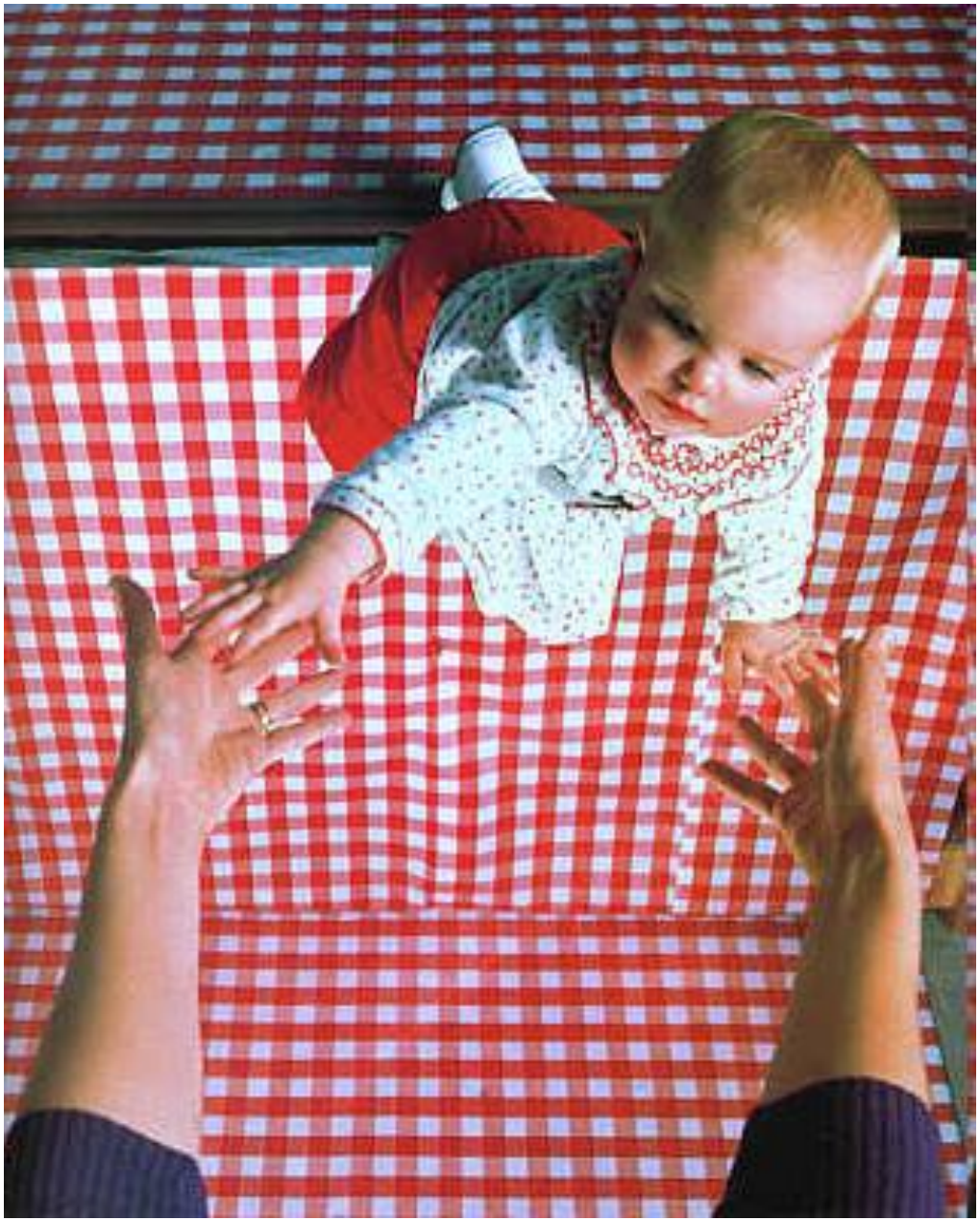
- Infamous experiments by Eleanor Gibson (1960s);
- Infants placed on glass surface across a gap;
- *Texture gradient specifies* a ledge…or a falling-off place!
- Glass is strong and hard and affords crawling over
- Do infants perceive any problem…*danger?*



Visual cliff

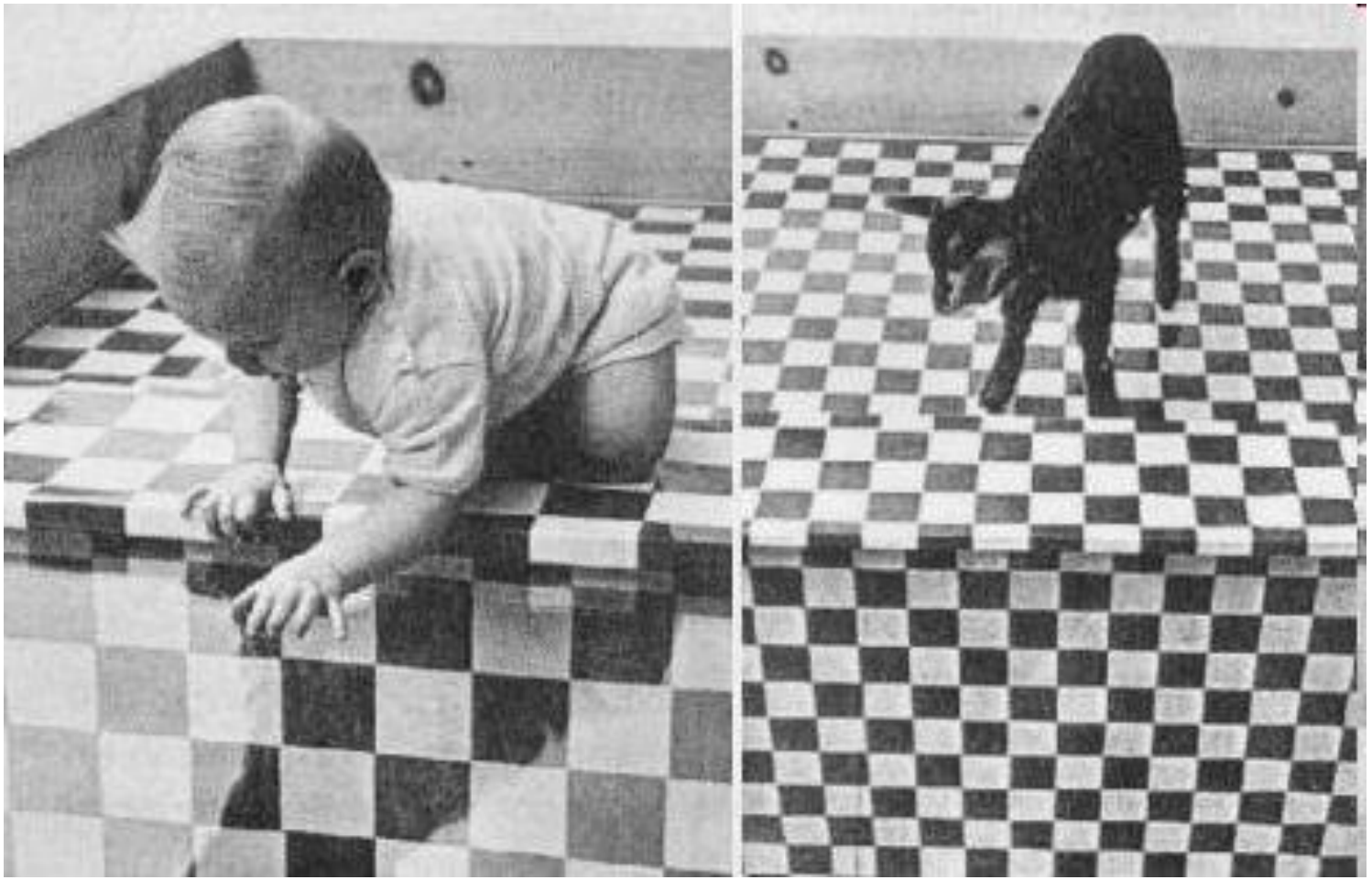
- Texture gradient discontinuity = information that *specifies* a ledge;
- Ledge is not just an optical contour - it has *relevance* for the baby
- It *means* something!
- The child has nev*er experienced falling down a cliff before* but refuses to cross.





Very rare!!

Even newborn animals will avoid crossing!



Goats won’t go!


2003. 10. 20
Mice won’t go!

Eleanor Jack ("Jackie") Gibson (1910 – 2002)

***National Medal for Science* (1992)**
("American Nobel Prize")

Women in psychology:

http://www.feministvoices.com/eleanor-j-gibson/

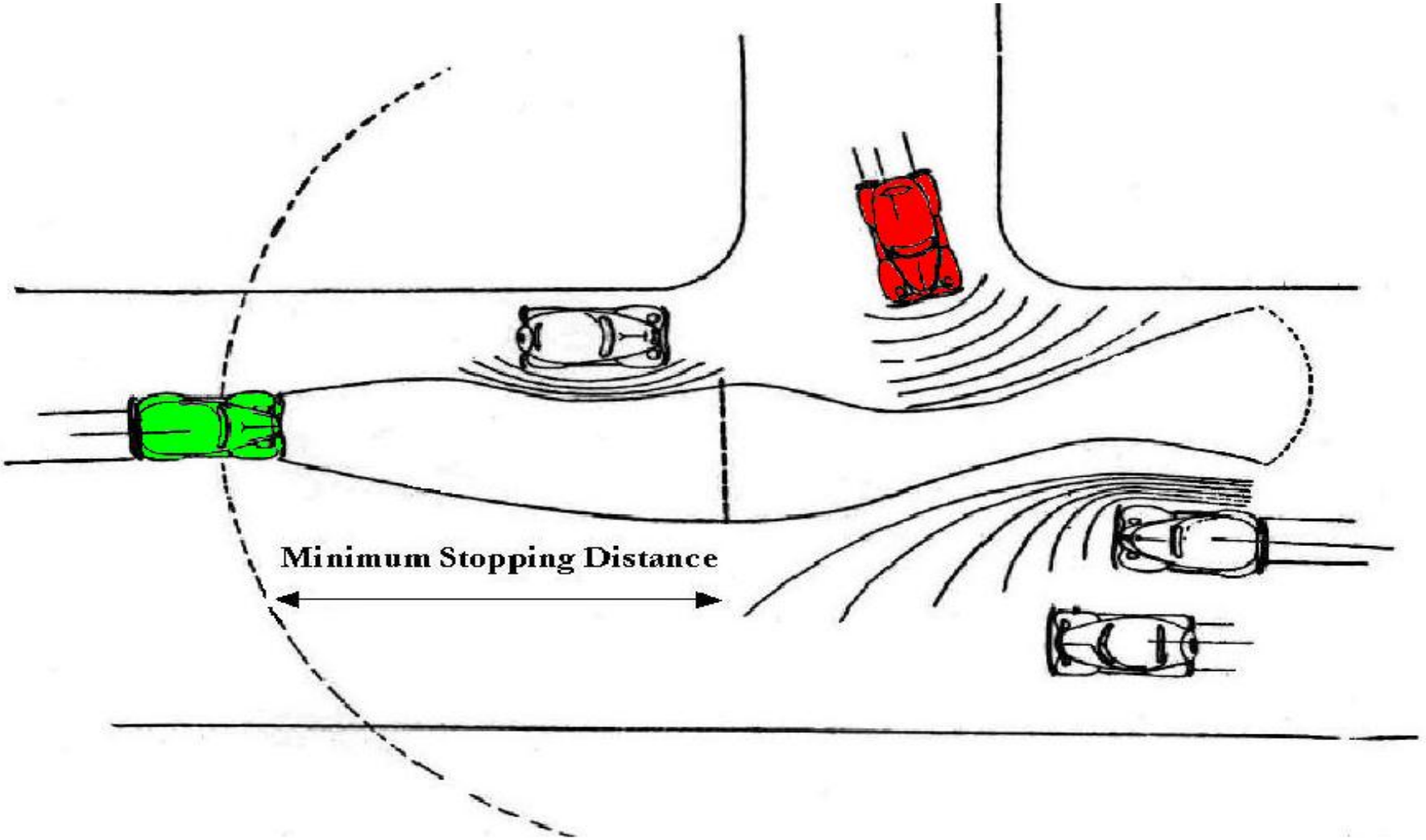
The perception of *meaning*

- The visual cliff: an early example by Gibsons to show that all animals already perceive - from birth – *meaningful dimensions of their environment;*
- *The cliff allows or affords certain actions such as falling down;*
- Gibson called these *perceivable possibilities for action* of the environment…

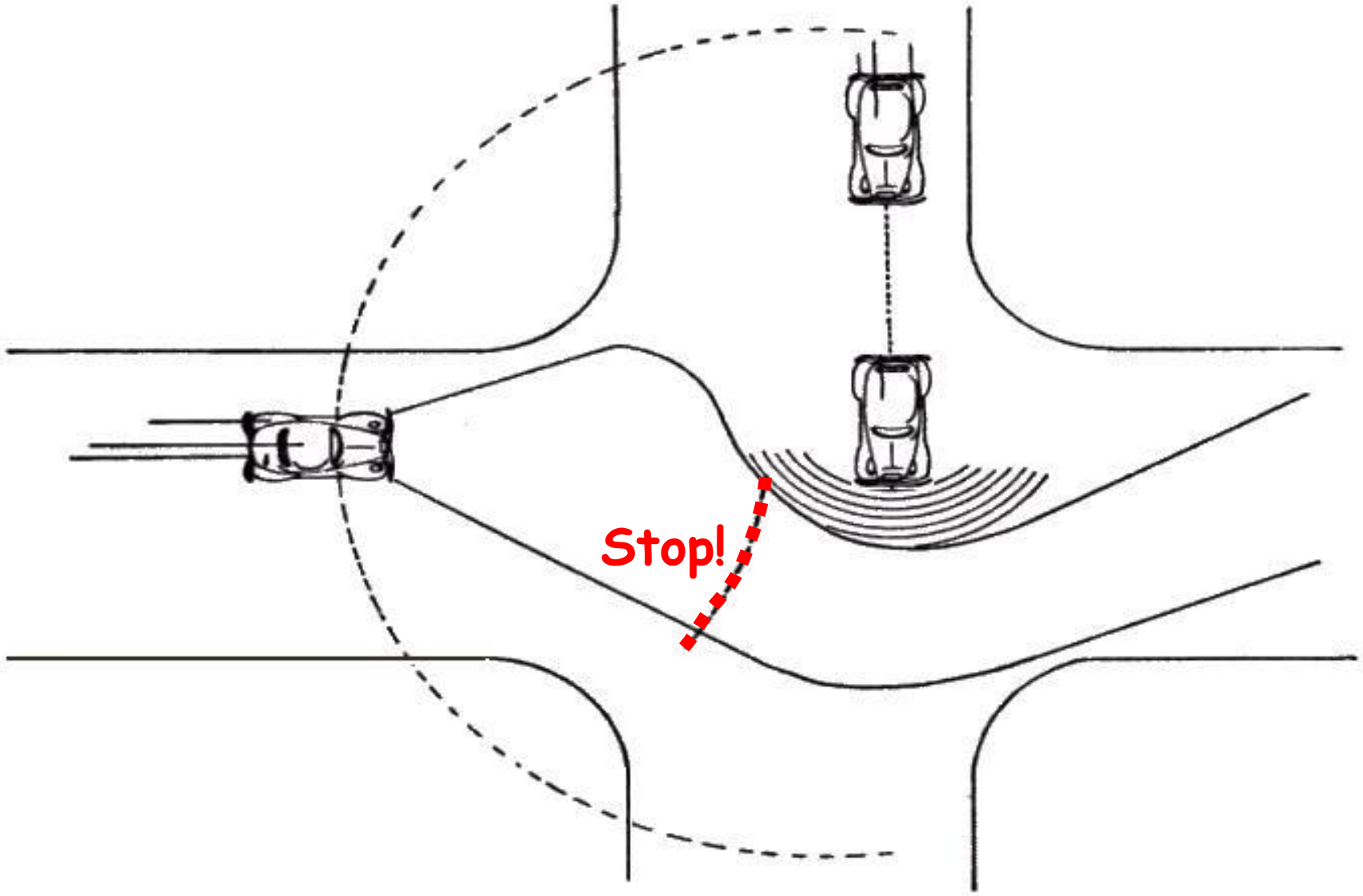
  the **“affordance properties”** of the environment or…

  “affordances”


OPTIC
FLOW



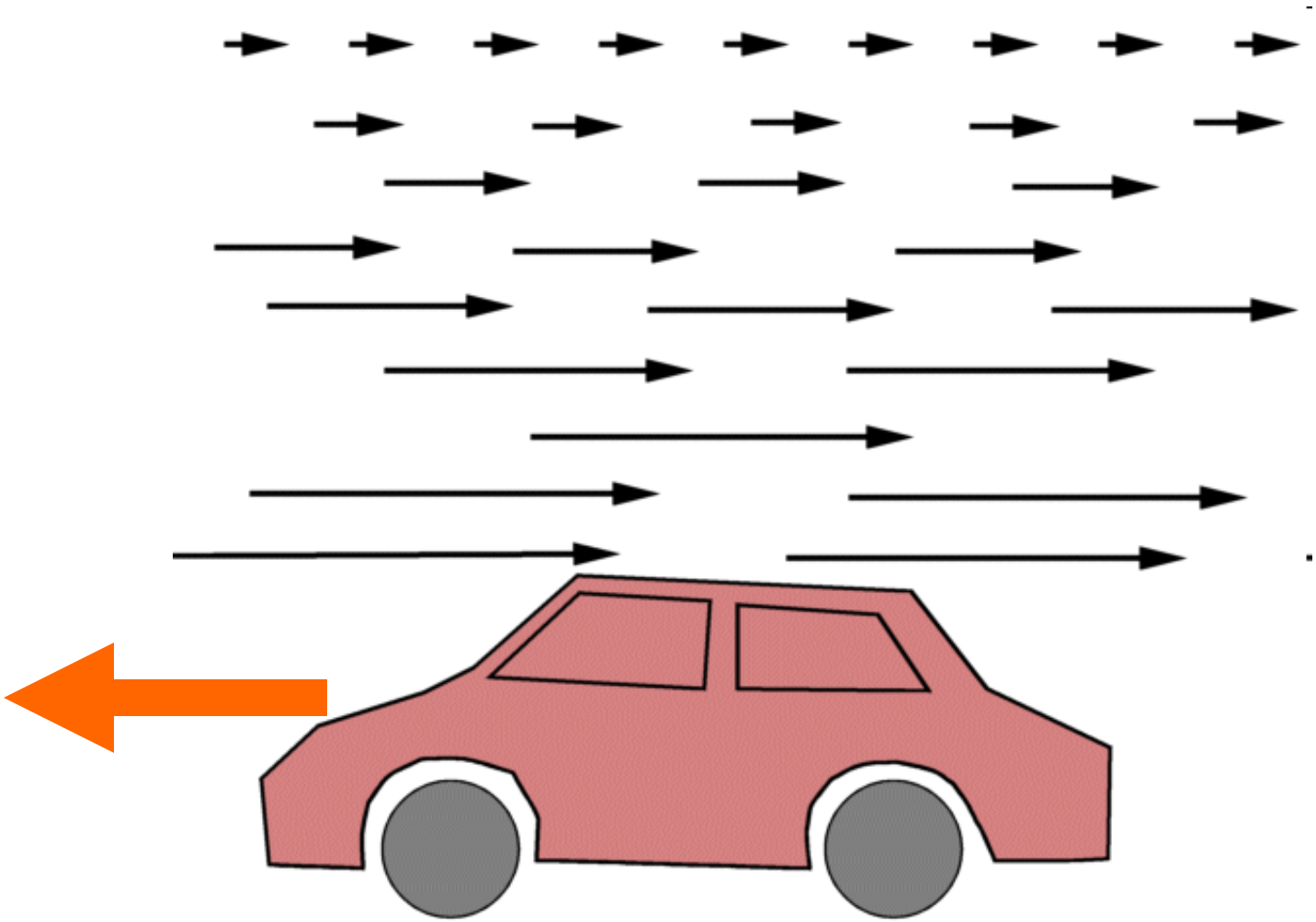
Gibson, J. J., & Crooks, L. E. (1938). A theoretical field-analysis of automobile driving*. American Journal of Psychology, 51,* 453-471.



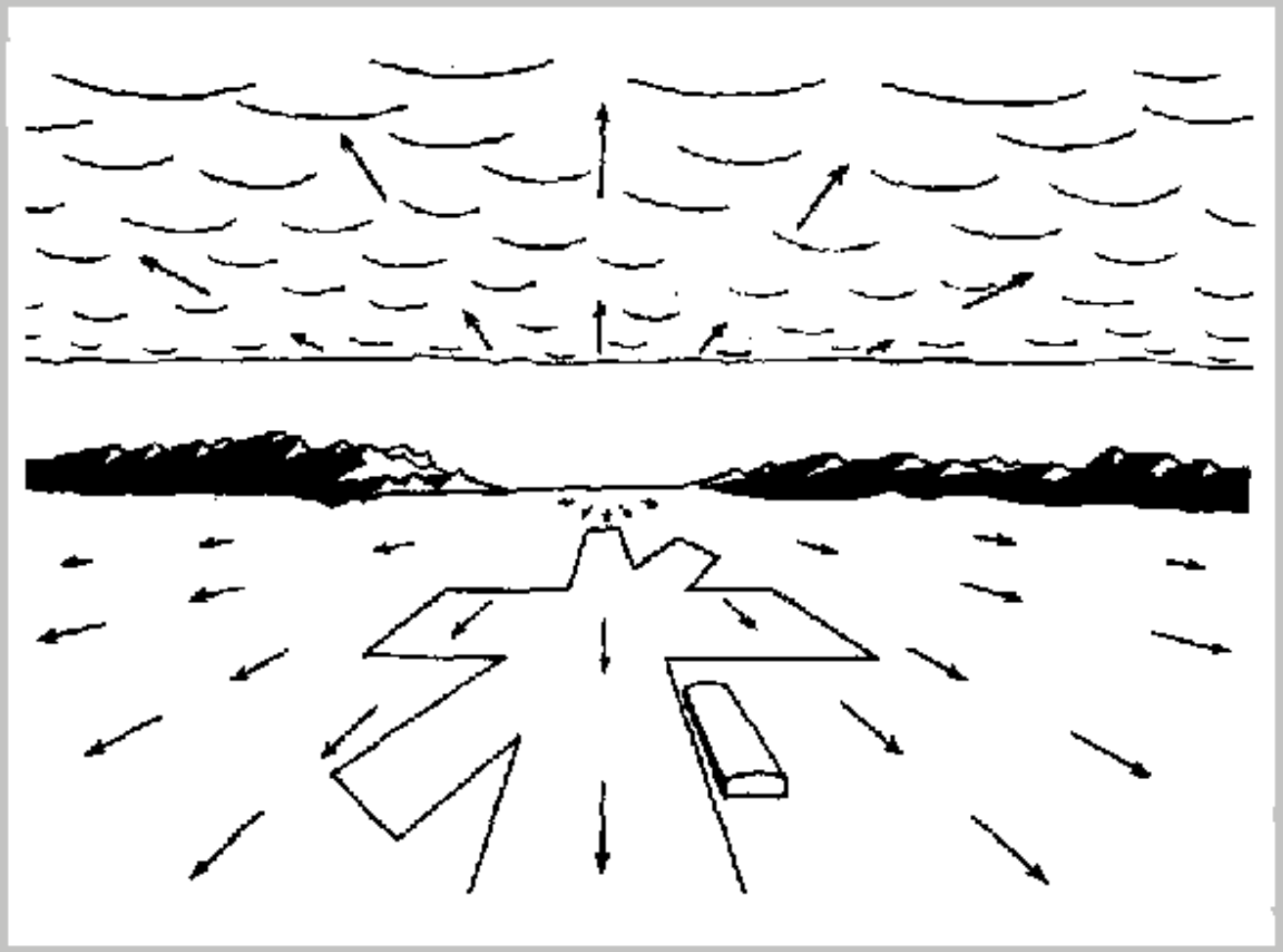
Gibson, J. J., & Crooks, L. E. (1938). A theoretical field-analysis of automobile driving*. American Journal of Psychology, 51,* 453-471.

Motion parallax (looking sideways)

Gibson (1950)

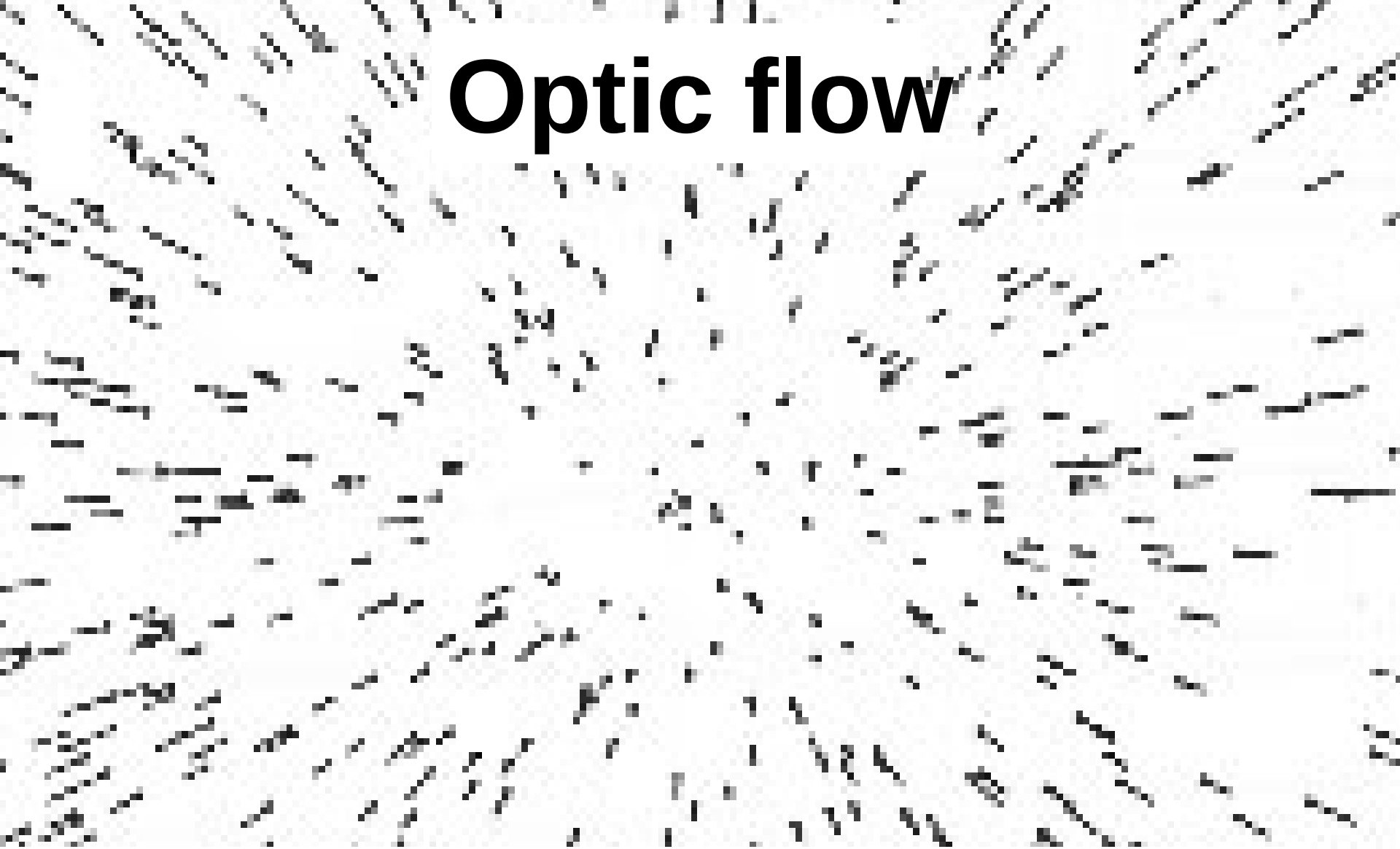


Optic flow



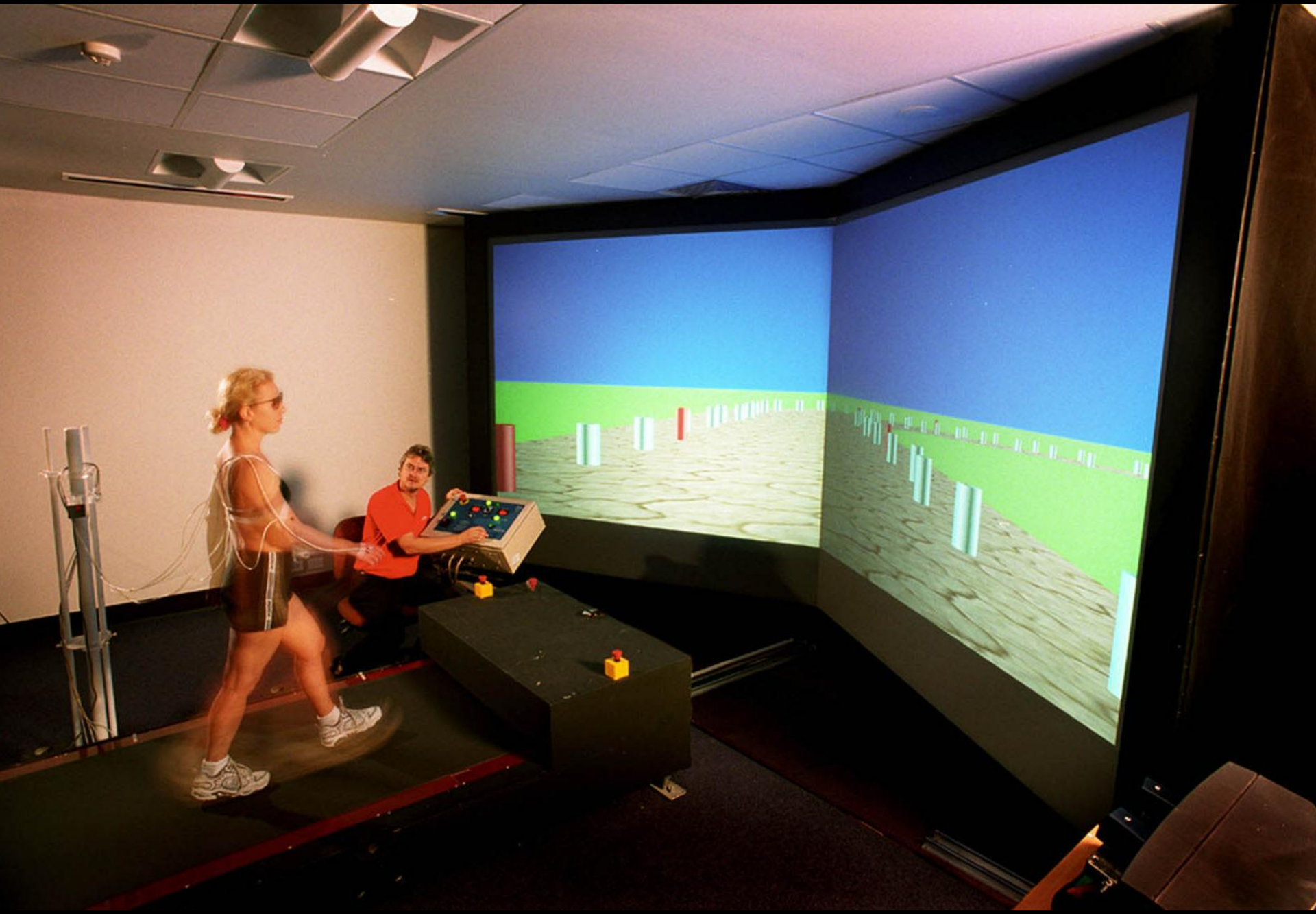
idealised flowfield (after Gibson, 1950)

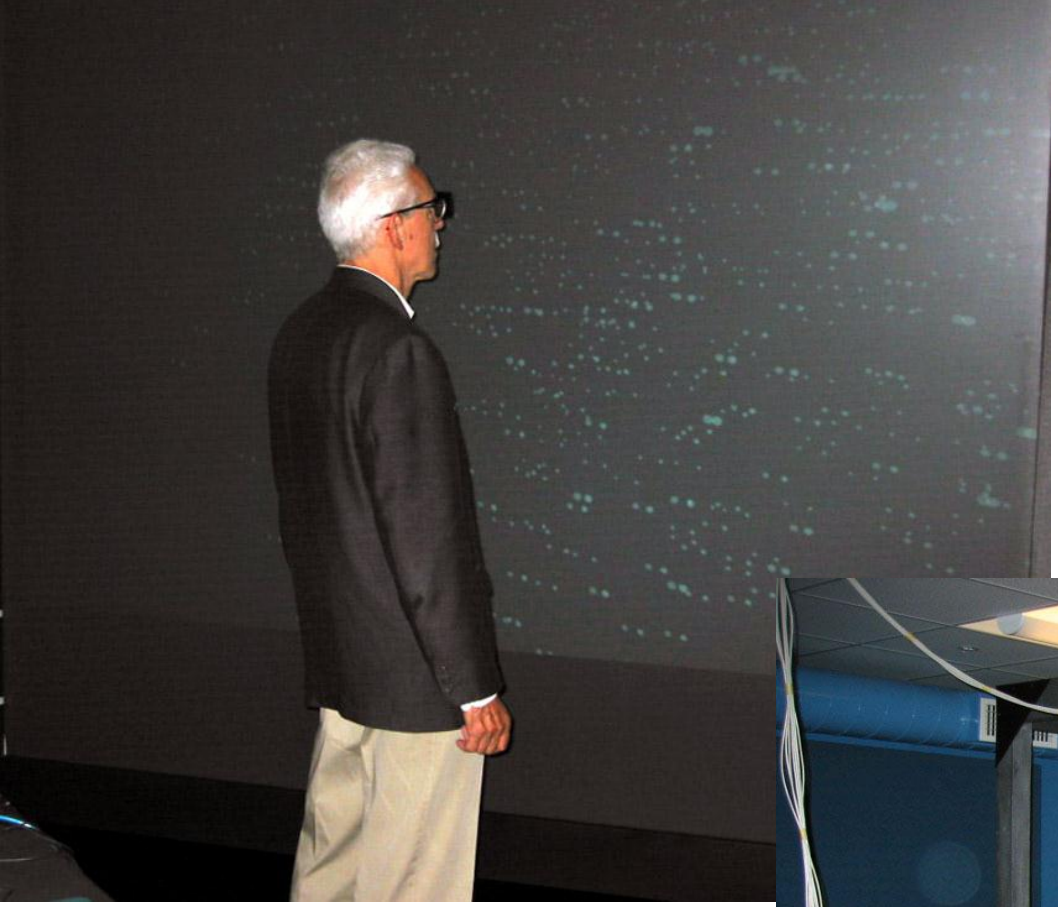
Optic flow



Specifies: direction of heading and *self-motion*

Clip: http://www.youtube.com/user/PMAResearchCentre#p/u/6/xTCNBt1OsIU

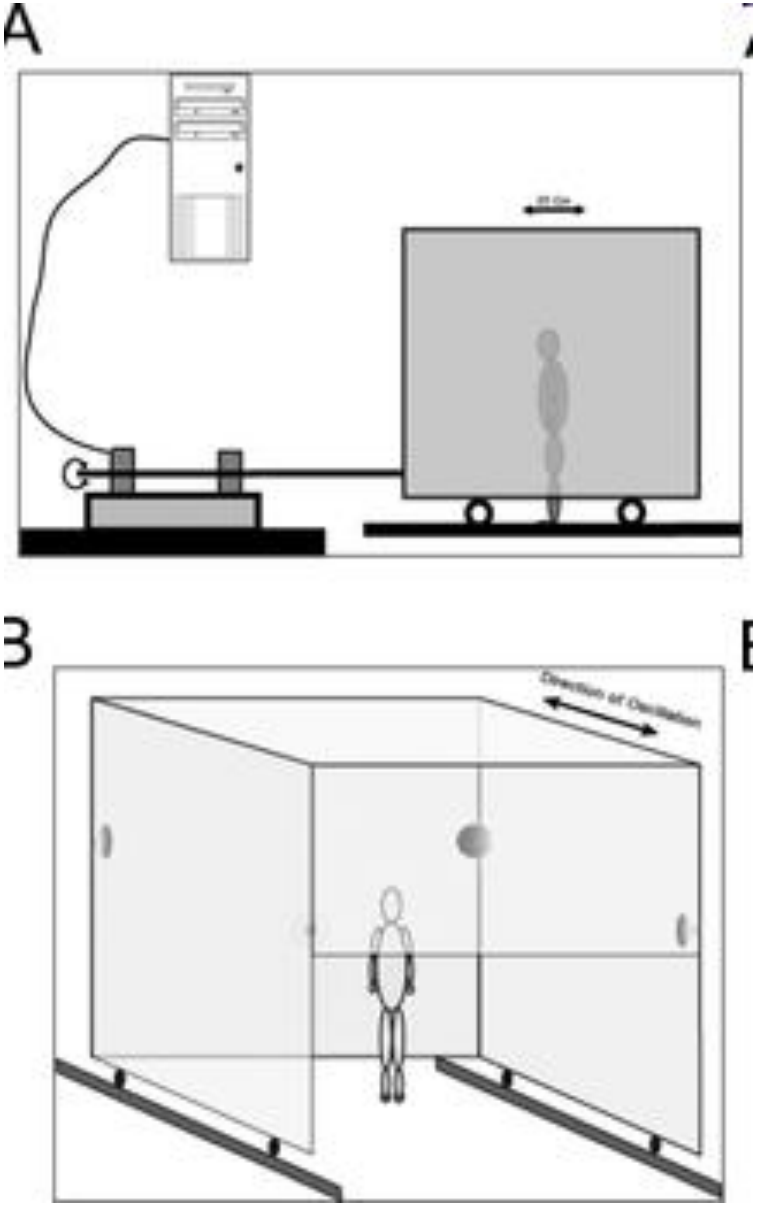




CAV lab
2003

The moving room

- David Lee (1975) optic flow experiment;
- How important is global optic flow for ***lawfully specifying*** your balance?
- Toddlers in room stand as room is moved…
  global optic flow…
  expansion/contraction…
- Optic information specifies SELF-MOTION (egomotion)



Clip on moving room experiment (2:08):

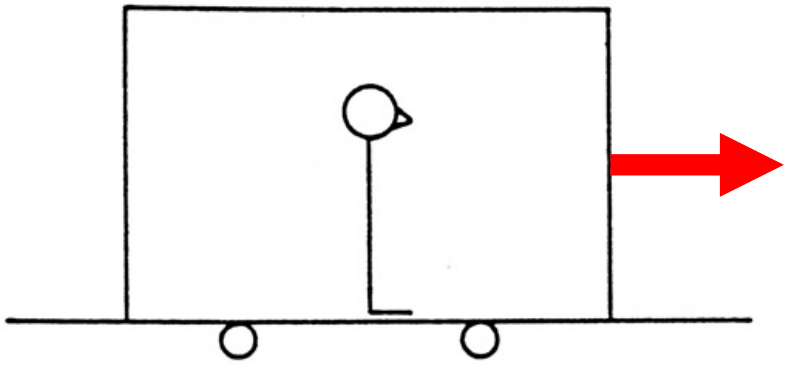
http://www.youtube.com/watch?v=NTVtmUJeInY

Shorter version (0:28):

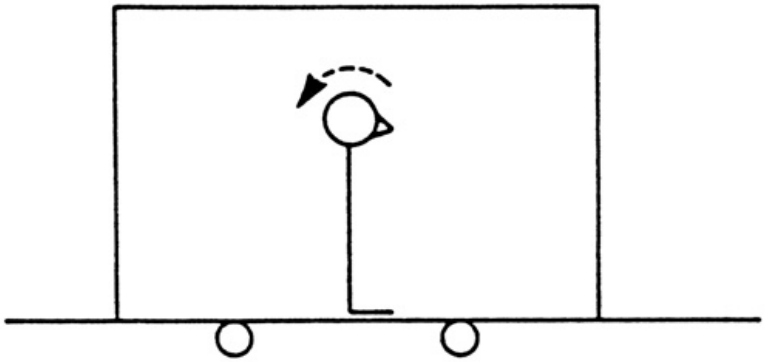
http://www.youtube.com/watch?v=RJrEnK8tQxc

Egomotion:
Self-perception

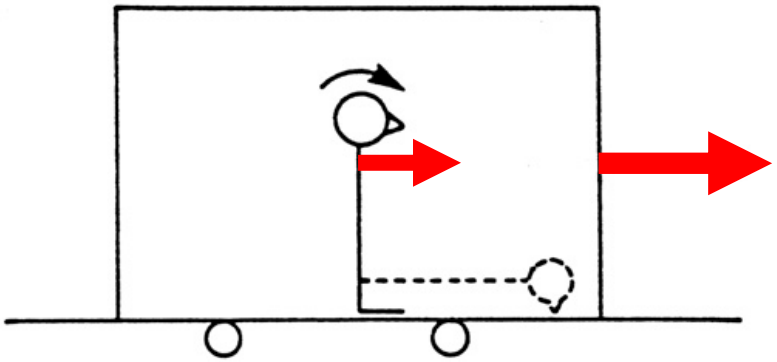
Room is moved forward (without me knowing it)



***To me it looks as if* I am *falling backwards* (optic contraction).**



So I lean forwards to try to keep balanced. But I don't really need to as I have *not really* been leaning backwards (it only *looks* that way)…so I over-compensate and fall forwards!



Gibson on objectivity / subjectivity: the "ecological self" and reality:

An important fact about the affordances of the environment is that they are in a sense objective, real, and physical, unlike values and meanings, which are supposed to be subjective, phenomenal, and mental. But actually, an affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. An affordance points both ways, to the environment and to the observer. (Gibson, 1979, p. 129).

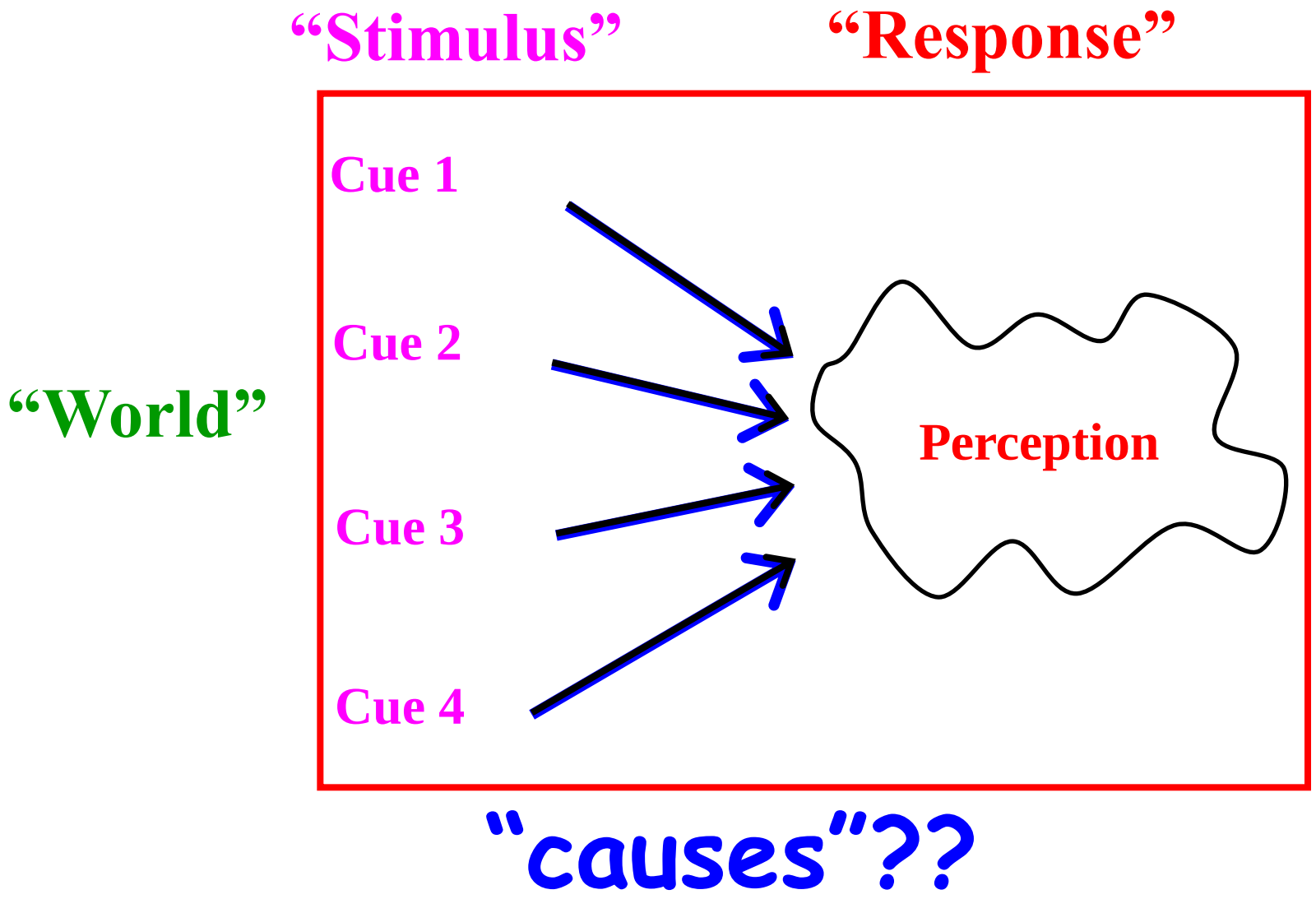
Egomotion: the "ecological self" in action
Affordances: the "ecological self" in perception

Affordances in AI? No. But getting there??

- Honda's "Asimo" (2000) (8:26)
  - http://www.youtube.com/watch?v=Q3C5sc8b3xM&feature=related
  - Early success (2000) in robotics.
- Sony's "dancing robots" (3:26)
  - Clip: http://www.youtube.com/watch?v=9vwZ5FQEUFg
  - Perceptual coordination? No! Just an illusion! Wireless coordination signals - like clockwork.
- Military robot (2008): "Big Dog"
  http://www.youtube.com/watch?v=W1czBcnX1Ww (3:29)
  http://www.youtube.com/watch?NR=1&v=xqMVg5ixhd0 (1:56)
  - Has to deal in real time with an unpredictable real-world environment.

Pike river coal mine disaster – Australian robot: ***useless!***

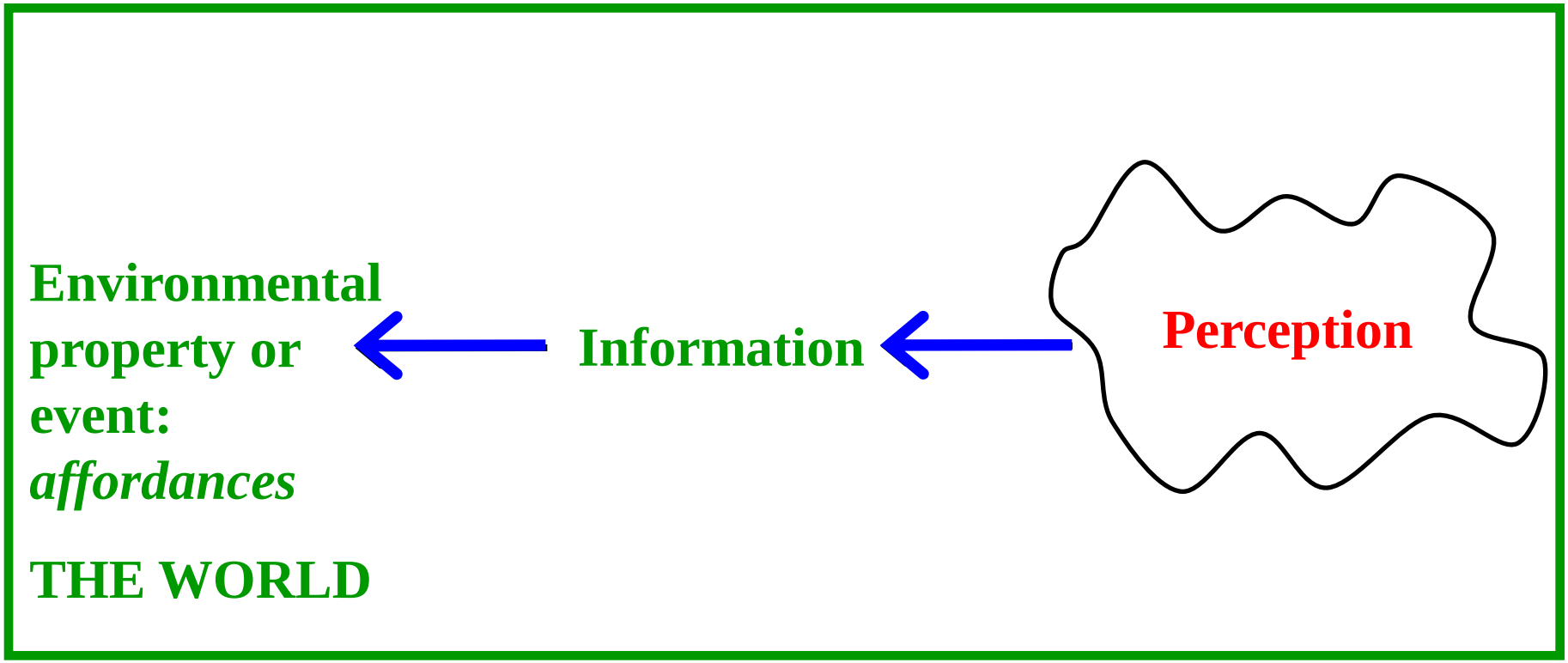
Indirect Perception



"causes"??

Direct Perception

("direct realism" or "ecological approach")



"is lawfully specific to"

Affordances: the *perceived properties* of the environment

- Information is ***detected*…**
- but affordances are ***perceived***

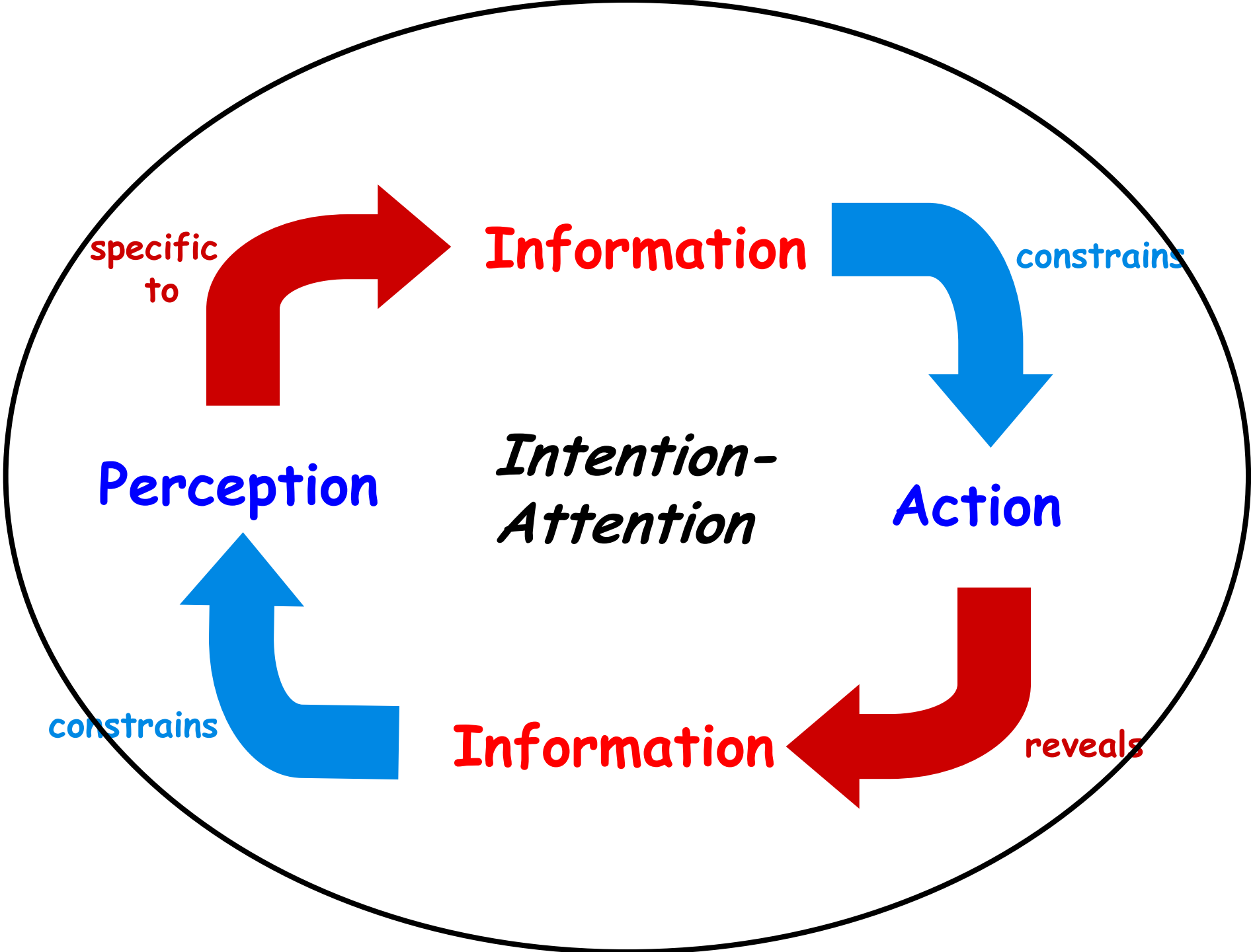
a) If information is specific to the environment

and

b) If perception is specific to information

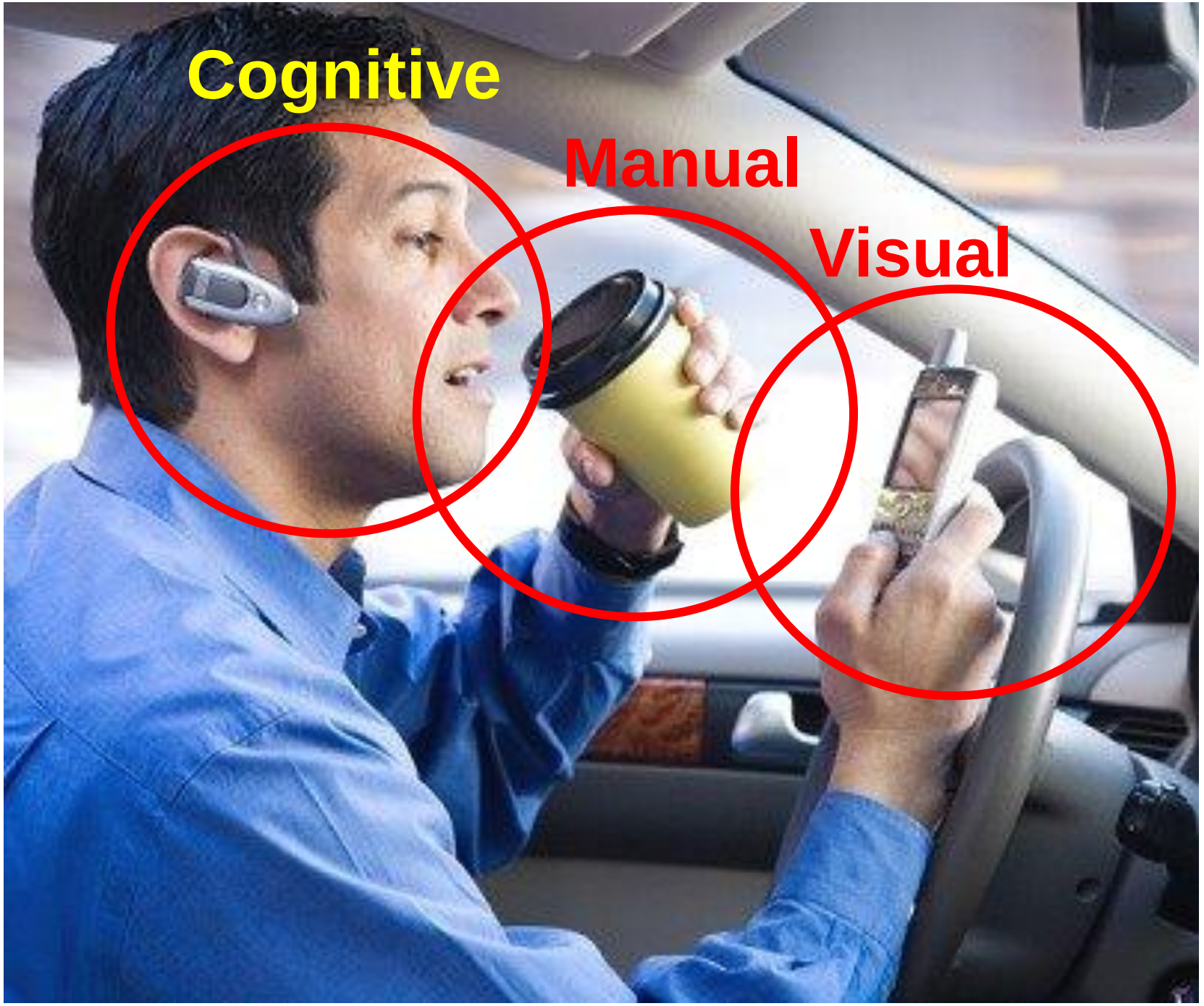
then

c) perception can be specific to the environment

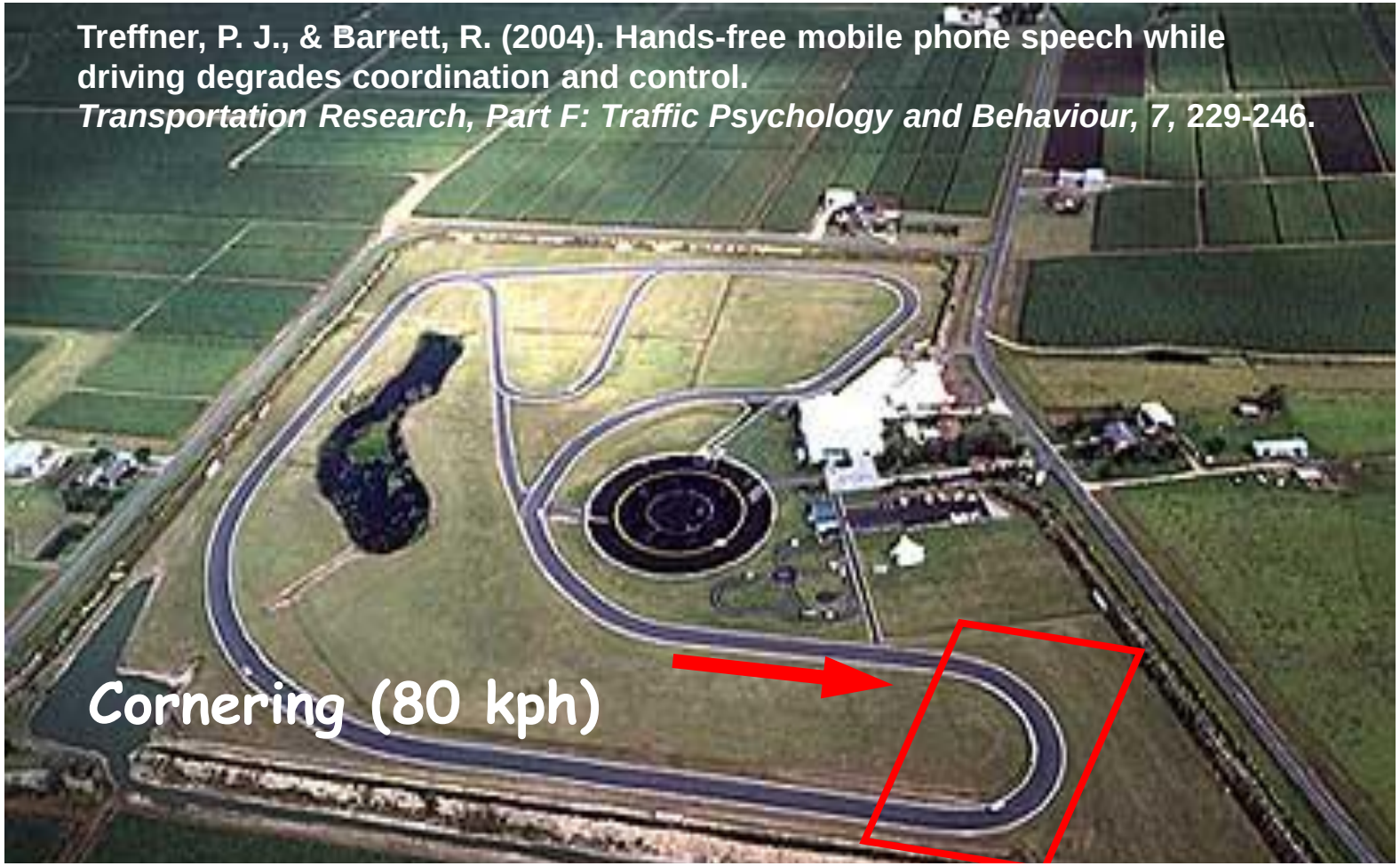

specific to
Information
constrains
Perception
Intention-
Attention
Action
constrains
Information
reveals

Attention is crucial

Change blindness


Cognitive
Manual
Visual

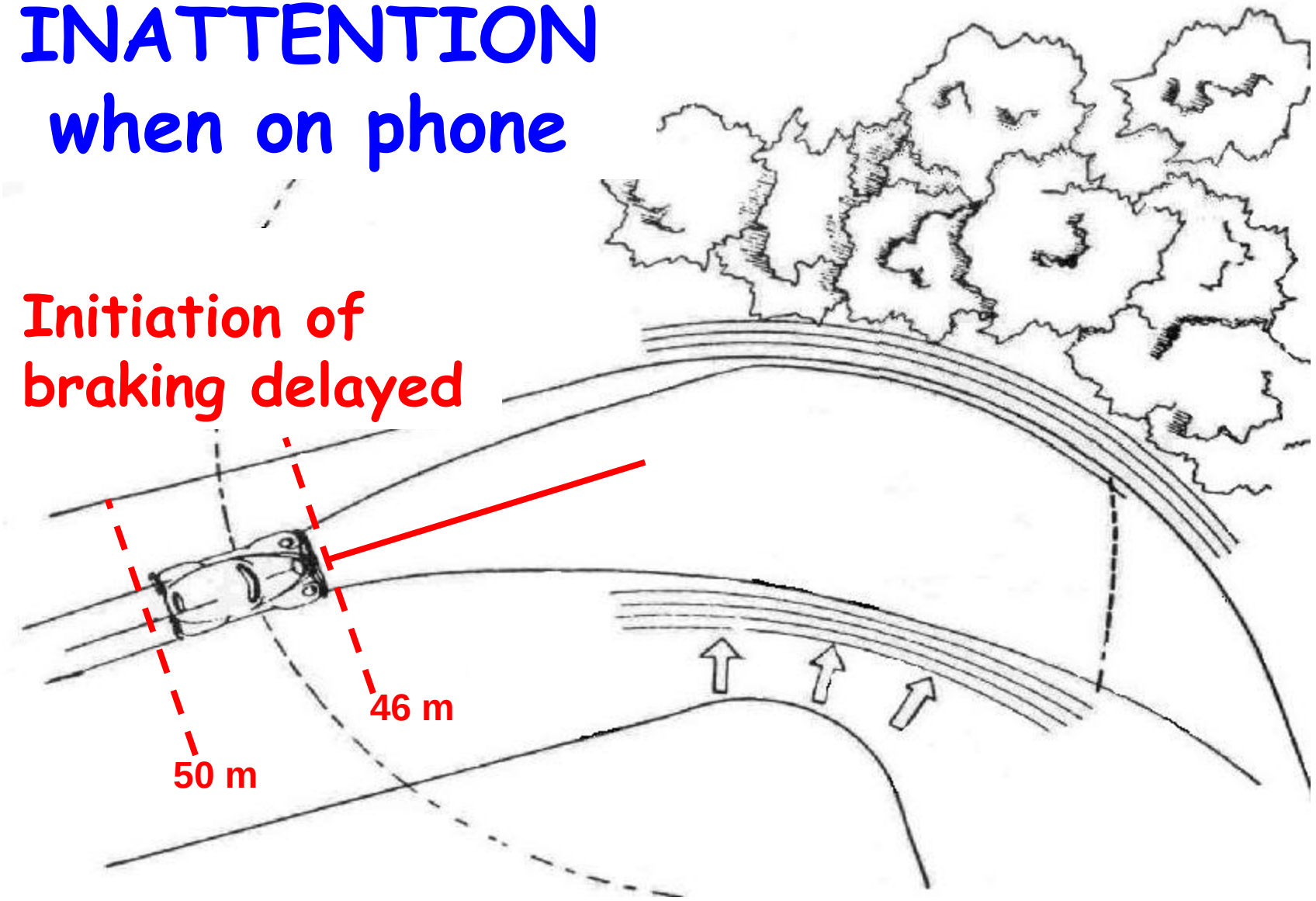
Hands-free mobile phone speech while driving degrades coordination and control



Delay in *initiation* of braking

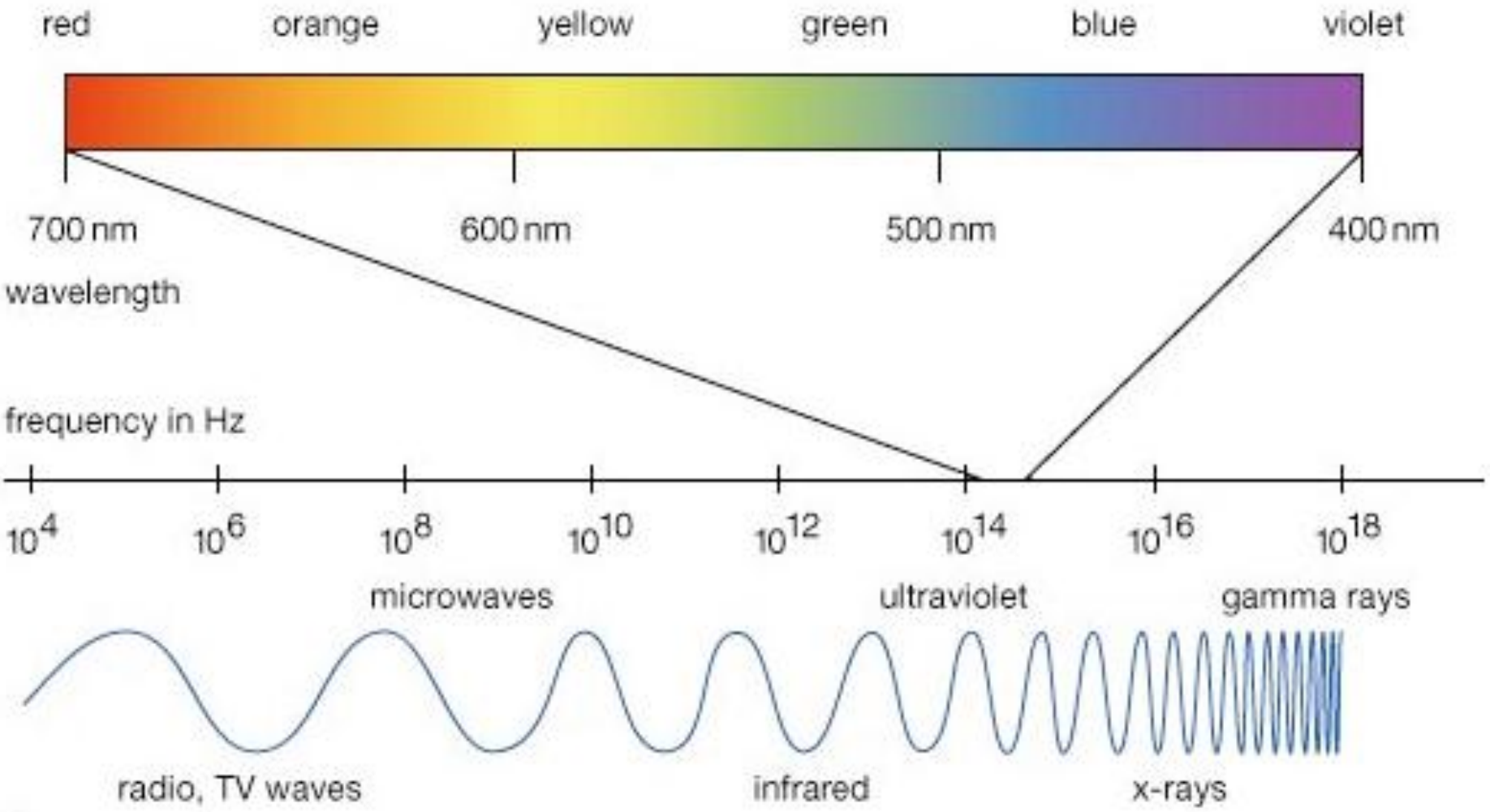
0.2 sec = 4 metres = 1 car length

INATTENTION
when on phone

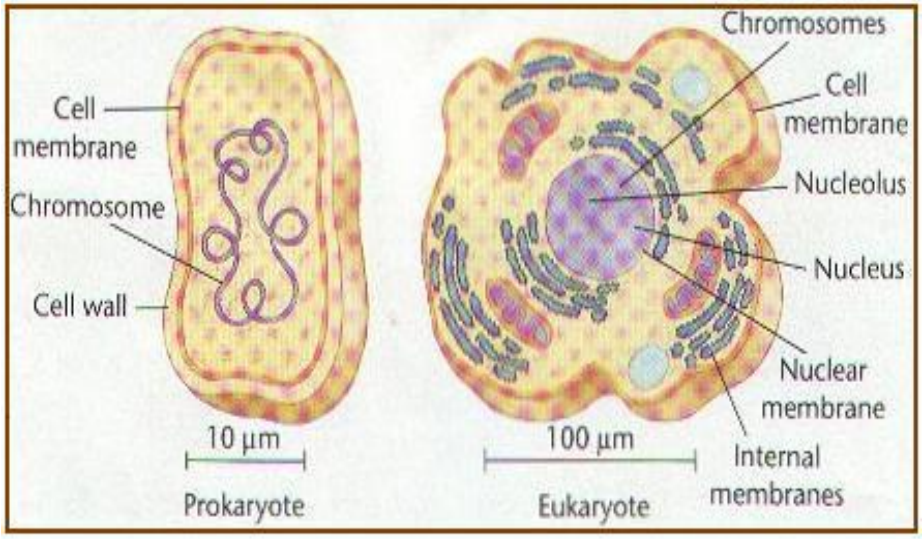


Gibson, J. J., & Crooks, L. E. (1938). A theoretical field-analysis of automobile driving. *American Journal of Psychology, 51,* 453-471.

Subjective “feel” of seeing



Subjective feeling (the “hard problem”) or What *is* seeing?



- Gunther Wachterhauser: origins of life
- Co-evolution photosynthesis & vision
- Photosynthesising organisms: blue-green algae (cyanobacteria – prokaryotes/no nucleus; 2000 mya):
- Phototrophs seek the light - light is their “food”
- Some bacteria (heterotrophs) engulfed (ate) others like them
- *But they did not digest their prey* - preserved them (endosymbiosis) inside to be *used to detect light - new resources* of still more bacteria
- Is light then a “cue” to be “interpreted”? No! *Light directly specifies food*
- Internal organelles *indicate* (resonate) where light is = food
- Cells then develop chloroplasts, nucleus, etc (eukaryotes)
- Perception *is* the *meaningful process of direct awareness* of resources (i.e., it’s all about “food”)
- “Subjective feeling” = *what this dynamical complex system is.*
- http://www.the-rathouse.com/2011/Origin-of-Perception.html

Summary: ecological realism

- Perception is based on *information*, not on sensations. The sensations are mere *side-effects* and irrelevant for an explanation;
- The information for a thing is not the thing…
- The information consists of *higher-order* properties, the *invariants* embedded within the optic array;
- The invariants can be detected by suitably attuned and active perceptual system;
- Information specifies affordances, the *real* opportunities for action in the *real* world.
- 2012: Searle finally acknowledges that Gibson "is on the right track":
  On action: http://www.youtube.com/watch?v=cCp_Y9qF2ok#t=06m08s
  On Gibson: http://www.youtube.com/watch?v=cCp_Y9qF2ok#t=07m18s
  On direct perception: http://www.youtube.com/watch?v=cCp_Y9qF2ok#t=29m20s