

# CS-503 Visual Intelligence: Machines and Minds

Amir Zamir

Lecture 4

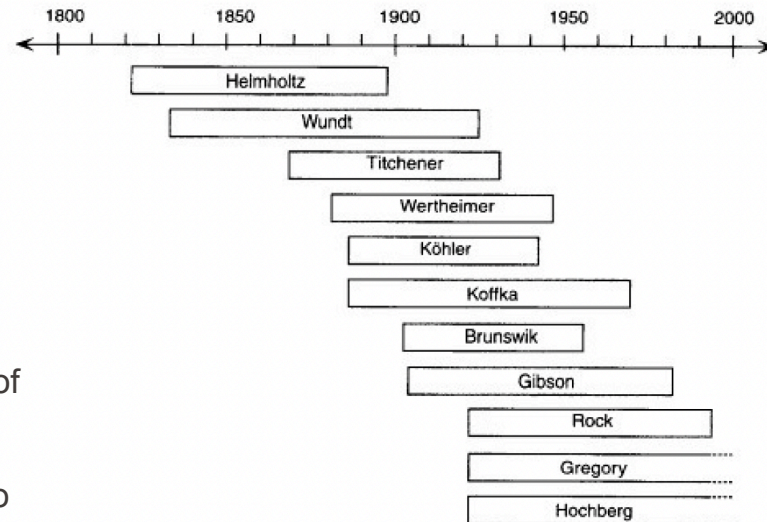
# Logistics

- First assignment notebook due 11/03/2025 23:59 CET.

Week Num.	Date	Item
1	20.02	- lecture 1
2a	25.02	- lecture 2
2b	27.02	- lecture 3
3a	04.03	- lecture 4
3b	06.03	- lecture 5
4a	11.03	- lecture 6 (+ Q&A)
	11.03	- Transformers notebook assignment due
4b	13.03	- lecture 7
5a	18.03	- lecture 8
5b	20.03	- lecture 9
6a	25.03	- lecture 10
6b	27.03	- lecture 11 (+ Q&A)
	01.04	- Active agents notebook assignment due
7a	01.04	- lecture 12
7b	03.04	- lecture 13
8a	08.04	- lecture 14
8b	10.04	- lecture 15 (+ Matchmaking session)
	13.04	- Project proposals due
	15.04	- all subsequent sessions from 15.04 onwards are for Q&A
	18.04	- Project proposals due, when revision is needed.
	22.04	- MidSem break - No classes
	25.04	- MidSem break - No classes
	29.04	- Foundation Models assignment due
	01.05	- lecture 16
	09.05	- Project progress report due
	13.05	- Robustness assignment due (extra credit)
	20.05	- Moodle homework due
	26.05	- Final project presentation video due
	27.05	- Final project presentation Part I
	29.05	- Final project presentation Part II
	30.05	- Project report due

# Classic Vision Theories



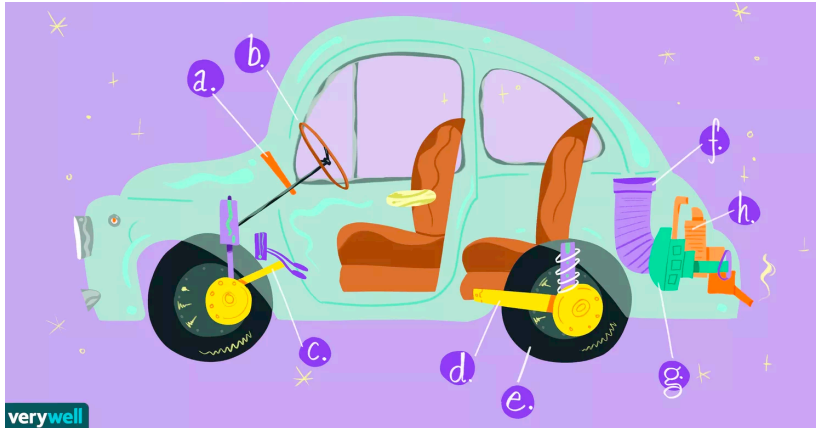


- "You Can't Play 20 Questions with Nature and Win."  
-Allen Newell 1973
- What's a "theory"? An integrated/consistent set of statements/hypotheses about underlying principles of something.
  - That not only organizes and explains known facts (eg existing experimental results), but also makes predictions about new ones.

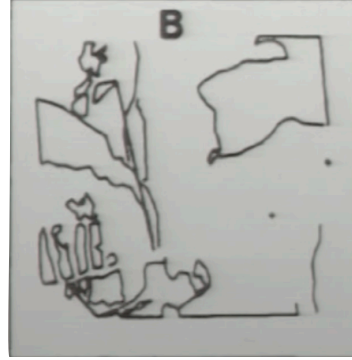
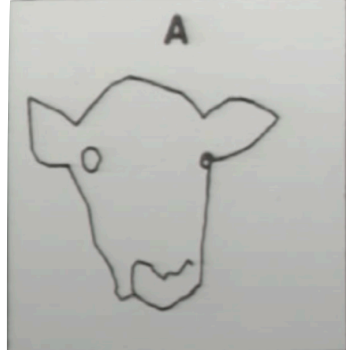
THEORY	NATIVISM vs. EMPIRICISM	ATOMISM vs. HOLISM	ORGANISM vs. ENVIRONMENT	PRINCIPAL ANALOGY	METHOD
Structuralism	Empiricism	Atomism	Organism	Chemistry	Trained Introspection
Gestaltism	Nativism	Holism	Organism	Physical Field Theory	Naive Introspection
Ecological Optics	Nativism	Holism	Environment	Mechanical Resonance	Stimulus Analysis

Wilhelm Wundt

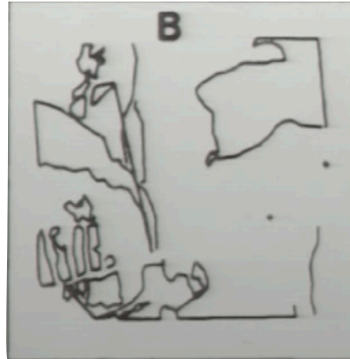
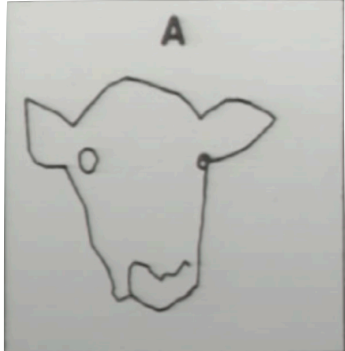
- Inspired by British Empiricists
- Progressive “concatenation” of “sensory atoms”







- Vision has to be more than bottom-up association.



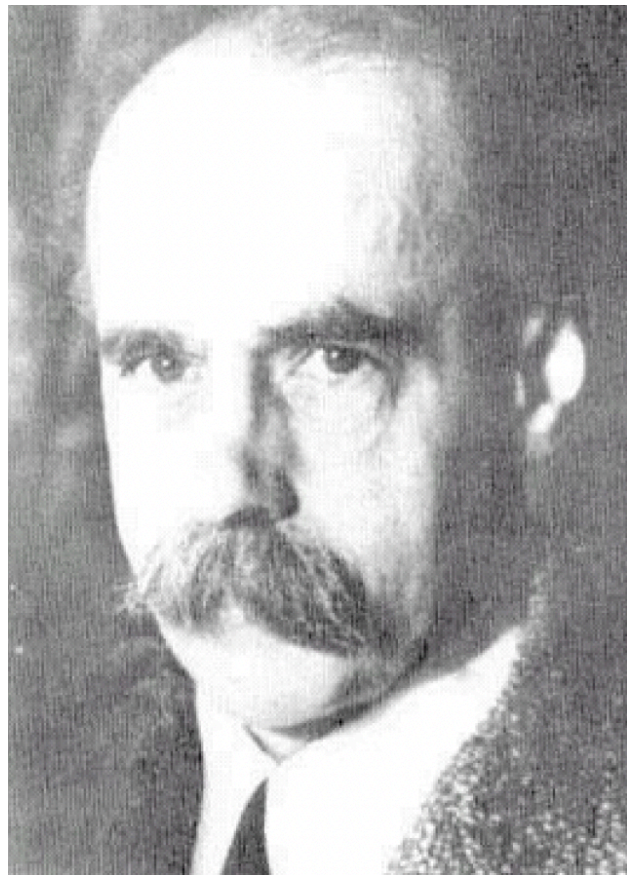
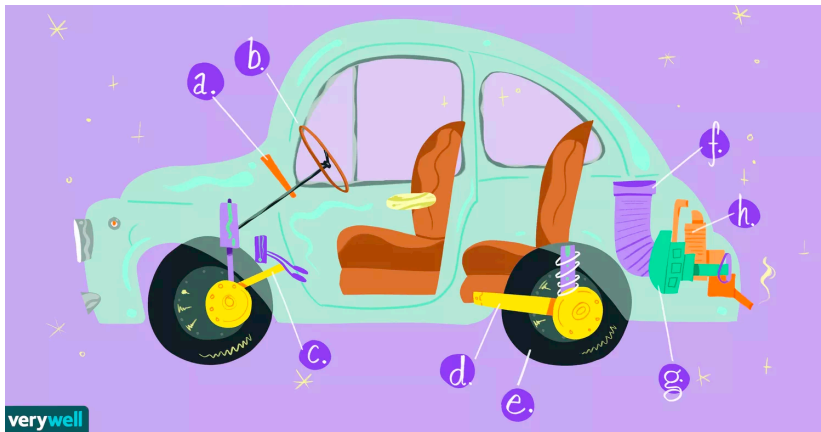


- Vision has to be more than bottom-up association.



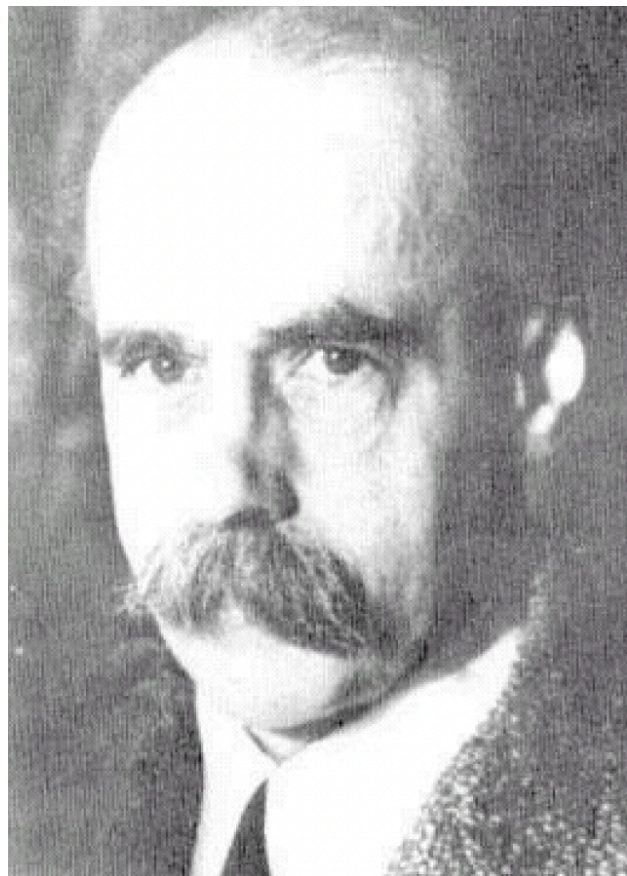
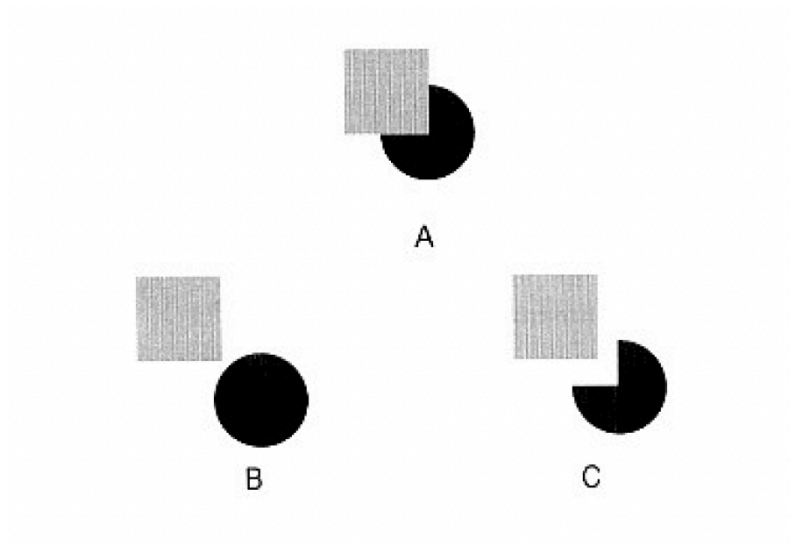
Max Wertheimer

- Wertheimer, Koffka, Kohler
- Whole is more than the sum of parts.

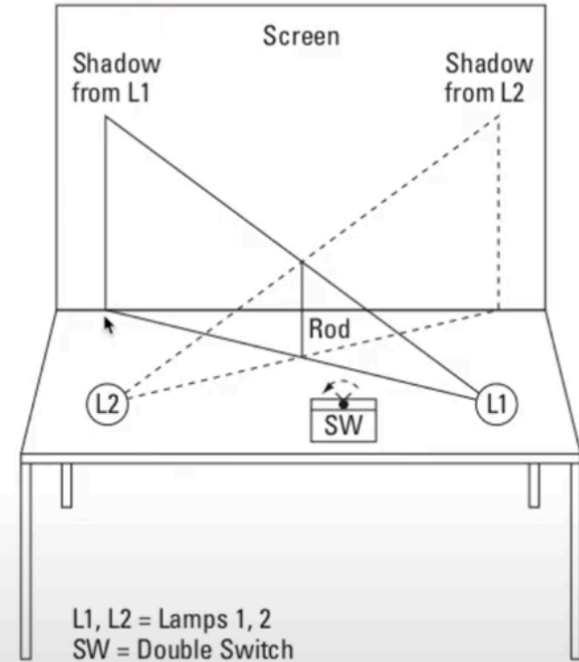


Max Wertheimer

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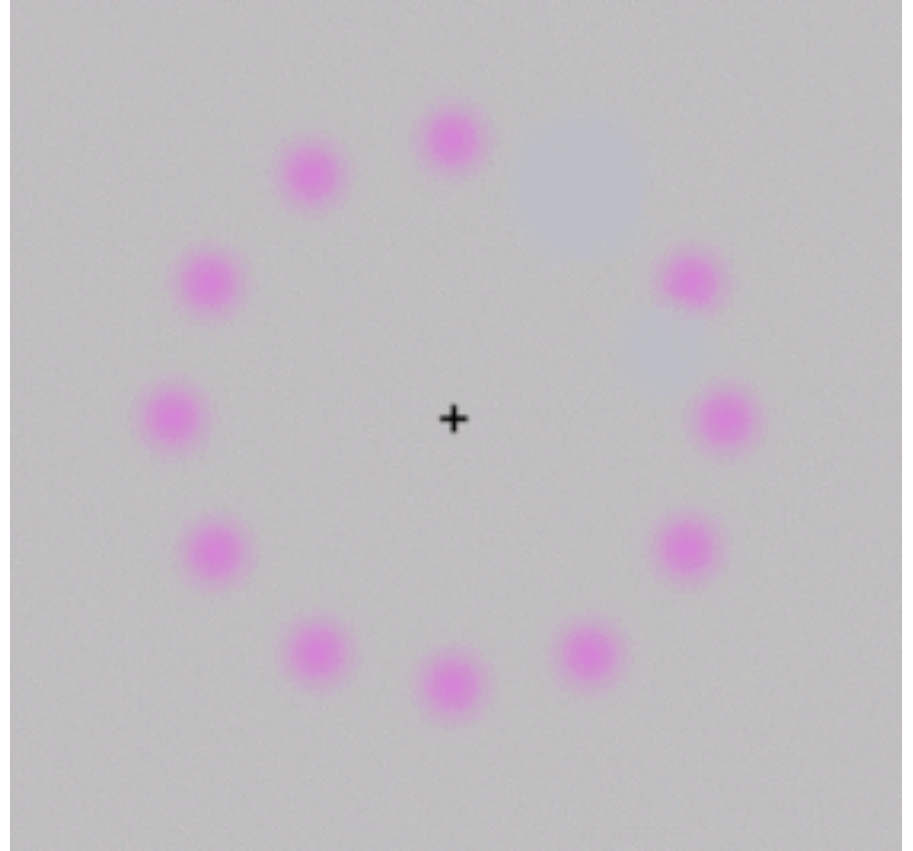
- The Minimum Principle



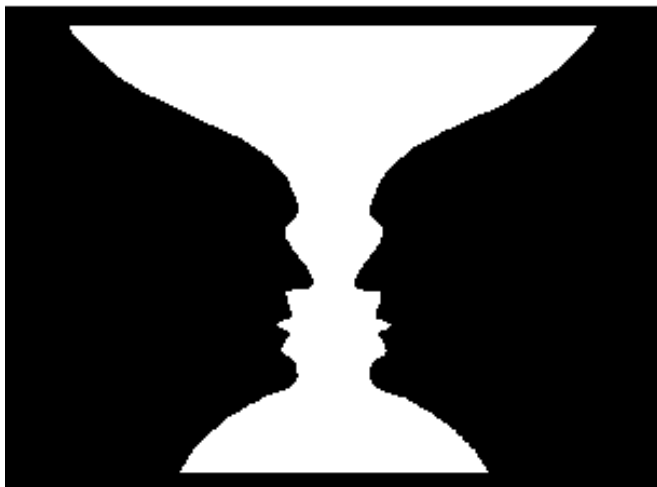
**Figure 10.1** Apparatus to demonstrate apparent motion.

Source: Wolfgang Kohler. *The Task of Gestalt Psychology*. © 1969, 1997 Princeton University Press. Reprinted by permission of Princeton University Press.

- The Minimum Principle







A     •   •   •   •   •   •   •   •

B     ••   ••   ••   ••

Proximity

C     •   •   ○   ○   •   •   ○   ○

Similarity

D



Good Continuation

E



Closure

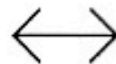
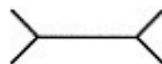
**Figure 10.3** Examples of Gestalt laws of organization.

Source: From *Mind & Language* vol. 5, issue 4 (Dec. 1990), "Modern Theories of Gestalt Perception" by Stephen E. Palmer. Copyright © 2007, John Wiley and Sons.



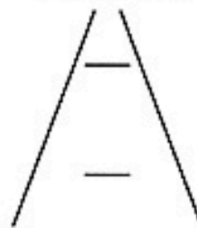
## ■ The Minimum Principle

Which horizontal line is longer?



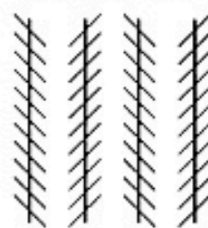
A

Which horizontal line is longer?



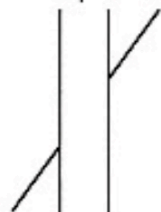
B

Are the long lines parallel or tilted?



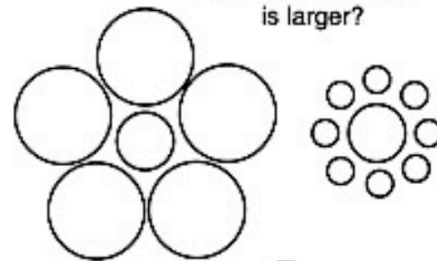
C

Do the diagonal lines line up or not?



D

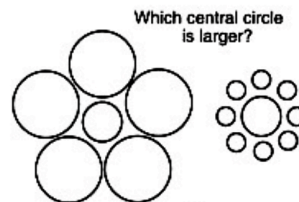
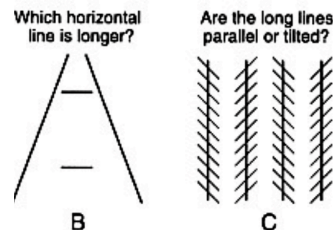
Which central circle is larger?



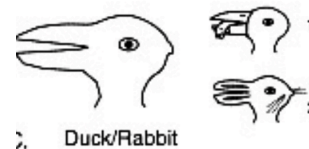
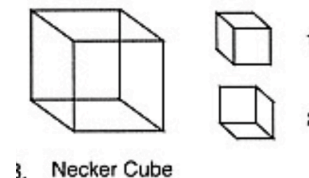
E

- Vision appears to be more than bottom-up association.

According to a research at Cambridge University, it doesn't matter in what order the letters in a word are, the only important thing is that the first and last letter be at the right place. The rest can be a total mess and you can still read it without problem. This is because the human mind does not read every letter by itself, but the word as a whole.

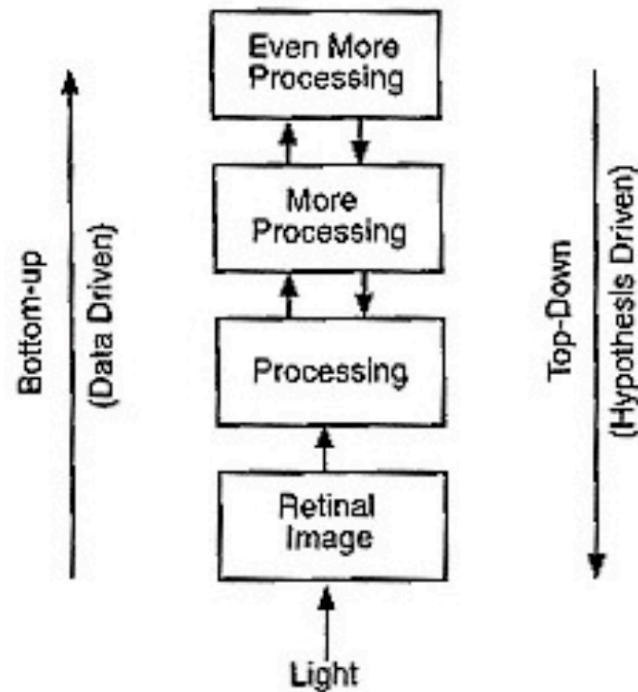


Visual illusion



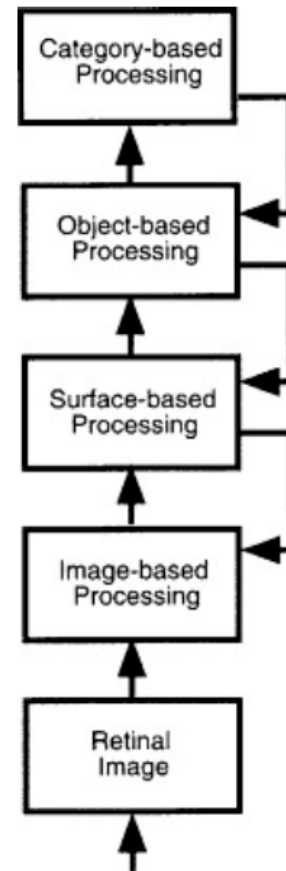
Bi-stable figures

- Vision appears to be more than bottom-up association.





- Vision appears to be more than bottom-up association.



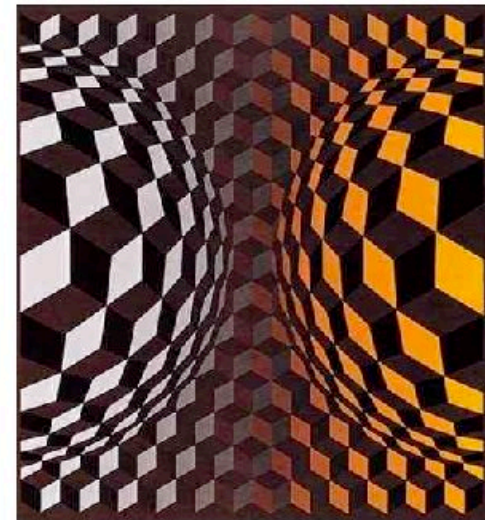
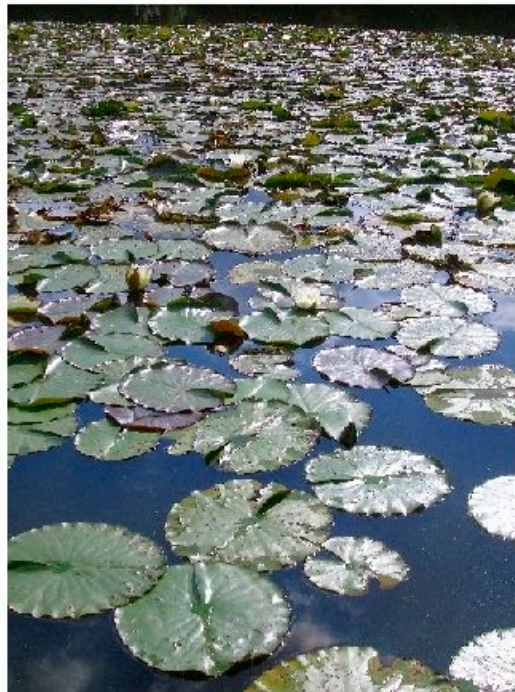
- Gibson: “Ask not what's inside your head, but what your head's inside” (Mace, 1977)

James J Gibson

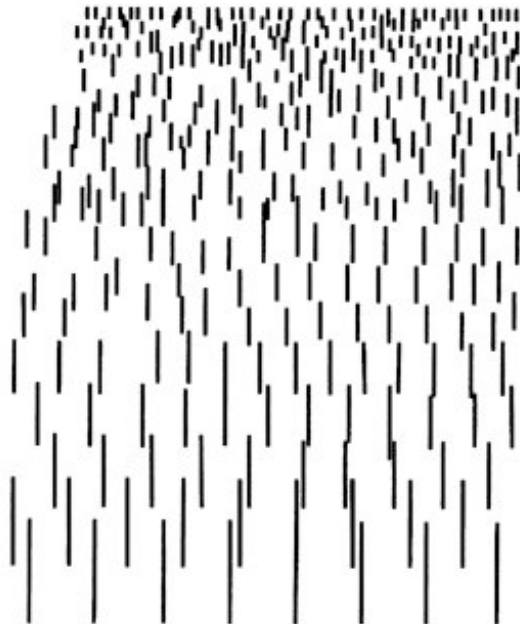
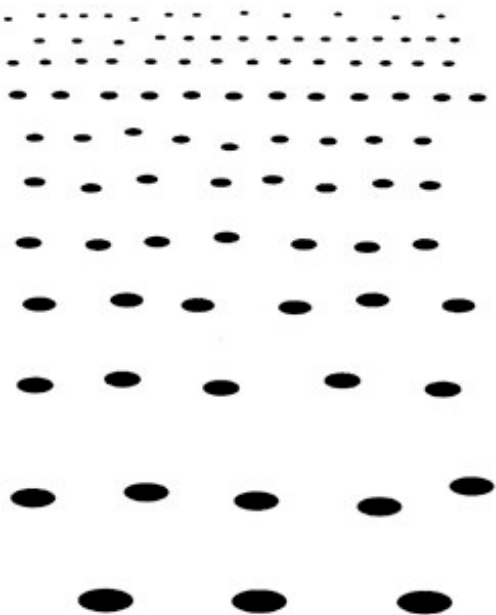


# EPFL Ecological Approach

- Motion and environment.
- Texture Gradient

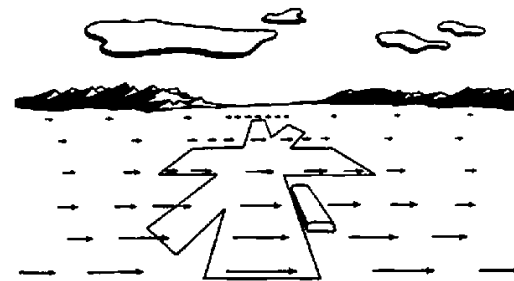
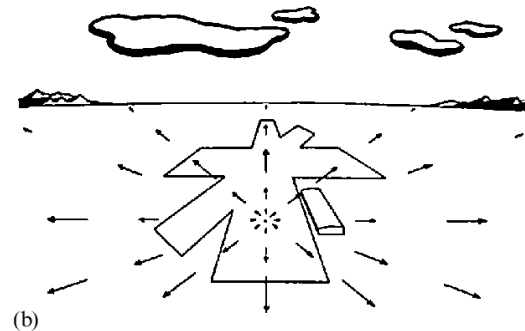
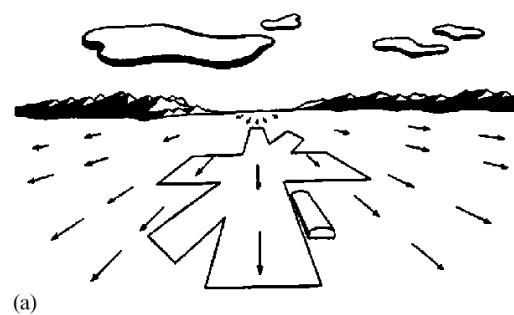


- Motion and environment.
- Texture Gradient



# EPFL Ecological Approach

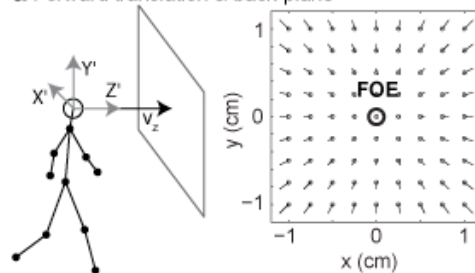
- Motion and environment.



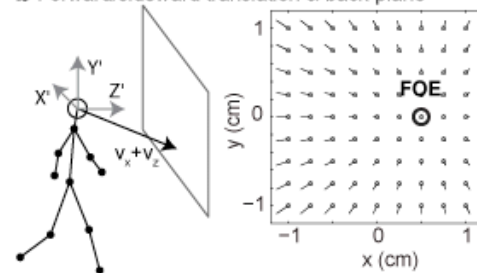


- Motion and environment.

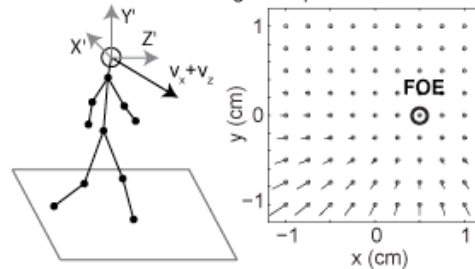
**a** Forward translation & back-plane



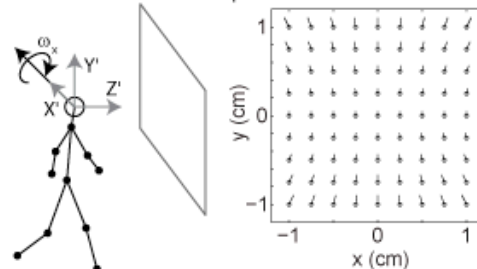
**b** Forward/sideward translation & back-plane



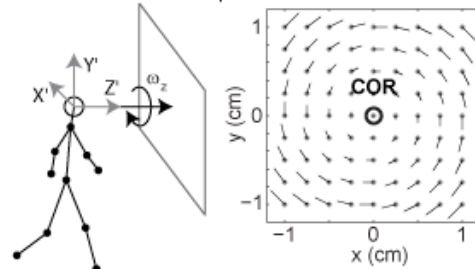
**c** Forward translation & ground-plane



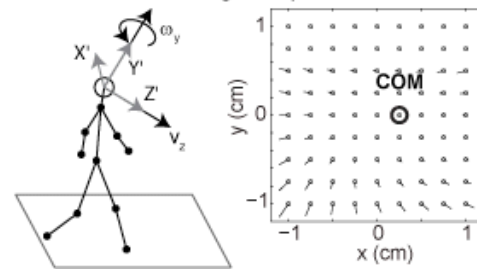
**d** Pitch rotation & back-plane



**e** Roll rotation & back-plane



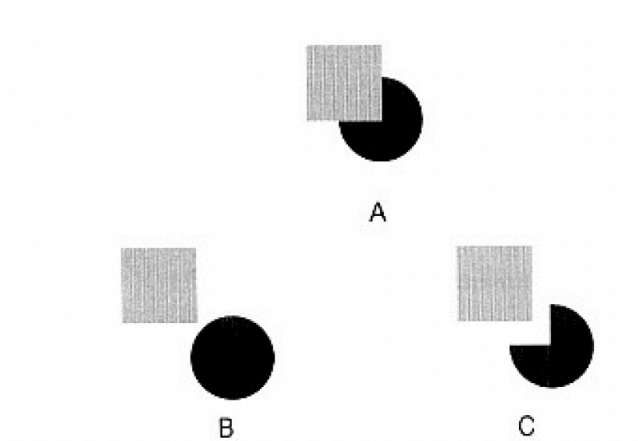
**f** Curvilinear motion & ground-plane



# EPFL Ecological Approach

- Gibson's **Direct Perception**:
  - he assumed sufficient information was available in the stimuli.

- Vision:
  - an indeterminate inverse problem from retinal images.
  - a “reconstruction” of the reality.
- Something other than retinal images needed.
- Likelihood Principle



Herman Helmholtz



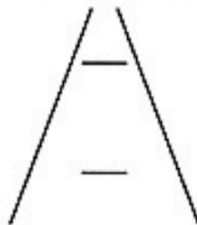
- Vision:
  - an **indeterminate** inverse problem from retinal images.
  - a “reconstruction” of the reality.
- Something other than retinal images needed.
- **Likelihood Principle**
  - Vs minimum principle
  - Brings environment and statistics in.
- “**Unconscious** inference”
- “**Heuristic** Interpretation”

Which horizontal line is longer?



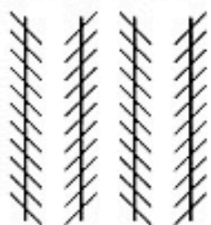
A

Which horizontal line is longer?



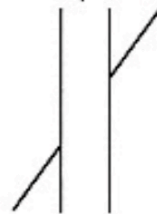
B

Are the long lines parallel or tilted?



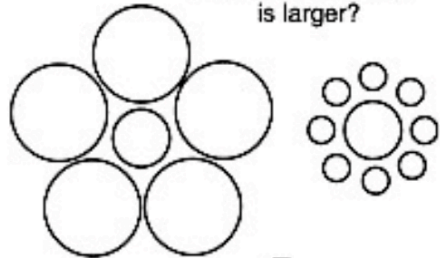
C

Do the diagonal lines line up or not?

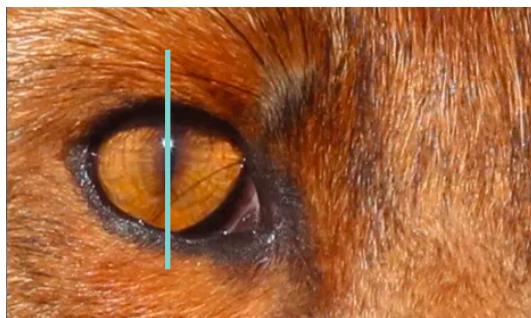


D

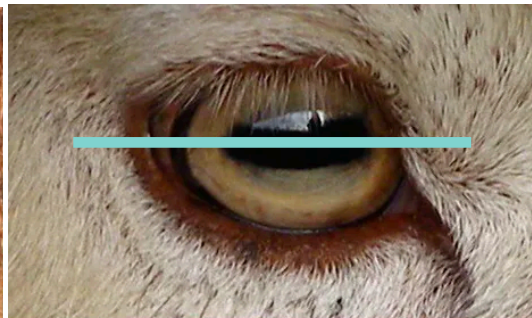
Which central circle is larger?



E



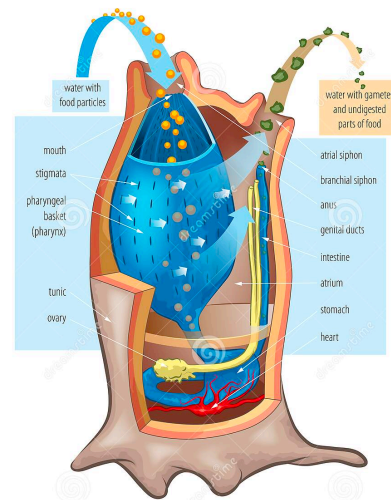
**Predator**



**Prey**

M. Bank et al., 2015.

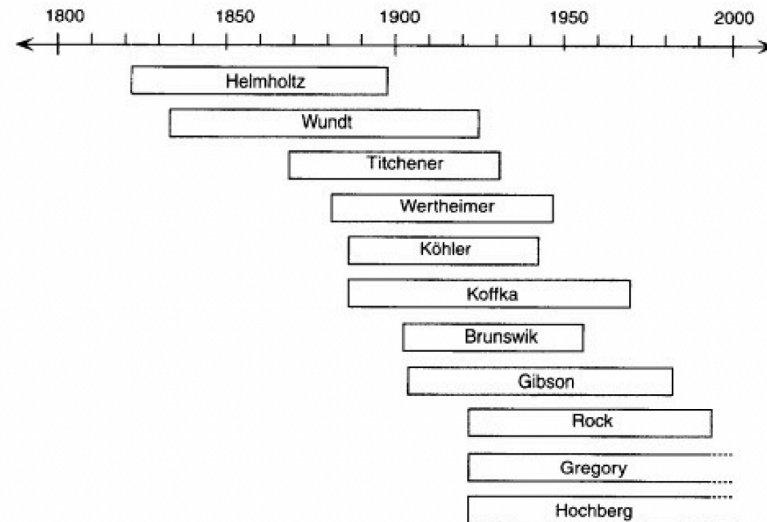
Sea Squirt





- A useful reconstruction of the world in a bottom-up and top-down way.
  - “Feedback” in modeling and inference.

# EPFL Vision theories



THEORY	NATIVISM vs. EMPIRICISM	ATOMISM vs. HOLISM	ORGANISM vs. ENVIRONMENT	PRINCIPAL ANALOGY	METHOD
Structuralism	Empiricism	Atomism	Organism	Chemistry	Trained Introspection
Gestaltism	Nativism	Holism	Organism	Physical Field Theory	Naive Introspection
Ecological Optics	Nativism	Holism	Environment	Mechanical Resonance	Stimulus Analysis

# Enjoy the Course!

<https://vilab.epfl.ch/>