



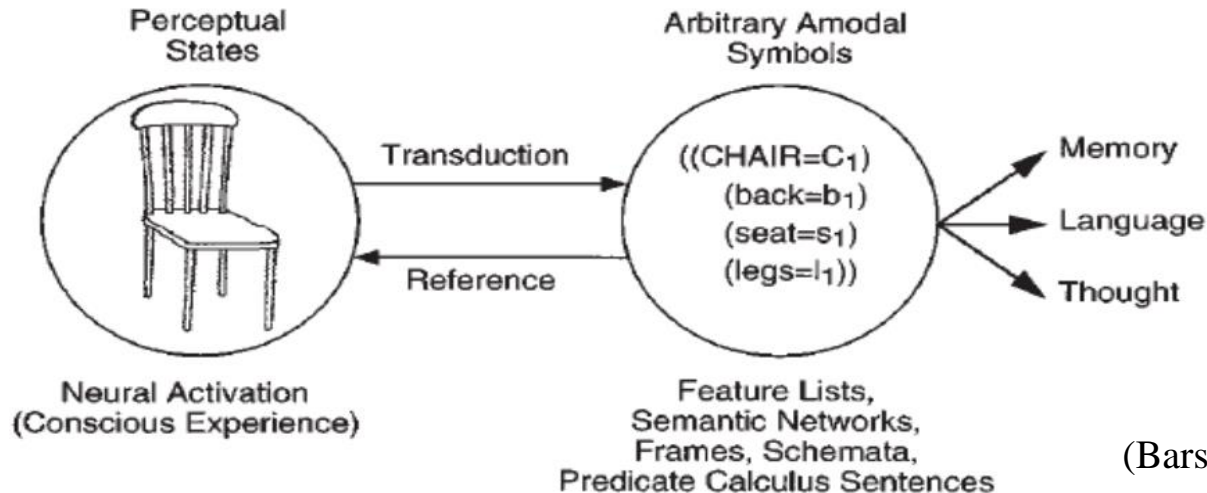
Introduction to cognitive science

Session 7: Embodiment and Situated Cognition

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Amodal conceptual representations

2

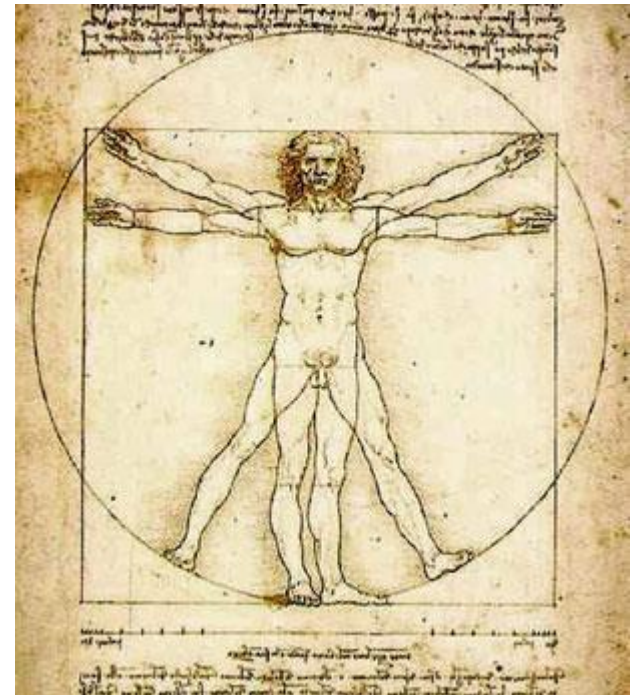


- **Basic assumption:** Internal (cognitive) structure does not resemble the perceptual states from which they originate.
- E.g., amodal representation of the colour of an object in the absence of that object is located in a different neural system from the representations of that colour during the process of perception.

Grounded cognition

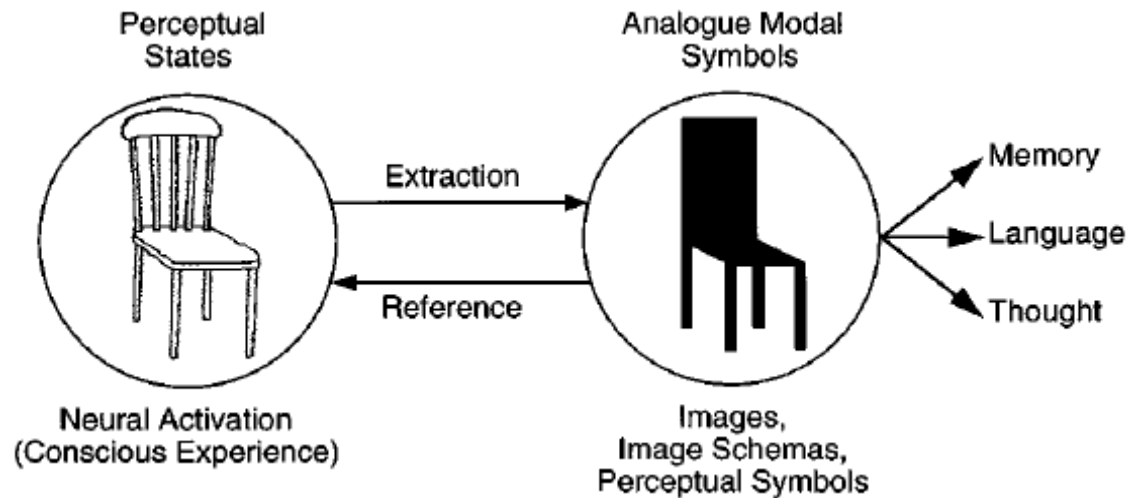
3

- Nature of the human mind is largely determined by the form of the **human body**
- **Cognition arises from bodily interactions with the world**
- Cognition shares the same mechanisms with **perception, action and introspection**
 - **Senses**
 - **Effectors**
 - **Environment**
- Rejects that **amodal symbols** represent knowledge



Perceptual symbol systems

4



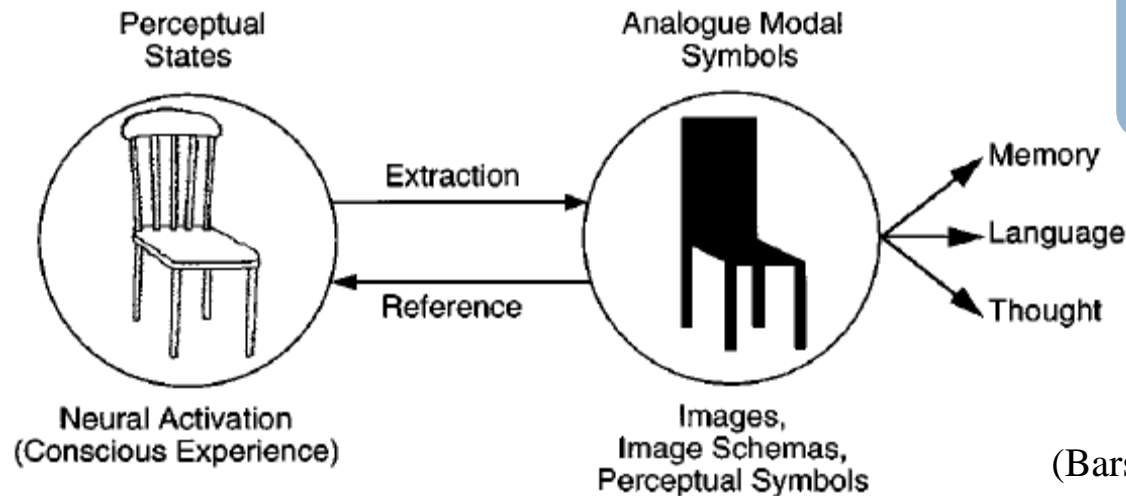
■ Simulation

- A core form of computation in the brain
- Reenactment of perceptual, motor and introspective states acquired during experience
- As experience occurs, the brain captures the states across modalities and integrates them with a **multimodal representation** stored in memory

Perceptual symbol systems

internal structure of these symbols is **modal**

they are analogically related to the **perceptual states that produced them**



(Barsalou, 1999)

■ Simulation

- A core form of computation in the brain
- Reenactment of perceptual, motor and introspective states acquired during experience
- As experience occurs, the brain captures the states across modalities and integrates them with a **multimodal representation** stored in memory

Categorization

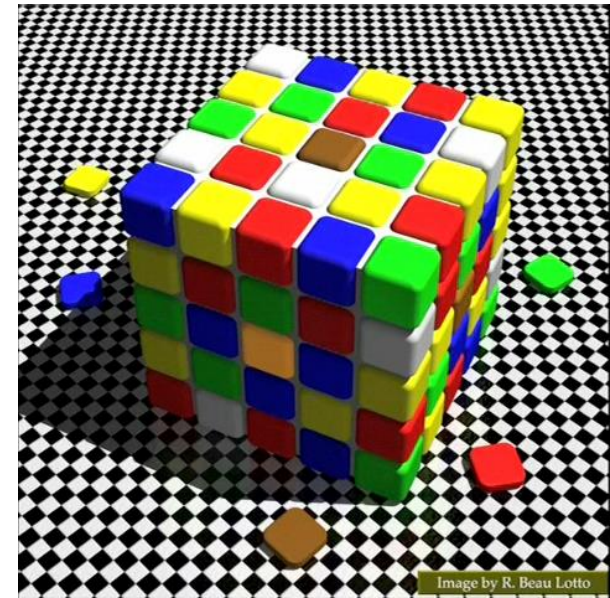
6

- Lakoff's "Woman, Fire and Dangerous Things: **What categories reveal about the mind.**"
- Categorization is one of the most basic ability of living beings.
 - ▣ Even amoeba categorizes the things into food and nonfood.
 - ▣ Animals categorize food predators, possible mates, members of their own species, etc.
- Why do we need categorization?
 - ▣ Reduction in complexity of rich sensory input
 - ▣ Generalization

What exactly categories are?

7

- Objectivistic Aristotelian view
 - ▣ Woman, fire and dangerous things have some properties in common
- Research on categories
 - ▣ Wittgenstein
 - Family resemblances
 - Central and non-central members
 - ▣ Berlin & Kay
 - Neurophysiology of vision
 - Colors are not objectively “out there”
 - ▣ Eleanor Rosh



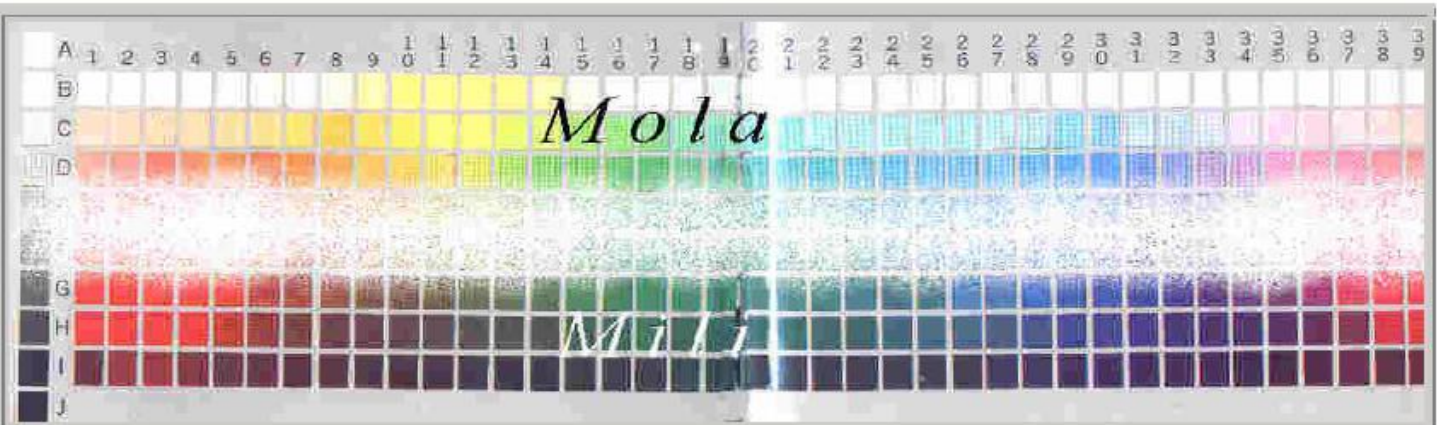
Eleanor Rosch

8

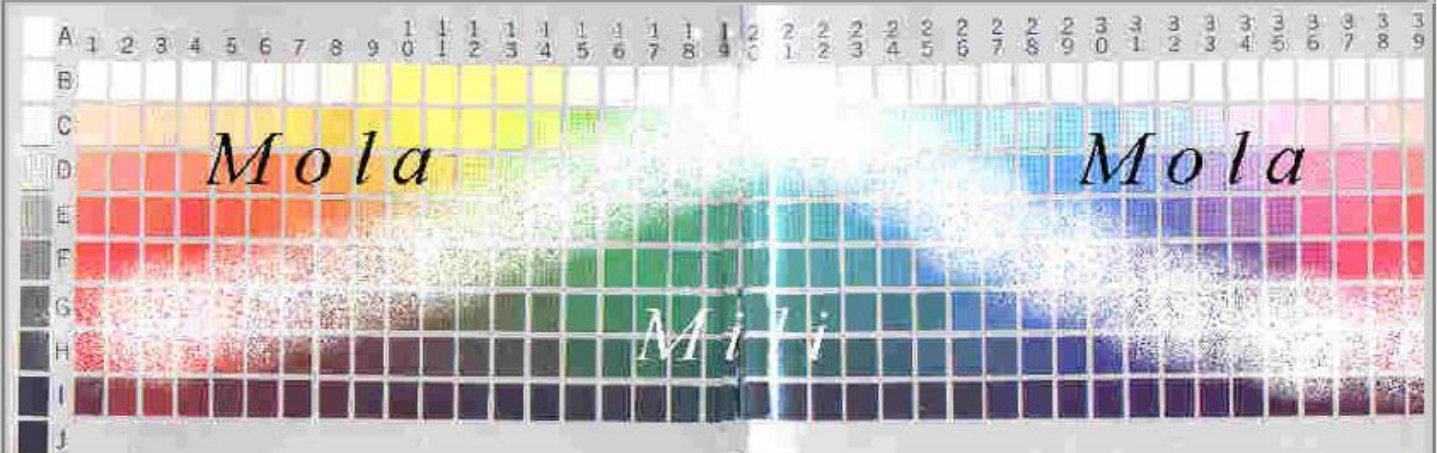
- Prototype theory
 - ▣ Research in New Guinea
 - Dani language
 - Mili = dark/cool (black, green, blue)
 - Mola = light/warm (white, red, yellow)
 - ▣ They choose focal colors as best examples
 - ▣ Primary colors are psychologically real even if they can't name them
 - ▣ Focal colors are learned more readily

Mola and *Mili*

B&K
1969



Revision
1978



Berlin & Kay

10

- 1969 study of 98 unwritten languages (20 in more detail) – 25 speakers per language on avg.
- (1976-2009 follow up study on 110 languages – World Color Survey)

Berlin & Kay - Instruction

11

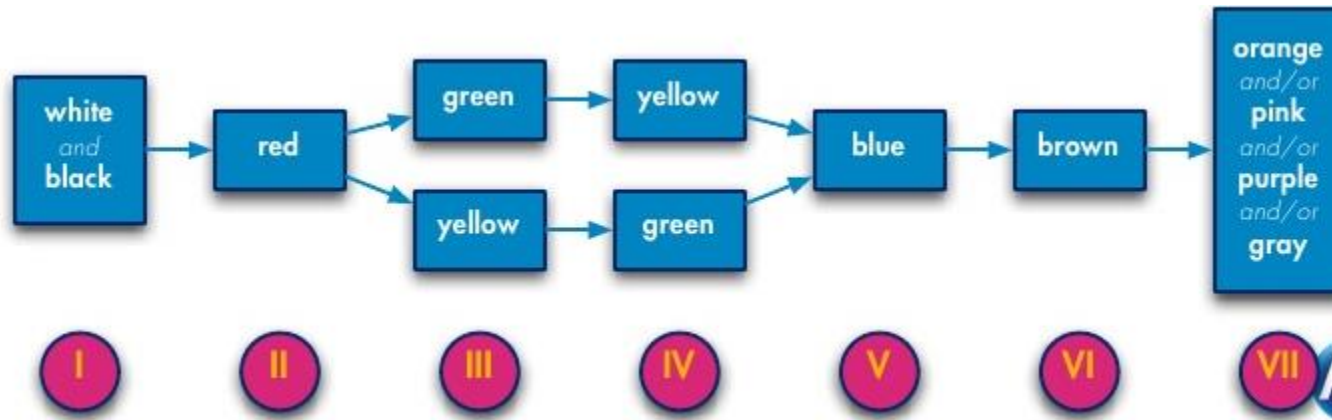
1. **Basic color terms:** Find the smallest number of simple words with which you could name any color.
2. **Focal colors:** For each of the color terms, find its best example.
3. **Category boundaries:** For each of the color terms, mark all samples that can be named with the term.

Munsell stripes:



Berlin & Kay - results

12



Berlin & Kay - results

13

1. All languages contain terms for black and white.
2. If a language contains three terms, then it contains a term for red.
3. If a language contains four terms, then it contains a term for either green or yellow (but not both).
4. If a language contains five terms, then it contains terms for both green and yellow.
5. If a language contains six terms, then it contains a term for blue.
6. If a language contains seven terms, then it contains a term for brown.
7. If a language contains eight or more terms, then it contains terms for purple, pink, orange, and/or gray.

Basic-level categories

14

- Eleanor Rosch
- Brown and Berlin
 - ▣ Basic level in nature

Basic-level categories

15



Basic-level categories

16

- Eleanor Rosch
- Brown and Berlin
 - ▣ Basic level in nature
 - People tend to name things on the level of genus instead of species
 - Short, most frequent, simple
 - Learned early in children, more readily
 - Greater cultural significance
 - Perceived as gestalts

Levels of conceptualization

17



Superordinate

- Fruit



Basic

- Apple



Subordinate

- Golden delicious apple
- Jonagold apple
- Granny Smith apple

Basic-level categories

18

1. Mental images

- ▣ It is the highest level at which a single mental image can represent the entire category

2. Gestalt perception

- ▣ It is the highest level at which category members have similarly perceived overall shapes

3. Motor programs

- ▣ It is the highest level at which a person uses similar motor actions for interacting with category members.

4. Knowledge structure

- ▣ It is the level at which most of our knowledge is organized

Spatial-relations concepts

19

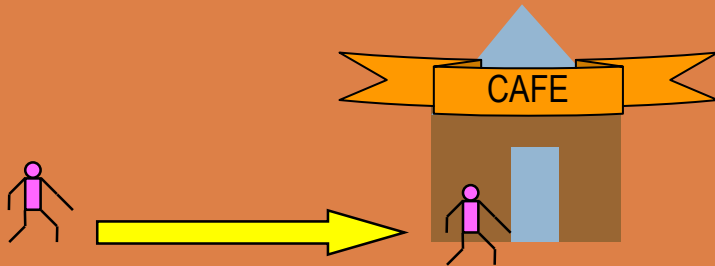
- How we make sense of space around us
 - ▣ We automatically “perceive” one entity as *in*, *on*, or *across* from another entity.
 - ▣ However such perception depends on an enormous amount of unconscious mental activity
 - ▣ Most spatial relations are complexes made up of elementary spatial relation
 - E.g. *into*, *on*
 - ▣ Elementary spatial relation have own structure
 - Image schema
 - Profile
 - Trajector-landmark structure



Meanings are embodied

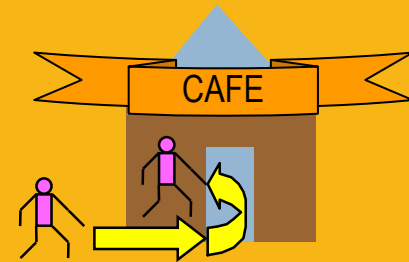
20

to



- Goal of action = **at** cafe
- Source = **away** from cafe
- cafe = **point-like** location

into

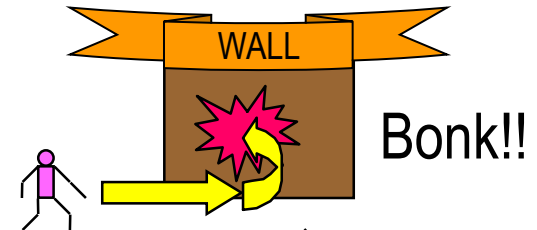


- Goal of action = **inside** cafe
- Source = **outside** cafe
- cafe = **containing** location

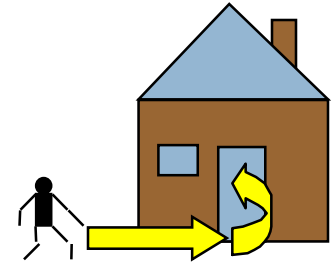
Syntax is not independent of semantics

21

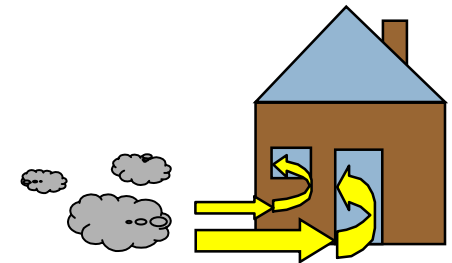
The scientist walked into **the wall**.



The hobo **drifted** into the house.



The smoke drifted into the house.



Spatial-relations concepts

22

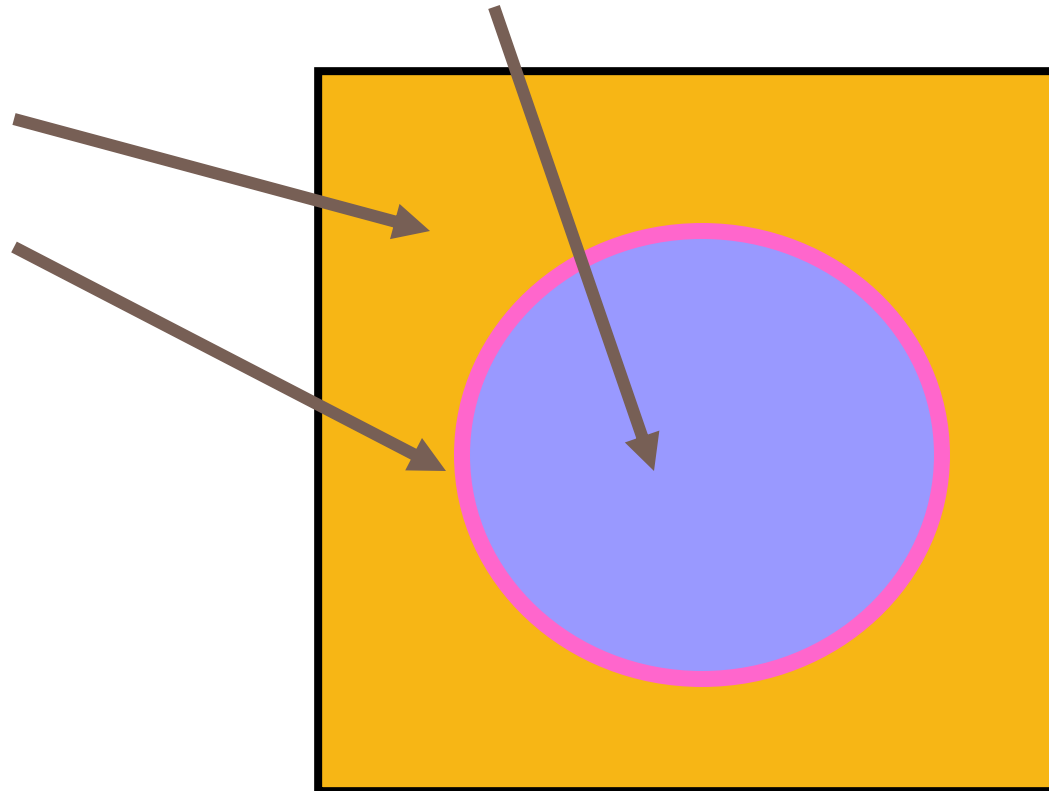
- English *in* consists of
 - ▣ Container schema (a bounded region in space)
 - ▣ Profile that **highlights** the interior of the schema
 - ▣ A structure that identifies the **boundary** of the interior as the landmark
 - ▣ Object overlapping with the interior as a trajector.
- Spatial relations have built-in spatial “logics”
 - ▣ Given 2 containers, A and B, and an object X, if A is *in* B and X is *in* A, then X is *in* B.

Container Schema

23

□ Roles:

- ▣ Interior: bounded region
- ▣ Exterior
- ▣ Boundary



Container schema

24

- It is a gestalt structure
 - ▣ The parts make no sense without the whole
 - There is no inside without an outside
- The structure is topological
 - ▣ The boundary can be made larger, smaller or distorted and still remain boundary

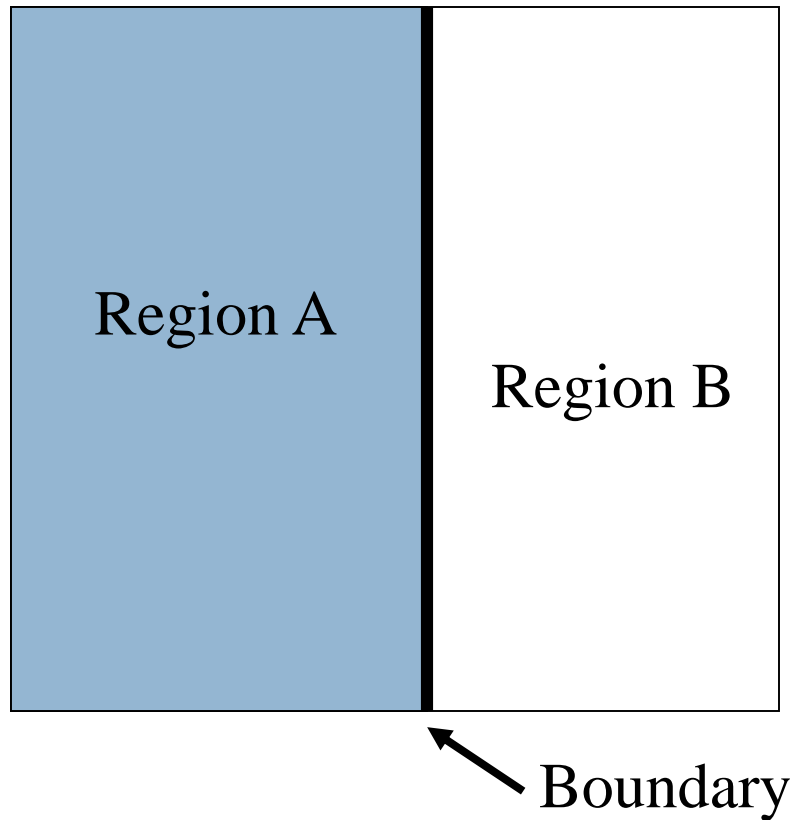
Other image schemas and elements of spatial relations

25

- Part-whole
- Center-periphery
- Link
- Cycle
- Iteration
- Contact
- Adjacency
- Forced motion
 - ▣ Pushing / pulling,...
- Support
- Balance
- Near-far
- Orientations
 - ▣ Vertical
 - ▣ Horizontal
 - ▣ Front-back

Boundary Schema

26



Roles:

Boundary

Region A

Region B

Bounded Region

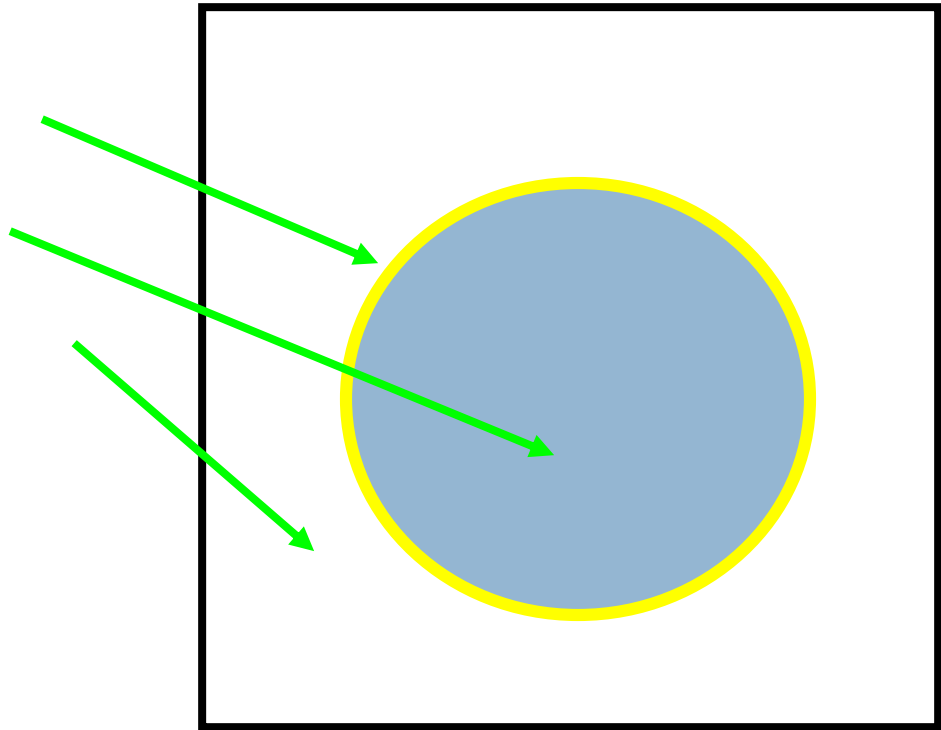
27

Roles:

Boundary: closed

Bounded Region

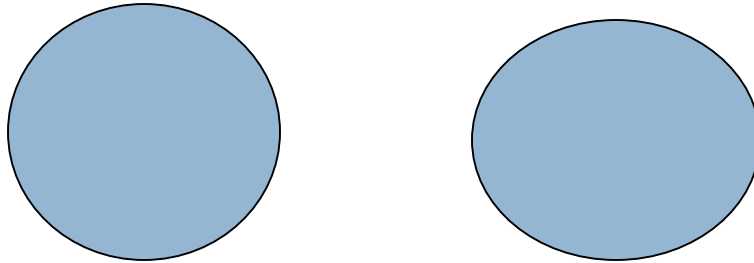
Background region



Topological Relations

28

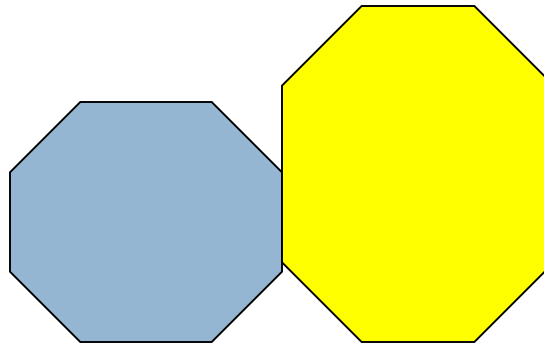
□ Separation



Topological Relations

29

- Separation
- **Contact**



Topological Relations

30

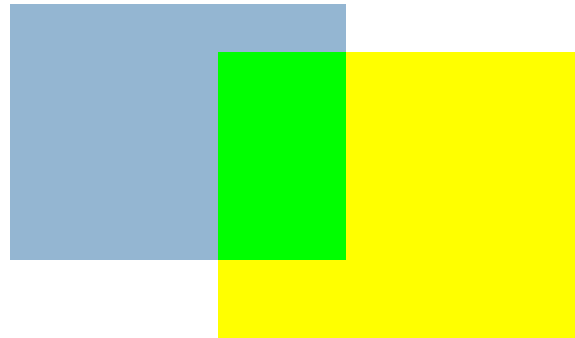
- Separation
- Contact
- **Coincidence:**



Topological Relations

31

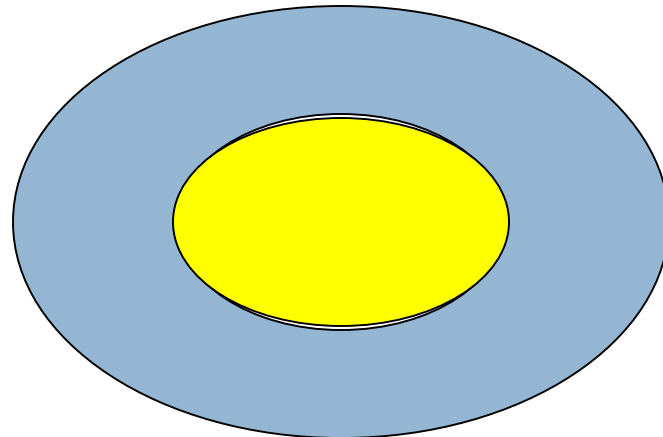
- Separation
- Contact
- Coincidence:
 - **Overlap**



Topological Relations

32

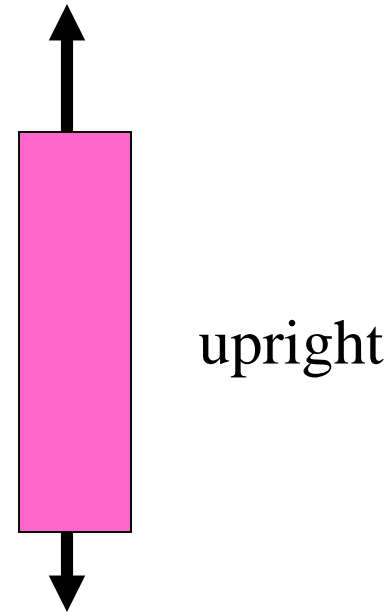
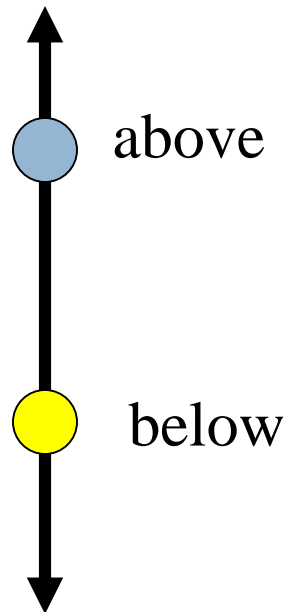
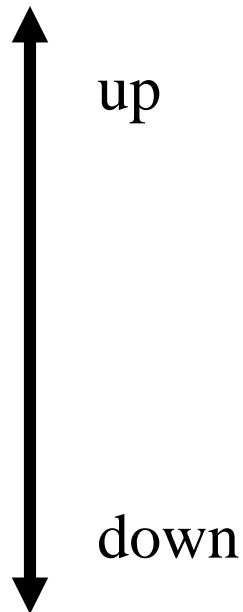
- Separation
- Contact
- Coincidence:
 - Overlap
 - Inclusion
- Encircle/surround



Orientation

33

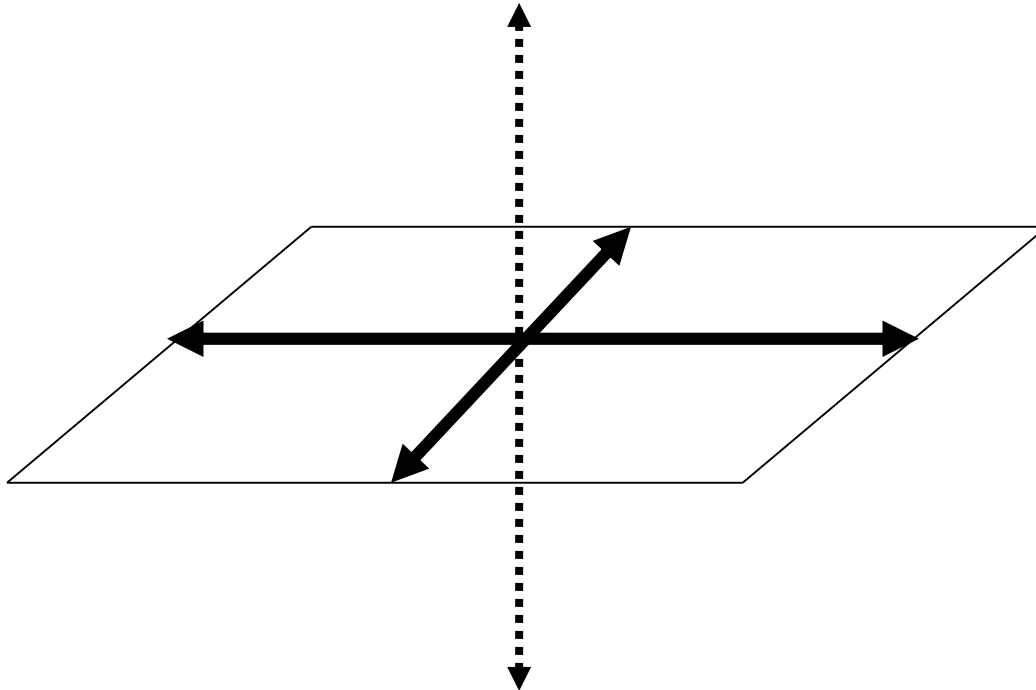
- Vertical axis -- *up/down*



Orientation

34

Horizontal plane – *Two axes:*



Conceptual metaphor theory

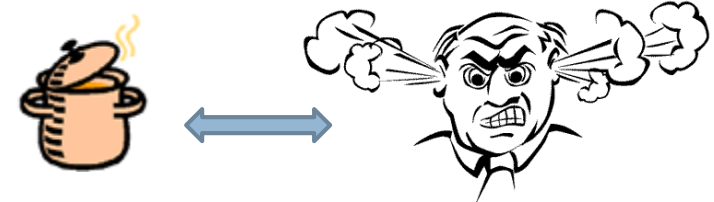
35

- Classical theories viewed metaphors as novel or poetic linguistic expressions outside the realm of ordinary everyday language.
- Metaphor has is in many cases central to understanding the meaning of many abstract concepts.
 - Many concepts that are important to us are either abstract or not well-defined in our experience
 - emotions, thoughts, time,...
 - We need to mediate access to them through the concepts that we understand more clearly
 - spatial orientation, objects,...

Example of conceptual metaphor

36

- ANGER IS HOT FLUID IN CONTAINER
 - His anger reached the top
 - His blood boiled
 - He was blowing off steam
 - He was about to blow out



| SOURCE – HOT FLUID IN A CONTAINER | → | TARGET - ANGER |
|--------------------------------------|---|-----------------------|
| Container | → | Body |
| Temperature / fluid level | → | Intensity of anger |
| Temperature of the fluid / container | → | Body temperature |
| Pressure in the container | → | Blood pressure |
| Simmer of fluid | → | Shivering of the body |
| Explosion | → | Loss of self-control |
| Cold / still fluid | → | Absence of anger |

Simple metaphor processing

37

□ HAPPY IS UP

- ▣ When evaluating words as positive or negative, people are faster when word is flashed correspondingly (Meier & Robinson, 2004)

□ Metaphorical movement

- ▣ Quicker pushing button near/far to their bodies upon reading (Glenberg&Kaschak, 2002)
 - Adam conveyed the message to you / You conveyed the message to Adam

Cultural variance

38

- Núñez & Sweetser (2006):
 - ▣ Speakers of Aymara face the past and have their backs to the future
 - Nayra = past (eye, sight, or front)
 - Q''ipa = future (behind, back)
 - Q''ipüru = tomorrow = q''ipa + uru (some day behind one's back)
 - ▣ Analyzed gestures use when talking about time



Affective simulation

39

- Subjects' faces configured according to sentences with emotional content (Havas 2007)
- When facial emotion matched the content comprehension was better
- **Gesture**
 - ▣ Producing gestures helps speakers retrieve words whose meaning are related to the gestures (Krauss 1998)
 - ▣ Also help listeners comprehend what speaker says
 - ▣ Children can gesture before speaking

Social Cognition

40

□ Embodiment effects

- Activating elderly stereotype causes people to walk slowly and to perform lexical decision slowly (Dijksterhuis & Bargh 2001)
- Engaging the smiling musculature produces positive affect (Strack et al. 1988)

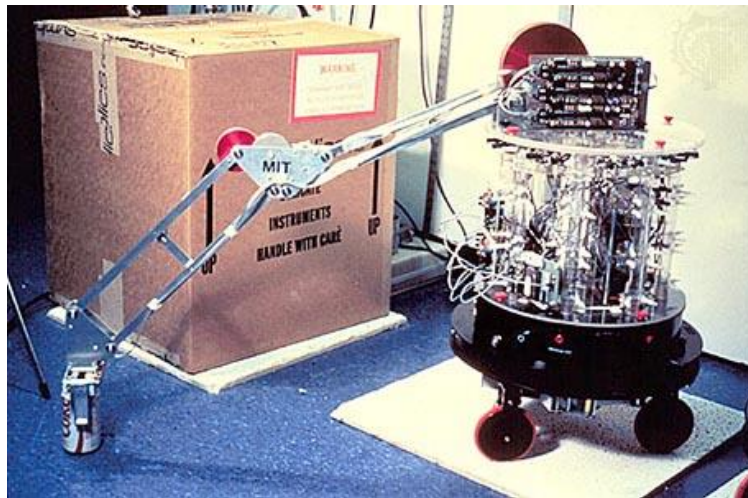
Inspiration from AI: AI Nouvelle

41

- Intelligence without representation
(Brooks, 1991)
- “*The world is its own best model.*” R. Brooks
 - ▣ example: [Mechanical lady bug](#)

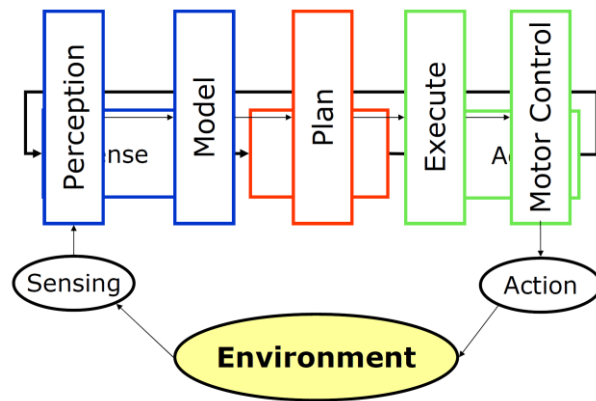
Nouvelle-AI

- Complete agents: Autonomy, embodiment and situatedness

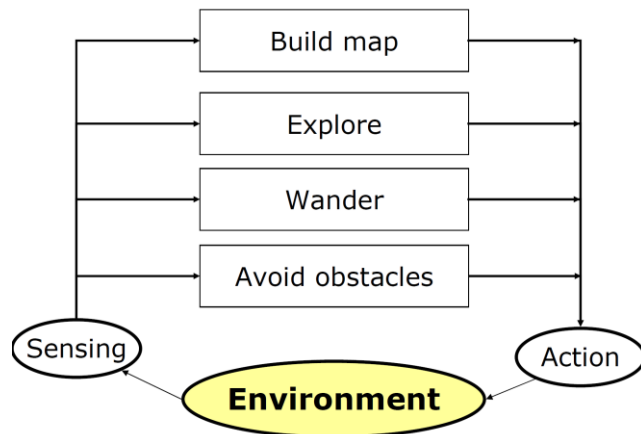


Nouvelle-AI

□ HorizontalDecomposition – centralised control

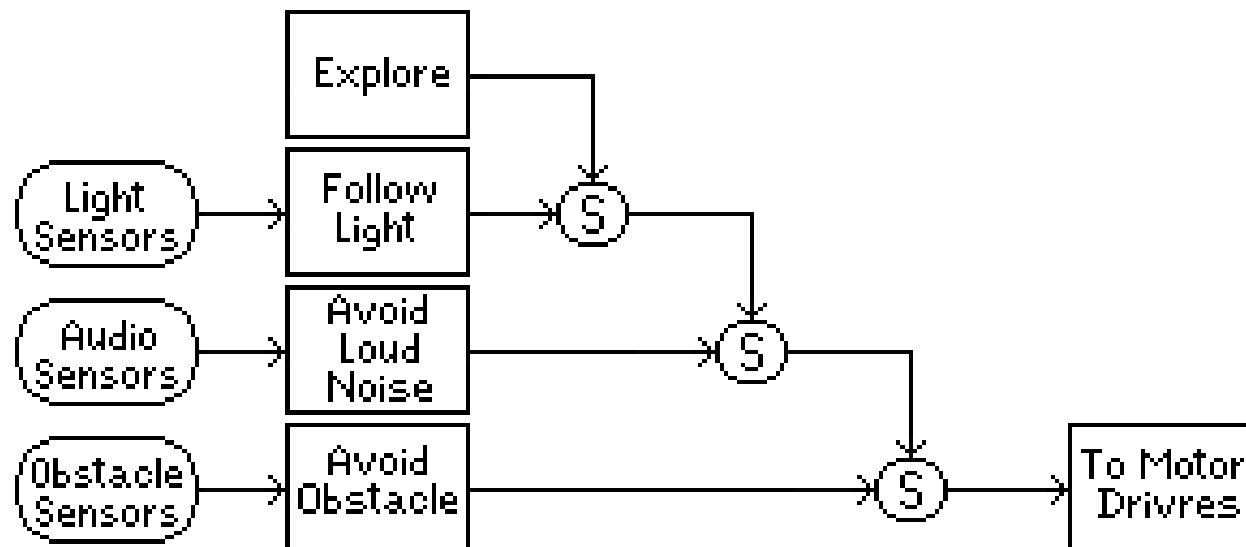


□ Vertical decomposition – layered design

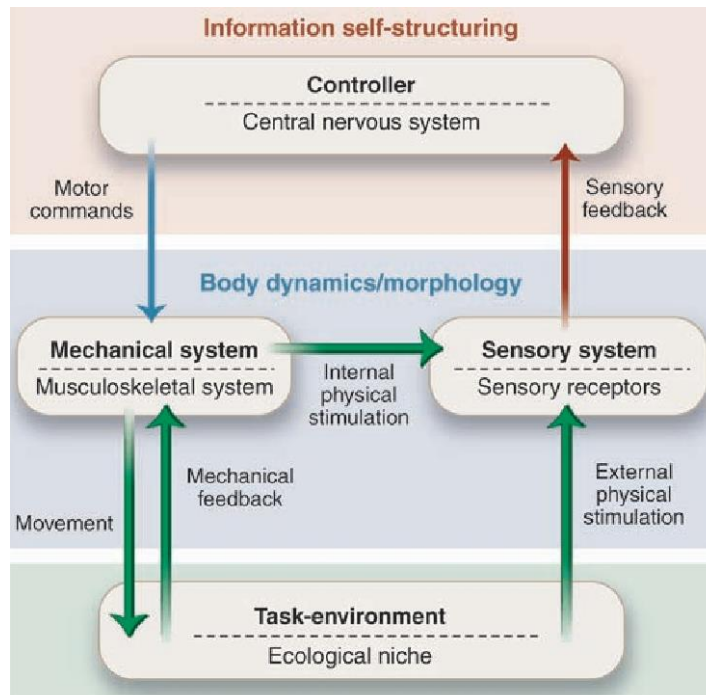


Nouvelle-AI

- Subsumption architecture (Brooks, 1992)



Offloading intelligence to body

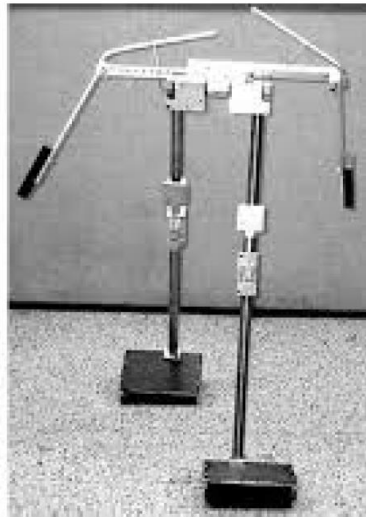


(Pfeifer et al., *Science*, 2007)

Intelligence in body mechanics

46

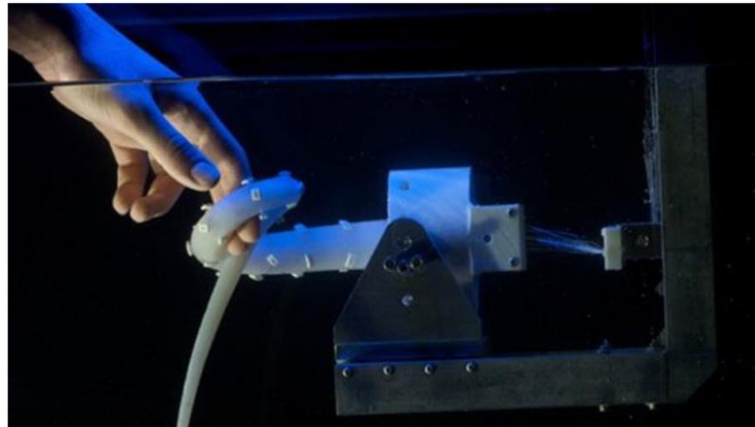
- Passive walkers (McGeer, 1990)
- Theo Jansen - Kinetic Sculptor (see also his TEDx Talk)



Intelligence in material

47

- Soft robotics
- Coffee-filled balloon gripper robot (Cornell Uni - iRobot)
- The Octopus Project



Body modification

- ▣ Self-modification – Evolvable hardware
- ▣ Artificial evolution: SIMS

Questions?

49

