What is an OAC?

PACO-PLUS: Perception, Actions and Cognition through Learning of Object-Action Complexes (OAC)

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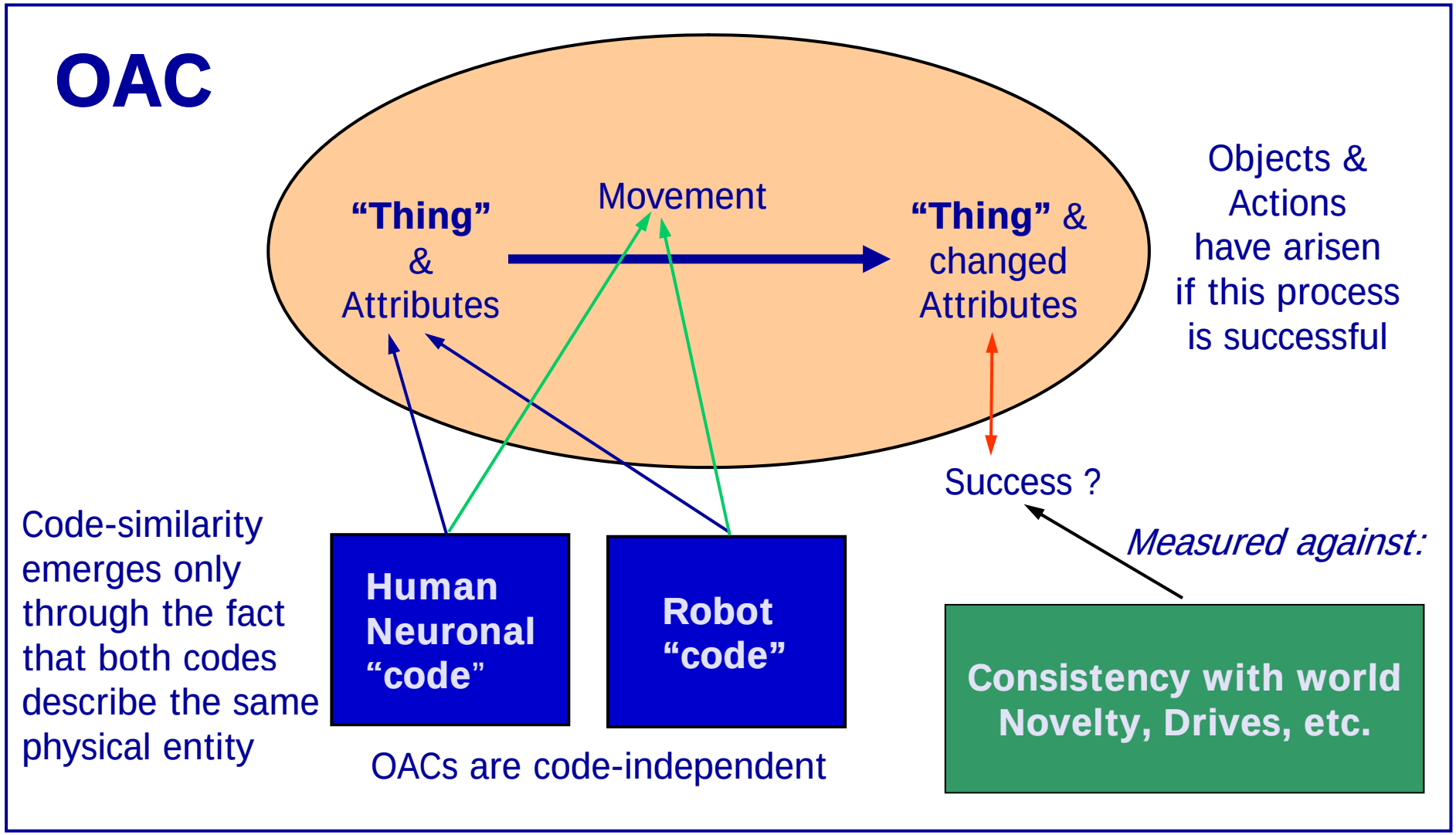
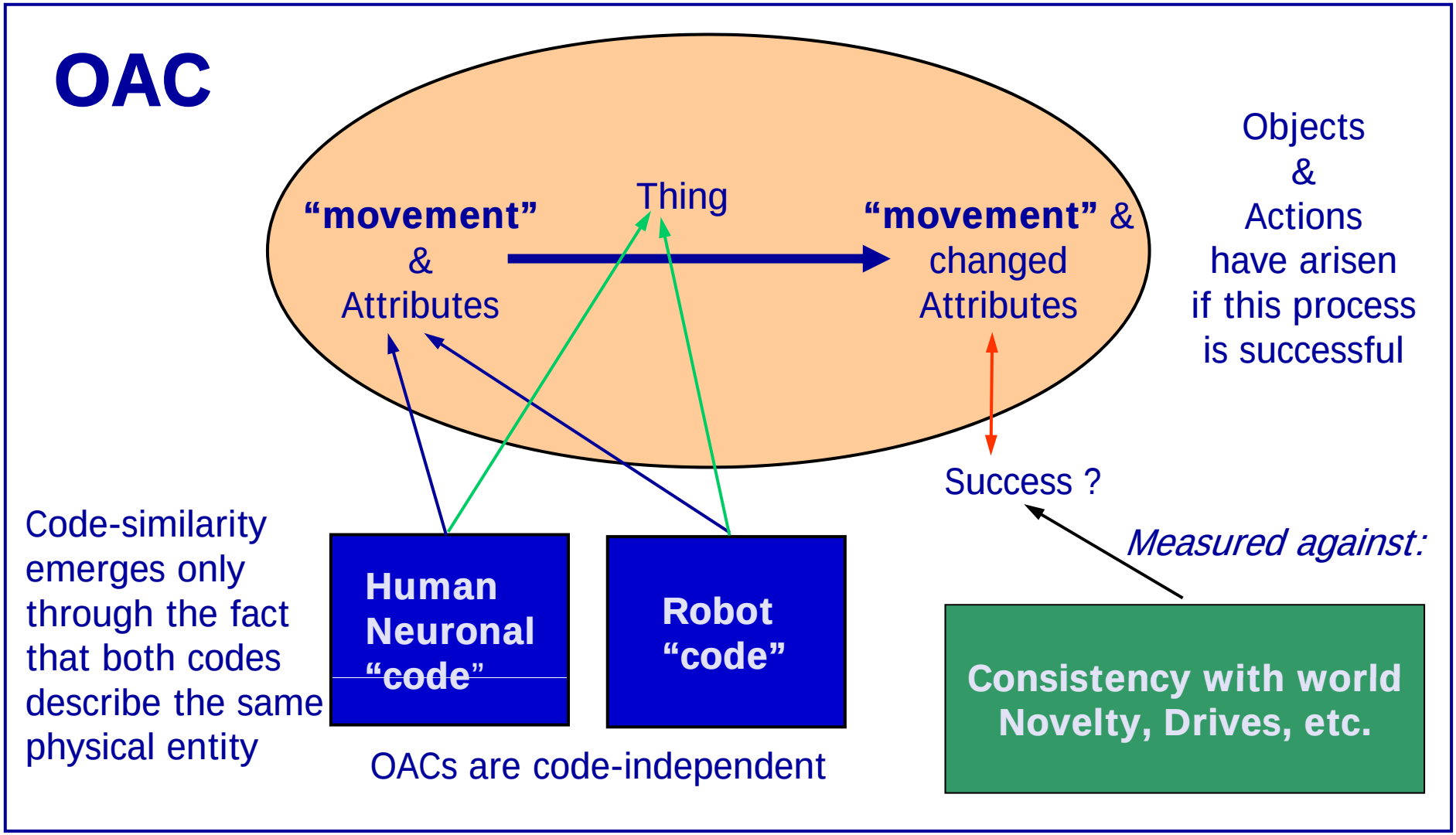
Object-Action Complex Concept

- Proposed by the European PACO-PLUS Consortium
- Objects and Actions are inseparably intertwined.
- Categories are determined (and also limited) by the action an agent can perform and by the attributes of the world it can perceive;
- the resulting, *so-called* **Object-Action Complexes (OACs)** are the entities on which cognition develops (action centred-cognition)
- Entities “things” in the world of a robot (or a human) will only become semantically useful “objects” through the action that the agent can/will perform on them.

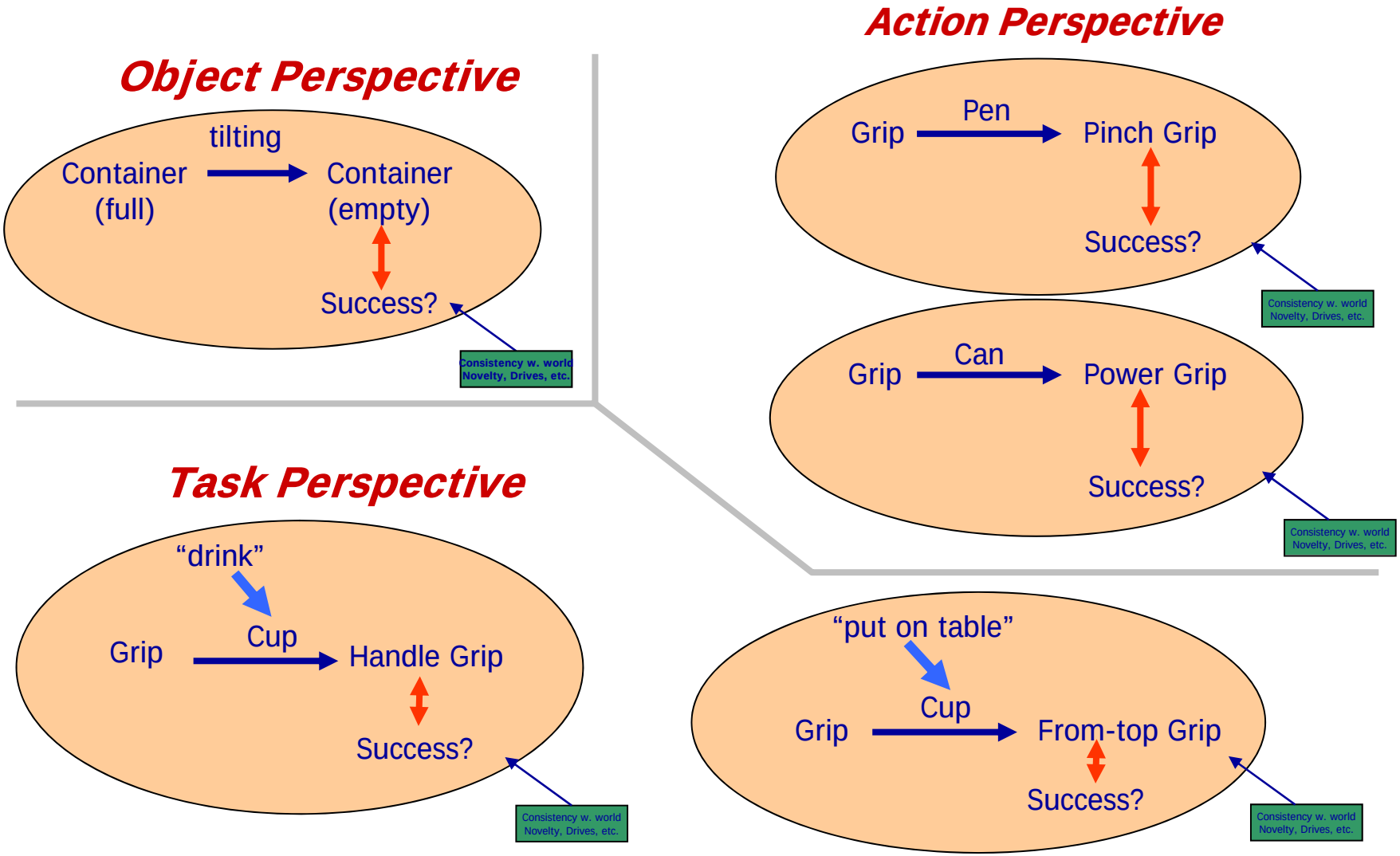
Object Perspective



Action Perspective



Object, Action and Task Perspective



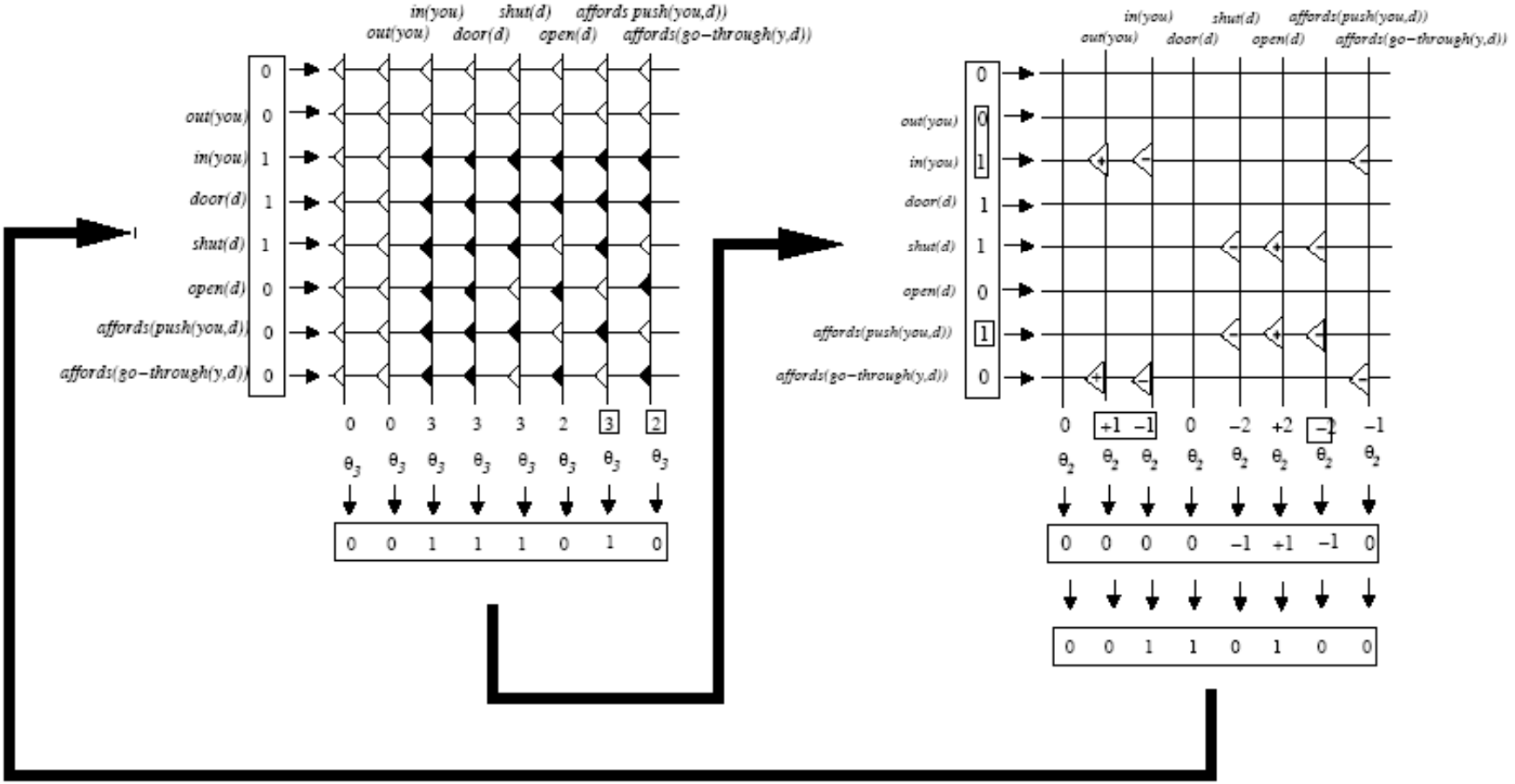
Object-Action Complexes

- Object-Action Complexes (OACs)
  - Actions define the meaning of Objects and
  - Objects suggest Actions

- OACs are associations of objects and affordances
  - Affordances can be expressed by STRIPS rules comprising:
    - Preconditions and
    - Deletions/additions

- Associative memory ensures that
  - Object representations (and other preconditions) evoke affordances
  - Representations of affordances (and other preconditions) evoke objects

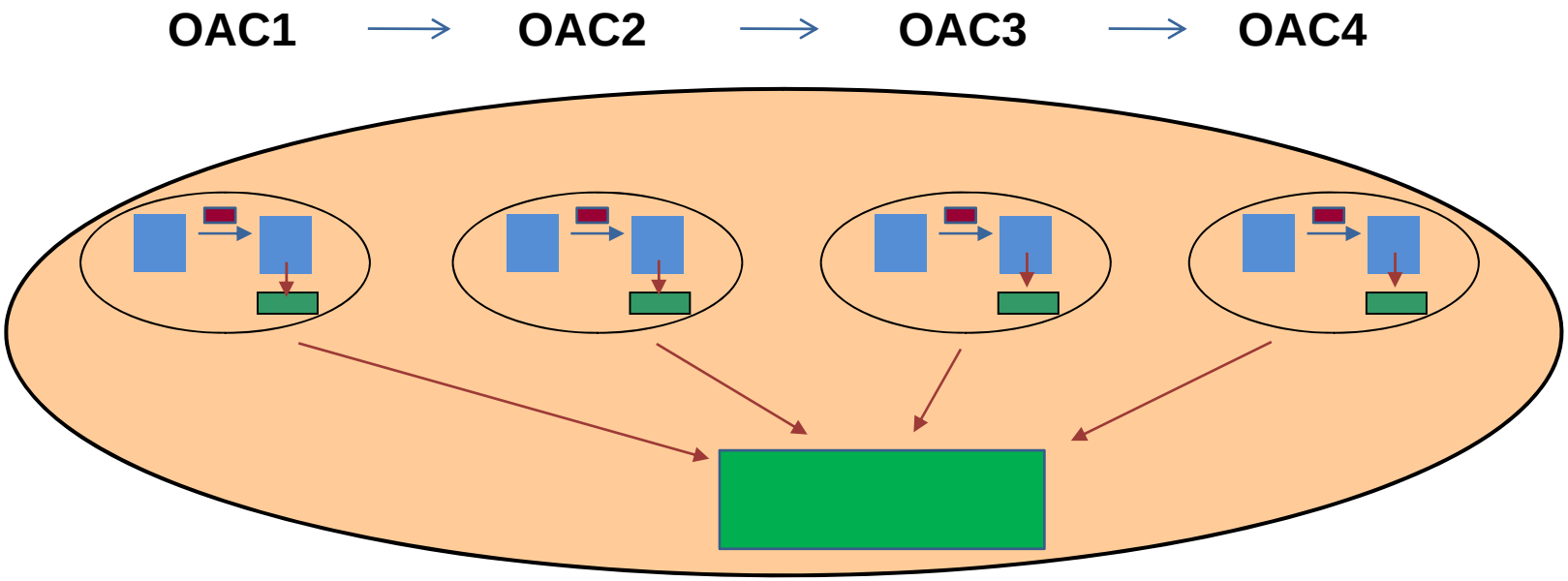
OACs as Associative Memory



Retrieving the affordance of push from an auto-associative net and generating the next state from the kernel perceptron.

Properties of OACs

- OACs can be combined (sequenced) = Planning
- OACs are compositional:
  OAC1; OAC2 = λs.OAC2(OAC1(s)) = **B**(**T** OBJ2)(**T** OBJ1)
- Generation of a new OACs = plan compilation/Explanation Based Learning



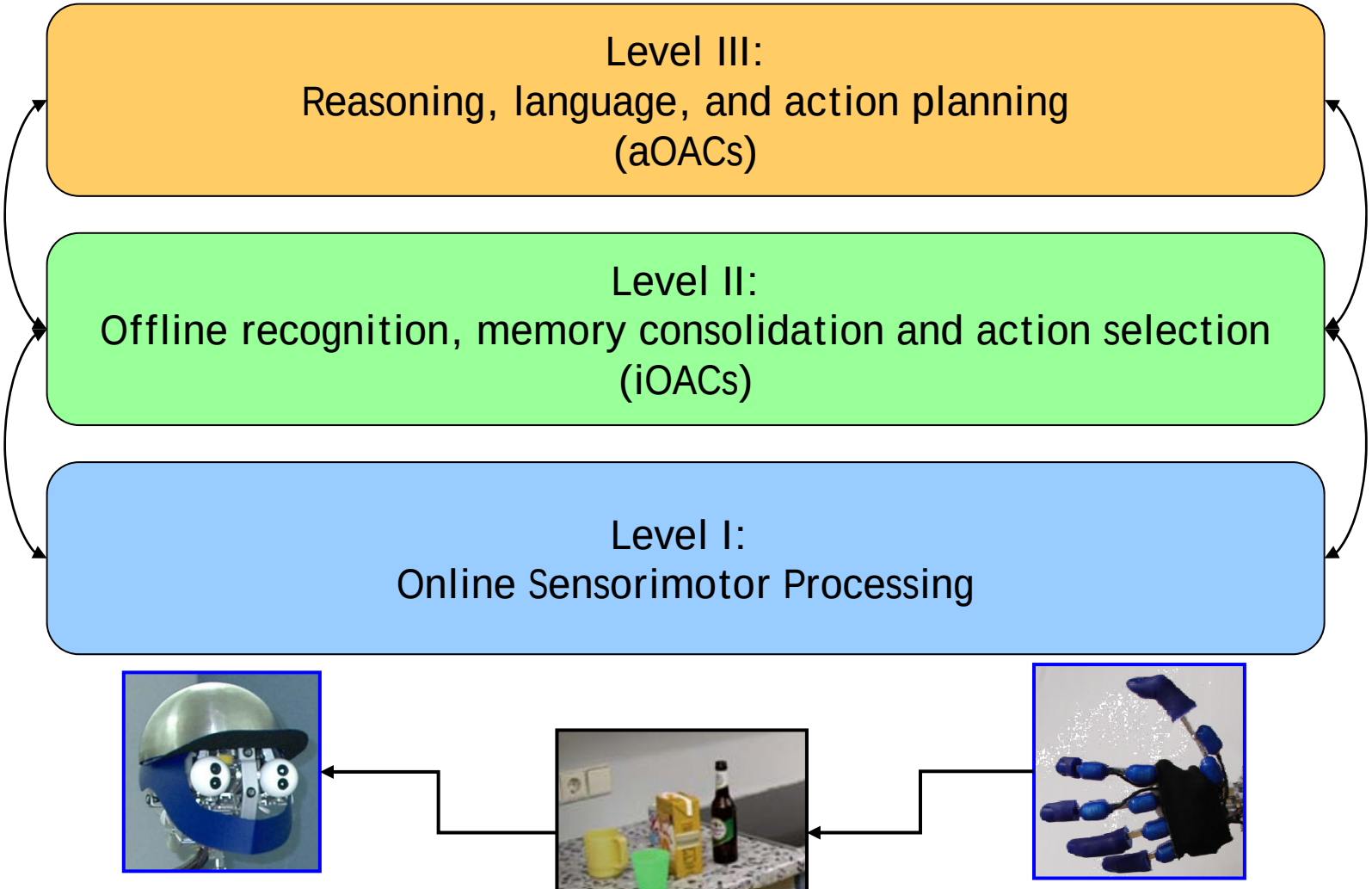
OACs vs. Affordances

- Affordances are “unidirectional”
  - Objects affords actions
- OACs are “bidirectional”
  - Object affords actions
  - Actions suggest objects

- OACs can be chained (new complex OACs from simpler OACs “Tasks from skills = Planning”)

- OACs (unlike affordances) are fully formalized and (partly) implemented.

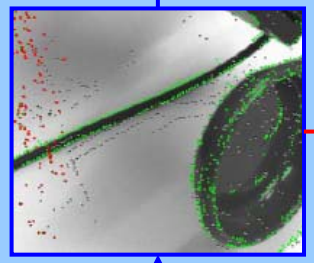
Cognitive Architecture



Level I:
Online Sensorimotor Processing

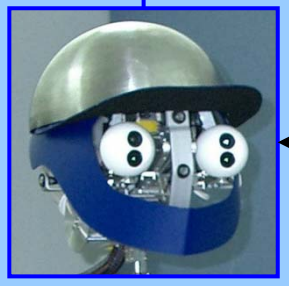
Gestalten, high-level Features

Postures, Forces



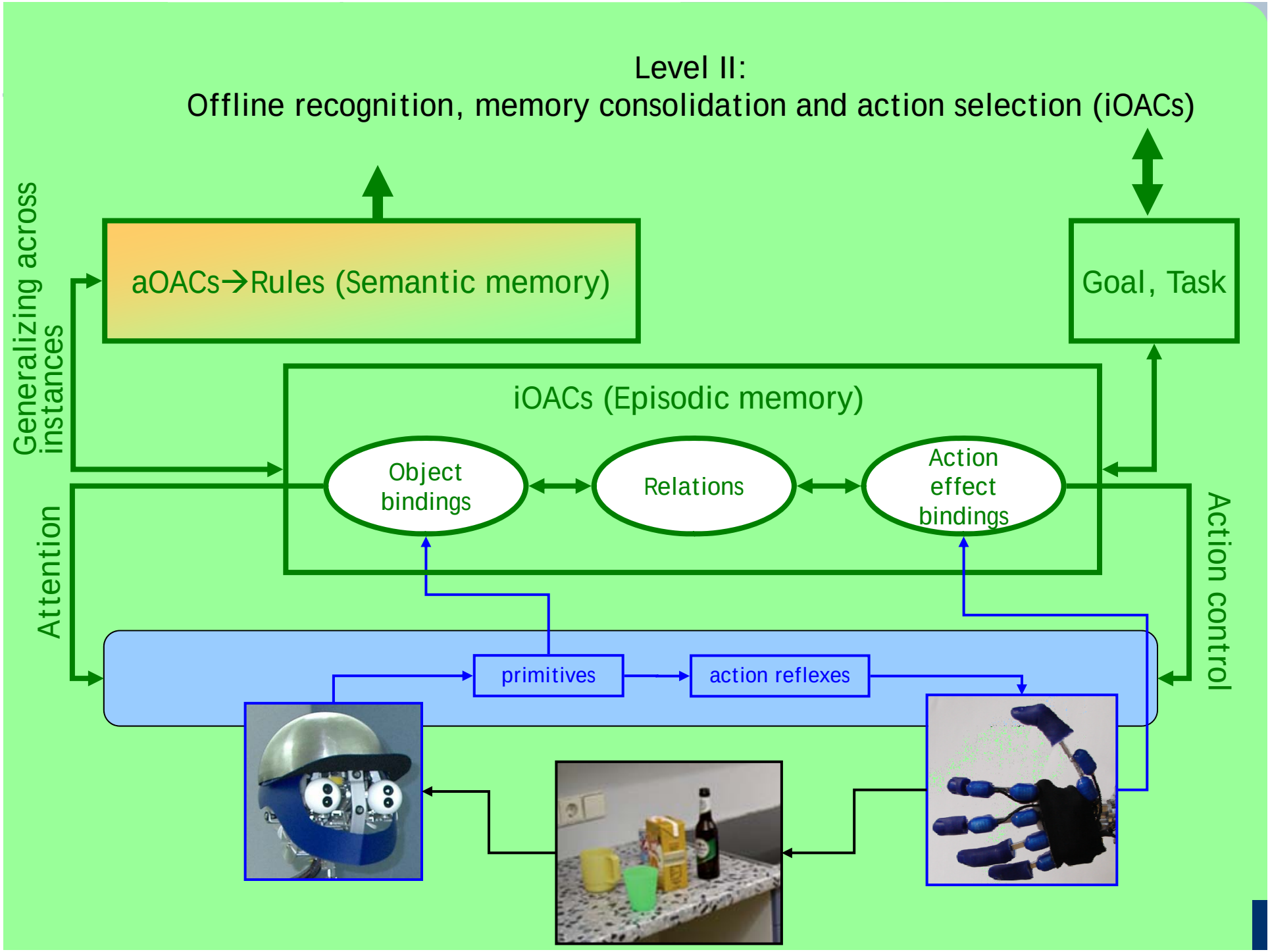
Preliminary segregation & coding of primitives (2D, 3D, co-linearity, co-planarity…)

Unknown stimuli trigger action reflexes: grasp, move, eye-hand coordination

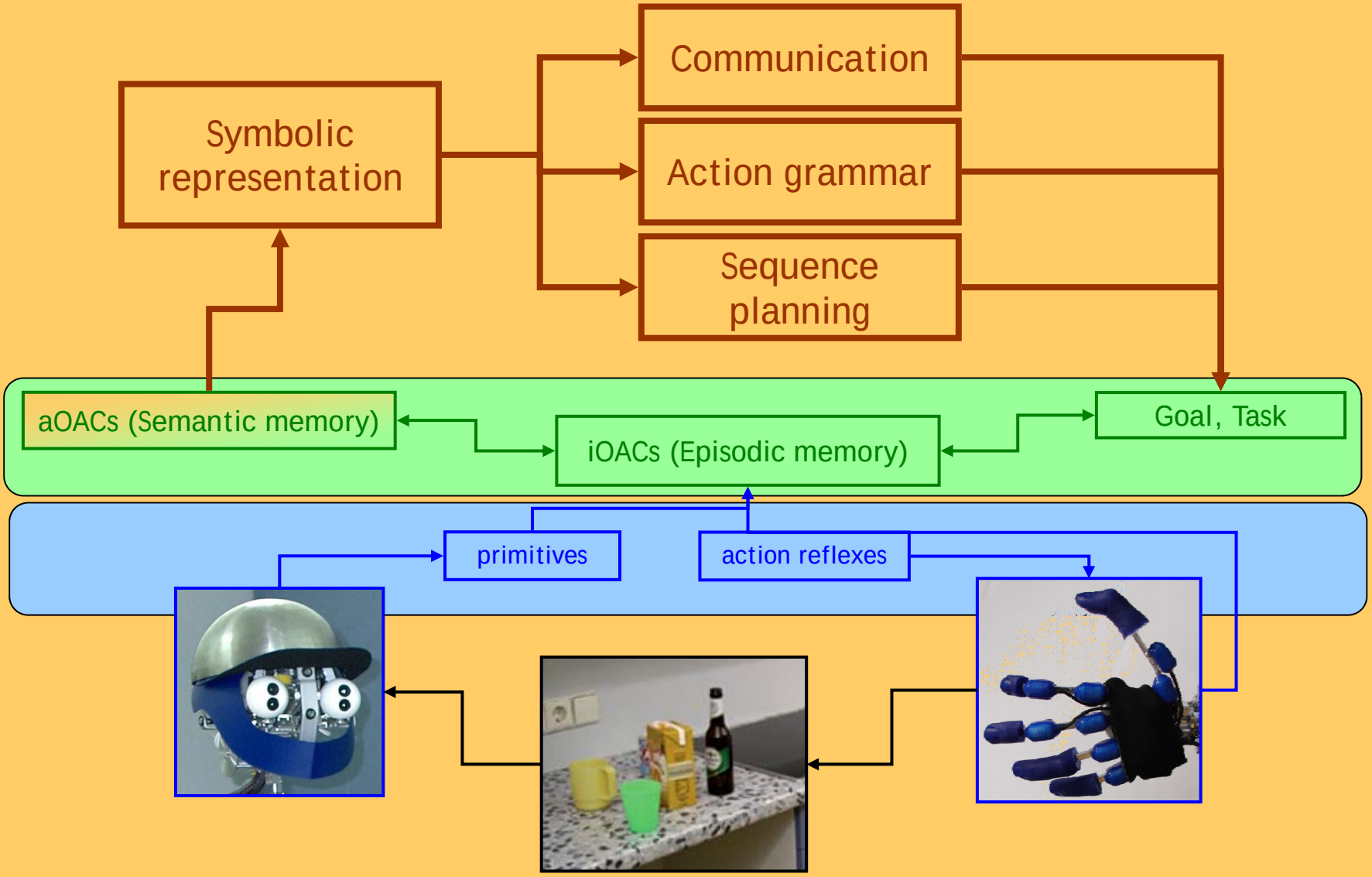


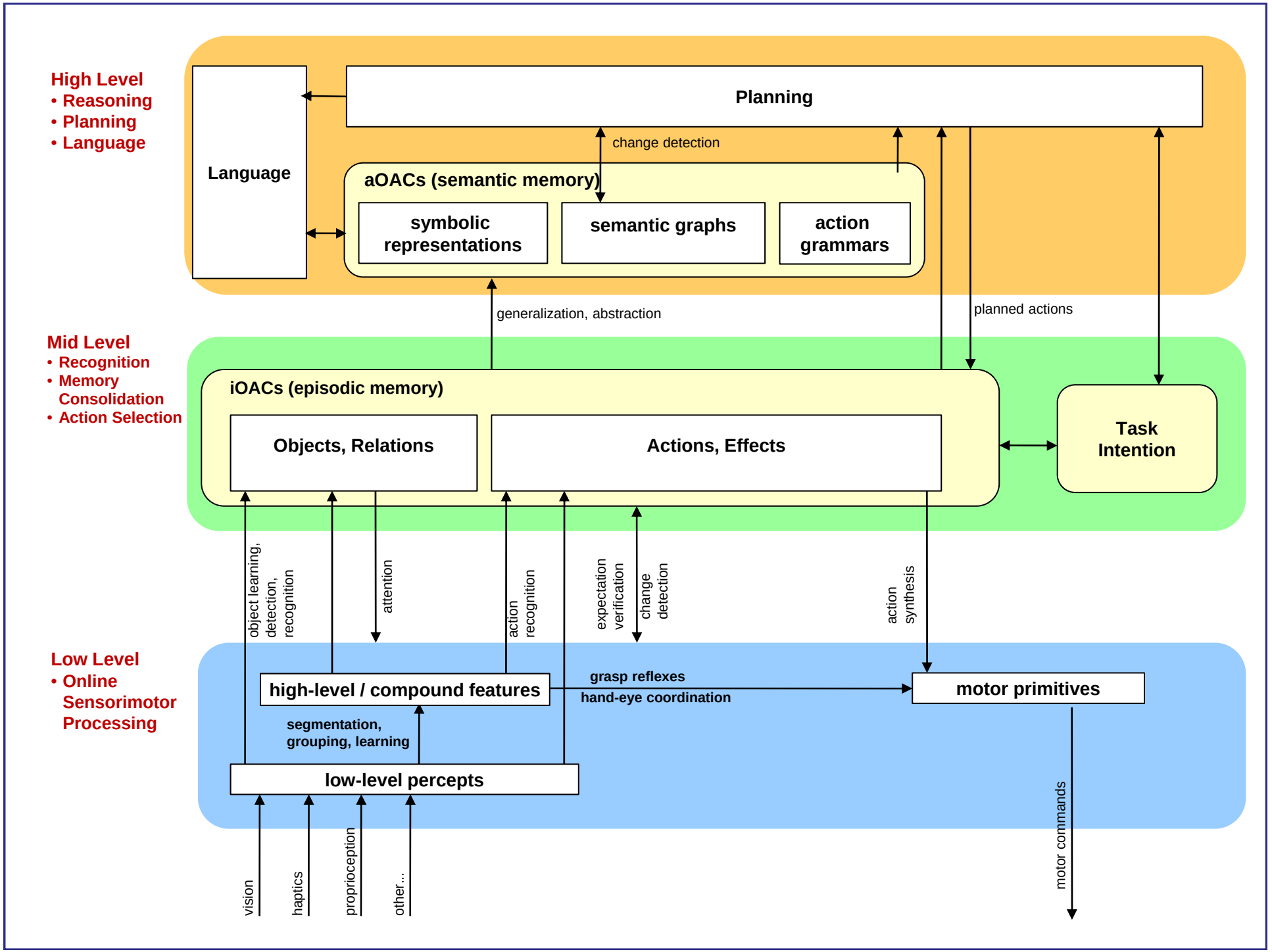
Perception of current states

Production of new states


Level II:
Offline recognition, memory consolidation and action selection (iOACs)
aOACs→Rules (Semantic memory)
Goal, Task
Generalizing across instances
iOACs (Episodic memory)
Object bindings
Relations
Action effect bindings
Attention
Action control
primitives
action reflexes

Level III:
Reasoning, language, and action planning (aOACs)




High Level
• Reasoning
• Planning
• Language
Language
Planning
change detection
aOACs (semantic memory)
symbolic representations
semantic graphs
action grammars
generalization, abstraction
planned actions
Mid Level
• Recognition
• Memory Consolidation
• Action Selection
iOACs (episodic memory)
Objects, Relations
Actions, Effects
Task Intention
object learning, detection, recognition
attention
action recognition
expectation verification
change detection
action synthesis
Low Level
• Online Sensorimotor Processing
high-level / compound features
grasp reflexes
hand-eye coordination
motor primitives
segmentation, grouping, learning
low-level percepts
motor commands
vision
haptics
proprioception
other...