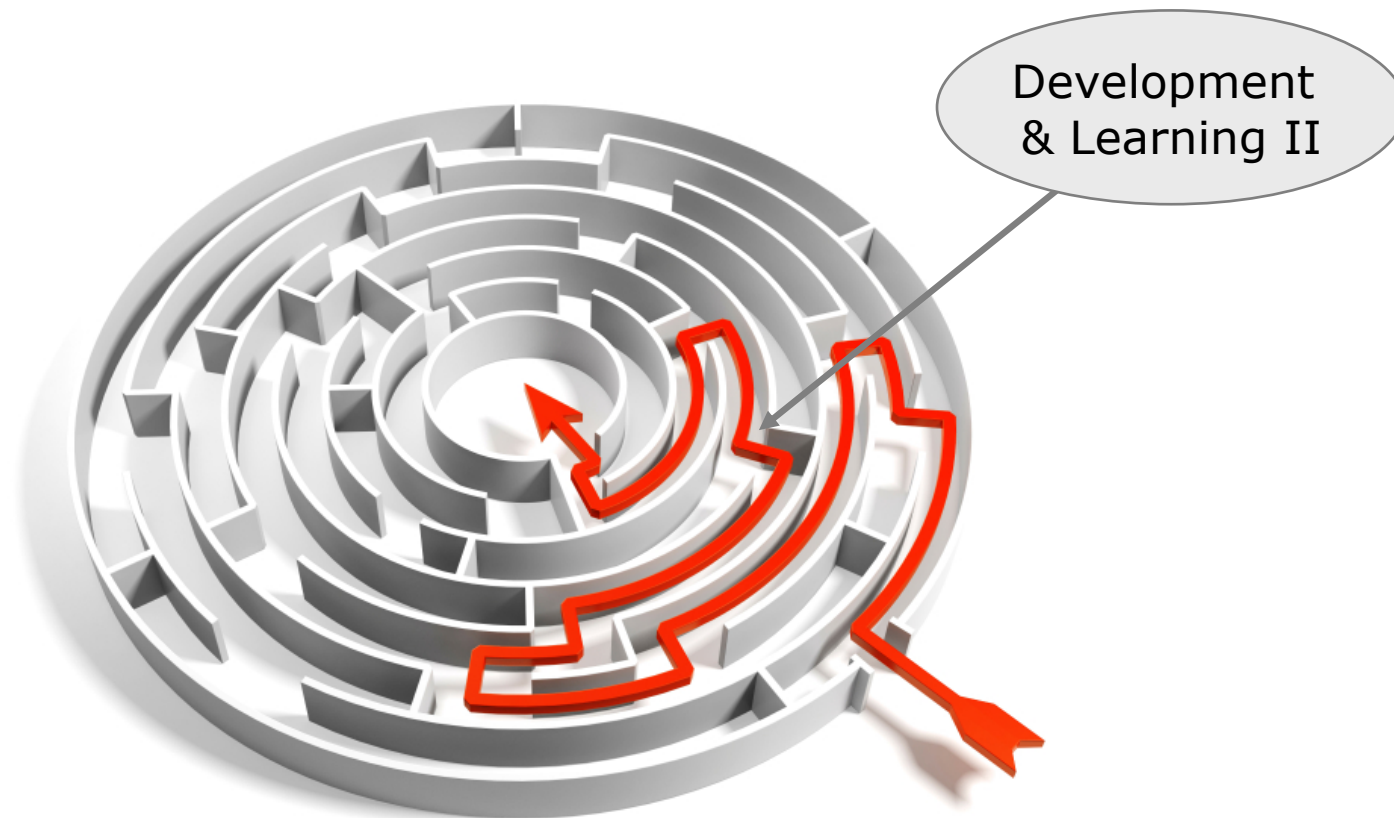


Artificial Cognitive Systems

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Topic Overview

Development and Learning

- Development
 - Motivation
 - Imitation
 - Development and learning
- Phylogeny vs. Ontogeny
- Development from the perspective of psychology
 - The Goal-directed and Prospective Nature of Action
 - Core Cognitive Abilities in Infants
 - Ontogeny

Development vs. Learning

Development

A process which an agent undergoes to

Expand its repertoire of possible actions

Extend the time horizon of its capacity for prospection:

the ability to anticipate (a) events and (b) the need to act

Development vs. Learning

Development

Non-monotonic:

To discover new ways of doing things

(a) **inhibit** existing abilities

(b) allow for (or cause) changes in the **physical structure** of the agent

Development vs. Learning

Learning

a process for estimating or improving the parameter values that govern the behaviour of a **known model**,

Development

a process for **generating** or discovering the **model** itself

requires two-way interaction between agent and world: structural coupling

Learning

1. Supervised

Teaching signals are directional error signals

2. Reinforcement

Teaching signals are scalar **reward** or reinforcement signals




(maximize the cumulative sum of rewards over time)

3. Unsupervised

No teaching signals

(uncover statistical regularities)

Learning

- Supervised: Cerebellum  ***Internal models of the environment
Short-cut models of input-output associations
learned elsewhere***
- Reinforcement: Basal Ganglia  ***Evaluate given state;
Select action***
- Unsupervised: Cerebral Cortex  ***Represent external state &
internal context;
Provide common representational
framework for Cerebellum and BG***

[Doya 1999]

Learning

- Hippocampus – Cortex Complementary Learning
- Hippocampus: rapid auto- and hetero-associative learning
- Hippocampus reinstates neo-cortex memories

[McClelland et al. 1995]

Phylogeny
(Cognitive Architecture)

Ontogeny
(Learning & Development + Motivations)

Drives
Value System

[Merrick 2016]

Phylogeny vs. Ontogeny

- What is the minimal architecture required to configure a cognitive system & enable it to boot-strap cognitive development?
- **Cognitivist stance:**
 - Balance between 'pre-knowledge' and acquirable knowledge
 - What do you need to know in order to learn?

Phylogeny vs. Ontogeny

- What is the minimal architecture required to configure a cognitive system & enable it to boot-strap cognitive development?
- **Emergent stance**
 - Balance between phylogeny and ontogeny
 - Phylogeny
 - evolution of the system configuration from generation to generation
 - Ontogeny
 - adaptation, development, and learning of the system during its lifetime

Recommended Reading

Vernon, D. “Cognitive Vision: The Case for Embodied Perception”, Image and Vision Computing, Special Issue on Cognitive Vision, Vol. 26, No. 1, pp. 127-141 (2008).

Vernon, D., von Hofsten, C., and Fadiga, L. A Roadmap for Cognitive Development in Humanoid Robots, Cognitive Systems Monographs (COSMOS), Springer, ISBN 978-3-642-16903-8 (2010); Chapter 6

Doya, K. What are the computations of the cerebellum, the basal ganglia and the cerebral cortex? Neural Networks, 12:961–974, 1999.

Hsu, J. “Will the Future of AI Learning Depend More on Nature or Nurture?”

<https://spectrum.ieee.org/tech-talk/robotics/artificial-intelligence/ai-and-psychology-researchers-debate-the-future-of-deep-learning>