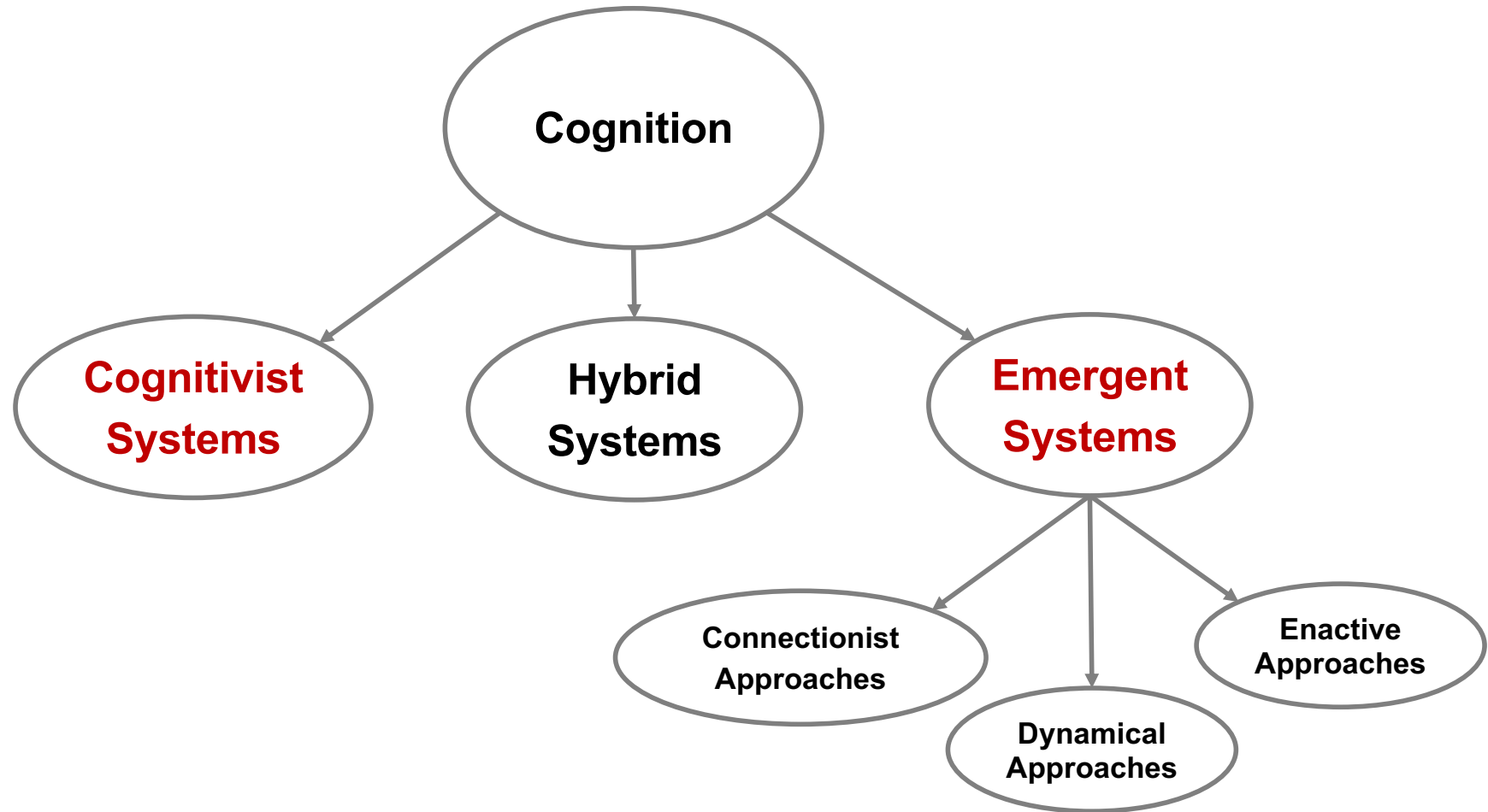# Artificial Cognitive Systems

Module 2: Paradigms of Cognitive Science

Lecture 3: Hybrid approaches; comparison of cognitivist and emergent paradigms

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Differences between Cognitivist & Emergent Paradigms

1. Computational operation
2. Representational framework
3. Semantic grounding
4. Temporal constraints
5. Inter-agent epistemology
6. Embodiment
7. Perception
8. Action
9. Anticipation
10. Adaptation
11. Motivation
12. Autonomy
13. Cognition
14. Philosophical foundation

[Vernon, Von Hofsten, Fadiga 2010]

The Cognitivist Paradigm vs. the Emergent Paradigm

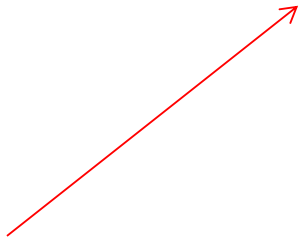| Characteristic	Cognitivist	Emergent
Computational Operation	Syntactic manipulation of symbols	Concurrent self-organization of a network
Representational Framework	Patterns of symbol tokens	Global system states
Semantic Grounding	Percept-symbol association	Skill construction
Temporal Constraints	Atemporal	Synchronous real-time entrainment
Inter-agent epistemology	Agent-independent	Agent-dependent
Embodiment	No role implied: functionalist	Direct constitutive role: non-functionalist
Perception	Abstract symbolic representations	Perturbation by the environment
Action	Causal consequence of symbol manipulation	Perturbation by the system
Anticipation	Procedural or probabilistic reasoning	Traverse of perception-action state space
Adaptation	Learn new knowledge	Develop new dynamics
Motivation	Criteria for goal selection	Increase space of interaction
Autonomy	Not entailed	Cognition entails autonomy
Cognition	Rational goal-achievement	Self-maintenance and self-development
Philosophical Foundation	Positivism	Phenomenology
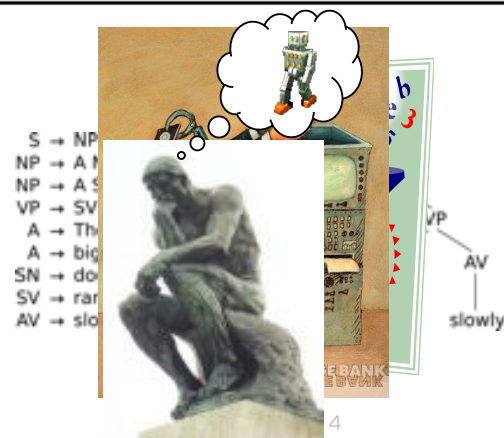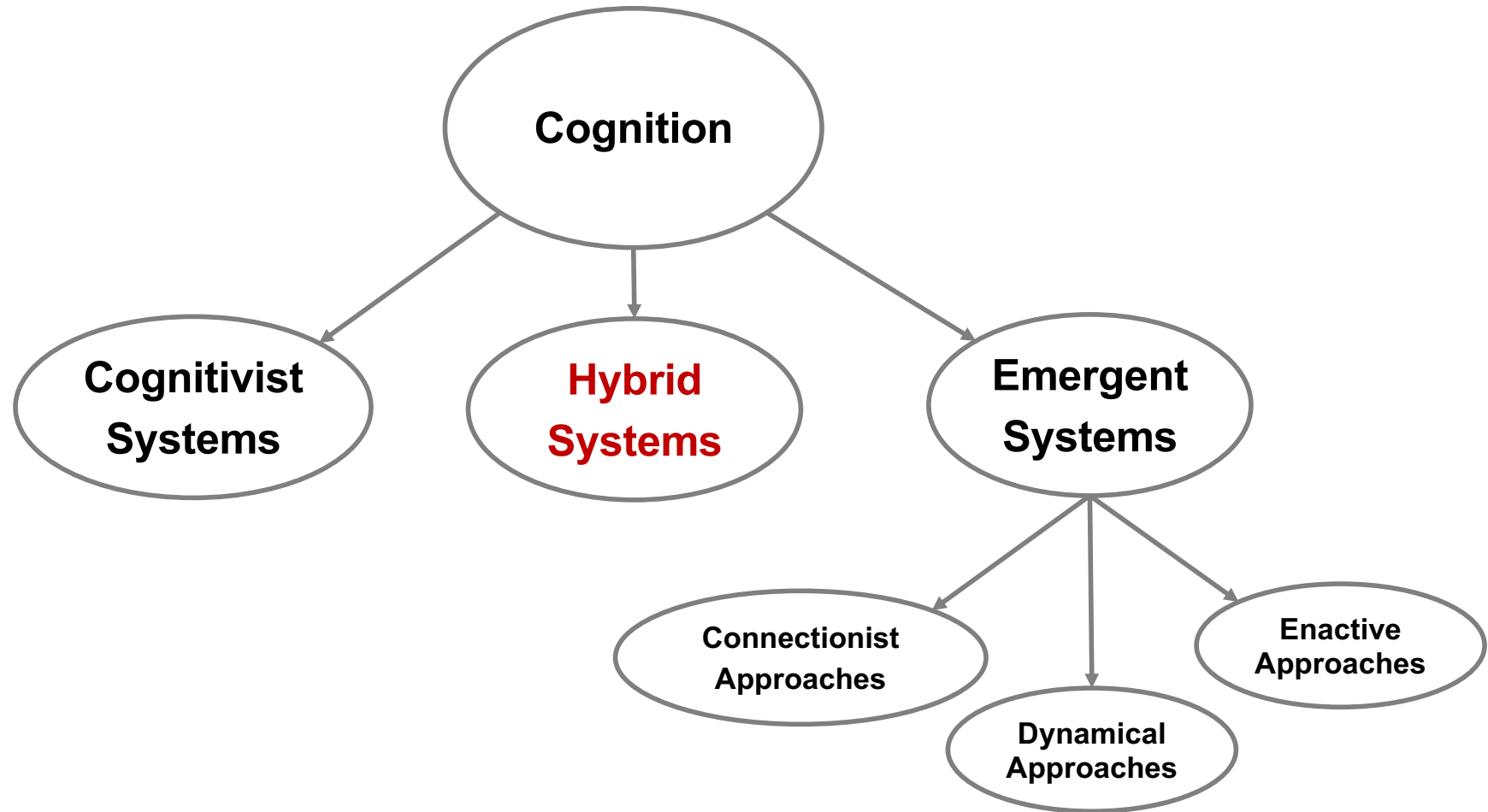
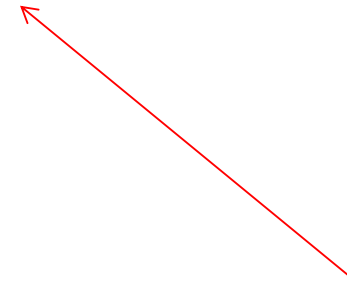# Hybrid Models

H vs h

Hybrid Models

H vs h

Reconcile all differences, including antagonistic philosophical foundations

Hybrid Models

H vs h

Symbolic & sub-symbolic
representations and processes

Which Paradigm is Correct?

- Paradigms are not equally mature

- Dynamical systems
  - Arguments are compelling but …
  - Not yet clear how to achieve higher-level cognition

- Cognitivist systems
  - More advanced
  - Not many achievements in generalization yet
  - More brittle (in principle)

- Enactive (& Dynamical)
  - Should be much less brittle (mutual specification through co-development)
  - But limited cognition at present

- Hybrid systems
  - Best of both worlds?
  - Unclear how one can really combine antagonistic philosophies
  - Still lots of disagreement on the right approach to take
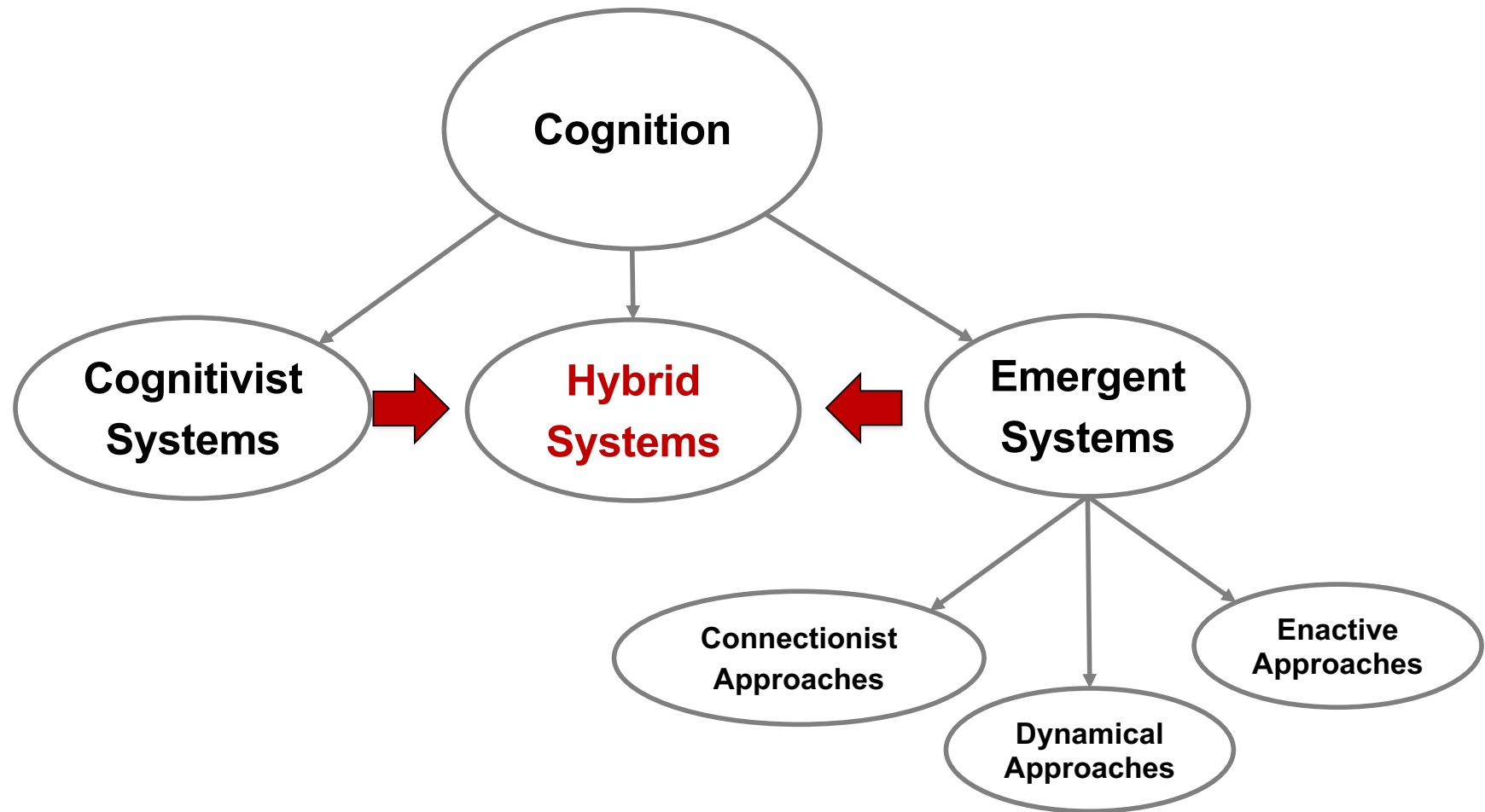
What is Cognition?

|	
Cognitivism	Information processing: rule-based manipulation of symbols
Connectionism	Emergence of global states in a network of simple components
Dynamical Systems	A history of activity that brings forth change and activity
Enactive Systems	Effective action: history of structural coupling which enacts (brings forth) a world

Adapted from (Thelen & Smith 94) and (Varela 88)

How Does it Work?	
Cognitivism	Through any device that can manipulate symbols
Connectionism	Through local rules and changes in the connectivity of the elements
Dynamical Systems	Through self-organizing processes of interconnected sensorimotor subnetworks
Enactive Systems	Through a network of interconnected elements capable of structural changes undergoing an uninterrupted history

What does a good cognitive system do?	
Cognitivism	Represents the stable truths about the real world, and solves problems posed to it
Connectionism	Develops emergent properties that yield stable solutions to tasks
Dynamical Systems	Becomes an active and adaptive part of an ongoing and continually changing world
Enactive Systems	Becomes part of an existing on-going world of meaning (in ontogeny) or shapes a new one (in phylogeny)
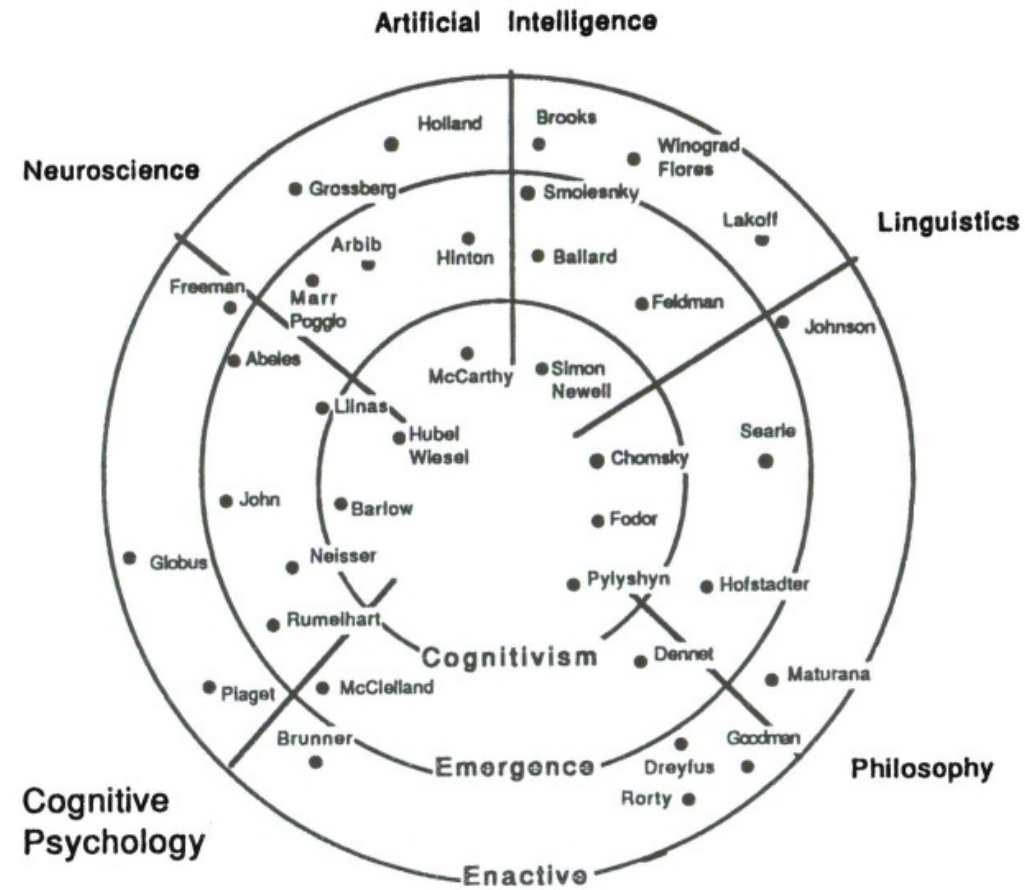
(From Varela 92)

Reading

D. Vernon, Artificial Cognitive Systems – A Primer, MIT Press, 2014; Chapter 2, 53-61.

C. D. Alupo, D. Omeiza, and D. Vernon, "Realizing the Potential of AI in Africa: It All Turns on Trust",
in Towards Trustworthy Artificial Intelligence Systems, M. I. Aldinhas Ferreira (Ed.), Springer,
in press.