HOW ARE COGNITIVE SYSTEMS ORGANIZED?

ARCHITECTURES FOR INTELLIGENT AGENTS
FODOR ON THE MODULARITY OF MIND
THE MASSIVE MODULARITY HYPOTHESIS
HYBRID ARCHITECTURES

MIND?

Cognitive scientists tend to think of the mind as an organized collection of specialized sub-systems carrying out specific information-processing tasks.

ARCHITECTURES FOR INTELLIGENT AGENTS

ONE OF THE AIMS OF AI RESEARCHERS IS TO BUILD INTELLIGENT AGENTS

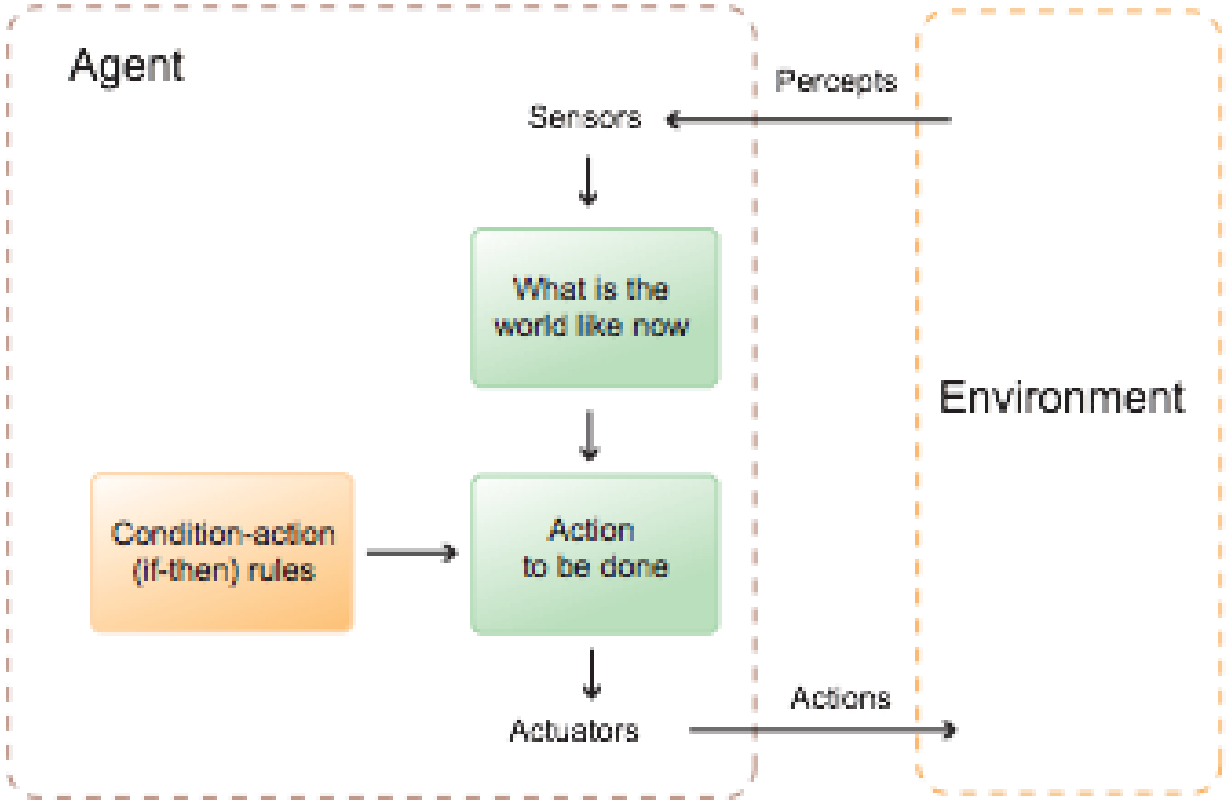
THREE DIFFERENT TYPES OF AGENT ARCHITECTURE

Agent: System that perceives its environment through ***sensory systems*** of some type and acts upon that environment through ***effector systems***. Different types of agent is distinguished by the complexity of the links between sensory systems and effector systems.

1. A simple reflex agent
2. A goal-based agent
3. A learning agent

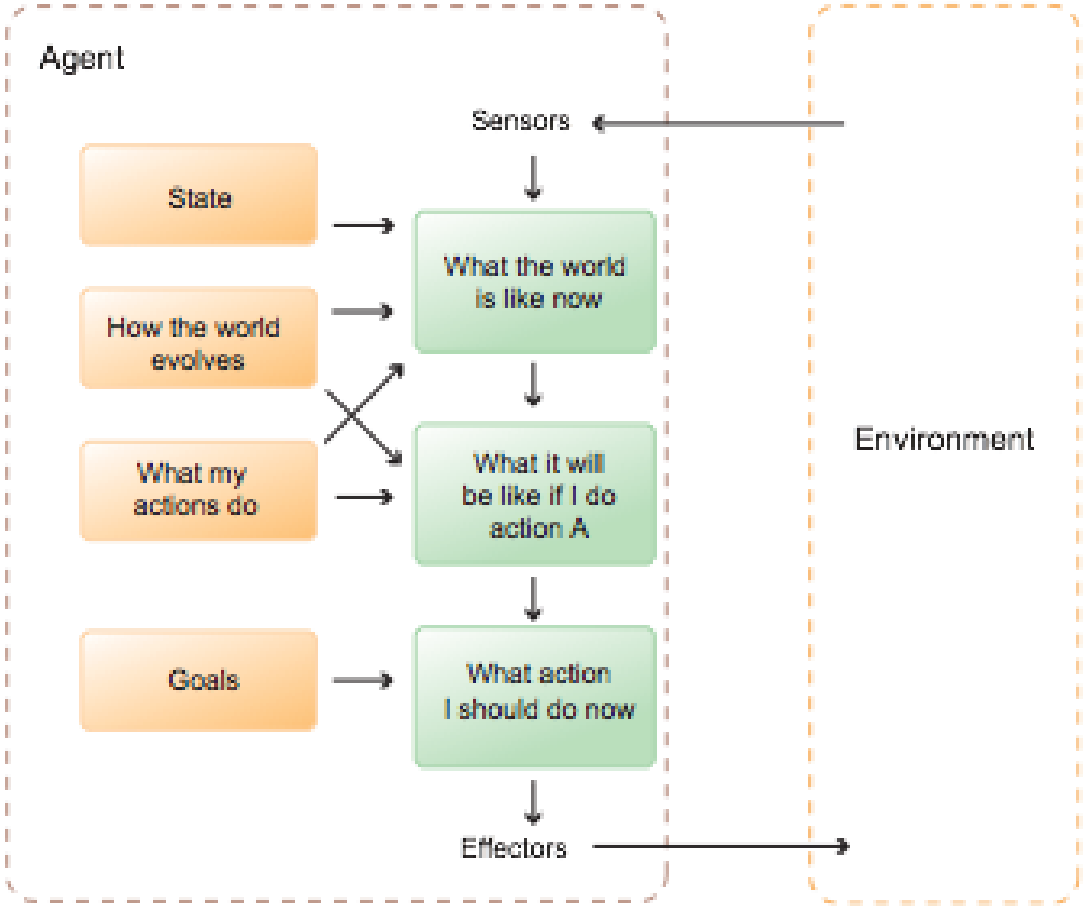
Ex) the robot SHAKEY, Shopping bots (internet)

A SIMPLE REFLEX AGENT



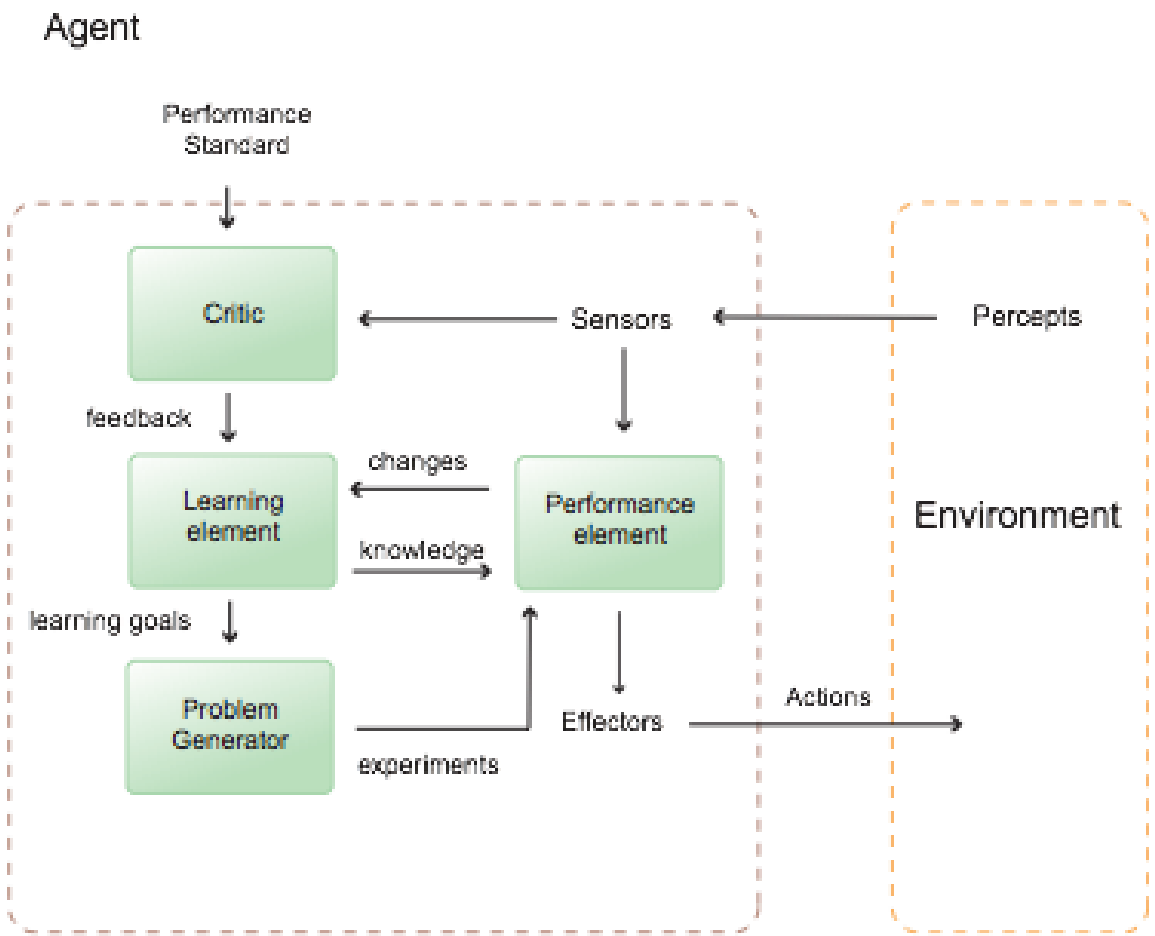
- Condition-action rules (production rules):
  IF *condition C holds* THEN *perform action*
- Simple reflex agents are not cognitive systems
  - Cognitive systems represent the environment
  - Cognitive systems can react differently to the same environmental stimulus

A GOAL-BASED AGENT



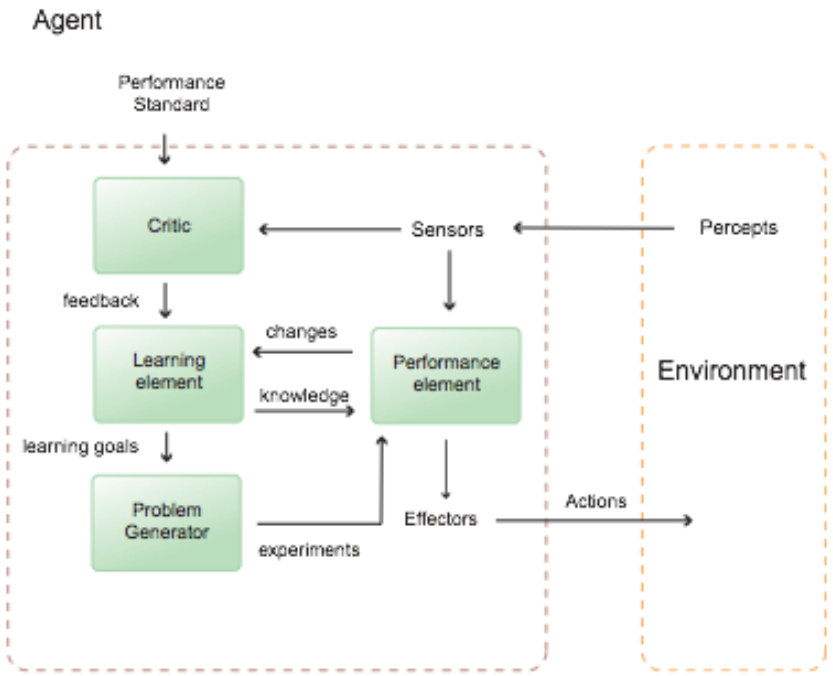
- Working out the consequences of different possible actions and then evaluate those consequences in the light of their goals.

A LEARNING AGENT



- Existence of sub-systems that operate inside the agent (the Critic sub-system)

A LEARNING AGENT



- How are we to identify and distinguish cognitive sub-systems?
- Are there any important differences between the sub-systems responsible for sensory processing and motor behavior, on the one hand, and those that operate between those input and output sub-systems?
- Do all the sub-systems in a cognitive system process information in the same way? Do they all involve the same type of representations?
- How "autonomous" are the different sub-systems? How "insulated" are they each from each other?

FODOR ON THE MODULARITY OF MIND

DOMAIN-GENERAL VS. DOMAIN-SPECIFIC

- Mind contains autonomous cognitive sub-systems (*The modularity of Mind*, 1983 - Jerry Fodor)
- Phrenologist Franz Joseph Gall
- Existence of domain-specific cognitive system (vs. domain-general, for example, attention, memory, etc.)

CHARACTERISTICS OF MODULAR PROCESSING

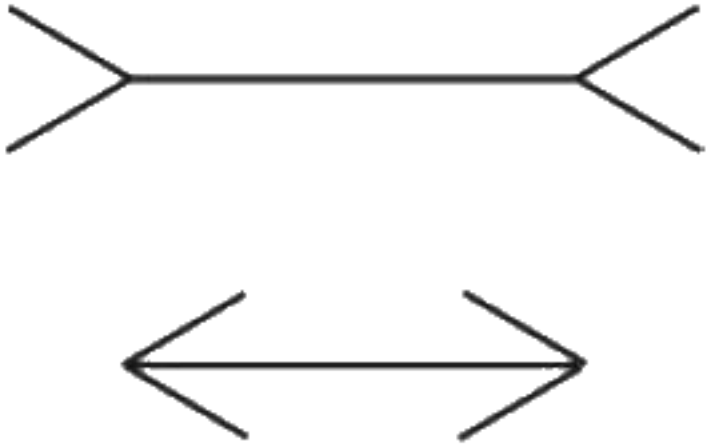
- *Domain-specific*: modules are highly specialized
- *Informational encapsulation*: independent, unaffected by other modules
- *Mandatory application*: responding automatically to stimuli of the appropriate kind
- *Speed*: Transformation of inputs to outputs is quick and efficient
- Fixed neural architecture
- Specific breakdown patterns: ex. Prosopagnosia

CENTRAL PROCESSING

- *Central Processing is Quinean and Isotropic (holistic and not informationally encapsulated)*

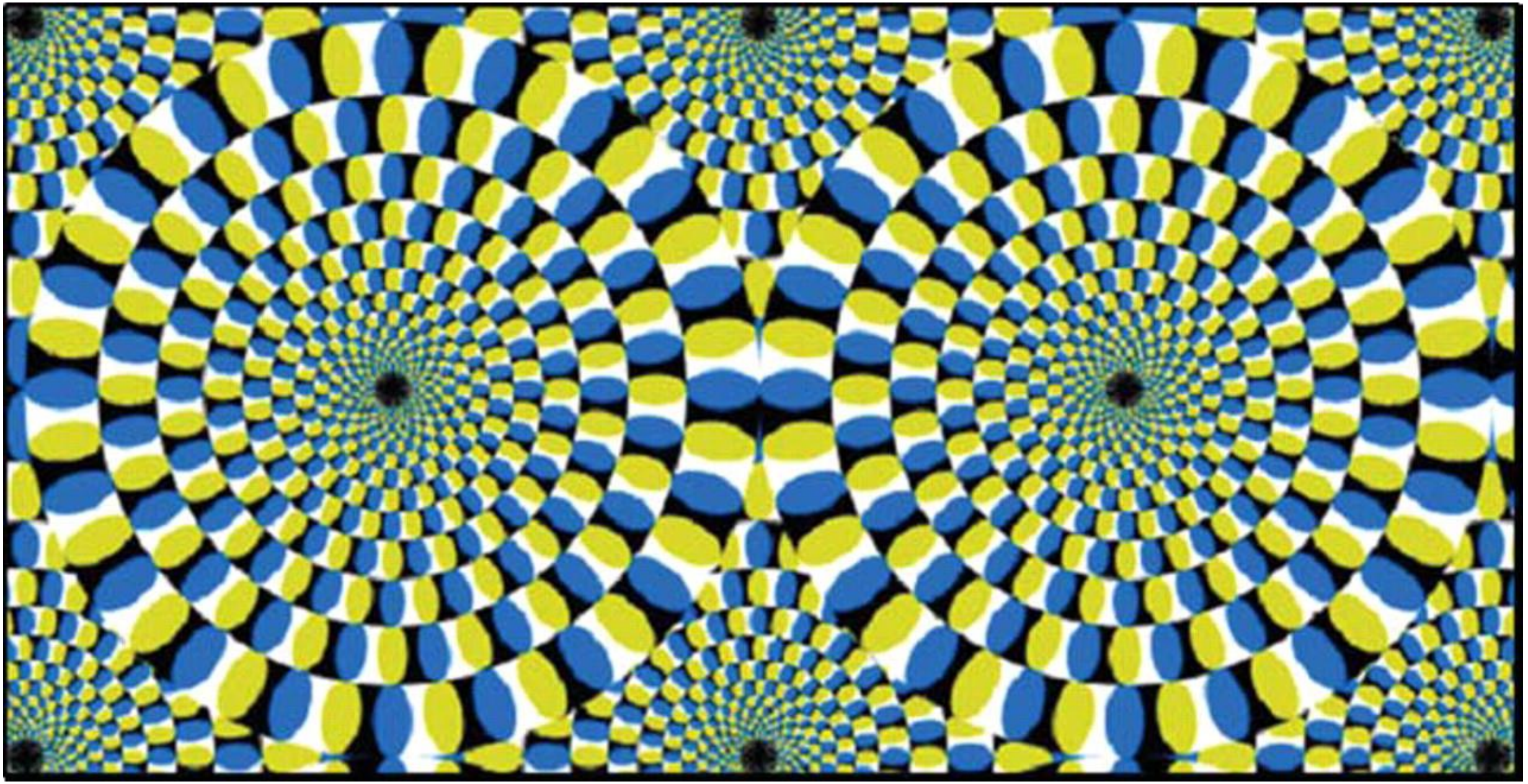
INFORMATIONAL ENCAPSULATION?

- *Informational encapsulation*: independent, unaffected by other modules



The Muller-Lyer illusion

ILLUSORY MOTION



INFORMATIONAL ENCAPSULATION?

- *Muller-Lyer illusion is affected by environmental, cultural differences*
- *McGurk effect*

THE MASSIVE MODULARITY HYPOTHESIS

MASSIVE MODULARITY HYPOTHESIS

- Fodor thought that central processing is non-modular because it is not informationally encapsulated
- The massive modularity hypothesis released the "informationally encapsulation" assumption from the requirements for modularity

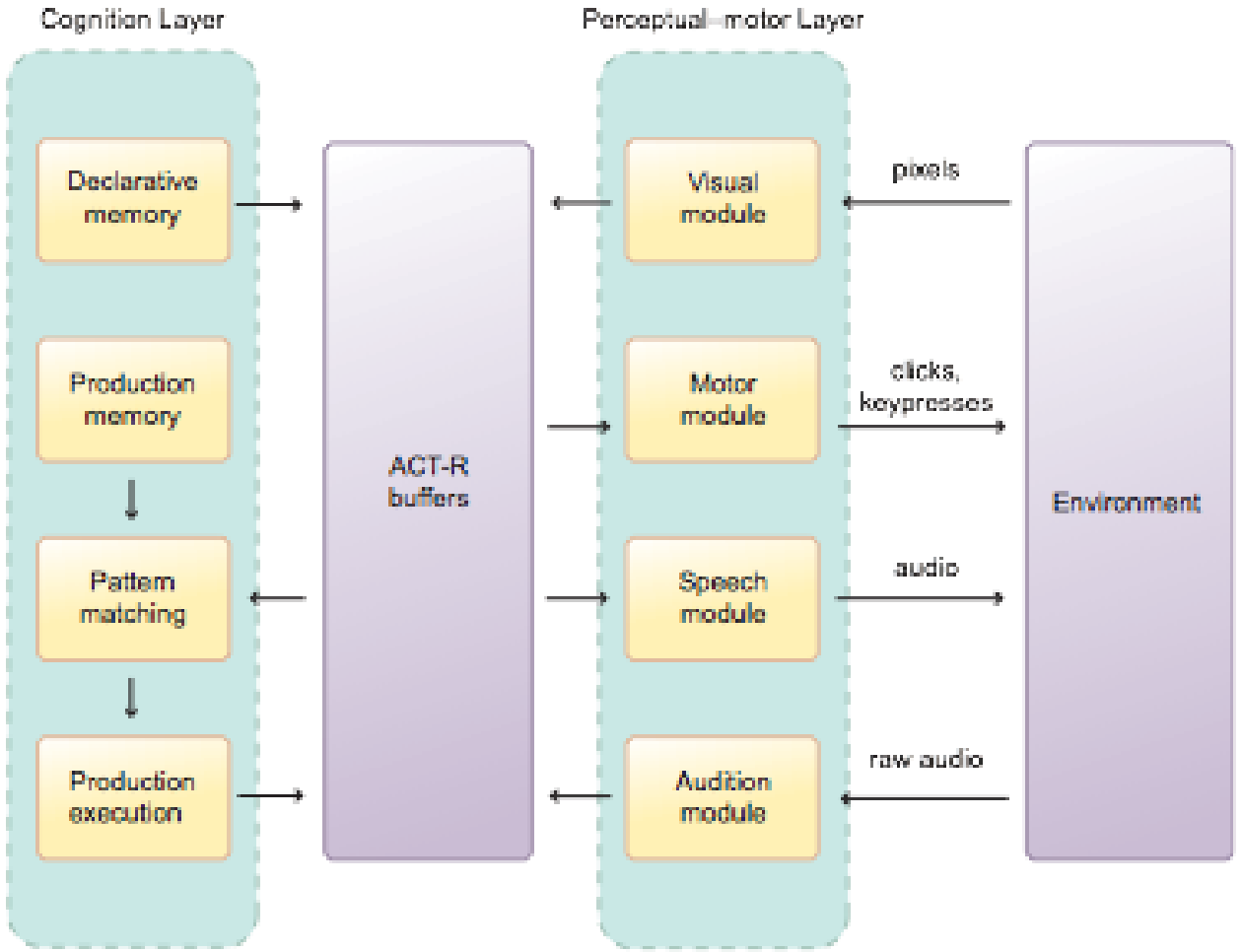
HYBRID ARCHITECTURES

ACT-R/PM COGNITIVE ARCHITECTURE

- ACT-R/PM: Adaptive Control of Thought - Rational/Perceptual-Motor
- Two layer system: perceptual-motor layer and cognition layer. Communication between layers is done through a number of buffers
- Cognition layer is built upon two types of knowledge (declarative and procedural)
- Declarative knowledge is organized in terms of ‘chunks’, procedural knowledge is represented in terms of production rules.

ACT-R/PM COGNITIVE ARCHITECTURE

- What makes decision? Central processing? Selection of production rule?
  - Pattern matching module performs this job
  - Calculation of utility of each production rule
  - Activation levels of chunks determine the selection



ACT-R/PM COGNITIVE ARCHITECTURE

- What makes decision? Central processing? Selection of production rule?
  - Pattern matching module performs this job
  - Calculation of utility of each production rule
  - Activation levels of chunks determine the selection

TABLE 10.2 Comparing the symbolic and subsymbolic dimensions of knowledge representation in the hybrid ACT-R/PM architecture

	PERFORMANCE MECHANISMS		LEARNING MECHANISMS	
	SYMBOLIC	SUBSYMBOLIC	SYMBOLIC	SUBSYMBOLIC
Declarative chunks	Knowledge usually facts) that can be directly verbalized	Relative activation of declarative chunks affects retrieval	Adding new declarative chunks to the set	Changing activation of declarative chunks and changing strength of links between chunks
Production rules	Knowledge for taking particular actions in particular situations	Relative utility of production rules affects choice	Adding new production rules to the set	Changing utility of production rules