Hierarchical Conceptual Rotation of Mental Knowledge Representation

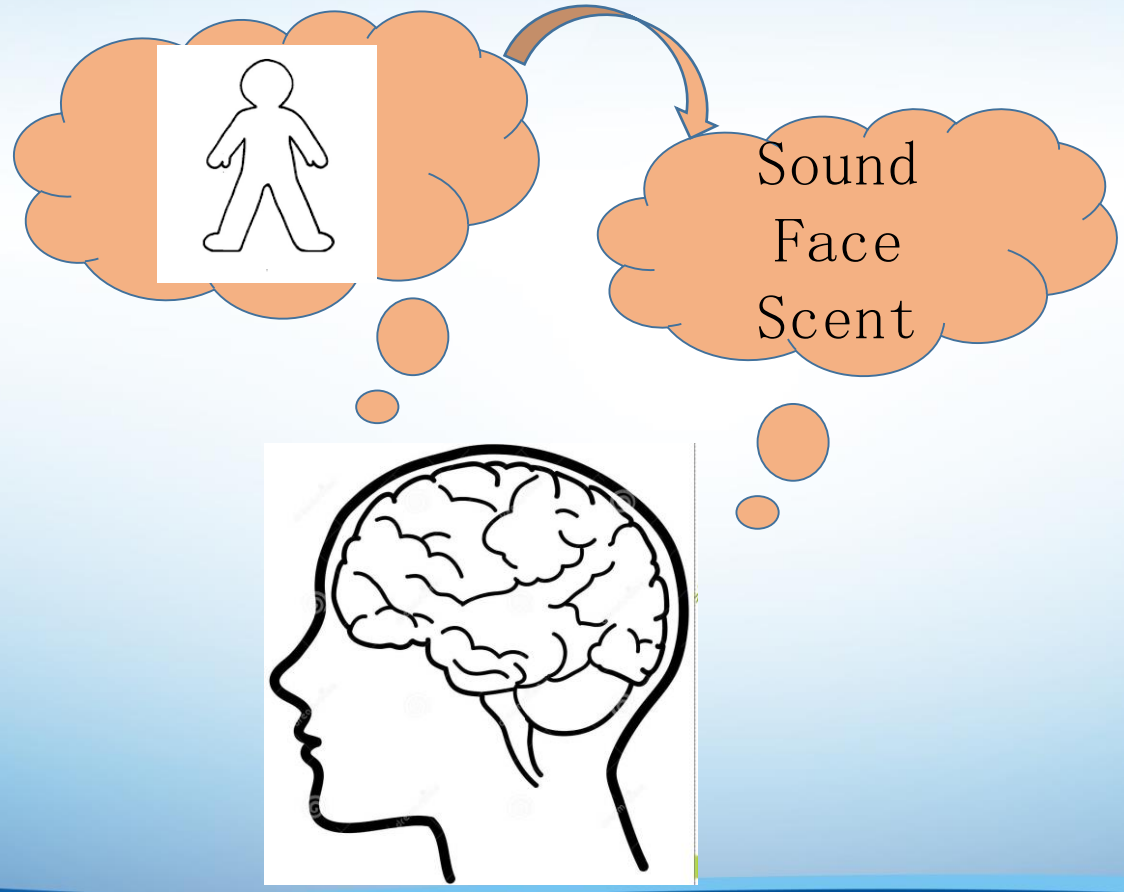
Kai Yi (易凯)
School of Software Engineering,
Institute of Artificial Intelligence and Robotics,
Xi'an Jiaotong University

June 7th, 2018

Knowledge Representation of Mental (Mental Imagery)

- Mental Imagery: The mental representation of things that currently are not in sensory perception (Kosslyn 1986)

- All the notions of a person's sound, the shape of his face, or his scent in the absence of that person, is a mental image



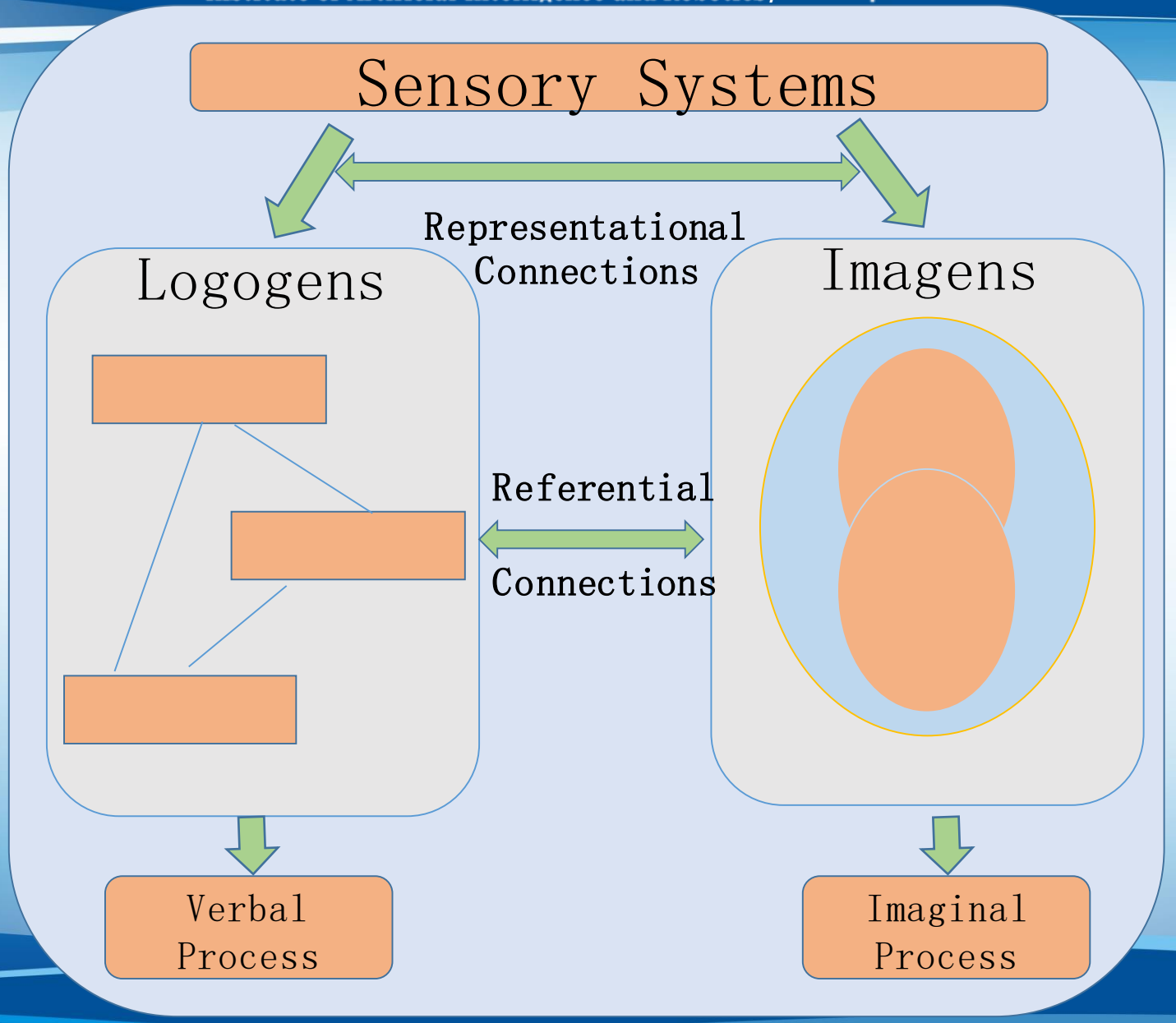
Three central hypotheses of mental imagery

- Dual Coding Theory: There are two codes and sotrage systems - one imaginal, the other verbal- And that information may be coded and stored in either or both (Paivio 1965)
- Conceptual Propositional Theory: Both visual and verbal information are represented in the form of abstract propositions about objects and their relationships (Anderson and Bower 1973)
- Functional Equivalency Theory: Imagery and perception employ similar processes (Shepard and Kosslyn 1971, 1973, 1975)

Dual Coding Theory

There are two codes and two storage systems - one imaginal, the other verbal- And that information may be coded and stored in either or both (Paivio 1965)

Store all physical objects and remember them are unrealistic



Conceptual Propositional Theory

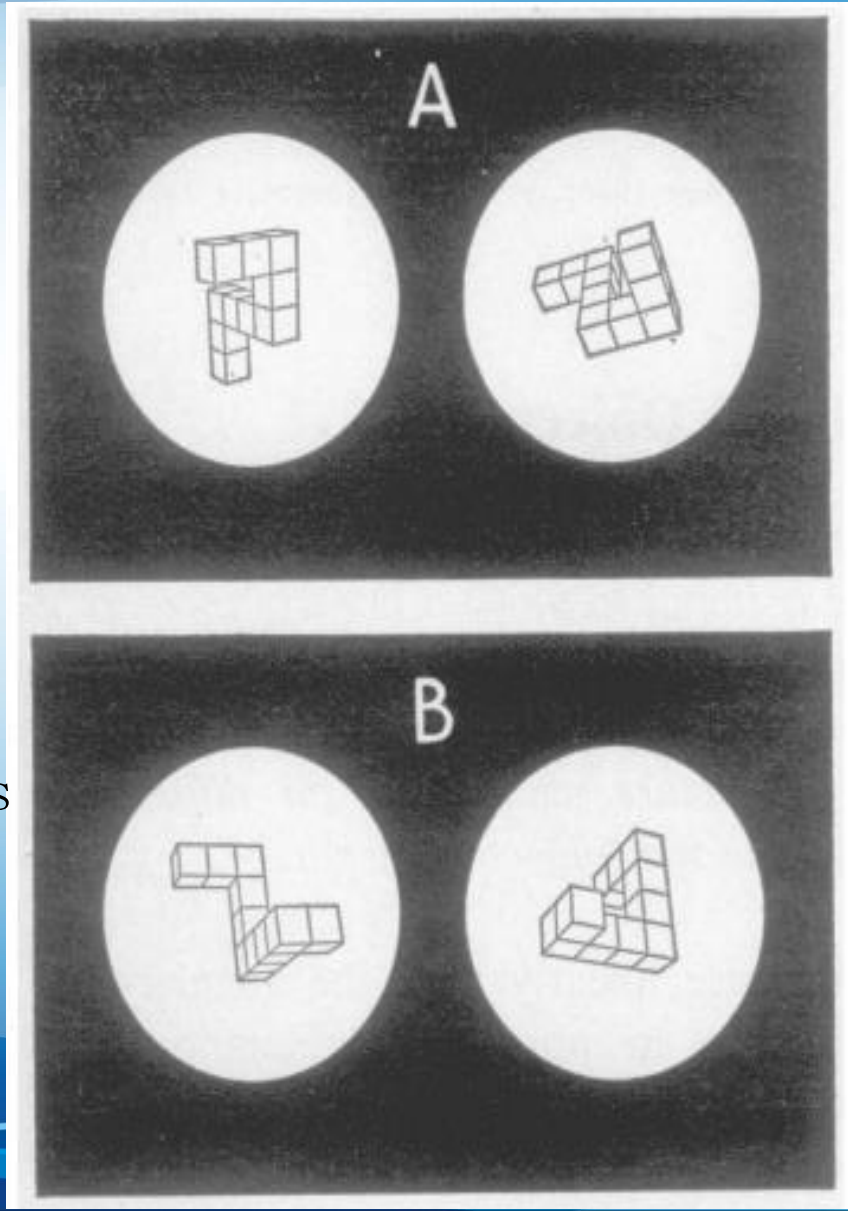
- There are two codes and storage systems - one imaginal, the other verbal- And that information may be coded and stored in either or both (Paivio 1965)
- It is our understanding of the relationship among objects that shapes our knowledge
- The arbitrary and sometimes incorrect choice of proposition can be witnessed in the way that things are conceptualized

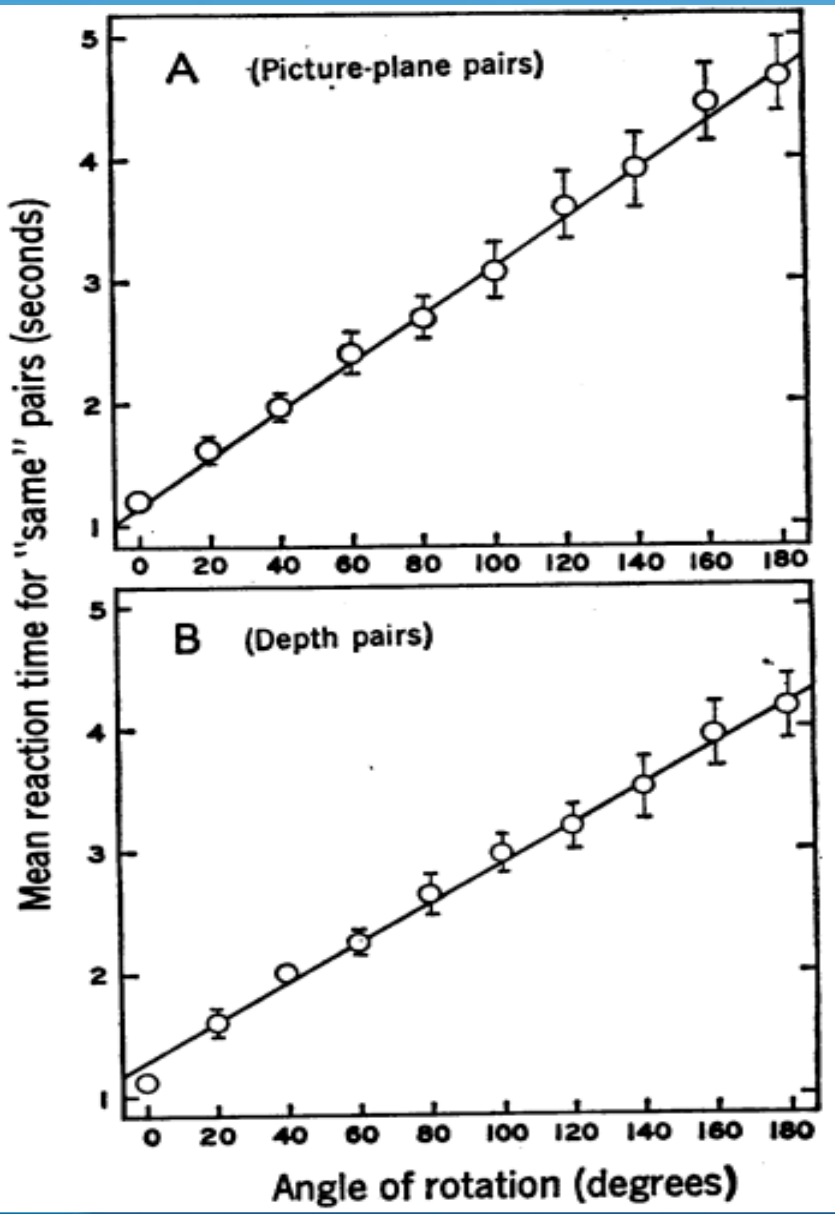
Functional Equivalency Theory

Imagery and perception employ similar processes

Imagery: Mental Rotation
Perception: Physical Objects

Mental Rotation (Shepard 1971). A is picture plane rotation, B is depth rotation





Comparison among Three Mental Imagery Theories

Theory	Key Point	Problem
Dual Coding Theory	Two code and storage systems	Limited storage capacity
Conceptual Propositional Theory	Concepts instead of objects in mental	Hard to explain the manipulation of imagery
Functional Equivalency Theory	Mental imagery is similar to perception	Functional Relevance, No provincing knowledge usage

We proposed a novel hierarchical conceptual rotation theory to solve all this problem!

Hierarchical Conceptual Rotation

Hypothesis: Knowledge representation of mental (mental imagery) is in a form of hierarchical conceptual rotation.

Hierarchical Conceptual Rotation

Hypothesis: Knowledge representation of mental (mental imagery) is in a form of hierarchical conceptual rotation.

Visual Image

Perception

Hierarchical Representation of Knowledge

- Physical
- Characteristical
- Functionial
- Rule

Knowledge Manipulation

Step into next level
If conf1 less than threshold1

Conceptual Rotation

- Concept-level Image Scaling
- Concept-level Image Scanning
- Concept-level Image Rotation

Deep Level Conf1

Identified Conf2

Output If conf2 greater than threshold2

Output

Hierarchical Conceptual Rotation

Mental imagery consists of two parts: hierarchical concepts with differnt level abstract and concept-based perception rotation

Hierarchical concepts consists of three or more levels: physical level (hard to distinguish from others), characteristic level (particular keypoints), functional level (fundamental linguistic), rule level (high-order concepts)

Conduct mental imagery in a bottom-up manner

Conceptual rotation: Concept-based image scaling, image scanning and image rotation.

Convert them to image.....

Hierarchical Conceptual Rotation

Hypothesis: Knowledge representation of mental (mental imagery) is in a form of hierarchical conceptual rotation.

Visual Image

Perception

Hierarchical Representation of Knowledge

- Physical
- Characteristical
- Functionial
- Rule

Knowledge Manipulation

Step into next level If conf1 less than threshold1

Conceptual Rotation

- Concept-level Image Scaling
- Concept-level Image Scanning
- Concept-level Image Rotation

Deeper Level Conf1

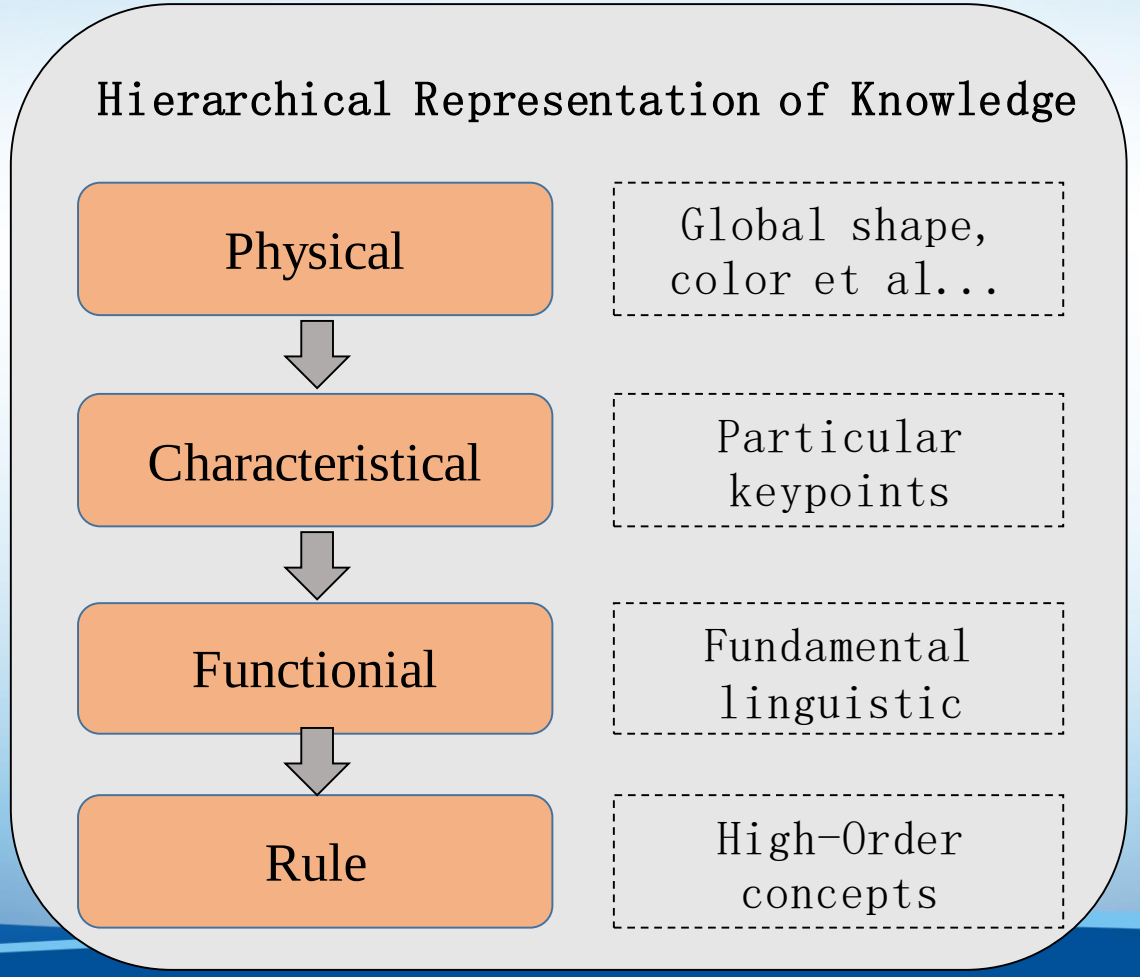
Identified Conf2

Output If conf2 greater than threshold2

Output

Hierarchical Representation of Knowledge

- **Four level with different degree of abstraction**
  - physical level (objects which are hard to distinguish from others)
  - characteristical level (particular keypoints)
  - functional level (fundamental linguistic)
  - rule level (high-order concepts)
- **Conduct mental imagery in a bottom-up manner**



Experimental Design

Perspectives

- The proposed novel mental imagery theory may contribute to the deeper understanding of human cognition

- The novel framework of the manipulation of perception may help to build more human-alike and dynamic artificial intelligence systems

- For this course, the procedure of the proposed theory may inspire more undergraduates to the field of research as it's really appealing and full of surprise

Thank You!

Xi'an Jiaotong University

IAIR Est. 1986

Institute of Artificial Intelligence and Robotics