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# Analogy: What's Missing

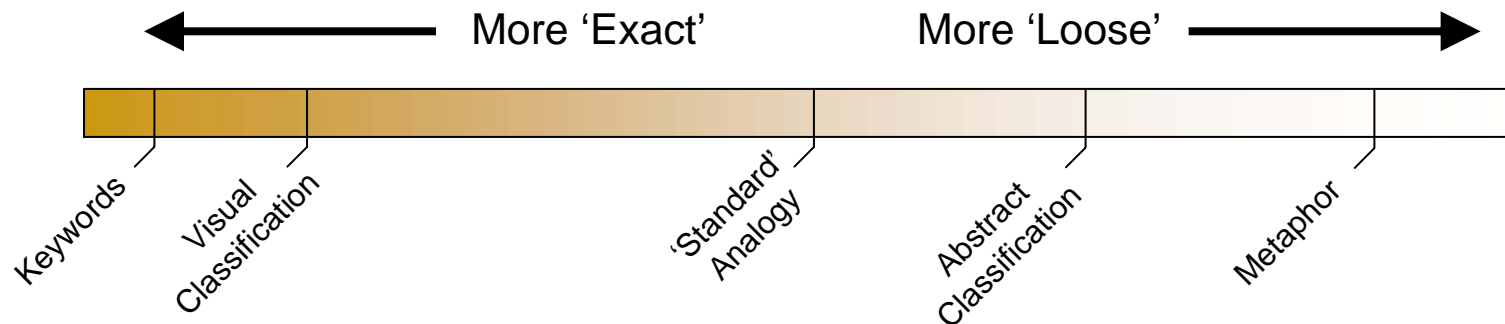
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# Analogy is Fundamental

Proposition: Analogy is a sine qua non of human intelligence

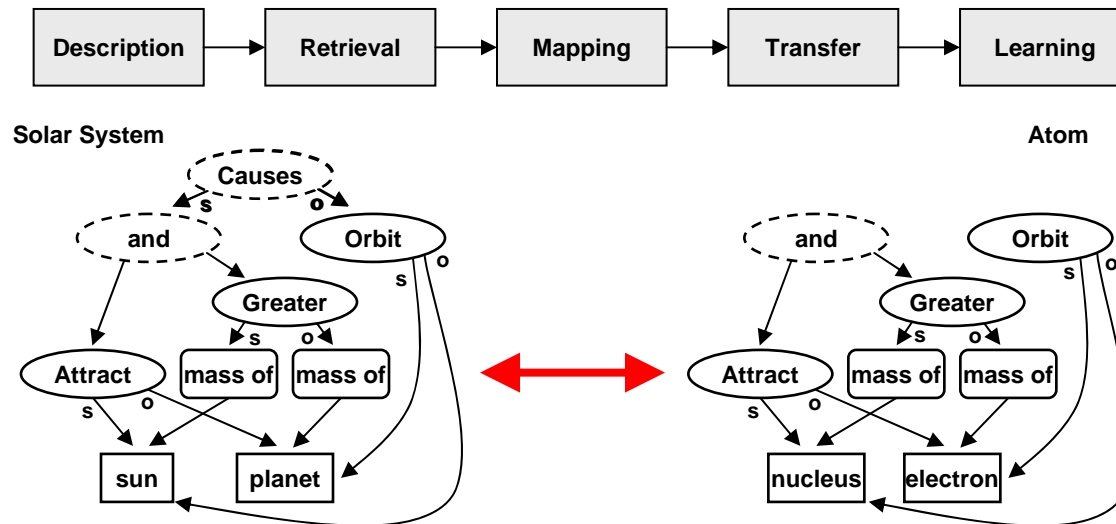
- Categorization of previously unknown examples
- Flexible application of prior knowledge to new problems
- Cross-domain transfer of ideas and understanding



# State of the Art in Computational Analogy

(to the first approximation)

- Structure-Mapping Theory (Gentner 1983)
- Structure-Mapping Engine (Falkenhainer *et al.* 1986)
- Incremental Analogy Machine (Keene *et al.* 1994)
- Intermediate Features (Finlayson & Winston 2005)



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# Experimental Work

- Mapping without Retrieval (Gick & Holyoak 1980)
- Retrieval without Mapping (Holyoak 1985)
- Mapping without Transfer (Novick & Holyoak 1991)
- Expertise Helps All Around (Novick 1988)
- Analogies Help you build Schemas (Genter *et al.* 2003)

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# Impediments to Progress

## ■ Representational Poverty

- Lack of computationally efficient representations
- The full scope of information that should be represented is unknown

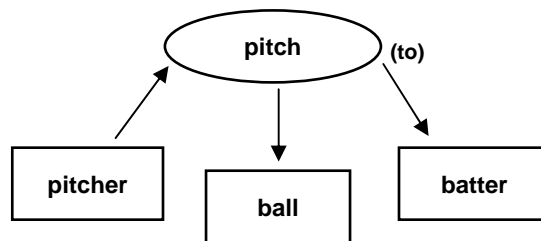
## ■ Lack of data

- Human intelligence draws on a vast store of experience
- Entering this experience into the computer is a major bottleneck

# What's Missing: Multirepresentationalism



The present way

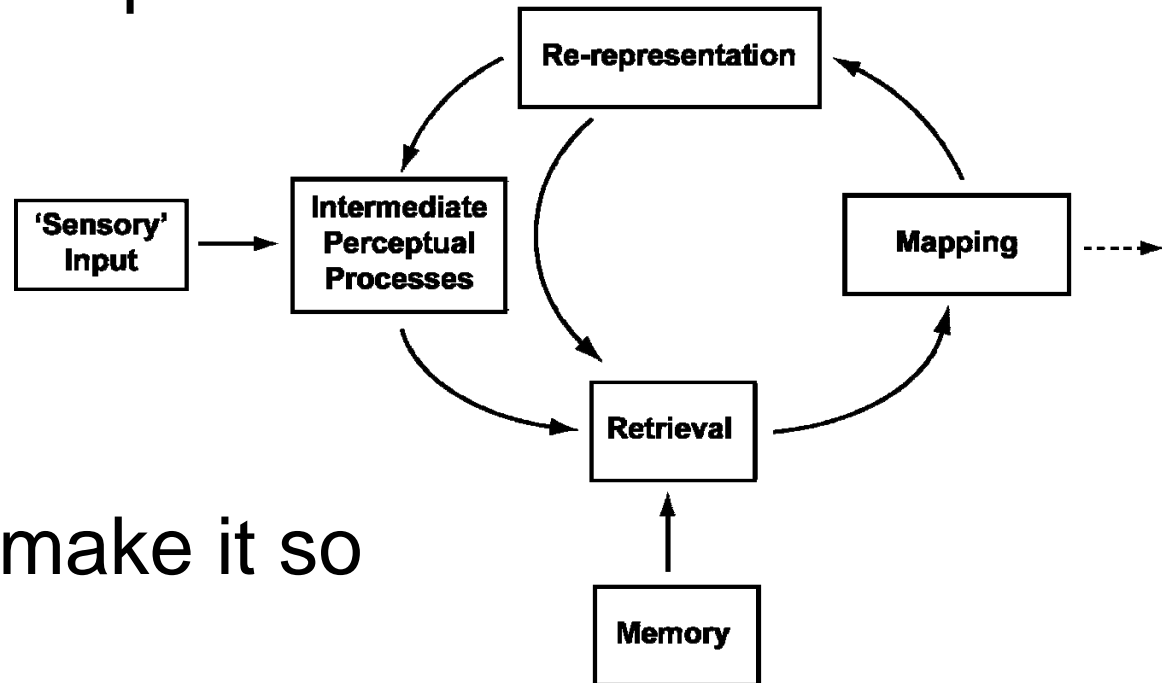


But what might we have represented?

- **Visual hue, intensity, and depth**  
(blob of white pixels, blob of blue, the former is closer)
- **Auditory Information**  
(the roar of the crowd, grunting of the players)
- **Pattern or trajectory of motion**  
(how the pitcher pitches)
- **Identities of Objects**  
(blob1 = man, pitcher; blob2 = man, 3<sup>rd</sup> baseman)
- **Physical Location**  
(pitcher is on the mound, baseman and crowd are in front of the pitcher)
- **Physical Causality**  
(pitcher's pitch causes the ball to fly forward)
- **Events and their relationships in time**  
(The look, the windup, then the pitch)
- **Emotions**  
(The pitcher is calm, the crowd is going wild)
- **Motivations**  
(The pitcher wants to win the game, wants to strike out this batter)
- **Abstract Identities**  
(They're playing a game, there are two teams)

# What's Missing: Re-representation

- The right information for matching is not automatically explicit



- You have to make it so

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# What's Missing in General

- Interaction with other cognitive or perceptual abilities to decide:
  - What is important to represent
  - How to represent it
- Currently, analogy is a theory unto itself

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# Advice

- If BICA is our goal, then:
  - Analogy is one of our fundamental building blocks

– but –

- We must overcome the impediments
- We must fill in the missing pieces