Introduction to Cognitive Science

(2: Three milestones)

Intro

- Language
    - One of the most sophisticated cognitive achievements
    - Animals?
    - Tool for thinking
    - Natural language is the center of CogSci
    - Language as such has two „issues”, which opens up research
        - Does not tell us how info is stored or accessed
        - Grounding/World knowledge

ELIZA
(1966 Weizenbaum)

BOX 2.1 A Conversation with ELIZA

ELIZA's responses are in uppercase.

Men are all alike
IN WHAT WAY?

They are always bugging us about something or other
CAN YOU THINK OF A SPECIFIC EXAMPLE?

Well, my boyfriend made me come here
YOUR BOYFRIEND MADE YOU COME HERE?

He says I'm depressed much of the time
I'M SORRY TO HEAR THAT YOU ARE DEPRESSED

It's true. I am unhappy
DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY?

I need some help. That much seems certain
WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP?

Perhaps I could learn to get along with my mother
TELL ME MORE ABOUT YOUR FAMILY

Natural Language Processing (1972 Winograd)

- Winograd's doctoral disertation, presented in 1970
- SHRDLU
- A program whose aim is to use **language** to interact with the **environment**
- Also, a robotic arm (effector) for manipulation
- Three reasons why is it important:
  - Model of knowledge representation
  - Models a cognitive task by breaking it into components
  - Encapsulated the idea of language as an algorithmic process

Natural Language Processing (1972 Winograd)

- SHRDLU does not really do justice to how conversations happen in real life
  - Assume e.g. that people generally tell the truth
- No complex structures like counterfactuals
- But, in general the underlying assumption is of critical importance
  - **One way of understanding a cognitive phenomenon is to built a machine that does it...**
  - AI is a great tool, but it is not the only tool here...

Natural Language Processing (1972 Winograd)

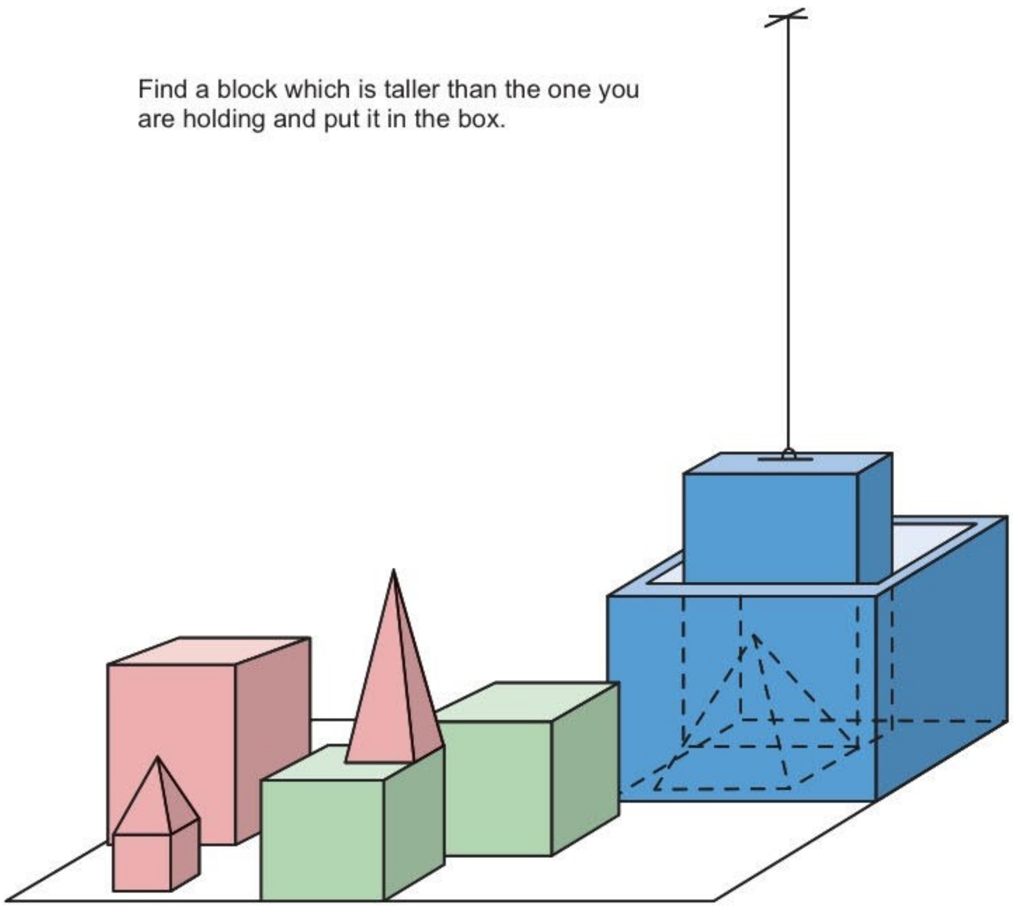


Figure 2.6 SHRDLU completing instruction 3 in the dialog: "Find a block which is taller than the one you are holding and put it in the box." (Adapted from Winograd 1972: Figure 3)

Mental rotation
(1971 Shepard and Metzler)

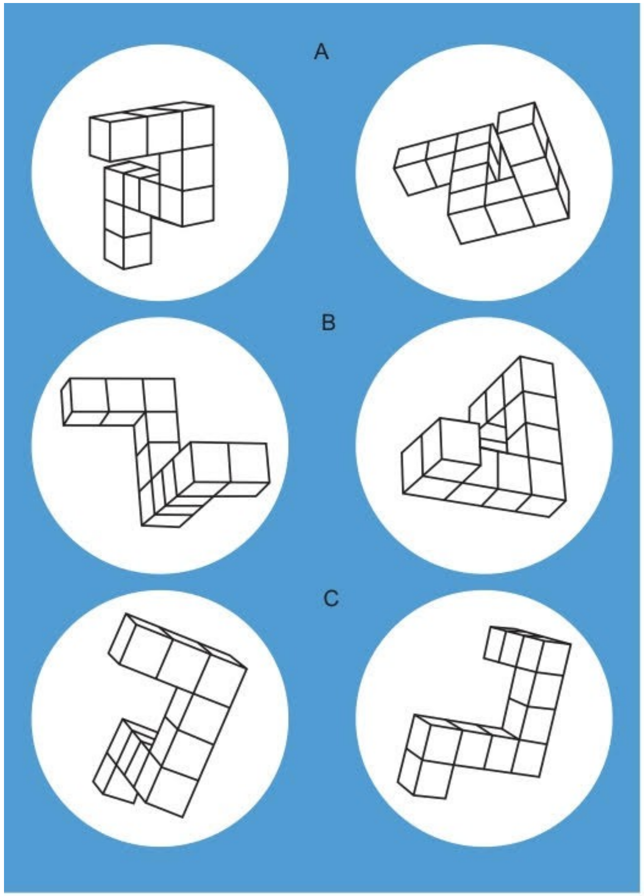
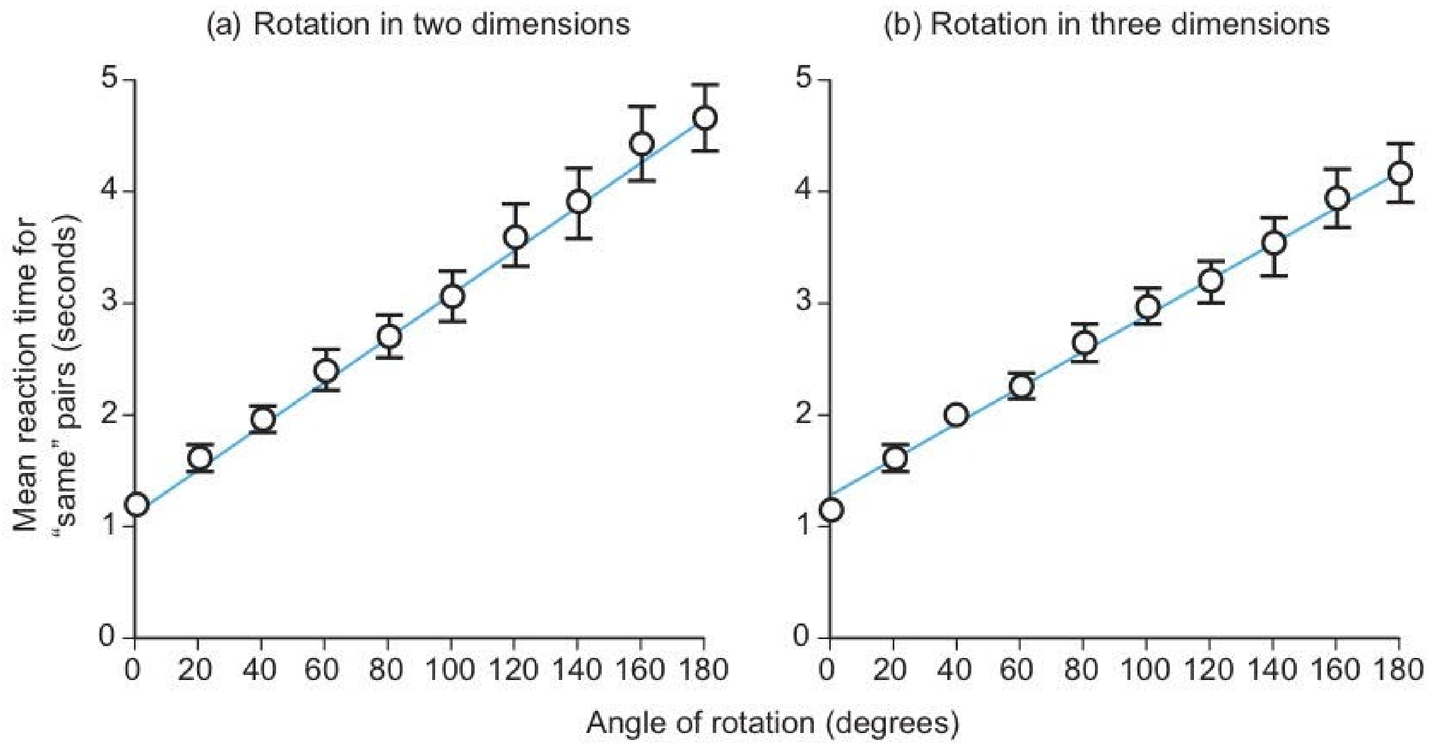


Figure 2.7 Examples of the three-dimensional figures used in Shepard and Metzler's 1971 studies of mental rotation. Subjects were asked to identify which pairs depicted the same figure at different degrees of rotation. (Adapted from Shepard and Metzler 1971)

Mental rotation (1971 Shepard and Metzler)

- Direct, **linear** realtionship between the time it took to solve it and the degree of rotations
- **Forming** mental representations and manipulating them



A couple of comments and observations

- What makes mental images/models possible?
    - Rotation in my „mind's eye” does not really expain what is going on in our minds
- Suppose we a have a pixel by pixel description
    - Now, solving the rotations is a **comparison of two matrices** according to some relation, which evals to TRUE or FALSE
    - Do we get 2d images? Do we have some faculty that interprets them as 3d? Do I have some faculty that reinterprets a 3d „video” into mental representations? Or in „code” (like PROLOG code)?
    - **Which of this is the „native” representation for the human mind?**
- **Almost all cognitive scientists today think that cognition is information processing!**

Levels of explanation
(1982 Marr)

- **Fundamental problem in CogSci:** how to combine and integrate different levels of explanation
- Marr's book Vision: *A Computational Investigation into the Human Representation and Processing of Visual Information*
- Distinguishes three levels for analyzing cognitive systems:
  - (top) computational level
  - Algorithmic level
  - Implementational level
- Marr is a prime example of **top-down** analysis

Levels of explanation (1982 Marr)

TABLE 2.1 A table illustrating the three different levels that Marr identified for explaining information-processing systems

COMPUTATIONAL THEORY	REPRESENTATION AND ALGORITHM	HARDWARE IMPLEMENTATION
What is the goal of the computation, why is it appropriate, and what is the logic of the strategy by which it can be carried out?	*How can this computational theory be implemented? In particular, what is the representation for the input and output, and what is the algorithm for the transformation?*	*How can the representation and algorithm be realized physically?*

Note. Each level has its own characteristic questions and problems. (From Marr 1982)

Levels of explanation (1982 Marr)

- Marr's approach is intrinsically interdisciplinary
- Uses the results of Elisabeth Warrington's work on patients with damage to the **left and right parietal cortex**
  - Damage produces problems in perceptual recognition
  - **Right** parietal lesion patiens are able to recognize objects **if they see them** from a familiar angle
    - (left lesion seem to have no such effect)
  - If not, they vehemently deny the connection between objects

Levels of explanation
(1982 Marr)

Levels of explanation (1982 Marr)

Figure 2.10 Two images of a bucket. A familiar/conventional view is on the left, and an unfamiliar/unconventional view is on the right. (From Warrington and Taylor 1973)

Levels of explanation (1982 Marr)

- Quick conclusions from Warrington:
  - The info about the shape of an object must be processed **separately** from information about what the object is.
  - The visual system can deliver a specification of the object **even when** the perceiver fails to recognize the object
- At the **computational level**, the visual system's task (**goal**?) is to cnstruct a 3d representation in a form that will allow the object to be recognized
  - This representation should be **object-centered** rather than egocentric

Levels of explanation (1982 Marr)

- Analysis at the algorithmic level requires more details:
  - How exactly is the input and output information encoded?
  - What are the **representational primitives** (basic units on which computation is performed)?
  - What computations are carried out on those primitives?

Levels of explanation (1982 Marr)

- A crucial part of the function of vision is to recover information about the surfaces in the field of view:
  - **Primal sketch**: makes explicit some basic information on the retinal image: light, relative brightness of areas, etc.
  - **2.5d sketch**: viewer-centered, depth and orientation of the visual surfaces
  - **3d sketch**: object-centered, keeps track of objects; permanence and object shape independent of viewpoints

Levels of explanation
(1982 Marr)

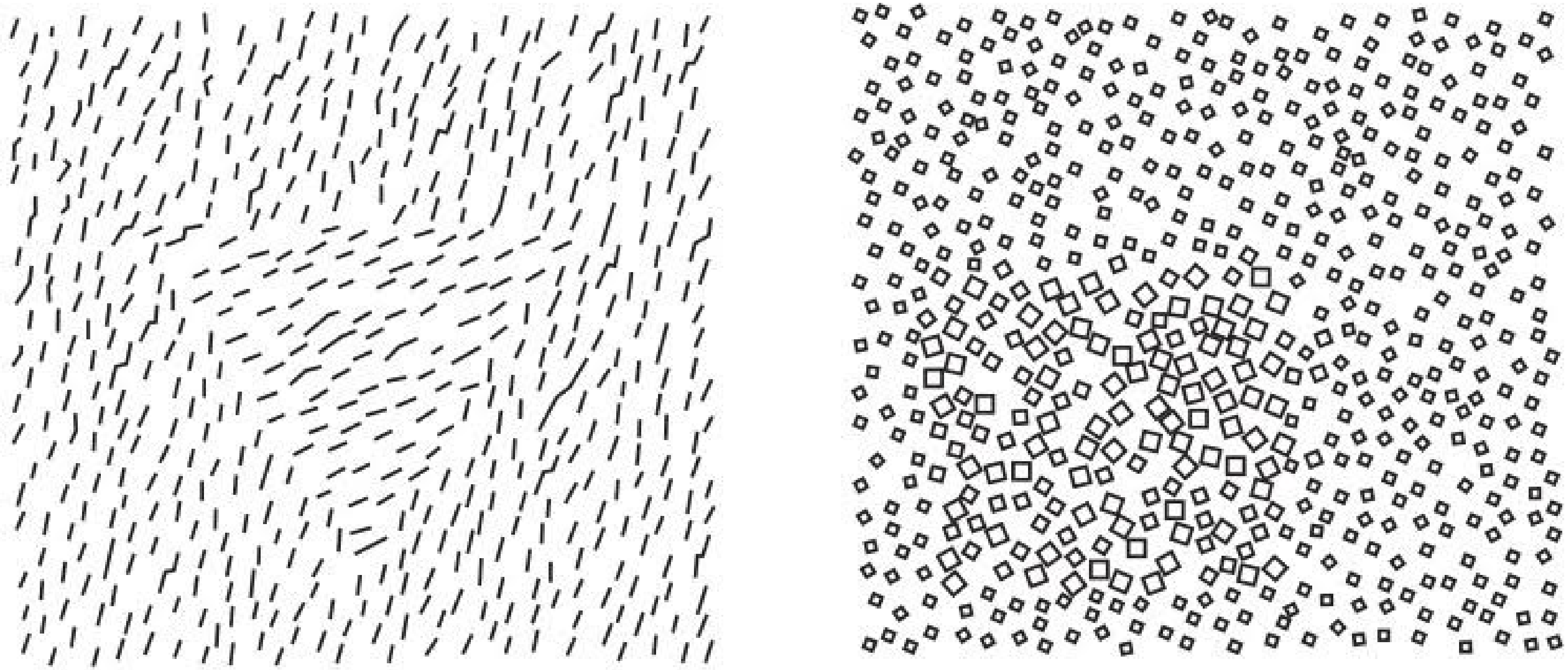


Figure 2.11 Two examples of Marr's primal sketch, the first computational stage in his analysis of the early visual system. The primal sketch contains basic elements of large-scale organization (the embedded triangle in the left-hand sketch, for example). (Adapted from Marr 1982)

Levels of explanation (1982 Marr)

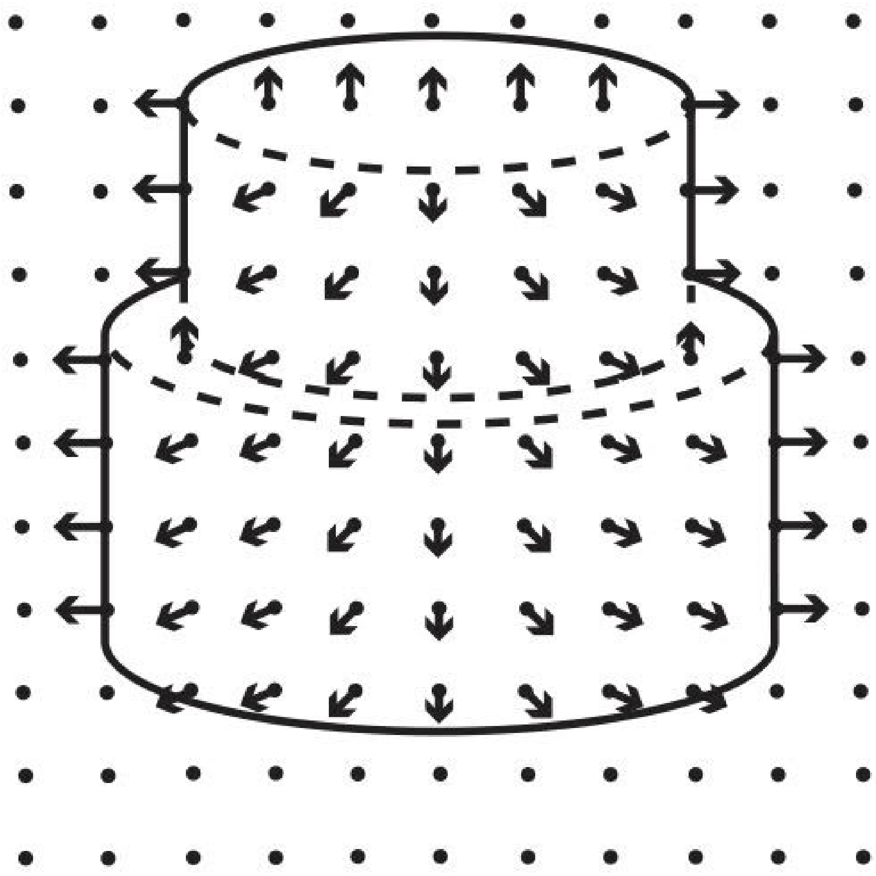


Figure 2.12 An example of part of the 2.5D sketch. The figure shows orientation information but no depth information. (Adapted from Marr 1982)

Levels of explanation (1982 Marr)

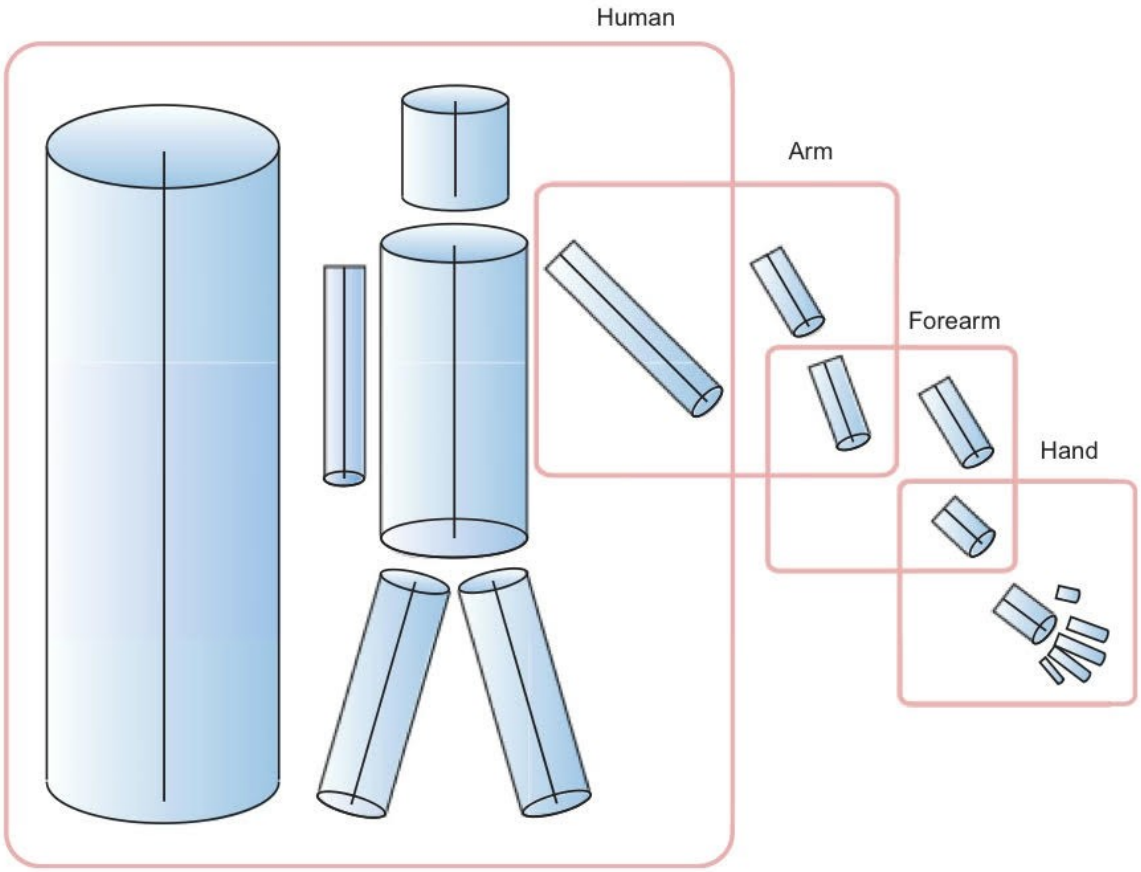
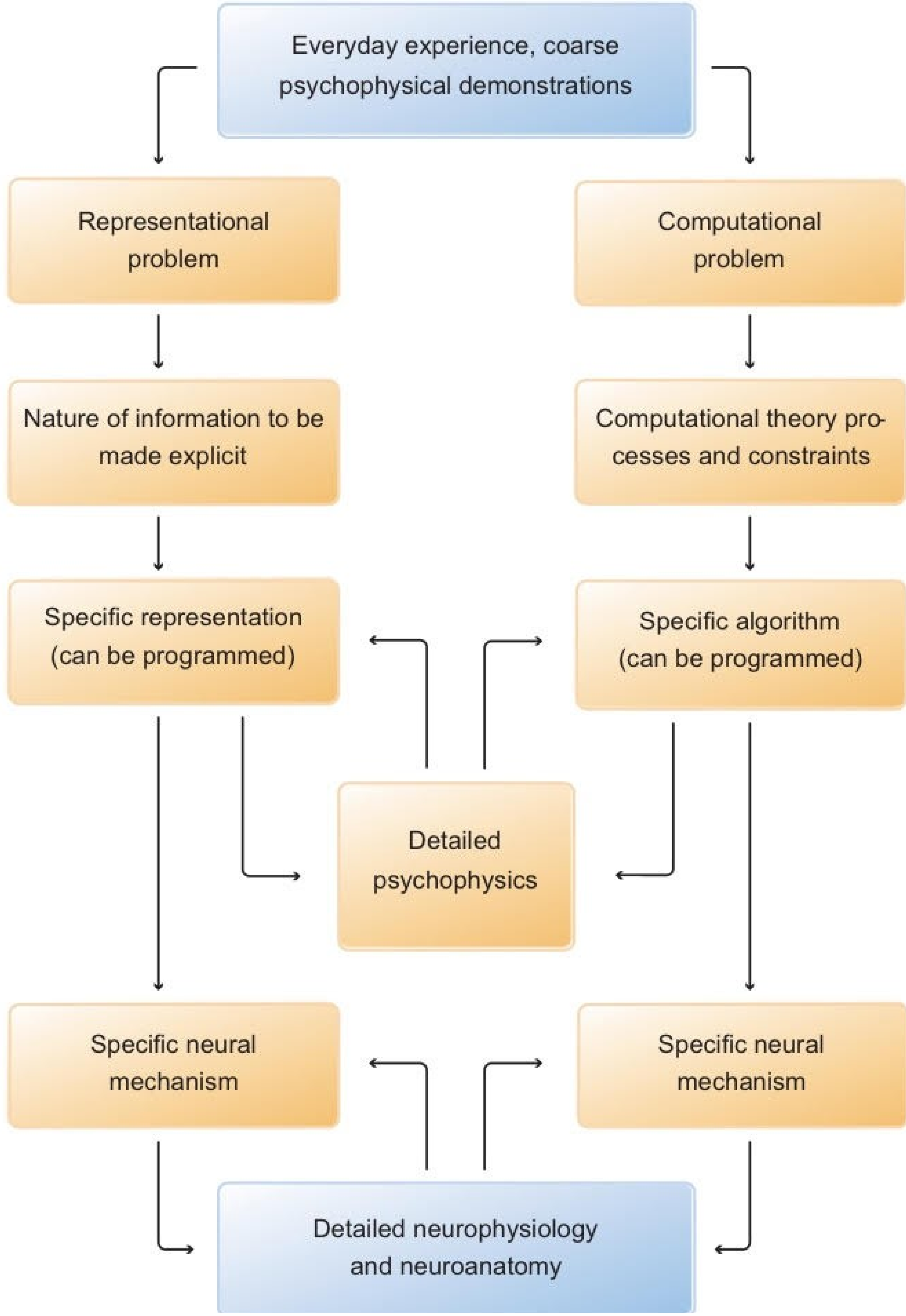
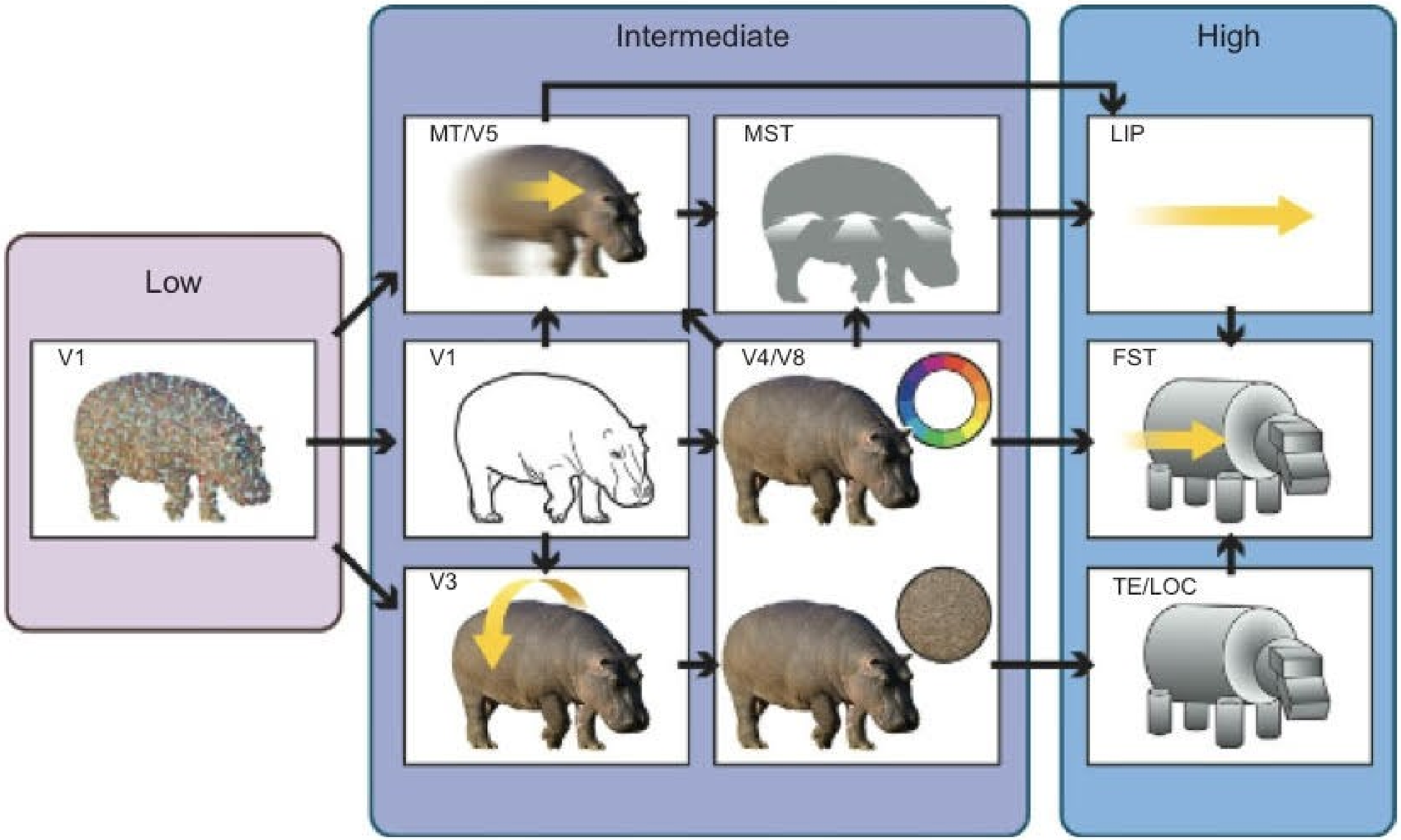


Figure 2.13 An illustration of Marr's 3D sketch, showing how the individual components are constructed. The 3D sketch gives an observer-independent representation of object shape and size. (Adapted from Marr 1982)

Levels of explanation
(1982 Marr)

- Representational primitives that Marr identifies are all closely related to light intensity:
  - **Zero-crossings**: registers of sudden changes in light intensity
  - Blobs
  - Edges
  - Segments
- The algorithmic description of the system **takes these primitives as inputs** and makes a **series of computational steps** that will transform them into the desired output
- **Output**: 3d representation of the perceived enviroment
- **Marr's analysis of the visual system clearly illustrates how a single cognitive phenomenon can be studied at different levels**


Everyday experience, coarse psychophysical demonstrations
Representational problem
Computational problem
Nature of information to be made explicit
Computational theory pro-cesses and constraints
Specific representation (can be programmed)
Specific algorithm (can be programmed)
Detailed psychophysics
Specific neural mechanism
Specific neural mechanism
Detailed neurophysiology and neuroanatomy



Key:

V1–V8: areas of the visual cortex in the occipital lobe (the back of the head). V1 produces the color and edges of the hippo but no depth. V2 produces the boundaries of the hippo. V3 produces depth. V4/V8 produces color and texture.

MT: medial temporal area (often used interchangeably with V5). Responsible for representing motion.

MST: medial superior temporal area. Responsible for representing size of the hippo as it gets nearer in space.

LIP: lateral intraparietal area. Registers motion trajectories.

FST: fundus of the superior temporal sulcus. Discerns shape from motion.

TE: temporal area. Along with LOC, is responsible for shape recognition.

LOC: lateral occipital complex