Representation of Mental Images

weekly_readings #week-1 #ch-2

How do mental images represent?

> One way to understand a complex cognitive ability is to try to build a machine that has that ability (or at least some primitive form of it). The program that the machine runs is a model of the ability. Often the ability being modeled is a very primitive and simplified form of the ability that we are trying to understand. This is the case with SHRDLU, which was intended to model only a very basic form of linguistic understanding. But even in cases like that, we can still learn much about the basic principles of cognitive information processing by looking to see how well the model works. This is why the history of cognitive science has been closely bound up with the history of artificial intelligence.

As we saw in the previous chapter, the emergence of cognitive psychology as a serious alternative to behaviorism in psychology was one of the key elements in the emergence of cognitive science. A good example of how cognitive psychology can serve both as an inspiration and as a tool for cognitive science came with what has come to be known as the imagery debate.

- The **imagery debate** began in the early 1970s
- inspired by a thought-provoking set of **experiments on mental rotation**
- carried by the psychologist ***Roger Shepard*** (in collaboration with Metzler and Lynn Cooper)

Mental Rotation of 3D objects (1971) - Shepard and Metzler

EXPERIMENT

- Subjects were presented with drawings of pairs (3) of 3D figures.
- Pair-1 and Pair-2 have same figure but rotated to different angles. Pair-3 has different figure.
- The subjects were asked to identify as quickly as possible pairs of drawings where the second figure is the same as the first

OBSERVATION

- There is a direct, linear relationship between the length of time that subjects took to solve the problem and the degree of rotation between the two figures.
- The length of time increased in direct proportion to the degree of rotation.

INTERPRETATION by Shepard, Metzler and others

- Subjects solved the problem by mentally rotating one figure to see whether or not it could be mapped onto the other.

This explanation raised 2 QUESTIONS

1. How is the information represented
2. How is it transformed

Information processing in Mental Imagery

The standard way of thinking about the mind as an information processor takes the digital computer as a model.

But there is a Slight Difference

- When information is digitally encoded, the length of time it takes to process a piece of information is typically:
  - a function of ONLY the **quantity of information** (type does not matter)
- However, mental rotation experiments show that the time taken by some information processing tasks are different even if:
  - **quantity of information is the same**

RESULT

- Many cognitive scientists have suggested that mental rotation tasks tap into ways of encoding information very different from how information is encoded in a digital computer.

The basic characteristic of an imagistic representation is that representation is secured through resemblance

EXPERIMENT by Stephen Kosslyn in 1973

- subjects were asked to memorize a set of drawings

OBSERVATIONS

- Kosslyn found an effect rather **similar to that in the mental rotation** studies, namely,
- The length of time it took the subjects to answer varied according to the distance of the parts from the point of focus. (*Example: If the subjects were asked to focus on the tail of the plane, it would take longer for them to confirm that the plane had a propeller than that there was not a pilot in the cockpit*)

INTERPRETATION by Kosslyn

- The type of information processing involved in answering the test questions involves **scanning imagistic representations**. Instead of searching for the answer within a digitally encoded database of information about the figures, the subjects scan an imagistically encoded **mental image of the airplane**.

An interdisciplinary model of vision

The mind can be studied at many different levels:

1. **Bottom-up approach:** beginning with individual neurons and populations of neurons, or perhaps even lower down, with molecular pathways whose activities generate action potentials in individual neurons, and then trying to build up from that to higher cognitive functions
2. **Top-down approach:** starting out with general theories about the nature of thought and the nature of cognition and working downward to investigate how corresponding mechanisms might be instantiated in the brain

> - On either approach one will proceed via **distinct levels of explanation** that often have separate disciplines corresponding to them.
>
> - A fundamental problem for cognitive science is working out how to combine and **integrate different levels of explanation**.

Levels of Explanation

A Computational Investigation into the Human Representation and Processing of Visual Information - 1982 Book explaining *David Marr's* model of "Human Visual system"

Marr distinguishes three different levels for analyzing cognitive systems:

1. **Computational Level:**
   The tasks of an analysis at the computational level are:

   - to translate a general description of the cognitive system into a specific account of the particular information-processing problem
   - to identify the constraints that hold upon any solution to that information processing task.
   - A computational analysis identifies the information with which the cognitive system has to begin (the input to that system) and the information with which it needs to end up (the output from that system)

2. **Algorithmic Level:**

   - how the cognitive system actually solves the specific information-processing task
   - how the input information is transformed into the output information

3. **Implementational Level:**

   - to find a physical realization for the algorithm, and
   - to find mechanisms at the neural level that can properly be described as computing the algorithm in question