# Concepts and Mental Representations

Introduction to Cognitive Science

# Mental Representations

- Cognition is seen as information-processing, and memory as the storage of information.
- But, how is information mentally represented? What is the nature of those representations?
  - Are representations ‘modality-related’ (visual, auditory, etc) or ‘modality-neutral’?
  - Relatedly, are representations specific or abstract?
  - If both, are there processes to relate one kind of representation to another?

# Imagery

- How many windows are in the house in which you grew up?

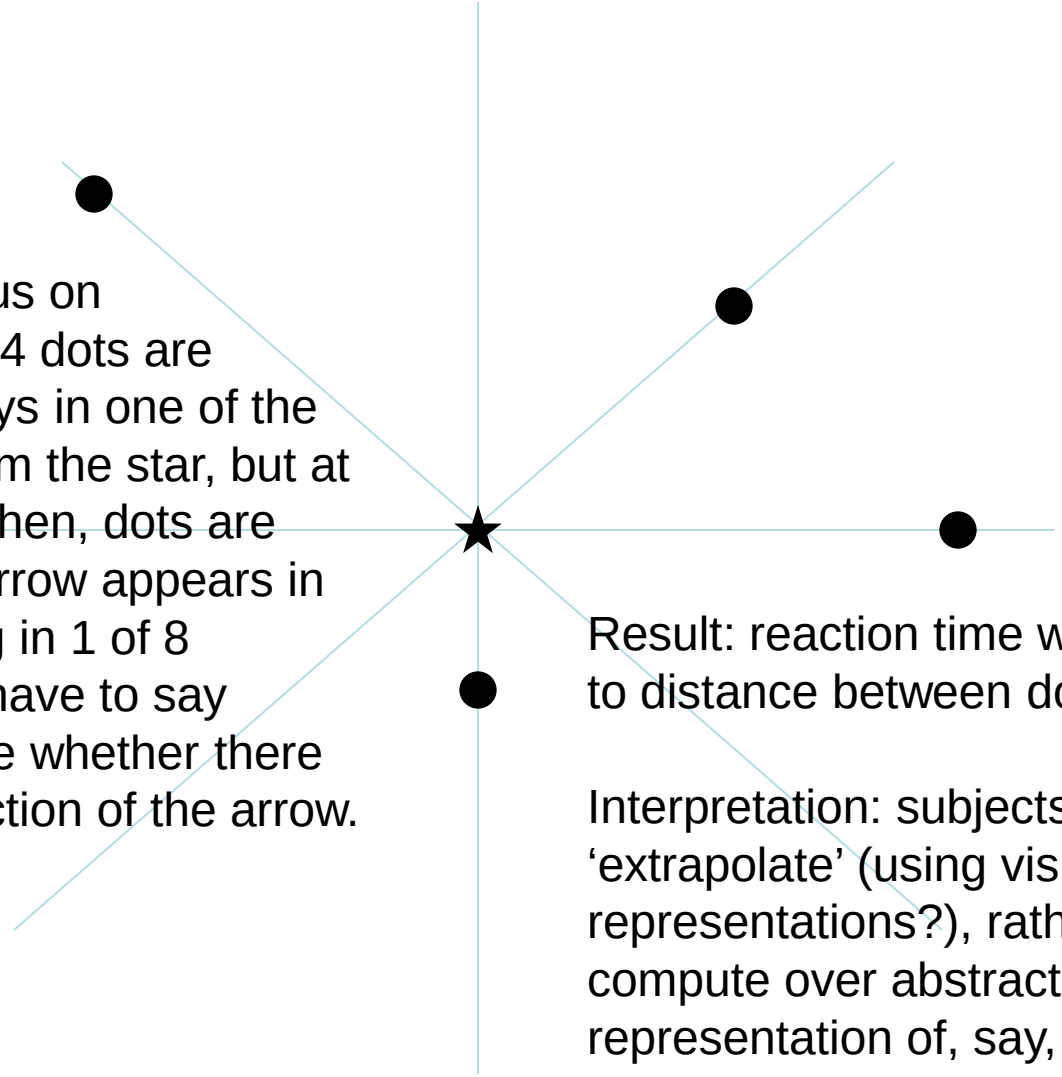
- Evidence for ‘pictorial’ (and sensory-motor) representations

# Other Experiments Supporting Modality-Specific Representations

- 4 dots and arrow experiment
- Shepard's "Mental Rotation" experiment
- Santa's configuration experiment
- Brooks' 'F' experiment

# Finke and Pinker's "Mental Extrapolation" Experiment

Experiment:
Subjects have to focus on star in middle. Then, 4 dots are shown, that are always in one of the 8 directions away form the star, but at different distances. Then, dots are removed. Then, an arrow appears in place of star, pointing in 1 of 8 directions. Subjects have to say as quickly as possible whether there was a dot in the direction of the arrow.



Result: reaction time was proportional to distance between dot and star.

Interpretation: subjects mentally 'extrapolate' (using visuo-motor representations?), rather than compute over abstract numeric representation of, say, x,y coordinates.

# Shepard's Mental Rotation Experiment

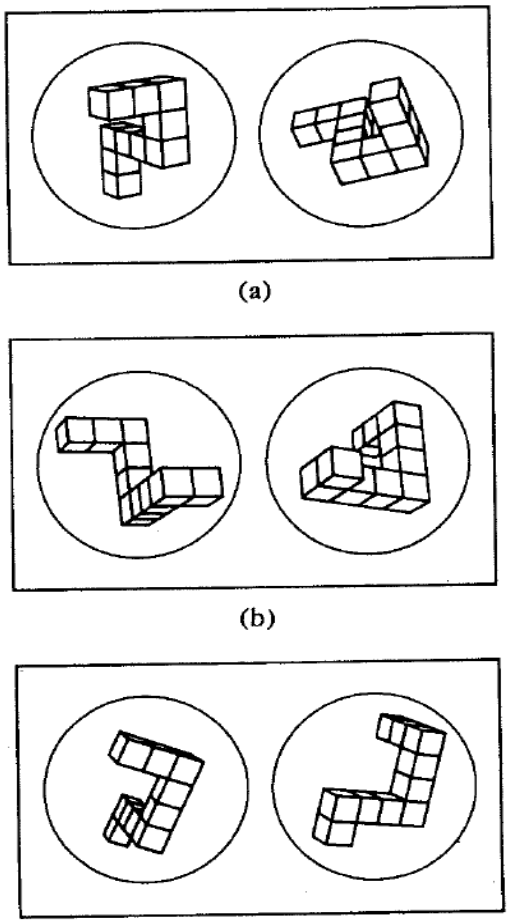



**Figure 4.4** Stimuli in the Shepard and Metzler study on mental rotation (1971): (a) the objects differ by an 80-degree rotation in the picture plane; (b) the objects differ by an 80-degree rotation in depth; (c) the pair cannot be rotated into congruence. (From Metzler & Shepard, 1974).

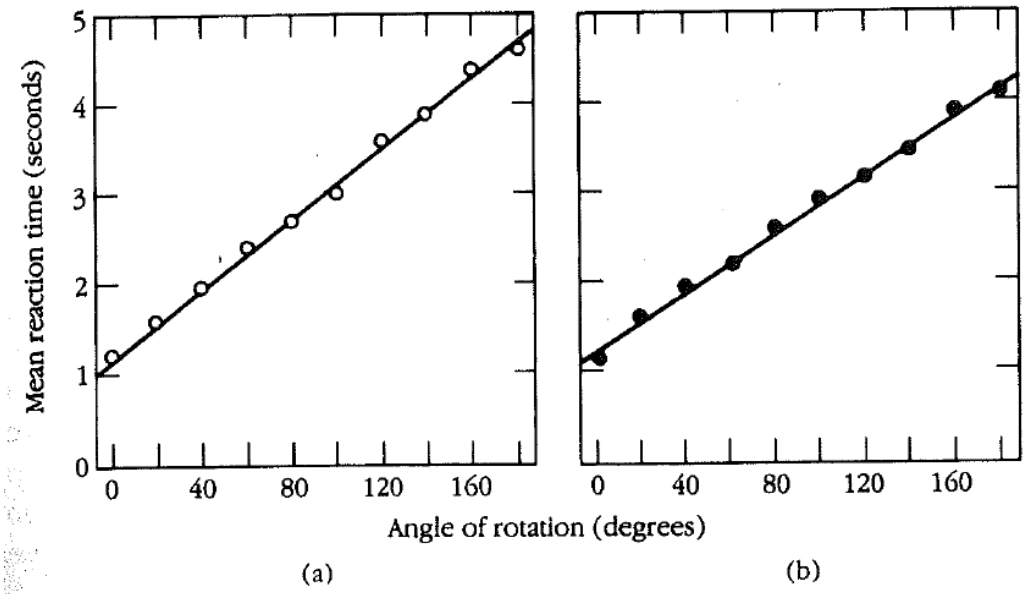



**Figure 4.5** Mean time to determine that two objects have the same three-dimensional shape as a function of the angular difference in their portrayed orientations. (a) Plot for pairs differing by a rotation in the picture plane. (b) Plot for pairs differing by a rotation in depth. (From Metzler & Shepard, 1974.)

Interpretation:
Subjects are mentally rotating objects using modality-specific (in this case, visuo-motor) representations, rather than doing numeric computations over abstract symbolic representation.

# Santa's Experiment

Experiment:

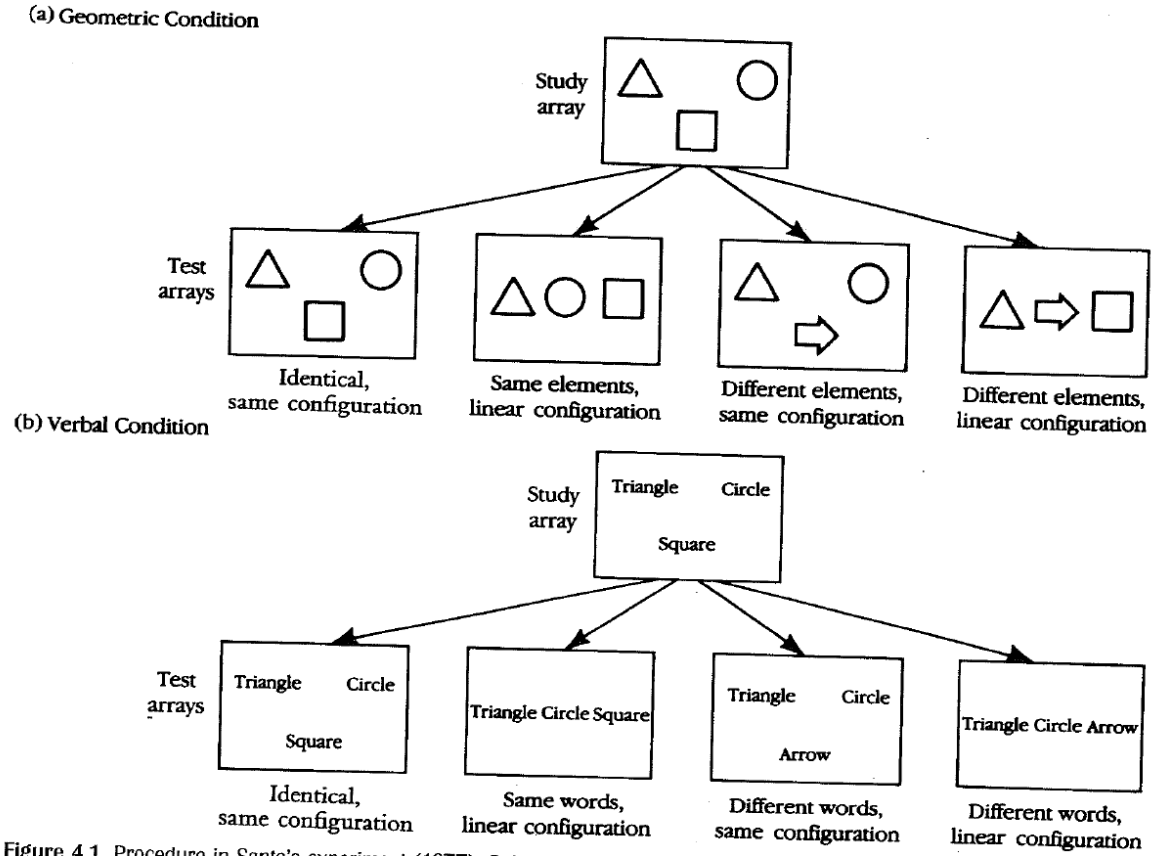
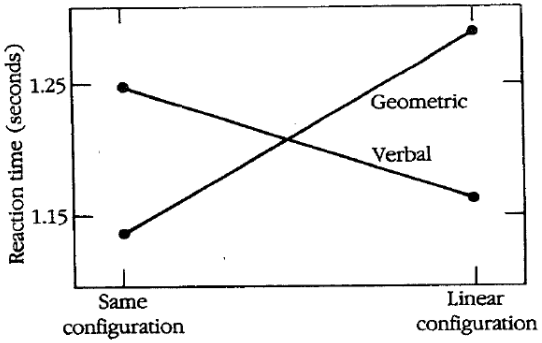



**Figure 4.1** Procedure in Santa's experiment (1977). Subjects studied an initial array and then had to decide whether a test array contained the same elements.

Result:




Conclusion:

Subjects store visual items differently than verbal items.

# Brooks' "Mental Image Scanning" Experiment

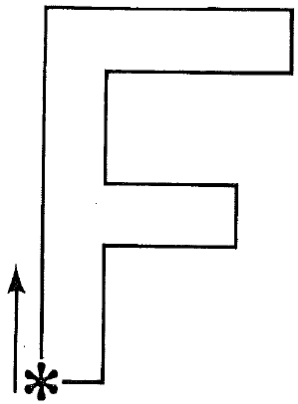


Figure 4.6 An example of a simple block diagram used by Brooks (1968) to study the scanning of mental images. The asterisk and arrow showed the subject the starting point and the direction for scanning the image. (Copyright ©1968 by the Canadian Psychological Association. Reprinted by permission.)

Experiment:

'Diagrams' condition: subjects had to say "Yes", "Yes", "Yes", "No", etc. to indicate whether, as one goes around the outside of the 'F', the encountered corners are at the very top or very bottom of the diagram. Subjects were presented with the diagram before, but not during this task

'Sentences' condition: similar to 'Diagrams', but now whether words in a sentence like "A bird in the hand is not in the bush" are nouns or not.

To indicate "Yes" or "No", subjects had to either point to written "Yes" or "No', tap left or right hand, or just say it.

Result:

Table 4.1 Mean Classification Times in Brooks, 1968

| | *Output, in seconds* | | |
|---|---|---|---|
| Stimulus Material | Pointing | Tapping | Vocal |
| Diagrams | 28.2 | 14.1 | 11.3 |
| Sentences | 9.8 | 7.8 | 13.8 |

Interpretation: representations are of different modality and, as such, interference effects may or may not take place.

# Experiments Supporting More Abstract Representations

- (Anderson) Subjects listened to a short story that contained the sentence
  - “The missionary shot the painter”
- Then, either immediately after the story, or after some delay, subjects were asked which of the following sentences appeared in the story:
  - “The missionary shot the painter”
  - “The painter got shot by the missionary”
  - “The painter shot the missionary”
  - “The missionary got shot by the painter”
- Result: In both conditions, almost everyone chose one of the first two sentences. However, with delay, many more subjects choose the second sentence instead of the first.

# Concepts

- Concepts are often seen as basic ‘units’ of thought.
- Concepts are abstract and general: they can be applied to describe (and think about) multiple specific scenarios. E.g. the concept of ‘cat’ can be applied to many different physical objects.
  - Concepts thus allow me to make predictions of what will happen in situations I am confronted with, which seems to be a fundamental purpose of cognition
- Vice versa, concepts are probably the result of a process to take specific observations and extract abstract commonalities from them. E.g. I probably develop my concept of a ‘cat’ through actual experiences I have with cats.
  - Of course, how and why did I classify specific objects as cats in the first place? There is a kind of chicken-and-egg problem here

# 2 Opposing Theories about Concepts/Categories

- ‘Concepts are precise’: Concepts are like definitions like you would find in a dictionary (e.g. a ‘bachelor’ is an unmarried adult male, ‘grandmother’ is the mother of a parent, ‘cat’ is a 4-legged, furry, purring, animal)
- ‘Concepts are fuzzy’: Concepts do not follow strict and abstract definitions. Some things are more ‘prototypical’ of a certain concept than others, and for some things it is just not clear whether they belong to that category or not.

# Arguments for Fuzzy Concept Theory

- Crisp and precise definitions can be hard, if not impossible, to find because of all the exceptions (e.g. not all cats have 4 legs; not all birds fly)
- Under the assumption that concepts are effected by experience, concepts probably gradually develop, going through subtle changes over time. The fuzzy concept theory seems to be a better fit with this.
- Having a crisp and precise definitions is not as useful as having a more fuzzy category. So even when a nice and crisp definition can be found, is that definition really all that useful to make reliable predictions?
  - e.g. we can usually predict certain things about the behavior of typical grandmothers that are not at all part of the definition of grandmother

# Experimental Evidence for ‘Fuzzy Concepts’

- Subjects were presented with claims like:
  - A robin is a bird
  - A hamster is a bird
  - A penguin is a bird
  - …
- And had to indicate, as fast as possible, whether they thought the claim was true or false.
- Result: subjects would be faster in saying that a robin is a bird than that a penguin is a bird
- Interpretation: we judge certain things to be as ‘more of an X’ than others.

# Fuzzy Concepts and Neural Networks

- Neural networks seem to be a great fit for the fuzzy concept theory: we saw how neural networks represent things less strictly and in more fuzzy ways.