Cognitive psychology

Knowledge: Representation and organization

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Cognition / Knowledge

- Models of cognition
  - IP-model,
  - Connectionism,
  - Cognitive semantics,
  - Situated cognition

Cognitive processes
Perception, Attention, Memory, Problem-solving, Categorization, Language, Thinking, Judgment and Decision-making etc.

A philosophical problem

- “the problem of mental representation might be the most difficult problem to solve in all of the sciences” (Paivio, 1986)
Representations

- External representations
  - Configurations in terms of pictures, diagrams, drawings etc.
  - Language-based configurations

- Internal (mental) representations
  - Symbolic
    - Analogical
  - Propositional
    - Objects
    - Relations
    - Schemas
  - Distributed

External representations

- Differences between pictures and language-based representations
- Picture-based representations are closer to reality since they render a structure of the object, spatial relations are “for free”

Other differences ....

- Language-based representations
  - Discrete symbols, least parts are very well defined
  - Explicit symbols with exact definitions
  - Grammatical rules for the combination of words
  - Abstract, and independent of senses

- Picture-based representations
  - Dividing up is fortuitous – no least parts
  - Distinct symbols are missing, implicit in context
  - No rules for how to combine parts
  - Concrete, tight connection to each sense
Internal representations

- Theory I: Mental representations in terms of propositions
  - Mentalase: A code or a language which is universal and independent of senses
  - Modeled with the help of logical language systems

Internal representations

- Theory II: Mental representations in terms of analogical structures
  - Internal imaginations admit a number of functions
    - Mental rotation tasks are possible to solve
    - Direct-scanning of spatial structures
    - Reinterpretations of ambiguous figures

Two systems of mental representations

- Paivio’s theory on double coding
  - Logogens – Verbal symbol system for coding (representation) of knowledge
    - At least three senses
  - Imagens – Non-verbal symbol system for storing of knowledge
    - Probably all five senses
  - Empirical investigations support this theory on double coding
Internal representations as parallel processes

- Kosslyn’s theory connects internal representations with visual perception
- Connectionist theories give explanations in terms of levels
  - Analogical and propositional internal imaginations are “rest products”, mirroring distributed, neural representations on lower levels

Summary on mental representations

- The imagination of an apple -
  - Language-based explanations
    - “the picture of an apple is a bi-product of a propositional knowledge representation”
  - Analog explanations
    - “the picture of an apple is a unique and distinct form of knowledge representation”
  - Distributed processes explanations
    - “the picture of an apple is a neural representation in terms of nodes in the brain”
Mental models

- A common misunderstanding is that mental representations and mental models is the same thing
- A mental model = a mental simulation of a course of events
- It can be a product of different kinds of mental representations

Different types of knowledge

- Descriptive knowledge
  - Gives a good overview
  - Is easy to share and report
  - Gives a more complete picture
  - Demands strategies on high levels

- Procedural knowledge
  - Gives a good operative ability
  - Is difficult to convey
  - Gives a lot of details
  - Demands strategies on low levels

Different mental models

- Descriptive knowledge
  - Gives a good overview
  - Is easy to share and report
  - Gives a more complete picture
  - Demands strategies on high levels

- Structural mental models

- Functional mental models
Mental models cont.

- Structural model
  - Example: A mental map over the subway routes or what a car engine looks like
  - Necessary for the complete picture
  - Extensive and sometimes redundant information

- Functional model
  - How you travel with the subway or how you drive a car
  - Fast, efficient and practical
  - Not enough when you run into problems or need to find alternatives

Mental models cont.

- Structural models
  - These models are often independent from context and as such they have the advantage that they can be used in new situations through integration with existing knowledge from other areas

- Functional models
  - These models are often context-dependent and as such they have the advantage that they are easy to use in a specific situation

Interface design 1

- The challenge for the system developer is to provide the user with a tool that supports the use of the mental model that the user needs in order to complete his or her work tasks

- Warning: look out for deficient and maladaptive mental models!
Functional models
- Many of the mental models we use in everyday tasks are incomplete and deficient
  - Our understanding of physical laws, ecological contexts and biological and chemical processes is limited
    - Intuitive conceptions about forces, motions, currents, developmental trends etc.

Train-driver cabin

ETCS-interface
Drivers’ planning view

Knowledge organization
- Knowledge must be organized in order to be efficiently used
  - Long philosophical discussion
    - All knowledge is native!
    - All knowledge is learned!
  - Conceptual systems must have a good cognitive economy
  - Concepts and objects are organized in hierarchies

Categorization
- What category an object belongs to depends on how typical it is
- Categories have no clear limits
  - Some objects are classified as typical, others may be so non-typical that their belongingness is questioned
Hierarchies of categories

- We mainly use three levels to organize objects
  - Top level
  - Middle level
  - Under groups
- One of the levels act as a base-level, that is where all classification occurs
  - Expertise results in a different base-level

Theory 1 about concepts

- Attribute theories
  - The meaning of a concept is defined by a number of unique attributes
  - Always clear on concept belongingness
  - All instances are typical to the same degree
  - Today: a week theory, not so much support recently

Theory 2 about concepts

- Prototype theories
  - All concepts have a central tendency
  - Concept belongingness is different for different instances – variation in terms of how representative they are
  - No clear limits between close concepts
  - Cultural differences in descriptions of colors support this theory
  - Abstract concepts are difficult to explain
Theory 3 about concepts

- Exemplar-based theories
  - Typical exemplars instead of central tendencies give the same explanations for why attribute-theories don’t work
  - Instances are grouped with each other through a similarity measure
  - Similarity matching is a central aspect in all conceptualization and categorization of objects

Interface design 2

- Different groups of users may need different search opportunities / strategies when searching databases
  - Domain experts and expert users are often good at using several different search strategies
  - Novices are dependant on a knowledge organization that is easy to navigate