Cognitive psychology

Thinking by reasoning and problem-solving

Anders Jansson

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

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

Reasoning
- Humans use three different forms of thinking
  - Induction
    - We confirm rather than falsify previous knowledge
  - Deduction
    - We conduct reasonable but not rational conclusions
  - Abduction
    - We construct probable causes based on previous knowledge

Humans use three different forms of thinking
- Induction
  - We confirm rather than falsify previous knowledge
- Deduction
  - We conduct reasonable but not rational conclusions
- Abduction
  - We construct probable causes based on previous knowledge
**Induction**
- Experience-based reasoning
- Instance 1 + Instance 2 = Knowledge
- Leads to generalizations
- Purpose - to reason from the specific case to all cases

**Deduction**
- Hypothetical reasoning
- Premise 1 + Premise 2 = Knowledge
- Leads to conclusions
- Purpose - to reason from given premises to a specific case

**Abduction**
- Reasoning by searching for causes
- Event x + Event x-1 + Event x-2 etc.
- Leads to explanations
- Purpose - to reason backwards from effect to reason
Interaction design

- In order to facilitate the use of natural induction and deduction, system developers must try to be **consequent** in the design of symbols, menus, buttons, maps etc.

Reasonable deductions

- Human thinking is often reasonable, but not always rational and logical
- Logic and truth is not the same thing
- Rationality and reasonableness is not the same thing
- Rationality and logic demands heavy computations. Our cognitive system does not comply with such procedures
- Instead we use heuristics

Wason selection task

On each card, there is a letter on one side and a number on the other side. Which of cards would you **need** to turn over to test the following rule:

"If there is a vowel on one side, then there is an even number on the other side".
Wason selection task II

Each card has an age on one side and the name of a beverage on the other side. Imagine you are a police officer applying the rule:

“If a person is drinking beer, then he or she must be over 20 years old”

Which of the cards must be turned over to determine whether the rule is being followed?

Reasonable inductions

- Induction is the most common form of reasoning – every-day thinking
- Builds on the principle “rather confirming than critically examining”
- Inductive thinking is supporting us in making the world understandable – we search for meaning

Dominance structuring

- A special form of induction
- Reconstruction of motives in hindsight in order to rationalize behaviors and decisions
  - Positive aspects are strengthened
  - Negative aspects are repressed
**Abduction**

- Is often used to explain unexpected actions and events
- Searching backwards in the chain of causes to find the triggering factor
- A common form of thinking in analyses where the purpose is to identify the human factor component in accidents

---

**Cognitive control**

- Conscious processes
  - Limited capacity
  - Slow
  - Demanding
  - Sequential
  - Exhaustive
  - Necessary in certain situations

- Automated processes
  - In principle unlimited
  - Fast
  - Efficient
  - Parallel
  - Quite
  - Manage routines and regularities

---

**Conscious processes**

- Use working-memory to a high degree
- Information content in conscious processes is (generally) easy to express
- Give rise to mistakes that follow the plan, but the plan is wrong
- We believe conscious processes are reliable, but they are unstable
Automated processes

- Since long learned routines
- Tacit knowledge, generally not possible to report verbally
- Give rise to errors which are evident in the same moment as they are realized
- We are uncertain about the outcome of automated processes, and therefore we underestimate their reliability

Cognitive decision levels

- Three levels of problem-solving and thinking within users and operators
  - Knowledge-level
  - Rule-level
  - Skill-level
  - Consciously
  - Automated level

Cognitive levels

- High, conscious cognitive level: One thing at a time
- Low, automated cognitive level: High parallel capacity
Task continuum I

Intuition (automated) \hspace{1cm} Analysis (conscious)

Natural task continuum

Intuition (automated) \hspace{1cm} Analysis (conscious)

Cognitive task continuum

Task continuum II

Intuition \hspace{1cm} Analysis

Natural task continuum

Intuition \hspace{1cm} Analysis

Artificial task continuum

Intuition \hspace{1cm} Analysis

Task continuum

Problem-solving

- Problem-spaces
  - Establishing a problem space
  - Means-ends analyses
  - Establishment of sub-goals
  - Limited capacity
  - Heuristics help

- Analogies
  - Reference problem with structural similarity
  - Strategies inherent from the reference problem
  - A risk for over-utilization
Framing

- To know how to understand a problem is an important part of the solution to the problem
- Creativity is often necessary
- To try a thought by analyzing its consequences is a common way of thinking (cognitive simulation)

Intelligence

- Adaptive problem-solving demands different types of intelligence
- Sternbergs Triarchic Theory
  - Three different cognitive processes
    - Meta-components – problem identification, formulation of hypotheses, strategies, evaluations
    - Performance-components – ability to use perception, memory, deductions etc.
    - Components for knowledge retrieval – learning, storing, ability to combine

Types of intelligence

- Analytic intelligence
  - Meta-components
- Practical intelligence
  - Performance-components
- Creative intelligence
  - Components for knowledge retrieval
Complex problems

- In order to solve problems that are complex, dynamic and non-transparent, it seems necessary to have a type of operative intelligence that classical intelligence tests cannot measure.
- Heuristic competence is a complementary factor.

Heuristic competence

- Ability to plan and evaluate on a strategic level.
- Ability to systematically investigate and develop an understanding of the problem or situation.
- Ability to critically examine ideas, hypotheses and strategies.
- Ability to use self-reflexion with respect to achieved results.

Maladaptive behaviors

- Lack of heuristic competence (causes)
  - Acting directly on feedback
  - Insufficient systematization
  - Insufficient control of strategies and hypotheses
  - No self-reflexion
- This can lead to.... (effects)
  - Selective information retrieval
  - Selective actions
  - Thematic vagabonding