PHIL/PSYCH 256

INTRODUCTION TO COGNITIVE SCIENCE

Week 2: Logic

PLEASE TURN OFF ALL ELECTRONIC DEVICES

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Logic

Deductive: the conclusion follows necessarily from the premises.

E.g. modus ponens

If p then q, p, so q.

Inductive: introduces uncertainty.

E.g. All UW students are under 7 feet tall.

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History of Logic

- Syllogism (Aristotle)
  - All students are overworked.
  - Anyone overworked is tired.
  - So: All students are tired.
- Formal logic (Frege, 19th century)
- Theory of computation (Turing, 20th century)
- Today: major role in philosophy and artificial intelligence

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Evaluating Theories of Representation

1. Representational power
2. Computational power
   - Problem solving
     - Planning
     - Decision
     - Explanation
   - Learning
   - Language
3. Psychological plausibility
4. Neurological plausibility
5. Practical applicability
   - Education
   - Design
   - Intelligent systems
   - Mental illness

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Logic: Representational power

- *Propositions*
  - b = Brad is handsome
  - a = Angelina is kind
  - ¬b (not)
  - b & a (and)
  - b v a (or)
  - b -> a (if then)
  - Probability: P(b) = .8
- *Predicates*
  - handsome(Brad)
  - kind(Angelina)
  - loves(Brad, Angelina)
  - Everybody loves Brad: (x)(person (x) -> loves(x, brad))

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Logic: Computational Power

- Rules of inference
  - Modus ponens
  - Modus tollens: if p then q, not-q, so not-p.
- Problem solving
  - Planning is deduction
  - Explanation is deduction
  - Decision making is utility maximization

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Logic: Computational Power

- Learning (induction)
  - Inductive generalization
    - Some A are B
    - So: All A are B.
  - Abduction
    - If p then q, q, so p.
    - Why q? p would explain q. So maybe p.
- Language: probabilistic

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Logic: Practical applicability

- Robotics using probability theory.
- Use Bayes theorem to update hypotheses based on incoming information.

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Discussion Questions

- Are people logical?
- Should they be?

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Key Points

- Logic includes many kinds of deductive and inductive reasoning.
- Probability theory is becoming increasingly important to cognitive explanations: thinking as statistical.

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Logic: Representational Problems

- Natural language is much more flexible than logic.
- Need exotic logics to handle mental attitudes, e.g. knows.
- Restricted to verbal information.

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Logic: Computational Problems

- Logical deduction is computationally explosive: p, so p & p.
- Much reasoning is non-monotonic: need to subtract beliefs as well as add them.
- Need for inductive learning.
- Visual reasoning is easy for some problems.
- Explanation is rarely deductive.

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Psychological Plausibility

- Wason experiment

Cards with letters on one side and numbers on the other:

[A] [B] [2] [3]

What cards do you need to turn over to determine whether the following is true?

If there is a vowel on one side of the card then there is an even number on the other side.

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Psychological Plausibility

Compare: cards with location on one side and age on other.

[in bar] [not in bar] [28] [17]

What cards do you need to turn over to determine whether this the following is true?

If someone drinks in the bar, then he/she is over 19.

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Psychological Plausibility

Explanations of Wason results:

People misunderstand question
Permission schema (Cheng)
Cheater module (Cosmides)
Mental models (Johnson-Laird)

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Mental Models

- A mental model is a representation that has the same structure as what it represents.
- Examples:
  - Visual: maps, diagrams
  - Abstract: concrete examples, e.g. cards in Wason task
  - General: rules to describe dynamics

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Johnson-Laird's Syllogisms

- All Ontarians are people. All people are conscious. What follows?
- Mental model: O=P=C O=P=C
  O=C?
- Visual example: left, tall.

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Discussion Question

- Is the view that people perform deduction by mental models more plausible than the view that they use formal rules?

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Key Points in Johnson-Laird & Byrne

- People are rational in principle but fallible in practice.
- There are three main classes of theory about the process of deduction: formal rules, content-specific rules, and mental models.
- The formal rule account is psychologically implausible because people are affected by the content of deductions.
- But the content-specific rules view ignores the fact that people are able to make valid deductions based solely on logical connectives and quantifiers.
- Mental models form the basis for various kinds of reasoning.

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Key Points

- Logic provides powerful methods of representation and inference.
- But experiments suggest that the mind works differently.

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