

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

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Logic: Representational power

- | | |
|---|---|
| <ul style="list-style-type: none"> • <i>Propositions</i> 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 | <ul style="list-style-type: none"> • <i>Predicates</i> handsome(Brad) kind(Angelina) loves(Brad, Angelina) Everybody loves Brad: (x)(person (x) -> loves(x, brad)) |
|---|---|



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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