Methods in AI Research

Common sense reasoning

Lecture 15

Tuesday, 17 October 2019

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Four lectures on logic and reasoning in AI:

Lecture 12. Knowledge-based reasoning

Lecture 13. Fragments and Subsymbolic vs symbolic AI

Lecture 14. Nonmonotonic reasoning

Lecture 15. Common sense reasoning

Exercises

1. *Last three lectures*
2. *Common sense reasoning*

1. Last Three Lectures

Lecture 12 *FOL: undecidable, very expressive, model-based, absolute*

Lecture 13 *DLs: decidable, less expressive but sufficient for many applications, model-based, absolute*

Lecture 14 *Nonmonotone reasoning, argumentation theory, dialectical, how to reason in argumentative situation*

Lecture 15 *Common sense & human reasoning: how humans actually reason*

2. Common Sense Reasoning

FOL and its fragments (DLs, propositional logic, modal logics, . . .) formalize rational reasoning.

Do humans always reason according to the principles of HOL? No!

Famous examples:

The Wason Selection Task

The Syllogism Task

The Suppression Task

Dfn. A syllogism consists of 2 premisses and 1 conclusion, all of the form:

all x are y	*A*	*Affirmo*
some x are y	*I*	*affIrmo*
no x is y	*E*	*nEgo*
some x are not y	*O*	*negO.*

Ex.

$$\frac{Eyx \quad Azy}{Ezx}\ \checkmark \qquad \frac{Ixy \quad Ayz}{Ixz}\ \checkmark \qquad \frac{Ixy \quad Iyz}{Ixz}\ x$$

The Syllogism Task: Given two premisses, in which x and z appear once and y in both, decide which of the statements Uxz or Uzx are true given that the premisses are true, for $U = A, I, E, O$.

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Ex.

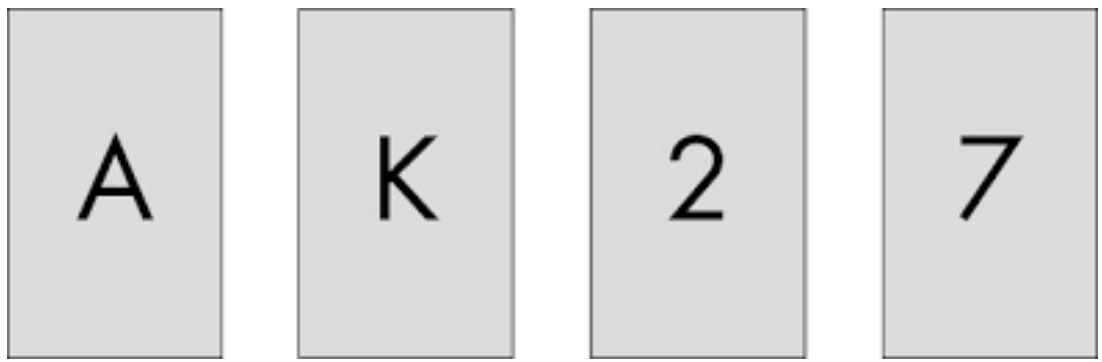
$$\frac{Eyx \quad Azy}{Ezx}\ \checkmark \qquad \frac{Ixy \quad Ayz}{Ixz}\ \checkmark \qquad \frac{Ixy \quad Iyz}{Ixz}\ x$$

In the Syllogism Task, humans do not reason according to FOL. For example,

- *Axy is inferred from Ayx,*
- *from Ixy it is concluded that Axy does not hold,*
- *the Figural Effect plays a role (premisses with xy yz lead to correct conlcusions more often than premisses with yx zy).*

(1966) Below is depicted a set of four cards, on each there is a number on one of its sides and a letter on the other.

Your task is to decide which if any of these four cards you must turn in order to decide if the rule below is true.

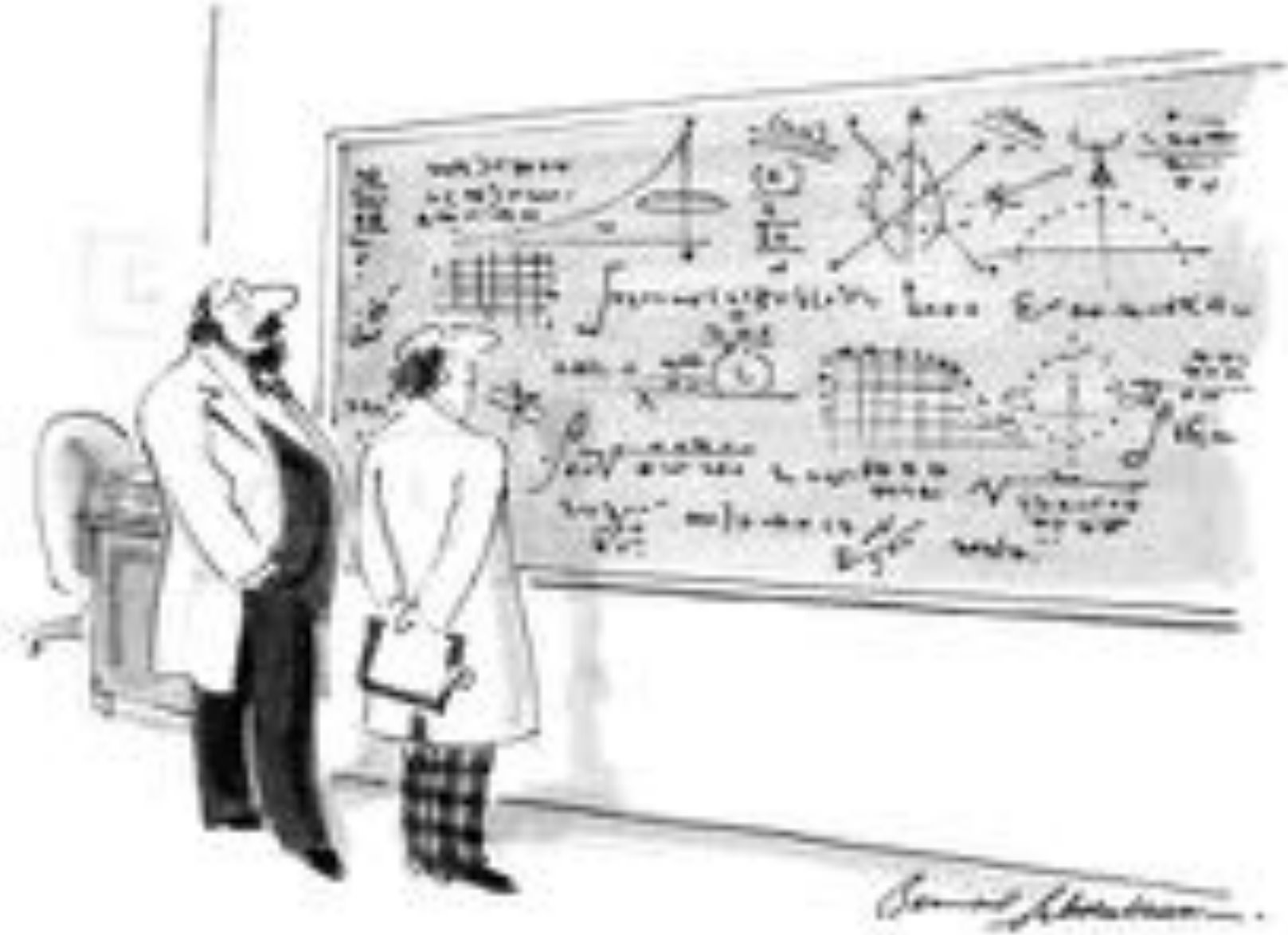


Rule: If there is a vowel on one side, then there is an even number on the other side.

5-10% of subjects turn A and 7
(the correct answer according to FOL).

On the basis of this: humans can't reason?

No, they can, but they sometimes use different logics.



"Oh, if only it were so simple."

Reasoning Tasks: Formalization, Modeling, Conclusion:

1. Experiment: subjects carry out a reasoning task.
2. Construct formal model.
3. How does the model fit the results in 1?
4. What does the model tell us about human reasoning?
5. What does the task tell us about human reasoning?

"I think you should be more explicit here in step two."

. *The Syllogism Task*

Reasoning about syllogisms . . .

. . . *is based on formal inference rules like in FOL (concrete method via Euler Circles);* *next slide*

. . . *is based on mental models (psychological representations of real or hypothetical situations)*
(Philip Johnson-Laird & Ruth Byrne 1980s);

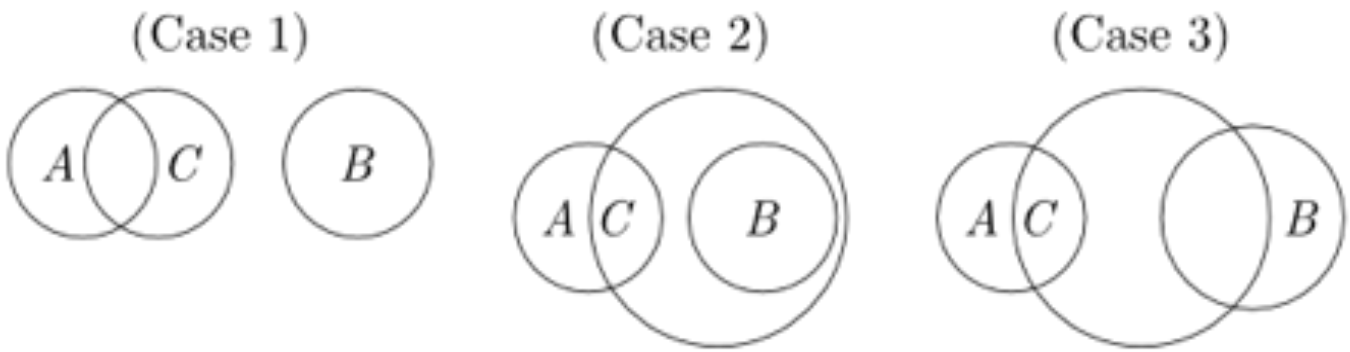
. . . *is probabilistic in nature (rational analysis of cognition)*
(Nick Chater & Mike Oaksford 1990s);

. . . *uses the "maxims" of Paul Grice*
(Stephen Newstead 1995); *next next slide*

. . . *consists of "reasoning to and from an interpretation" and uses nonclassical logics (different from FOL)*
(Keith Stenning & Michiel van Lambalgen 2000s).

Euler Circles are a method to solve syllogisms, but humans do not always seem to use that method (given their answers).

Ex. No A is B. Some C are A. So some B are not C. Not true:



Grice's Conversational Maxims (Paul Grice 1975). Maxim's of

- *Quantity*
  be exactly as informative as necessary
- *Quality*
  be truthful
- *Relation*
  be relevant
- *Manner*
  be as succinct as necessary

The maxims form the basis for the inferences we make in conversations (implicature).

(Newstead 1995): maxims in syllogistic reasoning.
Meaning "some" in logic: "at least one", in conversation: "at least one and not all".
Explains why humans conclude from Ixy that not Axy.

In 1930s Luria studied syllogistic reasoning among illiterates.

Syllogistic conclusions that are almost unversally drawn among literate people were not drawn by these subjects:

Question:
In the Far North, where there is snow, all bears are white.
Novaya Zemlaya is in the Far North.
What color are the bears there?
Answer:
I don't know what color the bears there are, I never saw them.

A better explanation in this case might be that the subjects are not used to be asked questions by a questioner that knows the answer.

. *The Wason Selection Task*

(1966) Below is depicted a set of four cards, on each there is a number on one of its sides and a letter on the other.

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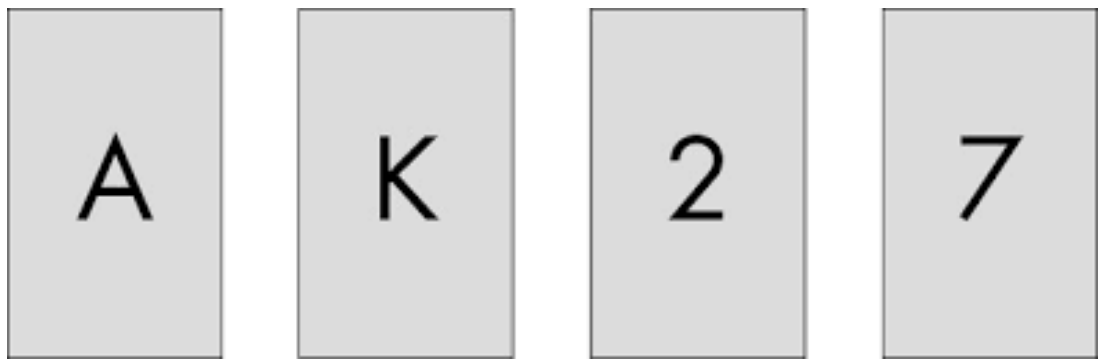

Rule: If there is a vowel on one side, then there is an even number on the other side.

5-10% of subjects turn A and 7
(the correct answer according to FOL).

(1970s) Four people in a bar each have a card such that one side depicts their age and the other side the drink they are having. You are shown the following sides of the four cards. Which one(s) do you have to turn to establish whether the rule below is violated or not?

Rule: Someone who drinks beer has to be at least 18 years old.

70-75% turn 16 and beer
(the correct answer according to FOL).

Various theories since 1966:

- *familiarity,*
- *pragmatic reasoning,*
- *social contract,*
- *deontic versus descriptive.* *next slide*

The rule in the Wason Selection Task is an implication, $p \rightarrow q$.
Van Lambalgen & Stenning 2002s: The implication can be interpreted in two ways:

deontic:
this is the rule, verify which cards violate it
holds for every card individually

descriptive:
verify whether this rule holds for the four cards
holds for the four cards taken together

Thesis van Lambalgen & Stenning: A deontic interpretation leads more often to an answer that is correct according to FOL than a descriptive interpretation.

Starting point of this research:

Although subjects may not always reason according to FOL, there are other logical models that explain their answers.

Ex. For the Wason Selection Task:
(1) a logical model in which the task in interpreted descriptively.
(2) a logical model in which the task in interpreted deontically.

Modeling or describing?

. *The Suppression Task*

Ruth Byrne 1989 shows that human reasoning uses more than the logical form of statements.

p	*she has an essay to write*	q	*she studies late in the library*
r	*she has a textbook to read*	s	*the library stays open.*

Modus Ponens (MP):

(Alternative) *Given: if p, then q $(p \to q)$. (conditional)*
Given: if r, then q $(r \to q)$. (conditional)
Given: p. Question: q?
96% answers "yes".
Short: Given $\{p \to q, r \to q, p\}$. Question: q?

(Additional) *Given: $\{p \to q, s \to q, p\}$. Question: q?*
38% answers "yes".

p	*she has an essay to write*	q	*she studies late in the library*
r	*she has a textbook to read*	s	*the library stays open.*

Affirmation consequent (AC):

(Alternative) *Given:* $\{p \to q, r \to q, q\}$. *Question:* p?
13% answers "yes".

(Additional) *Given:* $\{p \to q, s \to q, q\}$. *Question:* p?
54% answers "yes".

Denial antecedent (DA):

(Alternative) *Given:* $\{p \to q, r \to q, \neg p\}$. *Question:* $\neg q$?
4% answers "yes".

(Additional) *Given:* $\{p \to q, s \to q, \neg p\}$. *Question:* $\neg q$?
63% answers "yes".

Modus Tollens (MT):

(Alternative) *Given:* $\{p \to q, r \to q, \neg q\}$. *Question:* $\neg p$?
96% answers "yes".

(Additional) *Given:* $\{p \to q, s \to q, \neg q\}$. *Question:* $\neg p$?
33% answers "yes".

Stenning & van Lambalgen: *There are logical models (other than FOL) of the Suppression Task that model human responses to the task.*

Logics can (must?) be used in modeling human behavior in reasoning tasks.

What happens in our mind?

What is the justification of an interpretation?

Finis

What do reasoning tasks say about human reasoning?

Are logics the right tool to formalize reasoning?