What happens when logic and psychology meet?

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Core Logic

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Settling the interesting questions

- Are people logical?

- Under what circumstances, and why?

- What kind of question is this?

- And what should inform our standards for judging:
  - classical logic?
  - any of the new varieties of default logic?
  - natural language?

What happens when logic and psychology meet?

Two perspectives on the matter:

- a philosopher's: the role of thinking in logic
    cf. origins of logic in analysing argument structure

- a psychologist's: the role of logic in thinking
    cf. idea, from antiquity, that 'man is the rational animal'

History of the logic of thinking

Early studies:

- Aristotle's syllogisms

- Boole's propositional algebra

- Frege's function-argument predicate structure

- ... and today's panoply of logics, to fulfill all your modelling needs

- eg McCarthy's circumscription to mimic human intellegence

History of the psychology of reasoning

Isolated early studies:

- Wilkins (1928), Woodworth and Sells (1935)

- Bloom and Broder (1950)

- Wason (1968)

- Tversky and Kahneman deserve a mention here

The Linda Problem

(paraphrased from Kahneman & Tversky, 1983)

Linda is 31 years old single outspoken and very bright. She majored in philosophy. As a student,she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuclear demonstrations. Please rank the following statements by their probability:

    a) Linda is a teacher in a primary school

    b) Linda is a bank teller

    c) Linda is an active feminist

    e) Linda is a member of Women Against Rape

    f) Linda works in a bookstore and takes Yoga classes

    g) Linda is a bank teller and is an active feminist

Summary of empirical findings in syllogistic reasoning

- **Validity** (eg Newstead & Griggs, 1983)

    - valid syllogisms are easier than invalid ones

- **Belief bias** (eg Wilkins 1928, Evans et al, 1983)

    - believability of conclusions interferes with reasoning

- **Response bias** (eg

    - reluctance to answer 'no valid conclusion'

Empirical findings (contd)

- **Atmosphere effect** (eg Woodworth & Sells,1935)

  - a negative premise increases the chance of a negative conclusion

  - a particular premise is more likely to result in a particular conclusion

- **Illicit conversion** (eg Geurts 2003)

  - only 'some' and 'no' are symmetric

- **Term ordering** and **figure effects** (eg Stenning & Yule 1996)

  - more likely to order terms one way or other

  - AC preferred over CA, unless premises in form BA, CB for instance

Here's an example of **belief bias** at work (Oakhill et al., 1989):

Some of the women are not beautiful

All of the beautiful people are actresses

Some of the women are not actresses

vs

Some of the actresses are not beautiful

All of the beautiful people are women

Some of the actresses are not women

Here's an example of **belief bias** at work (Oakhill et al., 1989):

> Some of the women are not beautiful
> All of the beautiful people are actresses
> ———————————————————
> Some of the women are not actresses

Conclusion believable but invalid yet **46%** draw it

<div align="center">

vs

</div>

> Some of the actresses are not beautiful
> All of the beautiful people are women
> ———————————————————
> Some of the actresses are not women

Conclusion unbelievable and invalid - only **17%** draw it.

But seriously ...

- this is the motor of psychology of reasoning research

- logically equivalent $\neq$ cognitively equivalent

- what does this tell us about our psychology?

Mental models vs mental logic

In the **mental logic** corner, we have

- Braine (1978): based on natural deduction for propositional logic

- Rips (1994): based on natural deduction for predicate logic

In the **mental models** corner, we have

- Johnson-Laird (1983): based on model construction

- Byrne (1989): anti-logical nature of model building

Explaining errors

Mental logic:

- limited capacities of the cognitive system

- availability of various rules

- conflicts between rules

Mental models:

- working memory limitations

- coupled with # models needed to solve problem

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Overview of current approaches

- Bounded rationality (Gigerenzer)

- Evolutionary psychology (Tooby & Cosmides)

- Bayesian approaches (Oaksford & Chater)

- Dual process theory (Evans, S. Sloman)

What's going on?

Standard argument:

People are sensitive to content as well as form.

Logical inference is based solely on form.

People are not reasoning according to logic.

What's *really* going on?

Hidden equivocations in the standard argument:

- Grammatical form = logical form

- Natural language connectives = classical logic connectives

- Interpretative process in natural language is fixed, as it is in logic

These are assumptions we should not make! e.g. we should not assume natural language sentences can be translated into propositional or predicate logic without losing any of their 'logical' properties.

Classical logic has been immensely successful. But this very success has enshrined certain formats and procedures, that also have drawbacks. For instance, many themes suffer from what may be called 'system imprisonment'. We have to discuss the behaviour of [say] negation inside specific formal systems, such as propositional or predicate logic - even though these systems do not correspond to meaningful distinctions in the 'open space' of actual reasoning.

van Benthem (2000)

What we should be thinking about:

- At which level does logic operate?

- Balance judgement with attention to meaning-making processes

- See for e.g.
  - material must make sense: Fillenbaum (1978),
  - what's my role?: Stenning & van Lambalgen (2001),
  - familiarity with 'test' genre: Scribner & Cole (1981)

Meaning-making

- Premises as random sentences or as discourse? (Byrne, 1989 cf. Stenning and van Lambalgen, 2005, Scribner & Cole, 1981, Fillenbaum, 1978)

- Logic cued by 'cheater detection'? (Cosmides, 1989)

- Co-operative or adverserial communication? (Stenning & Cox, 2003)

Genuine cognitive differences

Compare

1. All of the atheists are bankers
   All of the bankers are chess players
   What follows?

with:

2. None of the atheists are bankers
   All of the bankers are chess players
   What follows?

What's the difference?

Where psychology meets logic

- there are certainly non-logical factors influencing performance on logical reasoning tasks, but

- we're still figuring out exactly where the lines should be drawn - not all of these factors are the reasoner's responsibility

- and what the interesting questions are: what are we hoping to find out?

- and maybe empirical results can tell us about the structure of natural languages

Where logic meets psychology

current (local) work:

- Verbrugge, on epistemic logic

- Baltag on multiple agents and the logic of announcement

- Schulz, van Rooy formalising pragmatics