Relating Classical And Nonmonotonic Reasoning

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Foundation of Formal Semantics

Summary of Wittgenstein's *Tractatus Logico-Philosophicus*:

1 The world is everything that is the case.

1.1 The world is the totality of facts, not of things.

3.25 There is one and only one complete analysis of the proposition.

4.001 The totality of propositions is the language.

4.116 Everything that can be said can be said clearly.

5 Propositions are truth-functions of elementary propositions.

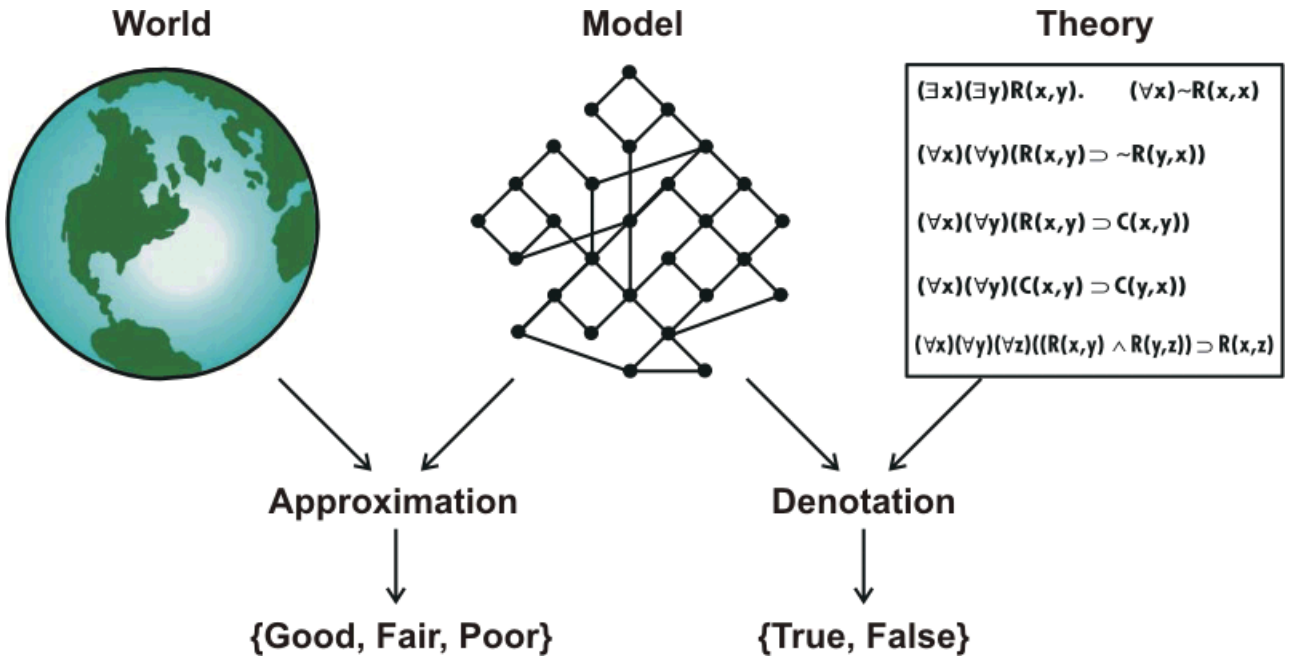
6.13 Logic is not a theory but a reflexion of the world.

7 Whereof one cannot speak, thereof one must be silent.

This book set the agenda for formal semantics in the 20th century.

It assumes that the world is a fixed model that determines the truth or falsity of any sentence in language or logic.

Model-Theoretic Semantics



In the *Tractatus*, Wittgenstein assumed that the world is the model.

If there is exactly one world, there is exactly one model, there is exactly one ontology, and any approximation is false.

Engineers are cynical, but realistic:

"All models are wrong. Some are useful."

Syntax, Semantics, and Pragmatics

For any formal logic L,

- Syntax is defined by a grammar that determines which patterns of symbols are sentences of L.
- Semantics is defined by an evaluation function Φ(s,M), which maps any sentence s and model M to the denotation T or F.
- Pragmatics consists of an open-ended family of methods for using the syntax and semantics of the sentences in L.

Examples of pragmatics:

- Methods of deduction, induction, and abduction based on Φ(s,M).
- Methods of theory revision based on Φ(s,M).
- Nonclassical proof procedures based on Φ(s,M).
- All methods of analysis, planning, message passing, learning, and question answering based on Φ(s,M).

Learning a New Theory

Observations generate facts:

```
Tweety is a bird.     Tweety flies.
Daffy is a bird.      Daffy flies.
Hooty is a bird.      Hooty flies.
```

Induction derives general axioms from multiple facts:

```
Every bird flies.
Every flying thing is a bird.
For every x, x is a bird if and only if x flies.
```

Any one of these axioms can be added to a subset of the facts to generate the other facts.

Heuristics give a slight preference for "`Every bird flies.`"

But the other axioms cannot be ruled out.

New Information Triggers Belief Revision

New observation:

```
Vampy is not a bird. Vampy flies.
```

This observation rules out two options, leaving just one:

```
Every bird flies.
```

Another observation:

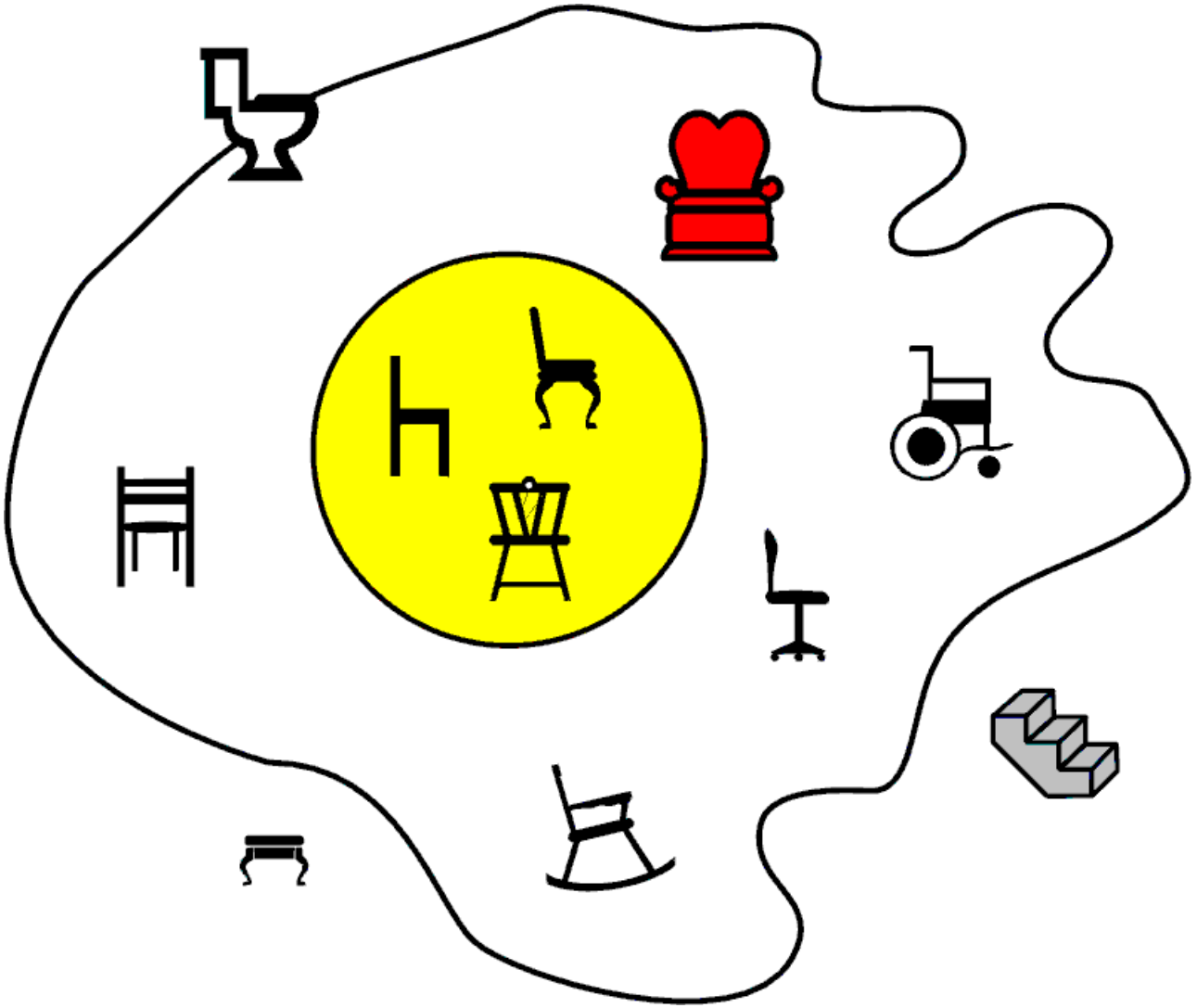
```
Tux is a penguin. Tux is a bird. Tux does not fly.
```

This observation restricts the universal quantifier:

```
Every bird that is not a penguin flies.
```

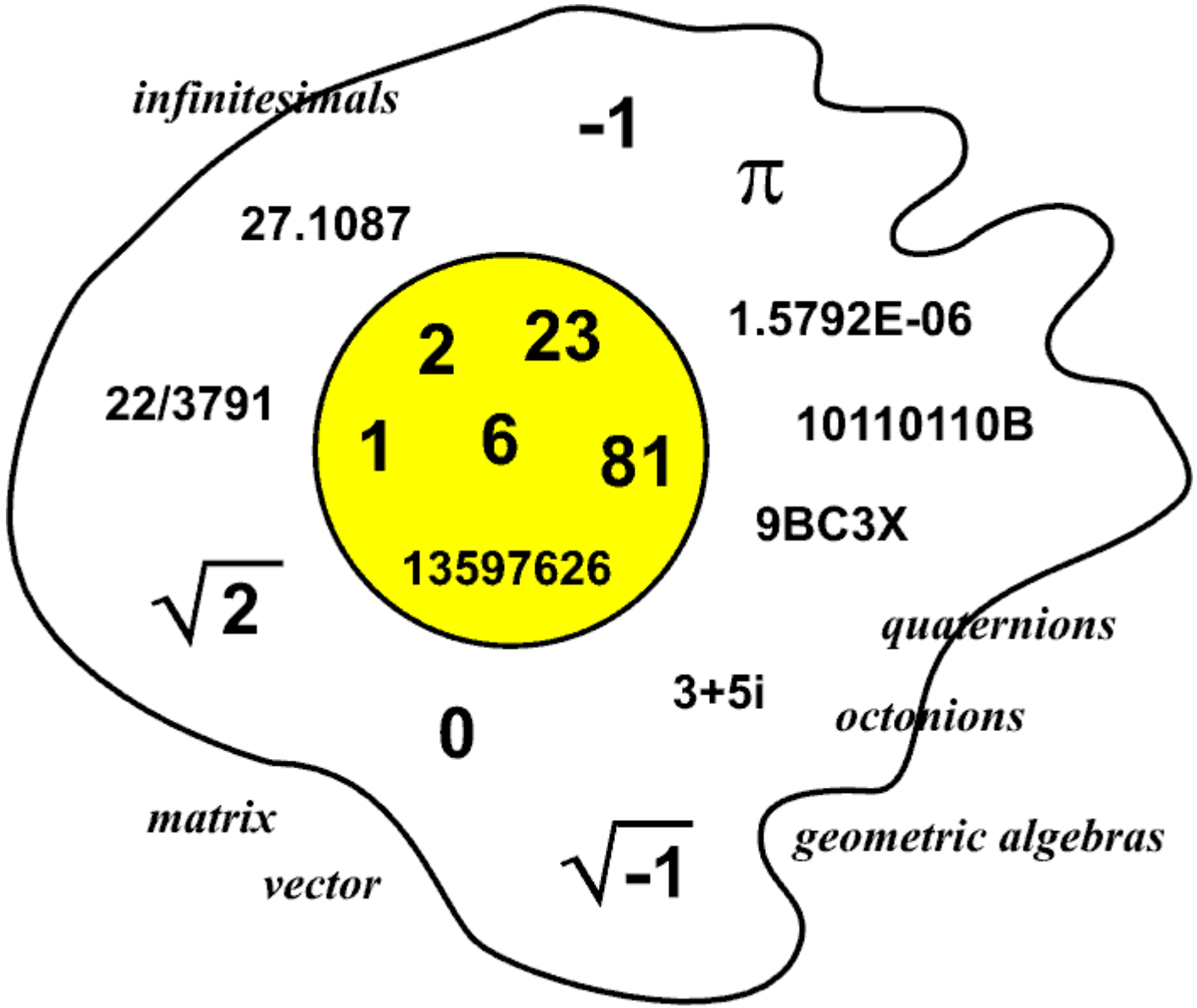
Learning and belief revision use the same semantics as deduction, but they make revisions to the theory.

What is a Chair?



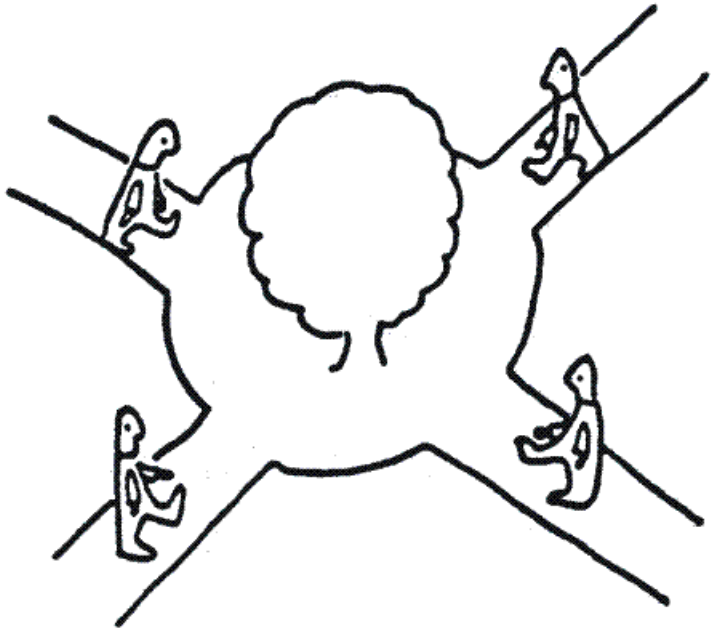
The egg-yolk theory puts typical examples in the yolk and unusual examples in the egg white (Lehmann & Cohn 1994).

What is a Number?

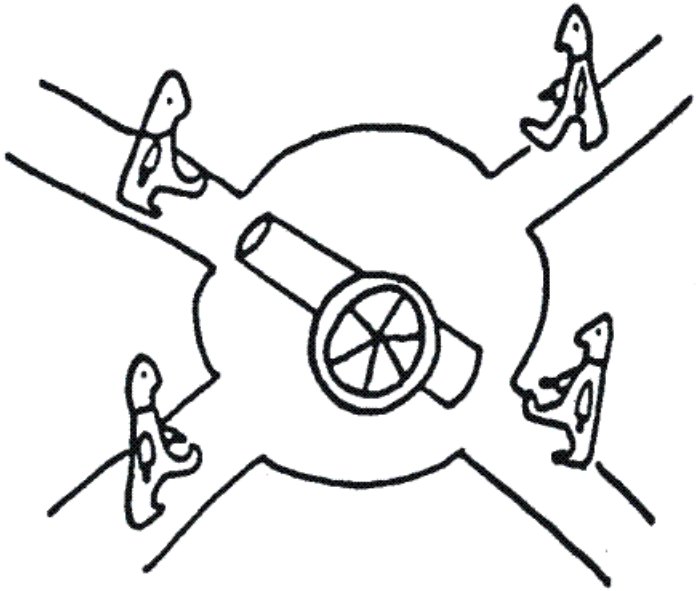


Concepts in science and mathematics grow and change.

Issues about Orientation



les présidents sont devant l'arbre
the presidents are in front of the tree



? les présidents sont devant le canon
the presidents are in front of the cannon

For a tree, any side could be could be considered the front.

But a cannon has distinct front, back, and sides.

Issues about Motion

le curé est avant le ministre
the priest is before the minister

le chêne est avant le peuplier
the oak is before the poplar

For stationary objects, such as trees, the speaker's viewpoint determines the choice of preposition.

For moving objects, their relative position is more significant.

But objects like snails and turtles, which move very slowly, are treated like stationary objects (unless their motion is relevant).

Issues about Function

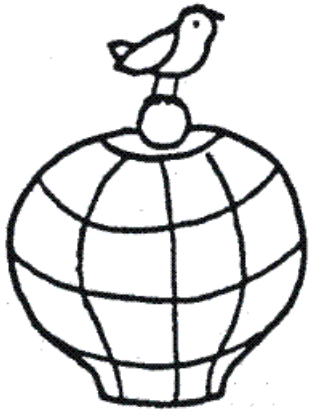
la poire est dans la coupe
the pear is in the bowl

The French preposition *dans* or the English *in* normally links something to a container.

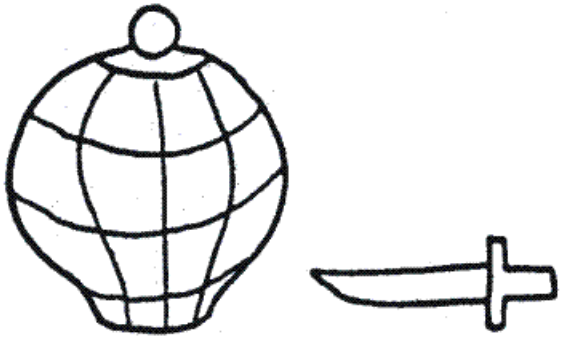
The primary function of a bowl is to serve as a container.

That function is more relevant than the question whether the bowl actually encloses the pear.

Issues about Background Knowledge



l'oiseau est à l'extérieur de la cage
the bird is outside the cage



?le couteau est à l'extérieur de la cage
the knife is outside the cage

A cage is sometimes used to enclose a bird.

But a cage is an unlikely container for a knife.

Normal comment: "The knife is to the right of the cage."

To say "The knife is outside the cage" implies that there is some reason why it might have been in the cage.

Nonmonotonic Reasoning

David Makinson (2005) defined three kinds of bridges that relate classical and nonmontonic methods.

- **Modify the set of assumptions.**
- **Constrain the set of permissible models.**
- **Use rules that make incremental changes of assumptions or models during a proof.**

These three methods enable any classical proof procedure to be used in nonmonotonic methods of belief revision.

They also enable the most widely used nonmonotonic proof procedures to be converted to classical proofs.

The classical proofs use the same semantics, but a modified set of axioms (assumptions and constraints).

Related Readings

A longer set of slides that have some overlap with these:
http://www.jfsowa.com/talks/goal.pdf

Role of Logic and Ontology in Language and Reasoning,
http://www.jfsowa.com/pubs/rolelog.pdf

Slides for a tutorial about patterns of logic and ontology,
http://www.jfsowa.com/talks/kdptut.pdf

For other citations in these slides, see the general bibliography,
http://www.jfsowa.com/bib.htm