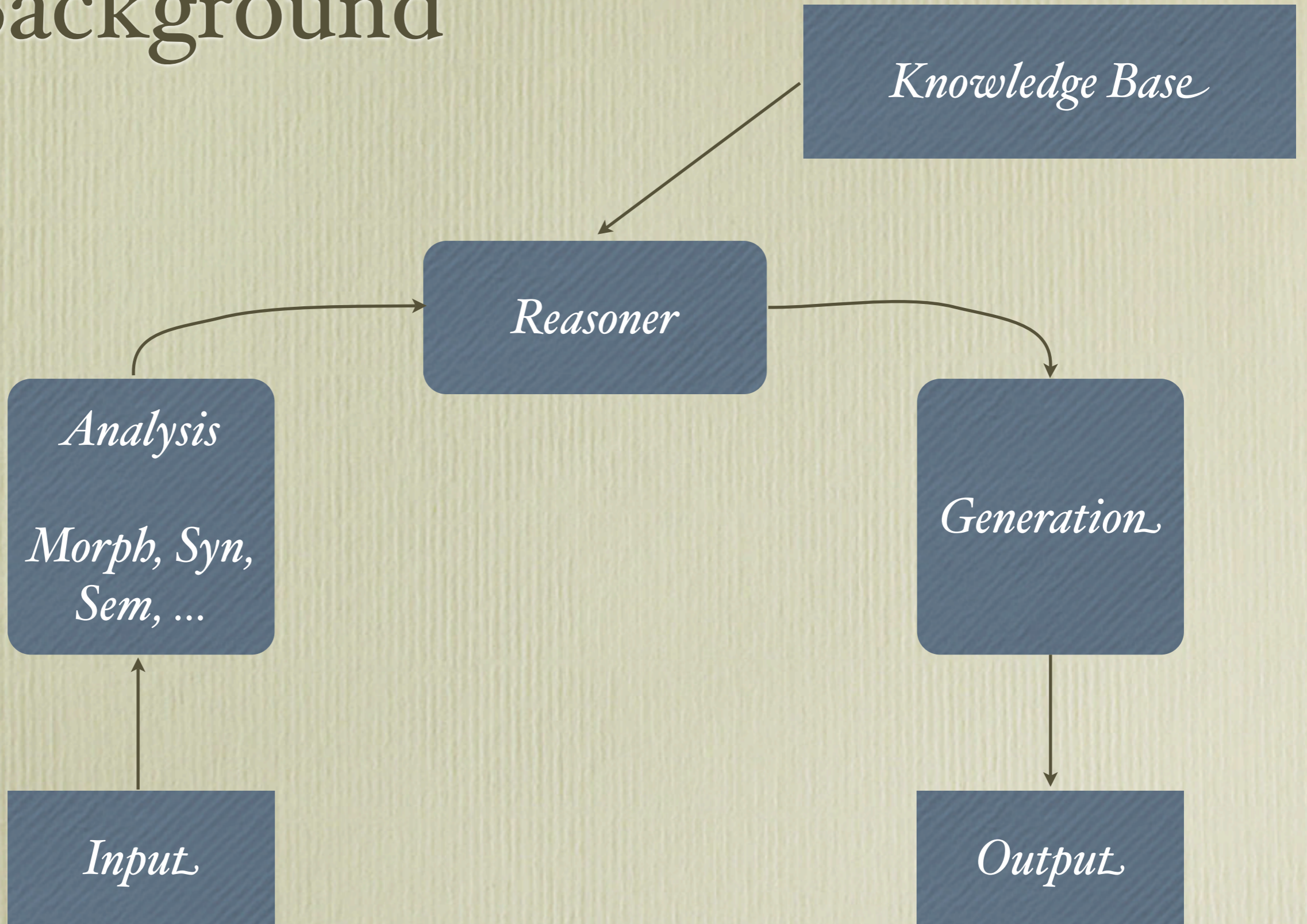# Introduction

Outline

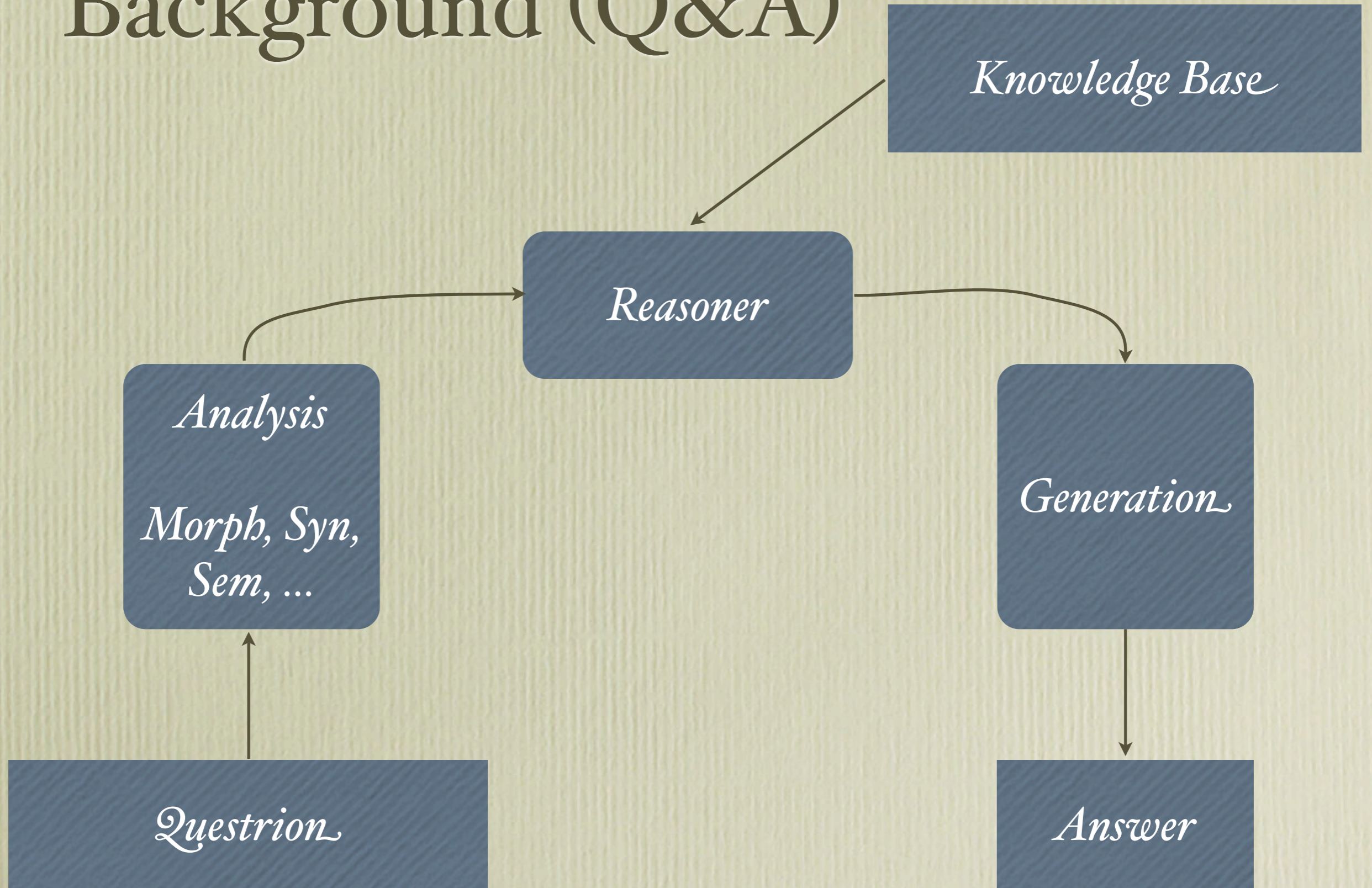- Background

- Organizational Matters

Background

Background

- Proper interpretation of natural language requires knowledge

- Knowledge needs to be formalized to be usable in CL-Systems

- Formalized knowledge is usually contained in knowledge bases

Background

Background (Q&A)

Background

- (Logical) Formalism used for

  - Knowledge Representation (KB)

  - "Language-independent" Sentence representation

- Formalism provides reasoning algorithms

First-Order Logic

- Logical Symbols:
  Connectives $\vee, \wedge, \neg, \rightarrow, \leftrightarrow$
  Quantification $\forall, \exists$
  Identity $=$

- Variables $IV = \{x, y, z, x_1, \dots\}$

- Non-logical constants

  - Individual constants $IC = \{a, b, c, a_1, \dots\}$
  - n-ary Relations: $RC_0 = \{p, q, r, \dots\}$;
    $RC_1 = \{F, G, H, \dots\}$;
    $RC_2 = \{P, Q, R, \dots\}$

First-Order ...

- $F(a) \wedge F(b)$

- $R(a, b) \wedge R(b, a)$

- $\exists x [F(x) \wedge \forall y [G(y) \rightarrow R(y, x)]]$

- $\forall y [G(y) \rightarrow \exists x [F(x)$

- $\forall x [F(x) \leftrightarrow x = a]$

Hans und Maria sind St...

Hans und Maria sind Freunde.

Alle sitzen in einem

Jeder sitzt in einem Boot.

Nur Maria ist intelligent.

First-Order Logic III

- Semantics!

- $M = \langle U, V \rangle$

- U: Individuals ($U \neq \emptyset$)

- V maps non-logical constants to values:

    - $V(R^n) \subseteq U^n, n \geq 1$ for n-ary relation constants R^n
    - $V(p) \in [0, 1]$ for sentence constants p
    - $V(a) \in U$ for individual constants a

- h maps variables to individuals: $h : IV \rightarrow U$

First-Order Logic IV

- $[\![x]\!]^{M,h} = h(x)$ for $x \in IV$

- $[\![R^n]\!]^{M,h} = V(R^n)$ for $R^n \in RC_n$

- $[\![\neg A]\!]^{M,h} = 1$ iff $[\![A]\!]^{M,h} = 0$

- $[\![A \rightarrow B]\!]^{M,h} = 1$ iff $[\![A]\!]^{M,h} = 0$ or $[\![B]\!]^{M,h} = 1$

- ...

Prolog

- Implements FOL (more or less)

- Pitfalls:

  - Ordering of rules

  - Negation as failure
    (Closed World Assumption)

Limitations of FOL

- Simple Models:

  - "Der Bundeskanzler fliegt nach China." vs. "Der Bundeskanzler wechselt."

- Simple Language:

  - "Das Auto ist rot" vs. "Intelligenz ist eine nützliche Eigenschaft"

Limitations of FOL II

- Vagueness

  - "Most people can read."
    "Some people can read."
    "Few people can read."

  - "The basketball player X is tall." vs.
    "The linguist X is tall."

- Exceptions / Generic Statements

  - "Bälle sind rund."

Background

- Natural language and knowledge bases work in different ways

- Formal knowledge is defined exactly

- Natural language expresses knowledge vaguely or "unsharply"

- This gap is not easy to bridge

Quelle: Werner Saurer, Vorlesungsskript Einführung in die Semantik