A Computational Model of Natural Language Communication

Interpretation, Inference, and Production in Database Semantics

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CLUE

Part I.
The Communication Mechanism of Cognition

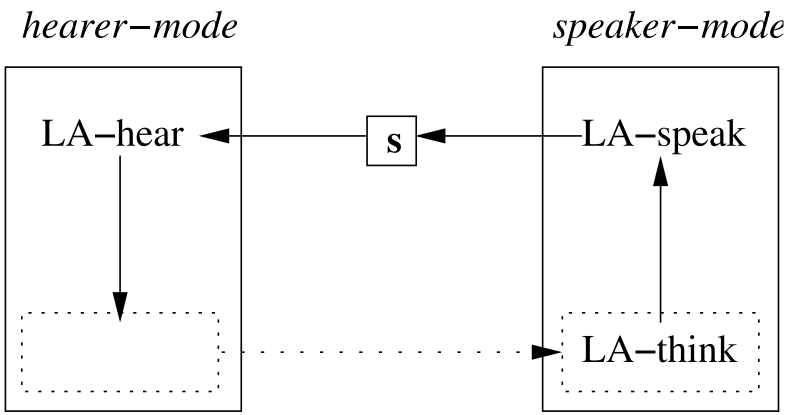
1. Matters of Method

1.1 Sign- or Agent-Oriented Analysis of Language?

The goal of Database Semantics is a theory of natural language communication which is complete with respect to function and data coverage, of low mathematical complexity, and suitable for an efficient implementation on the computer. The central question of Database Semantics is

How does communicating with natural language work?

1.1.1 The basic model of turn-taking

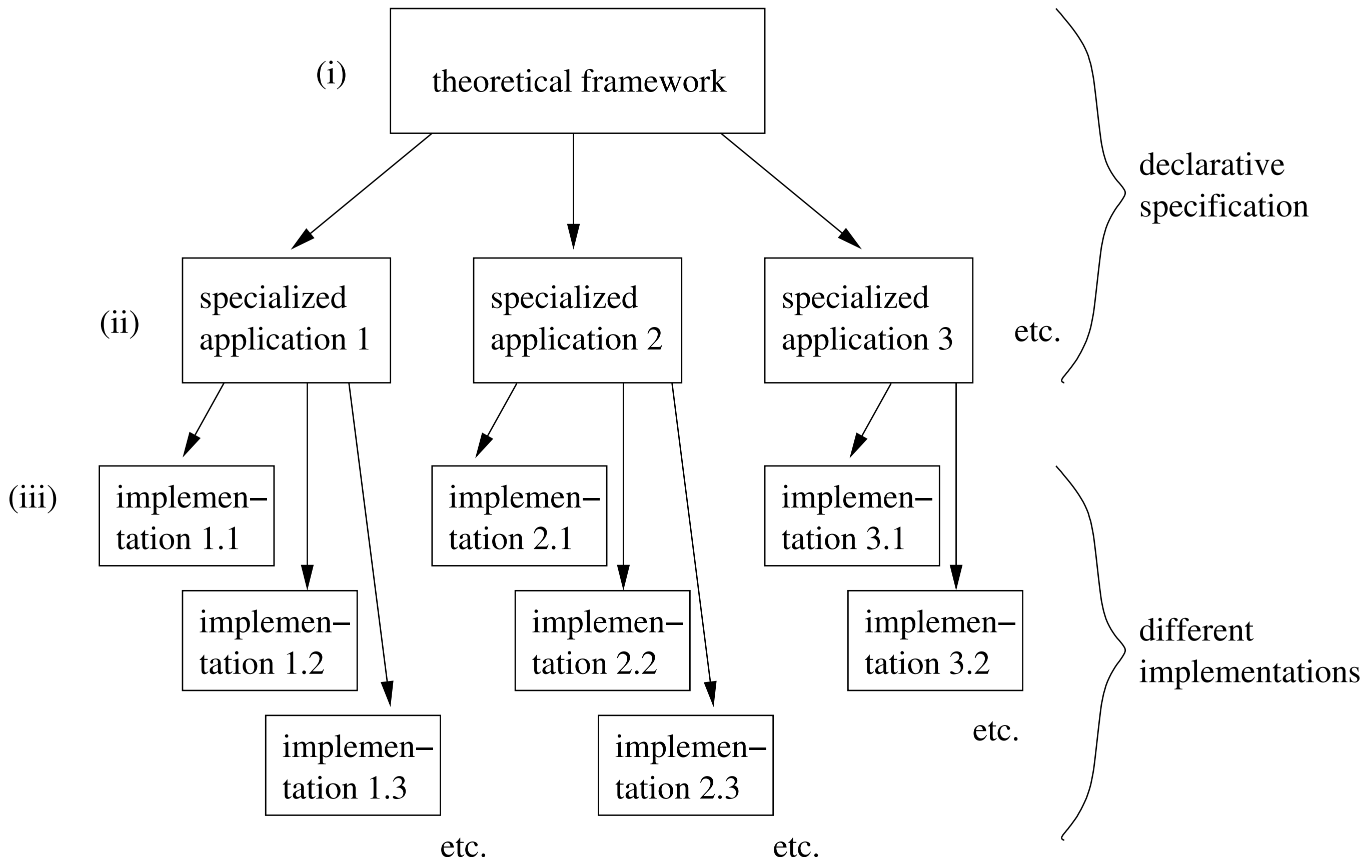


1.1.2 Two views of turn-taking

1. *Viewed from the outside:*
   Two communicating agents are observed as they are taking turns. This is represented by 1.1.1 when the two boxes are taken to be two different agents, one in the hearer- and the other in the speaker-mode.
2. *Viewed from the inside:*
   One communicating agent is observed as it switches between being the speaker and the hearer. This is represented by 1.1.1 when the two boxes are taken to be the same agent switching between the speaker- and the hearer-mode (with the dotted right-hand arrow indicating the switch).

1.2 Verification Principle

1.2.1 Correlation of declarative specification and implementations



1.3 Equation Principle

1.3.1 The equation principle of Database Semantics

1. The more realistic the reconstruction of cognition, the better the functioning of the model.
2. The better the functioning of the model, the more realistic the reconstruction of cognition.

1.4 Objectivation Principle

1.4.1 Constellations providing different kinds of data

1. Interaction between (i) the user and (iii) the robot
2. Interaction between (i) the user and (ii) the scientist
3. Interaction between (ii) the scientist and (iii) the robot

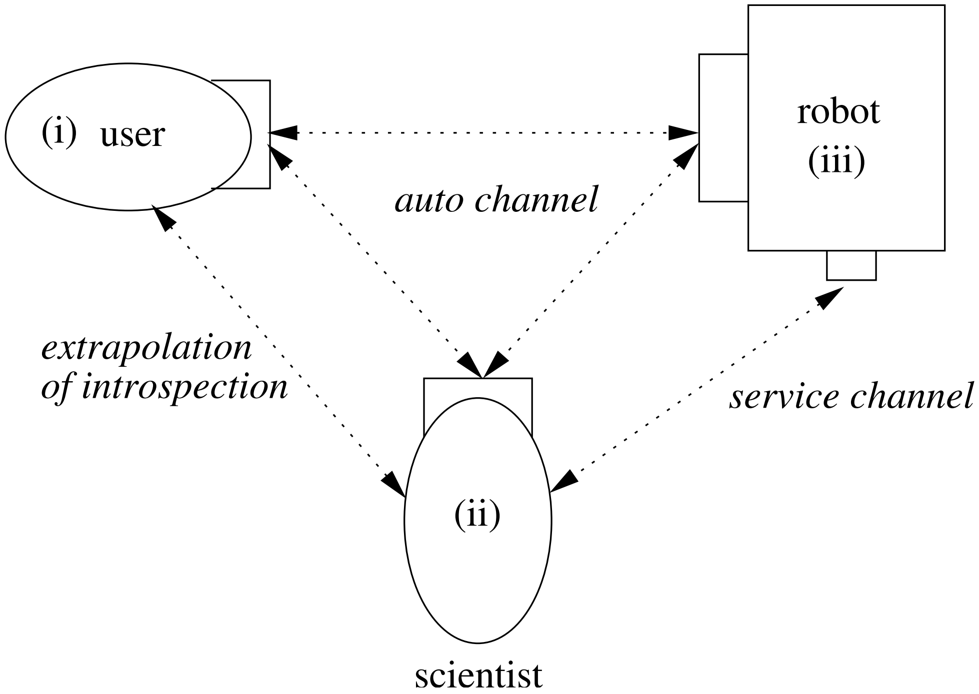
1.4.2 Data channels of communicative interaction

1. The *auto-channel*
processes input automatically and produces output autonomously, at the context as well as the language level. In natural cognitive agents, i.e. the user and the scientist, the auto-channel is present from the very beginning in its full functionality. In artificial agents, in contrast, the auto-channel must be reconstructed – and it is the goal of Database Semantics to reconstruct it as realistically as possible.

2. The *extrapolation of introspection*
is a specialization of the auto-channel and results from the scientists' effort to improve man-machine communication by taking the view of the human user. This is possible because the scientist and the user are natural agents.

3. The *service channel*
is designed by the scientist for the observation and control of the artificial agent. It allows direct access to the robot's cognition because its cognitive architecture and functioning is a construct which in principle may be understood completely by the scientist.

1.4.3 Interaction between user, robot, and scientist



1.5 Equivalence Principles for Interfaces and for Input/Output

The methodological principles of Database Semantics presented so far, namely

1. the *Verification Principle*
   i.e. the development of the theory in the form of a declarative specification which is continuously verified by means of an implemented prototype (cf. Section 1.2),
2. the *Equation Principle*
   i.e. the equating of theoretical correctness with the behavioral adequacy of the prototype during longterm up-scaling (cf. Section 1.3), and
3. the *Objectivation Principle*
   i.e. the establishing of objective channels for observing language communication between natural and artificial agents (cf. Section 1.4),

are constrained by

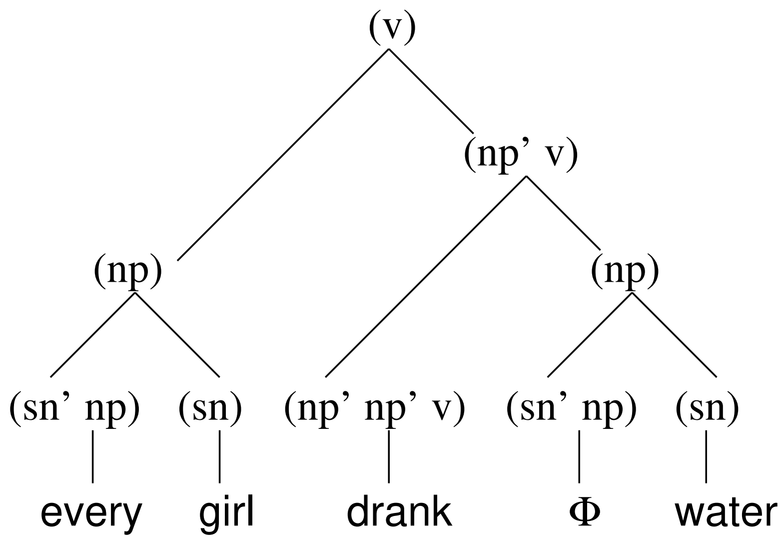
4. the *Interface Equivalence Principle* and
5. the *Input/Output Equivalence Principle.*

1.6 Surface Compositionality and Time-Linearity

1.6.1 Surface Compositionality

A grammatical analysis is surface compositional if it uses only the concrete word forms as the building blocks of composition, such that all syntactic and semantic properties of a complex expression derive systematically from the syntactic category and the literal meaning of the lexical items.

1.6.2 Analysis violating Surface Compositionality



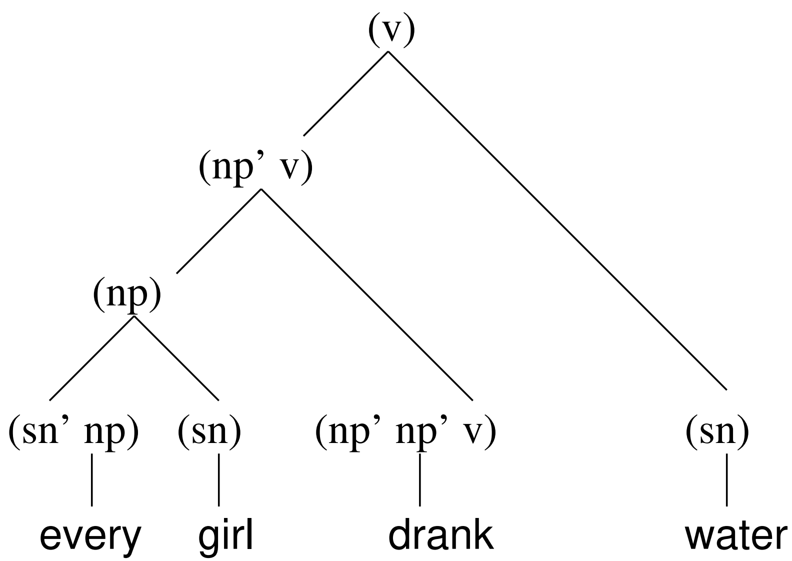
1.6.3 The categories of 1.6.2

(sn' np)	= *determiner*, takes a singular noun sn' and makes a noun phrase np.
(sn)	= *singular noun*, fills a valency position sn' in the determiner.
(np' np' v)	= *transitive verb*, takes a noun phrase np and makes a (np' v).
(np)	= *noun phrase*, fills a valency position np' in the verb.
(np' v)	= *intransitive verb*, takes a noun phrase np and makes a (v).
(v)	= *verb* with no open valency positions (sentence).

1.6.4 Rules computing possible substitutions for deriving 1.6.2

(v)	$\longrightarrow$ (np) (np' v)
(np)	$\longrightarrow$ (sn' np) (sn)
(np' v)	$\longrightarrow$ (np' np' v) (np)
(sn' np)	$\longrightarrow$ every, Φ
(sn)	$\longrightarrow$ girl, water
(np' np' v)	$\longrightarrow$ drank

1.6.5 Satisfying Surface Compositionality and Time-Linearity



1.6.6 Rules computing the possible continuations for deriving 1.6.5

(VAR' X) (VAR) → (X)
(VAR) (VAR' X) → (X)

1.6.7 Application of a rule computing a possible continuation

	ss		*nw*		*ss'*	
rule patterns	(VAR'	X)	(VAR)	$\rightarrow$	(X)	
						matching and binding
categories	(sn'	np)	(sn)		(np)	
surfaces	every		girl		every girl	

1.6.8 Variable definition of the time-linear rules for deriving 1.6.5

If VAR' is sn', then VAR is sn. (*identity-based agreement*)
If VAR' is np', then VAR is np, sn, or pn.(*definition-based agreement*)

