Formální a experimentální sémantika I

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Types of Predicates

Adjectives, Predicative Nouns

- implementing Frege's program: from (1) to (2-a-b)

(1) Vilda meows.

(2) a. Vilda is big.
b. Vilda is a cat.

- meaning of the copula:

1) semantically vacuous/empty meaning: deletion (non-interpretation) of its node

2) trivial property of a property: $<< e, t >, < e, t >>$, $[\lambda P.P]$: politician/loudspeaker

- similarly and even more complicated for English:
- because the indefinite article is certainly used meaningfully in argument positions – (4)

(3) Vilda is a cat.

(4) A cat ate my lunch.

(5) The/one/every cat ate my lunch.

- basic possibilities for the indefinite article:

1) two *a*s: argumental and predicative, the predicative is meaningless;
2) both the argumental and predicative *a* are meaningless, but in arguments, it signals the absence of other members (default?)
3) *a* has the same meaning in all uses, but then what is it?

Transitive Predicates

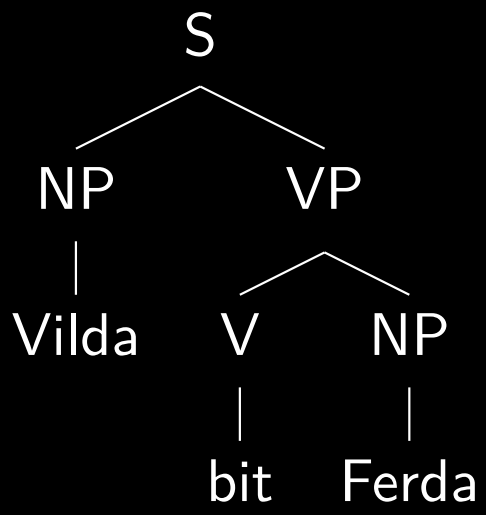
- even for Frege, there were two-argument predicates (*to be a mother*), but (6) would be for him a predicate + argument
- linguistically unattractive

(6) Vilda bit Ferda.

- doubly unsaturated predicates = relations

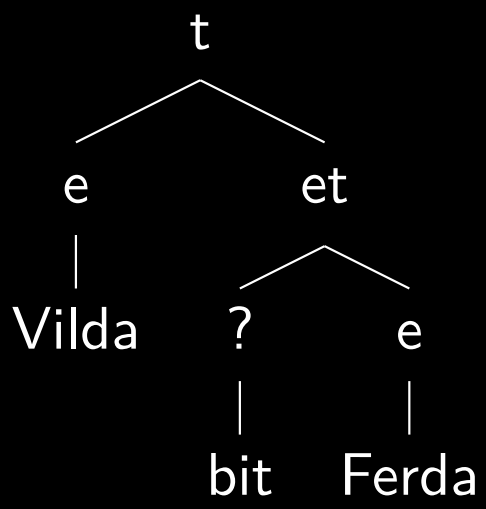
- bracketing according to syntax:

(7)



- semantic composition:

(8)



- principle of compositionality: $< e > \rightarrow$ $< e, t >:< e, < e, t >>$
- order of semantic composition mirrors syntactic structure $\leftrightarrow$ cleft tests, idioms, ...

Recap

- provisional logical types:

(9)
a. Petr, Masaryk, Prague ... $\langle e \rangle$ argumental use of N
b. to be president, to be a cat, to sleep ... $\langle e, t \rangle$ predicative use of N/intrans. V
c. to read, to write, ... $\langle e, \langle e, t \rangle \rangle$ transitive V
d. and, or, ... $\langle t, \langle t, t \rangle \rangle$ two-argument logical connectives
e. not- ... $\langle t, t \rangle$ one-argument logical connective

- argumental vs. predicative use:

(10)
a. Zeman is a gentleman.
b. A gentleman from Vysočina is a president.
c. A gentleman ate a wine sausage.
d. Masaryk was the first president.
e. The president wore a hat.

- logical connectives:

(11)
a. Masaryk and Beneš rode a horse.
b. Masaryk did not eat a wine sausage.
c. Masaryk or Beneš wore a hat.
d. Zeman and Ovčáček are a nice couple.
e. Sheep and cows outnumbered horses.

- more complex examples:

(12)
a. relational nouns: capital city of X, president of X, mother of X
b. similarly prepositions: on X (bridge on X), in X, ...
c. non-relational nouns: table, dog, ...
d. vacuous predicates: to exist

(13)
a. The capital city of the Czech Republic is big.
b. The president of hell exists.
c. The president of hell is horned.
d. Charles Bridge is in Prague.

Relative Clauses

- predicative use of a relative clause:

(14) This book is [what I was looking for.]

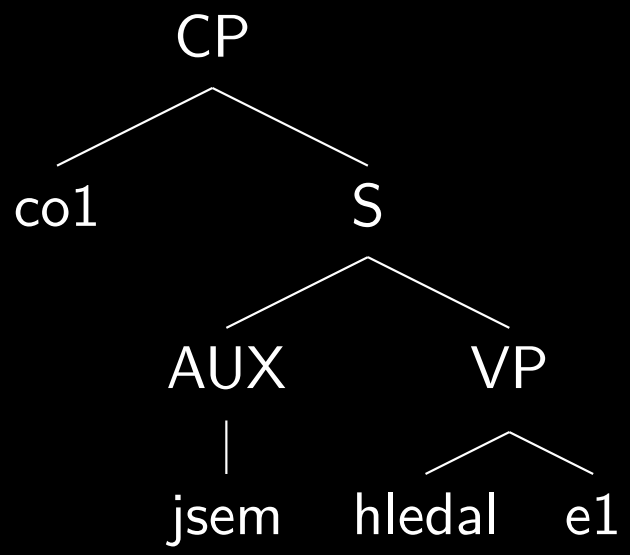
- relative clause: externally serves as a predicate, but internally is complex

- corresponds to λ-abstraction over one of the arguments:

(15) a. I was looking for Švejk.
   (i) $\mathit{ToLookFor}(I, \mathit{Svejk})$ ... type <t>
   b. [what I was looking for]
   (i) $[\lambda x.\mathit{ToLookFor}(I, x)]$ ... type <e,t>

- this also corresponds to the syntactic structure, where the trace corresponds to x from the formula and *what* in SpecCP to the λ-abstraction

(16)



- from a saturated proposition with a variable: $Hledat(Ja, x)$ (type t) to an unsaturated open proposition with a bound variable $[\lambda x.Hledat(ja, x)]$ (type et)

Topicalization

- similarly, predicates can be formed from sentences as opposed to [S[VO]] bracketing
- at least some theories (Krifka, Peregrin, . . .) explain the whole topic/focus this way
- e.g., unmarked word order:

(17) Vilda bit Ferda

- vs. marked:

(18) Ferda Vilda bit (but not Baruska) . . . topicalization

- forming a predicate: the set of things bitten by Vilda (applied to Ferda)
- vs. unmarked: the set of things that bit Ferda (applied to Vilda)

- unmarked:

(19) $[\lambda x.\mathit{Bite}(x, \mathit{Ferda})](\mathit{Vilda})$

- topicalization:

(20) $[\lambda y.\mathit{Bite}(\mathit{Vilda}, y)](\mathit{Ferda})$

- the semantics is the same as for a relative clause: variable + λ-abstraction

Semantics below the level of words (sub-atomic)

- meaning below the level of words: sub-atomic . . . T. Parsons
- **thematic roles**
- one of the cross-linguistically valid generalizations: transitive verbs always have the agent expressed as the subject and the patient affected by the action as the object
- i.e., there is no (even in other natural languages) lexicalized verb that expresses the reverse meaning of *to bite*:

(21) Vilda bit Ferda.

(22) *Ferda bit Vilda.

- to express similar generalizations: thematic roles

1) agens: the entity that performs an action (will, perception, movement)
2) patient: the entity affected by the action
3) location
4) experiencer
5) theme: moved objects

- thematic roles are unique for each sentence
- they can be used to express generalizations:

(23) If a sentence has an agent, it is expressed as the subject.

(24) If a sentence has a patient (and no agent), then the patient is expressed as the subject.

(25) If a sentence has both an agent and a patient, then the patient is expressed as the object of the sentence.

- in generative grammar: UTAH

(26) a. Petr weighs the pig.
b. The pig is weighed by Petr.

(27) a. The pig weighs two hundred kilograms.
b. #Two hundred kilograms are weighed by the pig.

- explanation: only a subject that is also an agent can be passivized

- in formal semantics, formalization often goes through events:

(28) Ferda bit Vilda.

a. There was a biting event in which Ferda was the agent and Vilda was the patient.

b. $\exists e[\mathit{Bite}(e) \wedge \mathit{Agent}(\mathit{Ferda}, e) \wedge \mathit{Patient}(\mathit{Vilda}, e)]$

- Davidson's argument:

(29) a. $\exists e[\mathit{Bite}(e) \wedge \mathit{Agent}(\mathit{Ferda}, e) \wedge \mathit{Patient}(\mathit{Vilda}, e) \wedge \mathit{Location}(\mathit{Garden}, e) \wedge \mathit{Time}(\mathit{Yesterday}, e)]$

b. $\rightarrow \exists e[\mathit{Bite}(e) \wedge \mathit{Agent}(\mathit{Ferda}, e) \wedge \mathit{Patient}(\mathit{Vilda}, e) \wedge \mathit{Location}(\mathit{Garden}, e)]$

c. $(p \wedge q) \rightarrow p$

d. $(p \wedge q) \rightarrow q$

- agens: relation between an event and an entity, where the entity causes at least part of the event by its will and the whole event would not occur without its causation
- patiens: relation between an event and an entity, where the entity is affected (at least partially) by the event
- sub-atomic: it is about selecting certain aspects of meaning:

(30) Petr/?stone/??square/#prime number sang.

Critique of semantic roles

- how many? how to define?
- David Dowty:
- cannot be precisely defined to actually derive argument assignment rules

(31) a. Joe hit the table with a hammer.
b. Joe hit the hammer against the table.

- generalizations assigning arguments to semantic roles force us to label *the table* as the patient in (31-a), but *the hammer* in (31-b)
- this goes against understanding semantic roles as functions! from events to entities

- similarly for Czech:

ex.

a. Petr napustil vanu vodou.
b. Petr napustil vodu do vany.

(32) a. Petr naložil papír na vozík.
b. Petr naložil vozík papírem.

- Dowty's solution: semantic roles are too coarse, we need a scale
- *Petr* is more agent than *paper/cart*, which are more patient than *Petr*
- however, it cannot be said which one is the only patient

- an argument is an agens if it meets certain implications:

(33) **proto-agens** implications: will, perception, causation, movement (relative to others), independent existence

- more agens-like properties $\rightarrow$ subject position
- similarly for patiens:

(34) **proto-patiens** implications: undergoes change, changes incrementally, is causally affected, does not move, does not exist independently of others

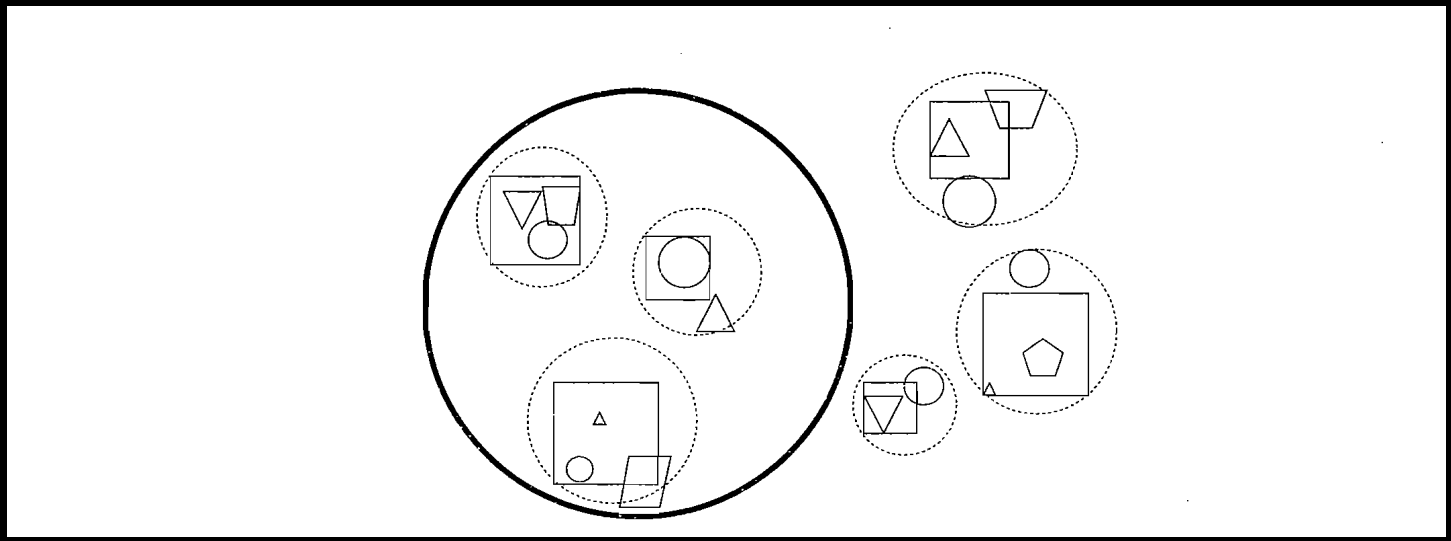
- some arguments can be equally patient-like

Modeling properties

1) Sets

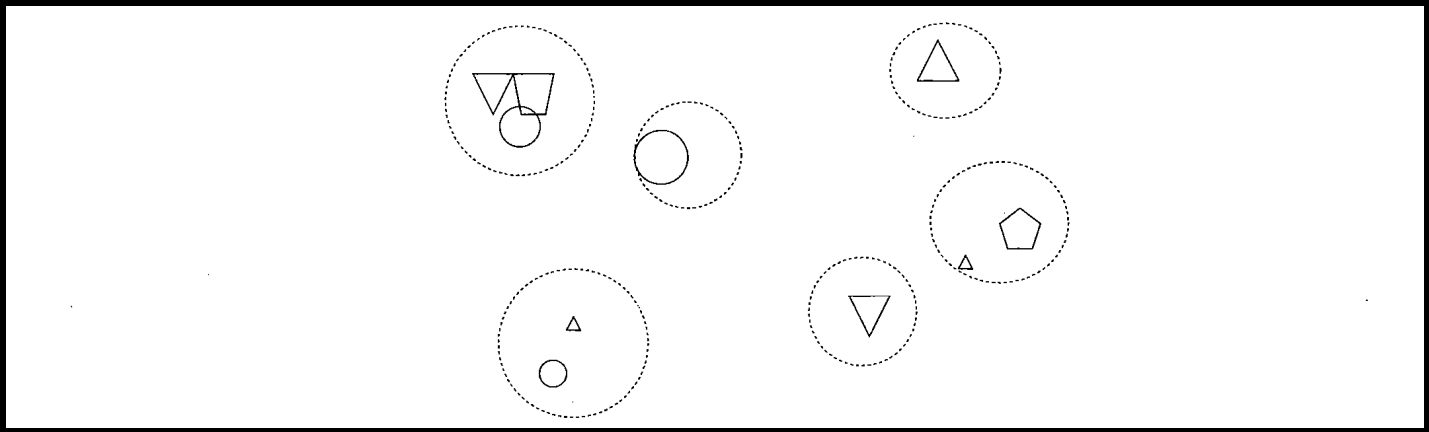
- proposition = set of situations/possible worlds

(35) The circle is inside the square.



- meaning of sets: for each situation/world, the set of entities that satisfy/represent the given predicate

(36) () is inside the square.



- set notation: *() is the head of the department at FF MU*: {Ondřej Šefčík, Zdeňka Jastrzembská, Zdeňka Hladká, . . . }
- composition:

(37) Ondřej Šefčík is the head of the department at FF MU.

2) Functions

- a function is a mathematical mapping: from an argument to a value
- the set of possible arguments is the domain
- the set of possible values is the range

- functional notation

(38) to be the head of the department at FF MU

a. Ondřej Šefčík $\rightarrow$ 1

b. Zdeňka Jastrzembská $\rightarrow$ 1

c. Karel Gott $\rightarrow$ 0

- type (extensionally): <e,t>
- fully $< s, < e, t >>$

- λ-notation:

(39)
a. y = x + 1
b. set notation: {<1,2>,<2,3>, . . . }
c. λ-notation: [$\lambda x.x + 1$]

(40)
a. () to be the head of the department at FF MU
b. set notation: {Ondřej Šefčík, Zdeňka Jastrzembská, Zdeňka Hladká, . . . }
c. λ-notation: [$\lambda x.x$ *is the head of the department*]

- reading λ notation:

1) in [] is NP: function from x to the number x + 1
2) in [] is a sentence/predicate: function from x to a truth value, if []

- examples:
- Rychlé šípy: {Mirek Dušín, Jarka Metelka, Červenáček, Rychlonožka, Jindra Hojer}
- Bratrstvo kočičí pracky: {Dlouhé bidlo, Bohouš, Štetináč}
- *friend*(e) → e
- friend: {<MD,JM>, <MD,JH>}

(41) a. $[\lambda x.\textit{friend } x]$ $\langle e, e\rangle$

b. $[\lambda x.x \textit{ belongs to } RS]$ $\langle e, t\rangle$

- examples:

(42) a. $[\lambda x.x \textit{ is small}]$
b. $[\lambda f.f]$
c. $\lambda x.[\lambda y.y \textit{ loves } x]]$

- x, y, ... individuals, f, g, ... functions, P,Q,R, ... predicates, p, q, r, ... propositions

(43) a. $\lambda P \lambda Q \exists x[P(x) \wedge Q(x)]$

- saturation of an unsaturated proposition:

(44) a. $[\lambda x.x \textit{ is small}](\textit{Cartman})$ . . . type <t>

b. $\lambda x.[\lambda y.y \textit{ loves } x](\textit{Romeo})](\textit{Juliet})$ . . . type <t>

(i) application of function to arguments:
$[\lambda y.y \textit{ loves Juliet}](\textit{Romeo})$

(ii) *Romeo loves Juliet*

Type checking in Python

- nice project from Kyle Rawlins:

Lambda notebook demo

slides