Computational Lexical Semantics

Generative Lexicon – Pustejovsky (1991)

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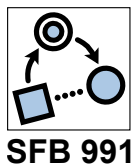


Outline

Worum geht's?

Aus der Kursbeschreibung:

> *Das Lexikon enthält diejenigen semantischen Informationen, die für die Bedeutungskomposition notwendig sind.*

1. Welche Einheiten enthält das Lexikon?
   - ⇒ Morpheme, **Worte** (Wortformen, Lexeme), Phrasen, …
2. Was ist "die Bedeutung"?
   - ⇒ Problem: Mehrdeutigkeit, Abstraktheit
3. Wie repräsentieren wir (lexikalische) Bedeutung?
   - ⇒ Paraphrasen, logische Formeln, Merkmalsstrukturen, Typenhierarchien, Vektoren, …

In diesem Seminar

eine **Auswahl** (2 SWS!) computerlinguistischer "Antworten"

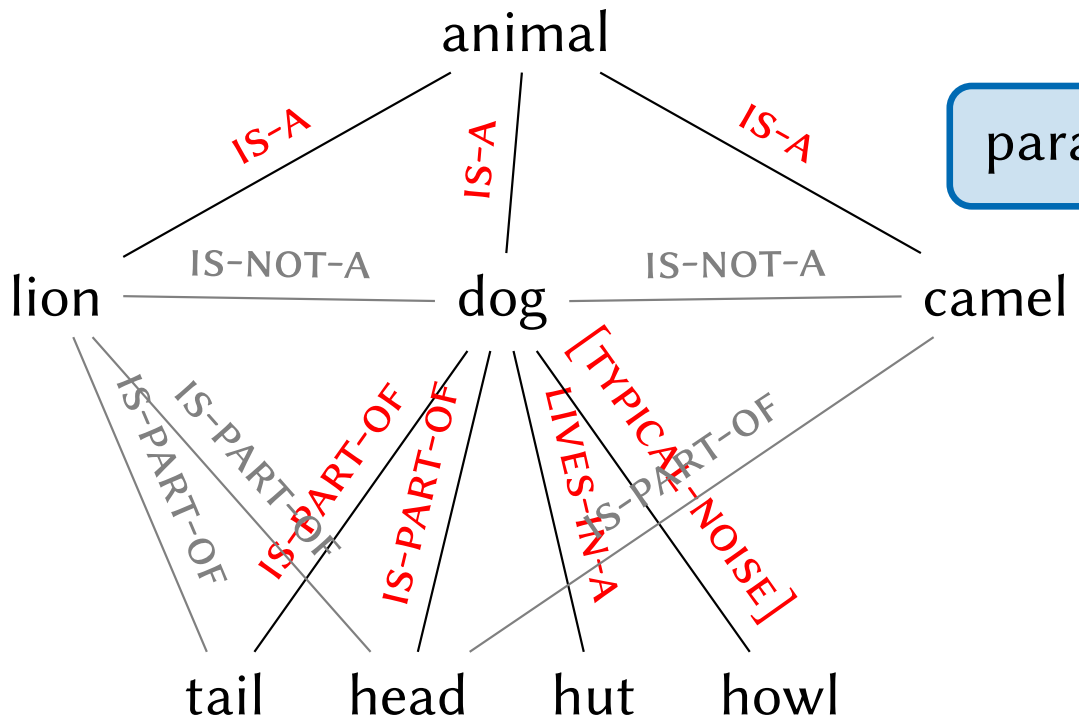
Stationen des Seminars

1. Theorie: Lexikon & lexikalische Semantik
2. Lexikalische Ressourcen: WordNet, FrameNet, VerbNet
3. Semantisch annotierte Korpora: SemCor, PropBank, OntoNotes
4. Anwendungen:
   - Word Sense Disambiguation
   - Semantic Role Labeling
   - …

Wiederholung: Cruse (2001)

2. Was ist "die Bedeutung"?

1. Contextual/holistic approach (sense relations)



paradigmatic relations

(1) The Prime Minster attended the White House reception accompanied by his ***Dad***/***father***.
(2) John drank the ***wine*** / ***filing cabinet***.
(3) a ***male***/***female*** aunt

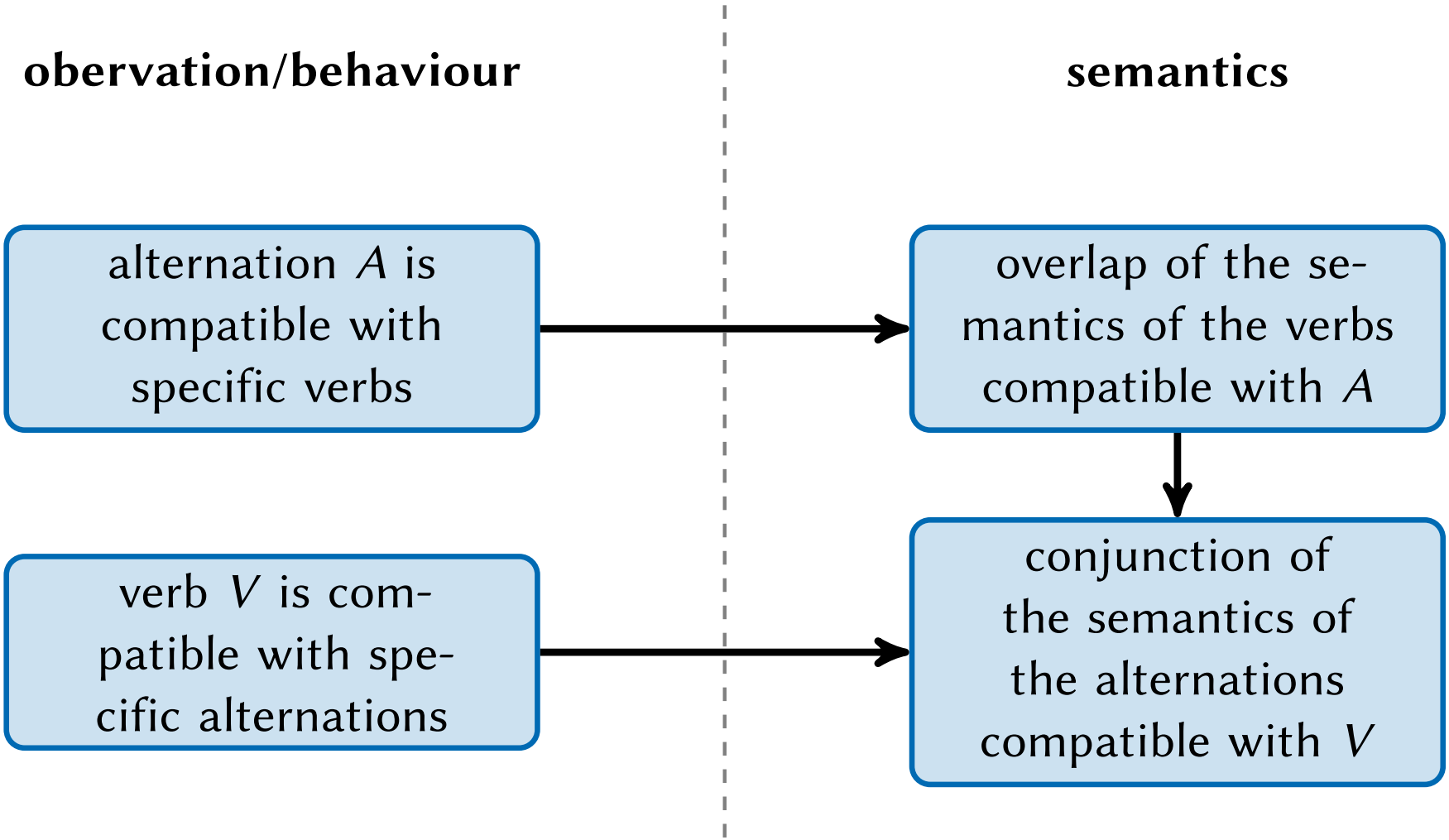
syntagmatic relations

Wiederholung: Pustejovsky (2016)

Further aspects of verbal meaning:

- argument structure & selectional constraints:
  (4) laugh(arg 1 [cat=NP,animacy=+])
    a. *The man ***laughed*** the ball.
    b. The man / *the rock ***laughed***.
- semantic roles:
  (5) a. put⟨agent,theme,location⟩
    b. borrow⟨recipient,theme,source⟩
- alternations:
  (6) a. The glass ***broke***.
    b. Mary ***broke*** the glass.
- event types / Aktionsarten (Vendler 1957) :
  state, activity, accomplishment, achievement

Wiederholung: Levin (1993)



⇒ unexpected similarities and differences between verbs

⇒ TODO: more structured lexical representations

Wiederholung: Levin (1993)

Diathesis alternations

alternation in the expression of arguments, sometimes accompanied by changes of meaning

Locative alternation:

(7) a. The farmer ***loaded*** apples into the cart.
    b. The farmer ***loaded*** the cart with apples.

(8) a. The farmer ***dumped*** apples into the cart.
    b. *The farmer ***dumped*** the cart with apples.

(9) a. *Gina ***filled*** lemonade into the pitcher.
    b. Gina ***filled*** the pitcher with lemonade.

Wiederholung: Levin (1993)

	touch	hit	cut	break
Middle	–	–	+	+
Conative	–	+	+	–
Body-Part Possessor Ascension	+	+	+	–
(Causative/Inchoative Alternation)	–	–	–	+

(10) a. Break Verbs: break, crack, rip, shatter, snap, . . .
b. Cut Verbs: cut, hack, saw, scratch, slash, . . .
c. Touch Verbs: pat, stroke, tickle, touch, .. .
d. Hit Verbs: bash, hit, kick, pound, tap, whack, . . .

⇒ relevant meaning components?

Wiederholung: Levin (1993)

	contact	motion	change of state
Middle			+
Conative	+	+	
Body-Part Possessor Ascension	+		
(Causative/Inchoative Alternation)	−	−	+

The picture that emerges is that a verb's behavior arises from the ***interaction of its meaning and general principles of grammar****. Thus the lexical knowledge of a speaker of a language must include knowledge of the meaning of individual verbs, the meaning components that determine the syntactic behavior of verbs, and the general principles that determine behavior from verb meaning.*

Pustejovsky (1991)

Pustejovsky, James. 1991. The Generative Lexicon. Computational linguistics 17(4). 409–441.

Die Leitfragen der Lektüre:

- Inwiefern ist das Generative Lexicon generativ?
- Welche Bedeutung wird Nomen wie *book* oder *cake* zugewiesen?
- Wie verhindert das Polysemie beim Verb?

Pusetjovsky (1991): Introduction

Turning point in research: "wedding" of linguistic theory and computational tools

Assumptions:

1. Without an appreciation of the **syntactic structure** of a language, the study of lexical semantics is bound to fail. There is no way in which meaning can be completely divorced from the structure that carries it.
2. The semantics of natural language should be the image of nonlinguistic conceptual organizing principles (whatever their structure).

Puestjovsky (1991): Introduction

Goals of computational lexical semantics:

1. A clear notion of semantic well-formedness will be necessary to characterize a theory of possible word meaning. This may entail abstracting the notion of lexical meaning away from other semantic influences.
2. Lexical semantics must look for representations that are **richer than thematic role descriptions**.
   - $\Rightarrow$ a principled method of lexcial decomposition
3. The lexicon is not just verbs.
   - $\Rightarrow$ balanced understanding of the lexicon and the methods of composition

Pustejovsky (1991): Methods in Lexical Semantics

1. typical semantic behaviour of a word of category X
   (verbs → predicators, nouns → arguments)
2. collocation and cooccurrence tests ⇒ selectional classes
   (***dog*** vs. ***book*** due to animacy)
3. alternation/diathesis tests (***break*** vs. ***cut***)
4. entailment tests (***killing*** entails a ***dying*** event)
5. ambiguity tests (homonymy versus polysemy)
6. test for the compositional nature
   - intensional ***alleged*** vs. intersective ***female***
   - wide scope: ***occasional sailor***
   - ***fast typist***/***car***/***waltz***

What has changed: advent of computational lexicography

Pustejovsky (1991): Descriptive Adequacy of Existing Representations

Descriptive adequacy for verbs: **good!** (thanks to Beth Levin et al.)

Descriptive adequacy for everything else: **not so good!**

> *[T]here is **no general coherent view** on what the **entire lexicon** will look like when semantic structures for other major categories are studied. […] It is clear, therefore, that the classifications made by Levin and her colleagues are an important starting point for a serious theory of knowledge representation. I claim that lexical semantics must build upon this research toward constructing a theory of word meaning that is integrated into a linguistic theory, as well as interpreted in a real knowledge representation system.*

Pustejovsky (1991): Explanatory Adequacy of Existing Representations

In what ways could lexical semantics affect the larger methods of composition in semantics?

- Usually, the **semantic weight** falls on the verb:

(11) a. John ***baked*** the potato. (change-of-state)
b. John ***baked*** the cake. (creation)

(12) a. Mary ***hammered*** the metal.
b. Mary ***hammered*** the metal flat. (resultative)

Given the conventional notions of function application and composition, there is little choice but to treat all of the above cases as ***polysemous verbs****. Yet, something about the systematicity of such ambiguity suggests that a more general and simpler explanation should be possible.*

⇒ Instead: **logical polysemy**

Pustejovsky (1991): A Framework for Computational Semantics

Two general approaches to word meaning

- primitive-based
- relation-based

New: “way of viewing primitives, looking more at the generative or compositional aspects of lexical semantics”
Needed: “method for the decomposition of lexical categories”

Pustejovsky (1991): A Framework for Computational Semantics

Traditional exhaustive approach based on a fixed set of primitives:

(13) a. The door is closed. (not-open)
b. The door closed. (become-not-open)
c. John closed the door. (cause-to-become-not-open)

Problem: being able to capture the full expressiveness of natural language
Solution: a fixed number of generative devices that can be seen as constructing semantic expressions

- for example: opposition (closed, not-closed)

Pustejovsky (1991): A Framework for Computational Semantics

Levels of semantic presentations:

1. **Argument Structure:** The behavior of a word as a function, with its arity specified. This is the predicate argument structure for a word, which indicates how it maps to syntactic expressions.
2. **Event Structure:** Identification of the particular event type (in the sense of Vendler [1967]) for a word or phrase: e.g. as state, process, or transition.
3. **Qualia Structure:** The essential attributes of an object as defined by the lexical item.
4. **Inheritance Structure:** How the word is globally related to other concepts in the lexicon.

Pustejovsky (1991): A Framework for Computational Semantics

Qualia Structure:

- **Constitutive Role:** the relation between it and its constituent parts;
- **Formal Role:** that which distinguishes it within a larger domain (its physical characteristics);
- **Telic Role:** its purpose and function;
- **Agentive Role:** whatever brings it about.

Example (p. 427)

```
novel(*x*)
  Const: narrative(*x*)
  Form: book(*x*), disk(*x*)
  Telic: read(T,y,*x*)
  Agentive: artifact(*x*), write(T,z,*x*)
```

Pustejovsky (1991): Theory of Qualia

Before: sense enumeration view

(14) a. John baked the potato.
`(bake1 = change(x, State(y)))`
b. John baked the cake.
`(bake2 = create(x,y))`

(15) a. Mary hammered the metal.
`(hammer1 = change(x, State(y)))`
b. Mary hammered the metal fiat.
`(hammer2 = cause(x, Become(fiat(y))))`

Why? Composition is centered on the verbal semantics. Nouns and adjectives are rather passive.

Pustejovsky (1991): Theory of Qualia

Now: cocompositionality, cospecification

One meaning for ***bake***:

$$\lambda y \lambda x \lambda e^P \; [\texttt{bake}(e^P) \wedge \texttt{agent}(e^P, x) \wedge \texttt{object}(e^P, y)]$$

The rest is contributed by the semantics/Qualia Structure of nouns and adjectives:

- ***potato*** is a natural kind ⇒ does not change ***bake***
- ***cake*** is an artefact ⇒ adds a transition event to ***bake***

(16) John baked a cake.
$\exists e^P, e^S \; [\texttt{create}(e^P, e^S) \wedge \texttt{bake}(e^P) \wedge \texttt{agent}(e^P, \texttt{j}) \wedge \texttt{object}(e^P, y) \wedge \texttt{cake}(e^S) \wedge \texttt{object}(e^S, y)]$

Pustejovsky (1991): Theory of Qualia

Other relevant cases: **type coercion** (metonymy, "reference shifts")

(17) a. Mary enjoyed the book.
b. John began a novel.

Qualia Structure of ***novel***:

λx [novel(x) $\wedge$ Const(x)= narrative'(x) $\wedge$
Form(x) = book'(x) $\wedge$
Telic(x) = $\lambda y, e^T$[read'(x)(y)(e^T)] $\wedge$
Agent(x) = $\lambda y, e^T$[write'(x)(y)(e^T)]]

Coercion = a request to find any transition event associated with the noun

(18) a. John began to read a novel.
b. John began to write a novel.

Pustejovsky (1991): Theory of Qualia

Example 49

a. John began a novel.

b. $\textbf{begin}'(Q_T(\textbf{a novel}))(\textbf{John}) \Rightarrow$

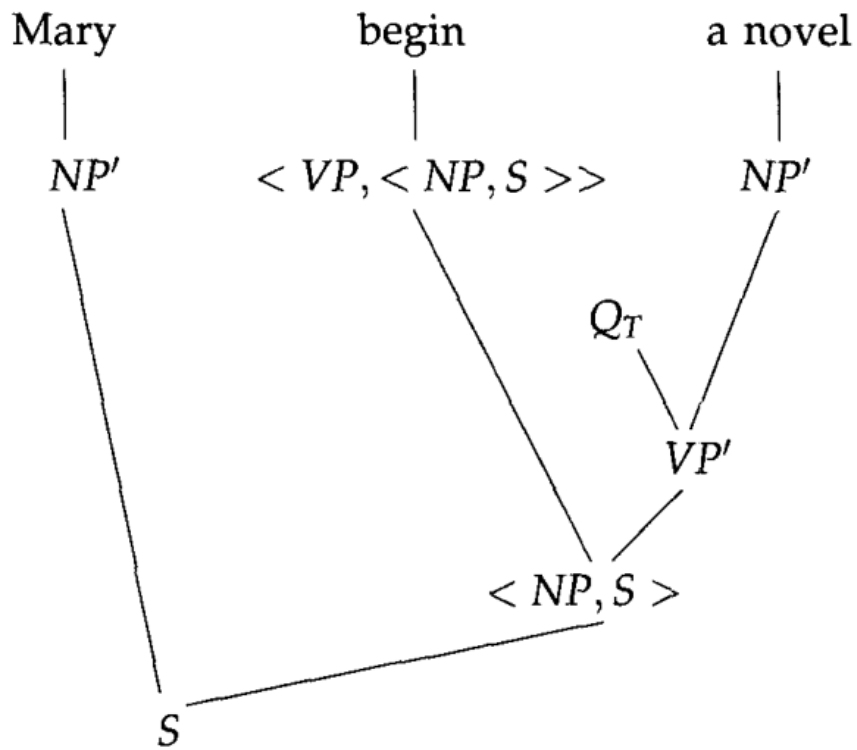
c. $\textbf{begin}'(\lambda x, e^T[read(\textbf{a novel})(x)(e^T)])(\textbf{John}) \Rightarrow$

d. $\textbf{John}\{\lambda x[\textbf{begin}'(\lambda x, e^T[read(\textbf{a novel})(x)(e^T)](x^*))(x^*)]\} \Rightarrow$

e. $\textbf{John}\{\lambda x[\textbf{begin}'(\lambda e^T[read(\textbf{a novel})(x^*)(e^T)])(x^*)]\} \Rightarrow$

f. $\textbf{begin}'(\lambda e^T[read(\textbf{a novel})(\textbf{John})(e^T)])(\textbf{John})$

g.



Pustejovsky (1991): Theory of Qualia

More relevant and interesting challenges:

- scalar modifiers

Example 52

a. **a fast car**: driving

$Q_T(car) = \lambda x \lambda y \lambda e^P [\, drive(x)(y)(e^P) \,]$

b. **a fast typist**: typing

$Q_T(typist) = \lambda x \lambda e^P [\, type(x)(e^P) \,]$

c. **a fast motorway**: traveling

$Q_T(motorway) = \lambda x \lambda e^P [\, travel(cars)(e^P) \ \wedge on(x)(cars)(e^P) \,]$

- "Double Figure-Ground"

(19) a. Mary painted ***the door***.

b. Mary walked through ***the door***.

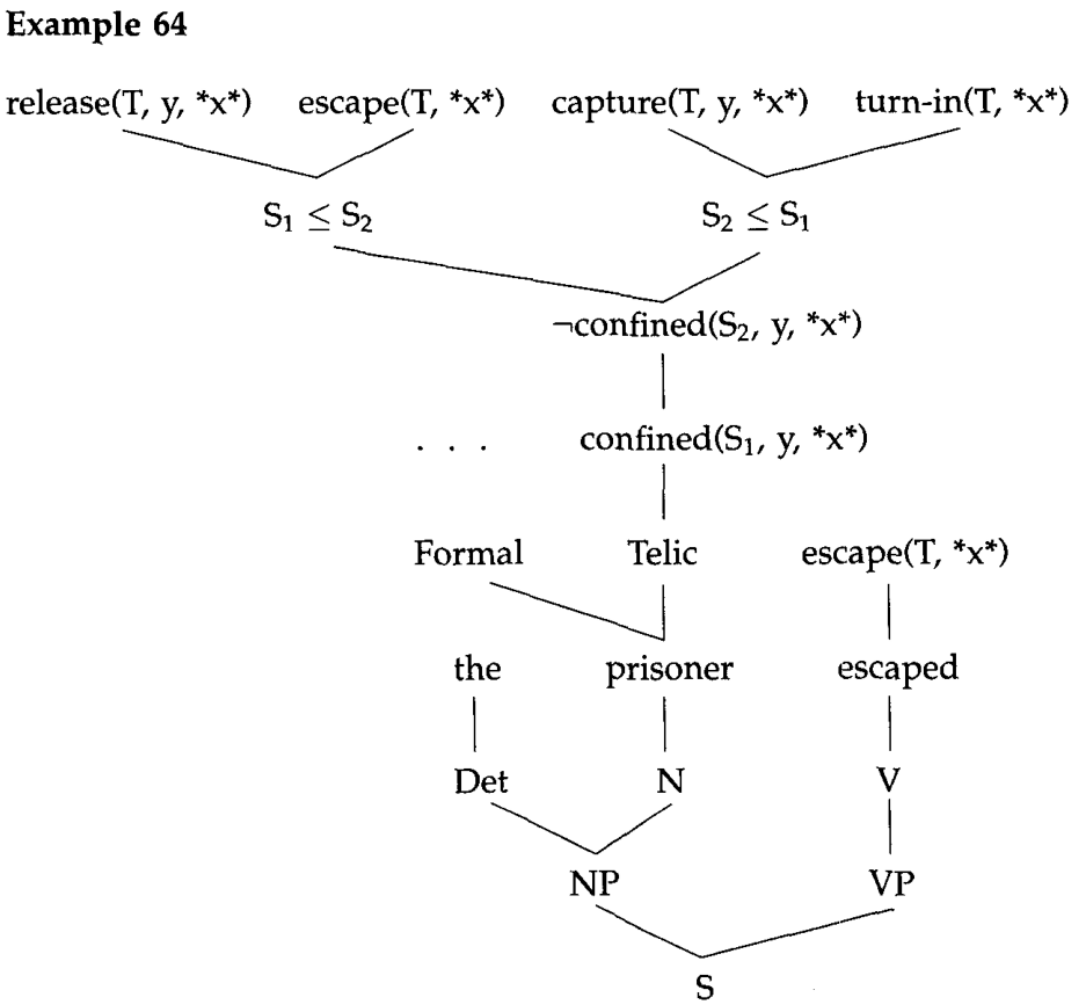
⇒ The foregrounding or backgrounding of a nominal's qualia is very similar to argument structure-changing operations for verbs.

Pustejovsky (1991): Lexical Inheritance Theory

Model "prototypicality" and semantic "proximity":

(20) a. The prisoner escaped last night.

b. The prisoner ate dinner last night.



Pustejovsky (1991): Conclusions

- against the view that word meanings are fixed and inflexible
- The lexicon can be seen as a **generative system**, where word senses are related by logical operations defined by the well-formedness rules of the semantics.
- The semantic load is spread more evenly throughout the lexicon to the other lexical categories (nouns and adjectives).
  - ⇒ Much of the lexical ambiguity of verbs and prepositions is eliminated.
- **generate** projective inheritance structures that connect the conceptual information associated with lexical items to the global conceptual lexicon

⇒ Qualia Structures + rules of composition that use them

… "perhaps somewhat programmatic"

Conclusion of the session

Composition of lexical meaning is a very hard problem!

References

[1] Cruse, D. Alan. 2001. The lexicon. In, 238–264.

[2] Dowty, David R. 1979. *Word meaning and Montague Grammar*. Reprinted 1991 by Kluwer Academic Publishers. Dordrecht, Boston, London: D. Reidel Publishing Company.

[3] Levin, Beth. 1993. *English verb classes and alternations: A preliminary investigation*. Chicago, IL: University of Chicago Press.

[4] Pustejovsky, James. 1991. The generative lexicon. *Computational linguistics* 17(4). 409–441.

[5] Vendler, Zeno. 1957. Verbs and times. *The Philosophical Review* 66(2). 143–160.