The challenge of polysemy for natural language semantics

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Outline

Characterising Polysemy & Copredication (common nouns)

Polysemy & copredication: a challenge to simply typed semantics

Going richer

- Example: Polysemy and copredication in TTR

Going leaner

- A possible response based on Liefke's monotyped semantics

Weighing the options

Polysemy

In English, *lunch* is arguably polysemous

- One form – multiple senses
- But the sameness of form is, in some sense non-accidental

(1) a. Lunch was delicious. [*food*]

b. Lunch lasted two hours. [*eventuality*]

Other examples of nominal polysemy:

Noun	Senses include
book	informational content, physical object
statement	eventuality, informational content, physical object
evidence	eventuality, informational content, physical object
city	population, area, (local) government
university	buildings, institution, population
beer	container, contents

Copredication

Usually only defined for common nouns

- One instance of the noun
- Used of modifiers to evoke different senses of the noun
  - including verbs, adverbials, adjectives

Copredication felicitous with polysemous nouns (e.g., Pustejovsky, 1995; Asher, 2011)

- At least in some cases

(1) The best university of the country has caught fire. (Ortega-Andrés and Vicente 2019)

(2) The beer Susan was drinking fell out of her hands. (Ortega-Andrés and Vicente 2019)

(3) Lunch lasted for two hours and was delicious. (Adapted from Asher and Pustejovsky 2006)

Selectional Restrictions: modifiers select for domains, normally considered disjoint

- *lasted two hours*: domain = *Ev*entualities
- *was delicious*: domain = *Phys*ical objects (esp. food)

Copredication beyond English

German (deTenTen20 corpus):

(4) Ein absoluter Geheimtipp für das schnelle aber qualitativ hochwertige
a absolute secret.tip for the fast but qualitatively high.value
Mittagessen.
lunch

'An absolute insider's tip for a quick, but high-quality lunch'

Finnish (fiTenTen14 corpus):

(5) ... nähtävyyksien uuvuttama matkustaja voi nauttia nopean ja
... sight.PL.GEN exhaust.PRTCPL traveller can enjoy fast.ACC and
herkullisen lounaan
delicious.ACC lunch.ACC

'... an exhausted sightseer can enjoy a fast and delicious lunch'

Restrictions on co-predication

There can be restrictions on copredication for more than two-ways polysemous nouns:

- *statement* (Sutton, 2022)
- *newspaper* (Ortega-Andrés and Vicente, 2019; Copestake and Briscoe, 1995)

(6) a. The statement in the envelope is inaccurate. (Phys, Inf)
b. ?The statement in the envelope lasted half an hour. (Phys, Ev)
c. The inaccurate statement lasted half an hour. (Inf, Ev)

(7) ?The newspaper fired its editor and fell off the table. (Inst, Phys)

(8) ?That newspaper is owned by a trust and is covered with coffee. (Inst, Phys)

Conclusion: Felicitous copredication entails that a noun is polysemous, but a failure of copredication does not entail that a noun is not polysemous.

Lexical ambiguity

In English, *party* is lexically ambiguous

- One form – multiple senses (like polysemy)
- But the sameness of form is, in some sense *accidental*

(9) a. The party last night was wild. [*celebration*]
b. The party elected a new leader. [*polit. org.*]
c. The party set off at dawn. [*travel group*]

At least three forms in German:

(10) a. Die Feier/Fete/Party letzte Nacht war wild. [*celebration*]
b. Die Partei hat eine neue Vorsitzende gewählt. [*polit. org.*]
c. Die Reisegruppe ist in der Morgendämmerung losgefahren. [*travel group*]

Zeugma and copredication as a test for lexical ambiguity

Zeugma: For expressions with multiple senses, evoking more than one often gives rise to semantic oddness

(11) a. ?This product is suitable for home freezing and vegans.
b. ?Alex and his nose ran.

(12) a. ?Dieses Product ist für die Tiefkühltruhe und Veganer geeignet.
b. ?Alex und seine Nase sind gelaufen.

Attempting copredication with lexically ambiguous expressions, gives rise to zeugmatic effects, e.g., Asher 2011

(13) ?The party chose a new leader and left base camp in the morning.
(14) ?The party lasted all night and left base camp in the morning.
(15) ?The party lasted all night and chose a new leader.

Polysemy versus Lexical ambiguity (Summary)

Polysemy:

e.g., $statement_{eventuality/information/physical\ object}$

- Inter-related senses
- Non-accidental homophony
- Not always zeugma with copredication

Lexical ambiguity:

e.g., $party_{political}$ *vs.* $party_{group}$ *vs.* $party_{celebration}$

- Either non-related senses (*bank*) or less related senses (*party*)
- Accidental homophony: *Partei* vs. *Reisegruppe* vs. *Feier* (German)
- Zeugma with copredication

Background: Chomsky's argument

(Chomsky, 2000; Collins, 2017; Pietroski, 2003, among others)

- Arguments from polysemy and copredication against an externalist, truth-conditional semantics
- Next slide: A slightly more precise version of the argument, made more relevant to common assumptions in semantic theory.

The argument from polysemy and copredication

(a) Polysemous nouns denote functions e.g., from worlds/situations to sets of entities.

(b) Informational entities, eventualities and physical entities etc. are of disjoint types.

(c) Copredication constructions show that polysemous nouns denote entities of different types (sometimes simultaneously).

(d) For disjoint types τ_1, τ_2, there is no function expressible in the simply-typed λ-calculus that can characterise a set of entities of type τ_1 and/or τ_2

(e) We cannot model the semantics of polysemous nouns in the simply-typed λ-calculus

- Let's unpack (d) a little

Simple Type Theory

(16) **Types in the simply typed λ-calculus**
From a non-empty set **BasTyp** of basic types, the set **Typ** of types is the smallest set such that:

a. **BasTyp** $\subseteq$ **Typ**

b. $\langle \sigma, \tau \rangle \in$ **Typ** if $\sigma, \tau \in$ **Typ** (functional type constructor)

	BasTyp	**Type constructors**
Montague (IL)	$\{e, t\}$	(16b) and $\langle s, \sigma \rangle \in$ **Typ** if $\sigma \in$ **Typ**
Gallin (TY2)	$\{e, t, s\}$	(16b)
Degree semantics	$\{e, t, s, d\}$	(16b)
Neo-Davidsonian	$\{e, t, s, v\}$	(16b)

Unpacking premise (d)

(d) For disjoint types τ_1, τ_2, there is no function expressible in the simply-typed λ-calculus that can characterise a set of entities of type τ_1 and/or τ_2

- Example: *lunch*
  - Assumption: eventualities and physical stuff (food) are of different types (in disjoint domains)
- $\lambda w_{:s}.\lambda x_{:\sigma}.LUNCH_w(x) \quad : \langle s, \langle \sigma, t \rangle \rangle$
- What type is σ?
  - Can't be v or e (this would exclude some readings of *lunch*)
  - Can't be a functional type (wrong truth conditions)

Responding to the argument

(a) Polysemous nouns denote functions e.g., from worlds/situations to sets of entities.
(b) Informational entities, eventualities and physical entities etc. are of disjoint types.
(c) Copredication constructions show that polysemous nouns denote entities of disjoint types (sometimes simultaneously).
(d) For disjoint types τ_1, τ_2, there is no function expressible in the simply-typed λ-calculus that can characterise a set of entities of type τ_1 and/or τ_2
(e) We cannot model the semantics of polysemous nouns in the simply-typed λ-calculus

Options:

- Deny at least one premise or accept the conclusion

Deny (a) set aside for today
Deny (b) *impoverish the type theory*
– possible approach using Liefke's monotyped semantics
Deny (c) *property inheritance* (Liebesman and Magidor, 2017)
Accept (e) *enrich the type theory*
– many proposals, I'll outline Sutton (2022)

The richly typed approach

Rich type theories

- Polysemy is one of many phenomena that indicates the need for more structure in semantics
- Richly typed semantics adds this structure
- A move from a system of simple types to a system of rich types is independently motivated

Two options

- Add at least one type constructor specifically for polysemous expressions (dot types)
- Make do with the type theory one anyway has

Informal introduction to dot types

(17) From a non-empty set **BasTyp** of basic types, the set **Typ** of types is the smallest set such that:

a. **BasTyp** $\subseteq$ **Typ**

b. $\langle \sigma, \tau \rangle \in$ **Typ** if $\sigma, \tau \in$ **Typ** (functional type constructor)

c. $\sigma \bullet \tau \in$ **Typ** if $\sigma, \tau \in$ **Typ** (dot type constructor)

- For types *p* ($phys$) and *v* (ev)
- . . . *lunch* denotes entities of type $p \bullet v$
  - entities that have a physical entity 'aspect' and an eventuality 'aspect'

(18) $[\![\text{lunch}]\!] = \lambda w.\lambda x_{:p \bullet v}.LUNCH(x)$

Treating Polysemy in RTT semantics

Modern Type Theories (MTT)

- Luo 2010; Chatzikyriakidis and Luo 2015, 2020
  - dot types, coercive subtyping
  - Extension to quantified copredication constructions with setoids

Type Theory with Records (TTR, Cooper 2012, 2023, a.o.)

- Pustejovskian 'aspects' based analysis without dot types (Cooper, 2011, 2007)
- Multi-participant situations Sutton 2022
  - Polysemy without dot types or aspects

[Not an exhaustive list!]

Records and Record Types in TTR

Record Types

(19) *There is a cat* $\mapsto \begin{bmatrix} x & : & Ind \\ c_1 & : & cat(x) \end{bmatrix}$

- Propositions in TTR (Record Types)
- Labels x, c_1 are like discourse referents
- *Ind* is a basic type
- $cat(x)$ is a type constructor: constructs a type given a value for the label x

Records (situations)

- Witnesses of record types

(20) $\begin{bmatrix} x & = & felix \\ c_1 & = & s_1 \end{bmatrix}$

- (20) : (19) iff
  - $felix : Ind$
  - $s_1 : cat(felix)$

Non-Polysemous Common Nouns in TTR

CNs denote properties of situations

- Not functions from worlds to sets of entities
- Functions from situations to situations types

Example:

(21) $[\![\text{cat}]\!] = \lambda r : \left[\text{x} \ : \ Ind \right] . \ \left[\ \text{c}_{\text{cat}} \ : \ \text{cat}(r.\text{x}) \ \right]$

- Functions from records, r, of some type: $\lambda r : [\text{x} : Ind]$
  - I.e., situations that contain some individual
- to a proposition
  - I.e., the type of situations in which the entity labelled x in r is a cat

Compositionality: Simplified example

for details see Cooper 2023

- We can treat proper names as GQs: functions from a property to the proposition that some individual has that property

(22) $[\![\text{Felix}]\!] = \lambda P : Ppty . P([\text{x} = felix])$

(23) $[\![\text{cat}]\!] = \lambda r : \left[\text{x} \ : \ Ind \right] . \left[\text{c}_{\text{cat}} \ : \ \text{cat}(r.\text{x}) \right] \ : Ppty$

(24) $[\![\text{Felix is a cat}]\!] = \left[\text{c}_{\text{cat}} \ : \ \text{cat}(felix) \right]$

Important theoretical point:

- CNs do not (directly) denote as properties of individuals
- CNs denote properties of situations that contain individuals
  - Inherited view from Situation Semantics e.g., Barwise and Perry 1983

Multi-participant situations (Sutton, 2022)

Polysemous nouns denote situations that contain multiple participants

- polysemous Ns constrain situations to witness at least two entities
- e.g., *lunch*: to witness at least some event and some physical entity
- the resulting record type constrains the event to be a lunch eating or lunch making event and the individual to be the food
- Additionally neo-Davidsonian inspired thematic role relations

(25) $[\![\text{lunch}]\!] = \lambda r : \begin{bmatrix} \text{x} & : & Phys \\ \text{e} & : & Ev \end{bmatrix} . \begin{bmatrix} \text{c}_{\text{food}} & : & \text{food}(r.\text{x}) \\ \text{c}_{\text{eat}} & : & \text{eat\_or\_make\_lunch}(r.\text{e}) \\ \text{c}_{\text{pat}} & : & \text{patient}(r.\text{x}, r.\text{e}) \end{bmatrix}$

Copredication

(26) $[\![\text{delicious}]\!] =$
$\lambda\mathcal{P} : ([\text{x} : \mathit{Phys}] \rightarrow \mathit{RecType}).\lambda r : [\text{x} : \mathit{Phys}].\mathcal{P}(r) \wedge [\text{c}_{\text{del}} : \mathit{delicious}(r.\text{x})]$

(27) $[\![\text{two-hour}]\!] =$
$\lambda\mathcal{P} : ([\text{e} : \mathit{Ev}] \rightarrow \mathit{RecType}).\lambda r : [\text{e} : \mathit{Ev}].\mathcal{P}(r) \wedge [\text{c}_{\text{time}} : \mu_{\mathit{hours}}(\text{e}, 2)]$

(28) $[\![\text{delicious two-hour lunch}]\!] =$

$$\lambda r : \begin{bmatrix} x : \mathit{Phys} \\ e : \mathit{Ev} \end{bmatrix} . \begin{bmatrix} \text{c}_{\text{food}} & : & \text{food}(r.\text{x}) \\ \text{c}_{\text{eat}} & : & \text{eat\_or\_make\_lunch}(r.\text{e}) \\ \text{c}_{\text{pat}} & : & \text{patient}(r.\text{x}, r.\text{e}) \\ \text{c}_{\text{del}} & : & \mathit{delicious}(r.\text{x}) \\ \text{c}_{\text{time}} & : & \mu_{\mathit{hours}}(e, 2) \end{bmatrix}$$

Features of the multi-participant analysis

(25) $[\![\text{lunch}]\!] = \lambda r : \begin{bmatrix} \text{x} & : & Phys \\ \text{e} & : & Ev \end{bmatrix} . \begin{bmatrix} \text{c}_{\text{food}} & : & \text{food}(r.\text{x}) \\ \text{c}_{\text{eat}} & : & \text{eat\_or\_make\_lunch}(r.\text{e}) \\ \text{c}_{\text{pat}} & : & \text{patient}(r.\text{x}, r.\text{e}) \end{bmatrix}$

Selling points:

- Situations can anyway be complex, so are suitable vehicles to explain the complex lexical semantics of polysemous expressions
- Relatively metaphysically innocent: a lunch situation consists of an event and some food standing in a patient relation

Bonus: relations like Patient explain restrictions on copredication

(29) The statement in the envelope is inaccurate. (Phys, Inf)

(30) ?The statement in the envelope lasted half an hour. (Phys, Ev)

(31) The inaccurate statement lasted half an hour. (Inf, Ev)

- (Phys, Ev) is bad because there is no *contents* relation between them
- See also Ortega-Andrés and Vicente (2019) (realization relations)

Prediction: Copredication can improve with context support

(32) a. Context: The police took verbal statements from witnesses, but all were simultaneously transcribed. The shorter transcriptions are on the desk.
b. The statements on the desk took less than 5 minutes.

- What does *transcribe* contribute to the context?
- Plausibly: a relation between the stating eventuality and a physical entity (the transcription)
- I.e., exactly what was missing, thereby licensing copredication

Summary:

- An account of polysemy in terms of situations containing entities of different types
- An account of restrictions on copredication via thematic role relations

Denying premise (c)

(a) Polysemous nouns denote functions e.g., from worlds/situations to sets of entities.

(b) Informational entities, eventualities and physical entities etc. are of disjoint types.

(c) Copredication constructions show that polysemous nouns denote entities of different types (sometimes simultaneously).

(d) For disjoint types τ_1, τ_2, there is no function expressible in the simply-typed λ-calculus that can characterise a set of entities of type τ_1 and/or τ_2

(e) We cannot model the semantics of polysemous nouns in the simply-typed λ-calculus

Deny that copredication is evidence of predicating entities of different types

- Informal suggestion from philosophical metaphysics (Liebesman and Magidor, 2017, 2019)
- "accounting for copredication requires no revisionary semantics or metaphysics" (Liebesman and Magidor, 2017, p.132)
- Any use of a noun denotes entities of one type
- Apparent selectional restrictions explained away via *property inheritance*

Property inheritance

(33) Three interesting books are on the shelf.

- "Informational books are distinct from physical books, but there are many properties that both can instantiate." (Liebesman and Magidor, 2017, p.137)
- Properties can be inherited via association relations
- (33) do not force us to explain how we can copredicate over different sorts of entities
  - This sentence can straightforwardly be about physical books described as interesting based on an inheritance of the properties of their contents
- And vice versa: *book* can denote informational books and prima facie physical predicates can apply to these based on property inheritance

(34) Mao's red book brought about many political changes despite being small.

Comments on Property Inheritance

Impact on the type theory

- *book* denotes EITHER physical OR informational entities
- if these types are disjoint, then the simply-typed λ-calculus is insufficient
- Minimally need join types: $\mathit{Phys} \sqcup \mathit{Inf}$

Conclusion

- Adding a join type constructor no more parsimonious than adding a dot type constructor
- Metaphysical ups and downs can be argued, but it is not true that "accounting for copredication requires no revisionary semantics" (Liebesman and Magidor, 2017, p.132)

Deny premise (b)

(a) Polysemous nouns denote functions e.g., from worlds/situations to sets of entities.

(b) Informational entities, eventualities and physical entities etc. are of disjoint types.

(c) Copredication constructions show that polysemous nouns denote entities of different types (sometimes simultaneously).

(d) For disjoint types τ_1, τ_2, there is no function expressible in the simply-typed λ-calculus that can characterise a set of entities of type τ_1 and/or τ_2

(e) We cannot model the semantics of polysemous nouns in the simply-typed λ-calculus

- Not, to my knowledge, previously proposed
- Outline a possibility making use of Liefke's monotyped semantics

Monotyped semantics

Liefke 2013, 2014; Liefke and Werning 2018, see also Partee 2007

Interpretations of DP and S and CP are of the same type

(35) (Liefke and Werning, 2018, p. 646)

a. [$_{\text{DP}}$ Bill] destroyed his friendship with John.

b. [$_{\text{CP}}$That Bill suspected John of courting Pat] destroyed his friendship with John.

(36) Pat remembered [[$_{\text{DP}}$ Bill] and [$_{\text{CP}}$ that he was waiting for her]]. (Liefke and Werning, 2018, p. 647)

Example

(37) a. **BasTyp** $= \{o\}$ (the type for $[\![[_{DP} \cdot]]\!]$ and $[\![[_{S} \cdot]]\!]$)

b. Functional types constructed recursively

(38) a. $[\![[_{DP} \text{ lunch }]]\!] : o$

b. $[\![[_{VP} \text{ was delicious }]]\!] : \langle o, o \rangle$

c. $[\![[_{VP} \text{ took ages }]]\!] : \langle o, o \rangle$

d. $[\![[_{VP} \text{ was delicious but took ages }]]\!] : \langle o, o \rangle$

e. $[\![[_{S} \text{ Lunch was delicious but took ages }]]\!] : o$

Types and sorts

Traditionally semantic types perform two roles

- avoiding paradoxes (e.g., Curry's paradox)
- marking conceptual distinctions between entities

But these roles can be separated e.g., Kohlhase 1992, 1994

- **Types** to avoid paradoxes
- **Sorts** to mark conceptual distinctions between entities

Monotyped semantics and sorts

Do same type responses need sorts? — Selectional restrictions

(39) a. The book was brown/was inaccurate/?started at 1pm.
b. Lunch was brown/started at 1pm/?was inaccurate.

Canonical treatment with types:

- Modifiers and predicates can be of different types, e.g.,
  - $\langle s, \langle e, t \rangle \rangle$ for predicate of physical entities
  - $\langle s, \langle v, t \rangle \rangle$ for predicate of eventualities

Alternative with sorts:

- Predicates are of the same type, but can presuppose different sorts
  - E.g. $[\![\ [_{VP}$ was delicious $]\ ]\!] : \langle o, o \rangle = \lambda x_{:x \in \textbf{phys}} \mathit{Delicious}(x)$

A re-emergence of the polysemy problem for sorts

For some sort **S**:

- $[\![\ [_{DP}\ \text{lunch}\ ]\ ]\!] = \iota x_{:x \in \mathbf{S}} Lunch(x) \quad : o$
- $[\![\ [_{VP}\ \text{was delicious but took ages}\ ]\ ]\!] =$
$$\lambda x_{:x \in \mathbf{S}} Delicious(x) \wedge Took\_Ages(x) \quad : \langle o, o \rangle$$

What sort is **S**?

- It should cover both **phys** and **ev**
- E.g., $Phys + Ev$ for some sort combinator $+$?
- Sorts start to look a lot like types
- I.e. we have base sorts and sort constructors

Overview and Outlook

Polysemy and copredication are challenging, given traditional assumptions. This seems to force a choice:

- Impoverish: eradicate at least some type distinctions
- Enrich: Introduce finer grained types, but most importantly, new ways of putting types together

In either case, we need semantic structure:

- Impoverish: structure less visible, located in the system of sorts
- Enrich: structure is more transparent (e.g., via the structure of records and record types)

Future work: Combining insights

- Monotype insight: DPs and CPs are interpreted as expressions of the same type
- Rich type insight: allow for fine-grained distinctions in types for common nouns and modifiers to account for selectional restrictions etc.

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Coercion

Meanings that are not lexicalized, but expressed in context

- Normally requires a trigger
- E.g., semantic type clash (Pustejovsky, 1995)

Is (40) evidence that *book* has a sense that denotes an eventuality, namely that of reading or writing a book?

(40) Mary began the book. (Pustejovsky 1995)

Standard answer: No

- The eventuality reading is coerced
- Type clash: selectional restrictions of *began* and the type of *the book*

Polysemy vs. Coercion: Terminology

	Pustejovsky 2008	Weinreich 1964; Pustejovsky 1995
polysemy	inherent polysemy	complementary polysemy
coercion	selectional polysemy	contrastive polysemy

Evidence for separating coercion from polysemy

Out of the blue contexts

- E.g., out-of-the-blue temporal modification for *book* is much less natural than the modifiers *thick* and *interesting*:

(41) War and Peace is a thick/interesting/?six-month book.

(42) ?That book is at least two months too long!

But context helps

(43) He has actually set it up to be read in 40 days (no comparison though to that other 40 day book) [enTenTen18]

(44) Context: A 24-hour RPG writing competition and national book writing month:
Follow your one day game with a one month book. [enTenTen21]

Polysemy vs. Lexical Ambiguity and Coercion

Clearly not possible to completely demarcate these phenomena

- Polysemy and Lexical ambiguity
  - Vagueness in how inter-related senses are
  - Senses of *party* are closer than the senses of *bank*
- Polysemy and coercion
  - Highly routinised coercions arguably are in the process of being lexicalized as polysemy
  - *2 pints* (UK Eng) – measure, glasses of beer

Types or type constructors?

(44) From a non-empty set **BasTyp** of basic types, the set **Typ** of types is the smallest set such that:

a. **BasTyp** $\subseteq$ **Typ**

b. $\langle \sigma, \tau \rangle \in$ **Typ** if $\sigma, \tau \in$ **Typ** (functional type constructor)

Formal semanticists like adding basic types to **BasType**

- Degrees, Eventualities, Roles, Concepts, Tropes, ...

But adding a type constructor is an alternative possibility

- Some examples:
  - Product types (e.g., Pustejovsky, 1995; Gotham, 2014; Rothstein, 2010; Sutton and Filip, 2020; Windhearn, 2021)
  - Dot types (e.g., Asher and Pustejovsky, 2006; Asher, 2011)

No in-principle reason not to go for type constructors

- Common in programming languages
  - tuples, lists, dataframes etc.

Crosslinguistic support

These effects do not appear to be language specific (Sutton, 2022)

(45) a. Die Stellungnahme in dem Umschlag ist sachlich.
the statement in the envelope is factual
'The statement in the envelope is factual.'

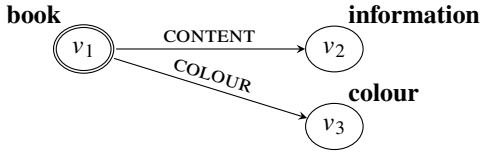
b. ?Die Stellungnahme in dem Umschlag hat eine halbe Stunde gedauert
the statement in the envelope has a half hour lasted
'The statement in the envelope took half an hour.'

Düsseldorf-style frame semantics

Babonnaud et al. 2016 and Kallmeyer and Osswald 2017

- A frame theory inspired by the work of Barsalou (1992)
- Building on e.g., Petersen 2015; Löbner 2015

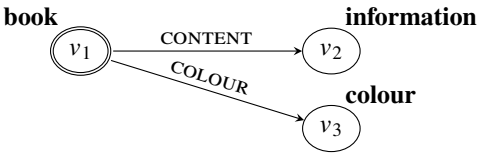
(46)



v_1, v_2	Values	E.g., physical books, informational contents, red
CONTENT, COLOUR	Attributes	Functions from values to values
book, **information**, **colour**	Types	Types of values in a type hierarchy

Frames and polysemy

(46)

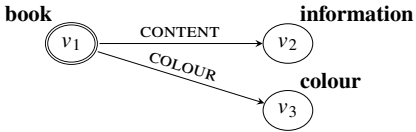


- For *book*, the attribute CONTENT, links the physical book to the contents (as the *formal* meaning component of the Generative Lexicon).
- Modifiers that e.g. add an attributes to the v_1 node (or fill in a value for v_3) modify physical books
- Modifiers that add an attributes to the v_2 node modify physical books
- Assumes that the core meaning of *book* is 'physical book'

Polysemy or coercion?

- Still an open question: Can we treat polysemy as (systematised) coercion?

(46)

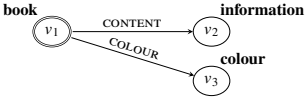


The central node is the physical book

- What about contexts that describe only informational books (allowing e.g. multi-volume books)?
- Shifting the central node?
- Something like: Frames as structures to constrain systematic coercions (constrained by what counts as the formal meaning component)

Frame semantics as a monotyped theory?

(46)



Types and Attributes

- Semantic types as we know them characterise ATTRIBUTES
- For some type σ, every attribute is of type $\langle \sigma, \sigma \rangle$
- Frames are structures of attributes

Types or Sorts?

- E.g., Petersen 2015 refers to **book**, **information** etc. as types in a type hierarchy
- However, these are better thought of as *sorts*
  - They stand in containment relations in the hierarchy e.g., **book** $\sqsubset$ **physical**
  - But they are not input into type constructors
- So, arguably, this is a mono-typed, multi-sorted semantics, with extra structures (frames)

Dot types and modification

Example: *book*

- where p is the type for physical object and i is the type for informational entity
- $[\![\text{book}]\!] \mapsto$ a property of entities, namely books, that have both a physical and informational aspect:

(47) $book \mapsto \lambda w.\lambda x_{:p \bullet i}.BOOK_w(x)$

Elaboration functions (simplified)

- Intuitive idea: to elaborate on/pick out an aspect of an object

(48) $[\![\text{lunch was delicious}]\!] =$
$\lambda w.\exists x_{:p} \exists v_{:v \bullet p}[LUNCH(v) \wedge O\text{-}Elab(x, v) \wedge DELICIOUS(x)]$

- The full system of TCL uses type presuppositions and subtyping relations
  - Beyond our scope

Note on dot-type based responses

Only a simplified picture

- The options for implementing a semantics with dot types are wide:

1. A richer, but nonetheless simple type theory
2. Implementation in category theory (Asher, 2011)
3. Richly typed approaches with dot types (Chatzikyriakidis and Luo, 2015)

Take home message

- It is possible, to model polysemy with a semantics based upon a conservatively extended simple type theory

Aspects modelled with type constructors (Cooper, 2011)

- No dot type constructor needed to represent aspects
- lunch_ev_fd($r.x, e, f$) constructs a type given values for r.x, e, and f
- I.e. the type of situation in which the entity labelled by x in r has two aspects:
  - that of being f of type $food$
  - that of being e of type $event$

(49) $lunch \mapsto \lambda r : \left[\text{x} : Ind \right] . \left[\begin{array}{lcl} \text{f} & : & food \\ \text{e} & : & event \\ \text{c}_{\text{lunch}} & : & \text{lunch\_ev\_fd}(r.x, e, f) \end{array} \right]$

In words:

- A property of situations that contain some individual
  - Individual understood rather broadly
- Returns the proposition that there is some food and some event that are aspects of the individual contained in the relevant situation

Comments on Cooper's analysis

Advantages:

- No special type constructor to model polysemy
- Predicates are anyway treated as type constructors, and aspects are a special kind of ternary relation

Puzzle:

- As with the Asher-Pustejovsky approach
  - We can't really say what *the* individual that is the lunch is

Alternative:

- As with the Asher-Pustejovsky approach
  - We can't really say what *the* individual that is the lunch is
- We could treat polysemous nouns as denoting less mysterious entities

The role of types in simply typed semantics

- Types are metalanguage descriptions of categories of expressions

(50) If $\phi \in ME_t$ and u is in Var_a, then $[\![\exists u\phi]\!]^{M,g} = 1$ iff for some e in D_a, $[\![\exists u\phi]\!]^{M,g^e_u} = 1$ (Dowty et al., 1981, p. 92)

- Types feature in the metalanguage as subscripts on sets
- We cannot refer to types directly in the object language
- But if types reflect our basic ontological categories, why can we not refer to them within the object language of our semantic theory?

From simple to rich type theory

Background

- Seminal work by Ranta (1994)
- Implementing a NL semantics based on Martin-Löf 1984
- Often, but not always more proof theoretic

Move 1: Let types feature as part of the object language

- Simply Typed Semantics: Construct arbitrarily complex expressions of some type which are then interpreted (e.g. in a model)
- Richly typed semantics: Construct types themselves of arbitrary complexity
  - Types have witnesses (things of that type)
  - But are individuated also in terms of their structure (fine-grained intensionality)

Example

Simple types: Expressions of some type

- *alex*, $\lambda x.\lambda y.Mother_w(x, y)$, $\lambda y.Mother_w(alex, y)$
- e, $\langle e, \langle e, t\rangle\rangle$, $\langle e, t\rangle$
- The predicate $\lambda y.Mother_w(alex, y)$ **depends** on the value *alex*

Rich types: Types with a structure

- Structured types with entities as witnesses
- $Mother(alex), Mother(billie)$ are types
- $Mother$ is a type constructor
  - It maps individuals to the type of being that individual's mother
- e.g. *billie* : $Mother(alex)$
  - *billie* witnesses the type of being Alex's mother
- The type $Mother(alex)$ **depends** on the value *alex*

From simple to rich type theory

Move 1: Let types feature as part of the object language

Move 2: Treat propositions as types

- Curry-Howard Correspondence (Curry and Feys, 1958; Howard, 1980)

Simple Type Theory (STT)	Rich Type Theory (RTT)
Sets of worlds	Types
Flat	Structured
Individuated by set membership	Individuated by witness set *and* structure

Hyperintensionality:

- The types $2 + 2 = 4$ and $5 - 3 = 2$ have the same witnesses (situations, worlds etc.)
- But can be individuated in terms of structure (and the manner of construction)

Dot types

Background

- Original proposal: Pustejovsky 1994, 1995
- Developed into Type Compositional Logic (TCL, Asher and Pustejovsky 2006; Asher 2011)
  - More type constructors and more basic types

Philosophical grounding

- Polysemous expressions refer to entities that have different *aspects*
- E.g., *lunch* refers to something that has a food aspect and an eating-event aspect
- Modifiers like *delicious* draw on the food aspect
- Modifiers like *half-hour* draw on the event aspect

Dot types in a simple type theory

Minimally: An additional type constructor

- Construct dot types from any two other types

(51) From a non-empty set **BasTyp** of basic types, the set **Typ** of types is the smallest set such that:

a. **BasTyp** $\subseteq$ **Typ**

b. $\langle \sigma, \tau \rangle \in$ **Typ** if $\sigma, \tau \in$ **Typ** (functional type constructor)

c. $\sigma \bullet \tau \in$ **Typ** if $\sigma, \tau \in$ **Typ** (dot type constructor)

- For types *p* ($phys$) and *v* (ev)
- . . . *lunch* denotes entities of type $p \bullet v$
  - entities that have a physical entity aspect and an eventuality aspect

(52) $[\![\text{lunch}]\!] = \lambda w.\lambda x_{:p \bullet v}.LUNCH(x)$

A puzzle about the denotations of dot-type expressions

Question:

- Suppose *a*, a lunch, is of type $p \bullet v$ (event dot physical entity)
- What is *a*? An object? If so, what sort?

Complex Objects?

- E.g. Asher and Pustejovsky (2006) deny this

Regular objects?

- Okay, but in what sense are, say lunches, regular objects?

Same type vs. Richer type responses

What does enriching the type theory do?

- At base level, it introduces *structure*
- E.g., structured types such as complex situation types

What does simplifying the type theory do?

- At base level, does it *destroy structure*?
  - Perhaps more accurate would be to say that it simply requires its relocation (e.g. into a theory of structured sorts)

Outlook

- Options for treating polysemy (Hogeweg and Vicente, 2020):
  - Richer lexicon (add structure)
  - Thinner (remove structure)
  - "very thin view and a very rich view may turn out to be indistinguishable in the long run"

Combining insights

- Monotype insight: Accept that e.g., DPs and CPs are interpreted as situation types
- Rich type insight: But allow for fine-grained distinctions in these types to account for selectional restrictions etc.