Generative Lexicon: Integrating Theoretical and Distributional Methods

James Pustejovsky
Brandeis University

Elisabetta Ježek
University of Pavia

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2. Qualia Structure
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Course Outline

- July 17: Introduction to GL and Distributional Analysis
- July 18: Qualia Structure
- July 19: Event Structure
- July 20: Argument Structure
- July 21: Meaning Composition and Co-composition

Lecture 1: July 17

Introduction to GL and Distributional Analysis

- Basic concepts in GL
  - Notation and Language: typed feature structures
  - Qualia Structure
  - Events and their participants
  - Meaning Composition in GL
- Distributed meaning: Spreading the semantic load
- Polysemy in language
  - Types of contextual variations
  - Detecting copredications in corpora
- Evidence-based linguistics and distributional analysis

Lecture 2: July 18

Qualia Structure

- What is a Quale?
- What motivates Qualia?
- Default Qualia and context updating
- Methodology to identify Qualia
- Data for each Quale
- Qualia and Conventionalized Attributes
- Qualia and Type Systems

Lab on Qualia identification in corpora using SkE

Lecture 3: July 19

Event Structure

- Events as Structured Objects
- Event Types
  - States
  - Transitions
  - Point Verbs
  - Processes
- Events as Labeled Transition Systems
- Dynamic Event Models

Lab on identification of event type properties in corpora

Lecture 4: July 20

Argument Structure

- Argument Types in GL
  - True Arguments
  - Shadow Arguments
  - Hidden Arguments
- Argument Structure Representation
  - Semantic Types and Lexical Sets
  - Distributional Approach to Semantic Types
- Arguments and Defaulting
- Dynamic Argument Structure

Lecture 5: July 21

Meaning Composition and Co-composition in GL

- Basic Assumptions
- Simple Function Application
- Coercion
- Subselection
- Co-composition

Studies in evidence-based coercion

Lecture 2: Qualia Structure

- What is a Quale?
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Causation as Understanding

- Hume's cause: Counterfactual future (Agentive quale)

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- Inherent cause: Constitutive quale
- Class distinction: Formal quale

Moravcsik's 1975 interpretation of Aristotle's notion of *Aitia*

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- *fresh bread* = "bread which has been baked recently."

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  - *a built house.
  - a recently built house.

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- GL draws insights about the meaning of a word by looking at the range of its contextual interpretations, and by examining how this range can be predictably derived from the underlying meanings.
- On this basis, the meaning is decomposed into the relevant features.

Qualia Relations or Roles

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- Telic (T): encoding information on purpose and function (the *used-for* or `functions-as` relation);
- Agentive (A): encoding information about the origin of the object (the `created-by` relation).

Qualia Structure

$$\begin{bmatrix} \alpha \\ \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{what } x \textbf{ is} \\ \text{C} = \textbf{what } x \textbf{ is made of} \\ \text{T} = \textbf{function of } x \\ \text{A} = \textbf{origin of } x \end{bmatrix} \end{bmatrix}$$

Qualia Structure

$$\begin{bmatrix} \textit{car} \\ \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{vehicle} \\ \text{C} = \textbf{engine, door, wheels,...} \\ \text{T} = \textbf{drive} \\ \text{A} = \textbf{build} \end{bmatrix} \end{bmatrix}$$

Methodology for identifying Qualia Values

- Linguistic evidence determines what information is stated to be lexically associated with the Qualia Structure of a word.

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- Pustejovsky and Jezek 2012.

Identifying Qualia Values

- The rock shattered the window.

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- The rock shattered the window.
- ([C = pane])

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- ([C = water])
- the banks of a polluted river.

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- Not all lexical items carry a value for each Q-role.
- Some values are left unspecified, while others are populated with more than one value.
- Nouns denoting natural kinds (e.g., *rock*, *fish*, *air*, *sea*) typically do not have a value for the A.

Default Quale and Context Updating

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- Default values may be updated from discourse context in composition.
- Unspecified Q-values may be introduced in context.

The Formal

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- This relation enables one to grasp the nature of an entity by discriminating it from other kinds.
- What type of entity is x denoting? *rock* denotes a natural kind, *table* denotes an artifact, *car* denotes a vehicle, *park* denotes a location, *water* denotes a liquid, *plant* denotes a living thing, *fish* denotes an animal, *hand* denotes a body part, *glass* denotes a container, and so on.

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- Classifications at different levels of generalization are available for reference:
- a liquid such as water.
- fluids such as water or air.
- substances such as fluids, salts, glucose and carbon dioxide.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.
- Size and dimensional properties.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.
- Size and dimensional properties.
- Shape and form.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.
- Size and dimensional properties.
- Shape and form.
- Color.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.
- Size and dimensional properties.
- Shape and form.
- Color.
- Position.

Formal factors for the class of nouns denoting concrete entities

- Spatial characteristics, intrinsic orientation.
- Size and dimensional properties.
- Shape and form.
- Color.
- Position.
- Surface.

Values for Formal factors of nouns denoting concrete entities

- a red car

Values for Formal factors of nouns denoting concrete entities

- a red <u>car</u>
- (Color$_F$)

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table
- (Shape$_F$)

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table
- (Shape$_F$)
- a red pen

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- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table
- (Shape$_F$)
- a red pen
- (Color$_F$) or T/C (depending on contextual interpretation)

Values for Formal factors of nouns denoting concrete entities

- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table
- (Shape$_F$)
- a red pen
- (Color$_F$) or T/C (depending on contextual interpretation)
- a flat screen

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- a red car
- (Color$_F$)
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- (Dimension$_F$)
- a round table
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- (Color$_F$) or T/C (depending on contextual interpretation)
- a flat screen
- (Shape$_F$)

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- (Dimension$_F$)
- a round table
- (Shape$_F$)
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- (Color$_F$) or T/C (depending on contextual interpretation)
- a flat screen
- (Shape$_F$)
- a thick sweater

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- a red car
- (Color$_F$)
- a long dress
- (Dimension$_F$)
- a round table
- (Shape$_F$)
- a red pen
- (Color$_F$) or T/C (depending on contextual interpretation)
- a flat screen
- (Shape$_F$)
- a thick sweater
- (Dimension$_F$)

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor
- (Surface$_F$)

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor
- (Surface$_F$)
- a large round table

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor
- (Surface$_F$)
- a large round table
- (Size$_F$) (Shape$_F$)

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor
- (Surface$_F$)
- a large round table
- (Size$_F$) (Shape$_F$)
- *a round and square table

Values for Formal factors of nouns denoting concrete entities

- the lenght of the table
- (Dimension$_F$)
- the facade of the building
- (Orientation$_F$)
- wipe the floor
- (Surface$_F$)
- a large round table
- (Size$_F$) (Shape$_F$)
- *a round and square table
- (Shape$_F$) (Shape$_F$)

Formal-specific Constructions

- NP *such as* NP: *events such as lectures, walks, tours and meetings*;

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- NP *such as* NP: *events such as lectures, walks, tours and meetings*;
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- NP *such as* NP: *events such as lectures, walks, tours and meetings*;
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- NP, *including* NP: *recyclable materials including glass*;

Formal-specific Constructions

- NP *such as* NP: *events such as lectures, walks, tours and meetings*;
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- NP, *especially* NP: *cool temperate countries especially Europe and North America*;

Formal-specific Constructions

- NP *such as* NP: *events such as lectures, walks, tours and meetings*;
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- NP *or other* NP: *insects or other animals*
- NP, *including* NP: *recyclable materials including glass*;
- NP, *especially* NP: *cool temperate countries especially Europe and North America*;
- *favorite* NP is NP: *Mario's favorite food is pasta*.

The Constitutive Quale

- The Constitutive (C) role encodes information about what is "inside" the object denoted by the word, particularly the material the object is made of (i.e., its stuff), and the parts it consists of.

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The Constitutive Quale

- The Constitutive (C) role encodes information about what is "inside" the object denoted by the word, particularly the material the object is made of (i.e., its stuff), and the parts it consists of.
- There is a fundamental distinction between inherently individuated things, such as humans, tigers, and trees, and inherently undifferentiated stuff, such as water, air, and sand.
- This is reflected in the count vs. mass distinction in linguistics.

Count Nouns and Mass nouns in GL

COUNT NOUN: (where $\alpha \neq \beta$).

$$\begin{bmatrix} \textbf{N} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \alpha \\ \text{C} = \beta \end{bmatrix} \end{bmatrix}$$

MASS NOUN:

$$\begin{bmatrix} \textbf{N} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \alpha \\ \text{C} = \alpha \end{bmatrix} \end{bmatrix}$$

The Formal-Constitutive Equivalence Constraint for mass nouns in GL

$$\begin{bmatrix} \textit{water} \\ \text{QUALIA} = \begin{bmatrix} \text{F/C} = \textbf{liquid} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{rock} \\ \text{QUALIA} = \begin{bmatrix} \text{F/C} = \textbf{solid\_substance} \end{bmatrix} \end{bmatrix}$$

but cf.

$$\begin{bmatrix} \textit{rock} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{solid\_object} \\ \text{C} = \textbf{solid\_substance} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.
- ([C = water])

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.
- ([C = water])
- The river became polluted.

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.
- ([C = water])
- The river became polluted.
- ([C = water])

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.
- ([C = water])
- The river became polluted.
- ([C = water])
- the banks of a polluted river.

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

Default values for MADE-OF relation in C

- The river had frozen during the severe weather.
- ([C = water])
- The river became polluted.
- ([C = water])
- the banks of a polluted river.
- ([C = water])

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \end{bmatrix} \end{bmatrix}$$

MADE-OF RELATION introduced in composition

- Nominal compounding
  - plastic bag

MADE-OF RELATION introduced in composition

- Nominal compounding
  - plastic bag
  - paper cup

MADE-OF RELATION introduced in composition

- Nominal compounding
  - plastic bag
  - paper cup
  - leather shoes

MADE-OF RELATION introduced in composition

- Nominal compounding
  - plastic bag
  - paper cup
  - leather shoes
  - gold watch

MADE-OF RELATION introduced in composition

- Nominal compounding
  - plastic bag
  - paper cup
  - leather shoes
  - gold watch
  - milk chocolate

MADE-OF RELATION introduced in composition

- Adjective-Noun constructions
  - a golden ring

MADE-OF RELATION introduced in composition

- Adjective-Noun constructions
  - a golden ring
  - a wooden floor

MADE-OF RELATION introduced in composition

- Adjective-Noun constructions
  - a golden ring
  - a wooden floor
  - a metallic paint

Constitutive-specific construction

- N_1's N_2: *the room's wall*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
- N_2 of N_1: *the door of the car*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
- N_2 of N_1: *the door of the car*.
- NP_2 is a part of NP_2: *brain is a very sensitive part of the body*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
- N_2 of N_1: *the door of the car*.
- NP_2 is a part of NP_2: *brain is a very sensitive part of the body*.
- NP_1 made of NP_2: *monuments made of stone and marble*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
- N_2 of N_1: *the door of the car*.
- NP_2 is a part of NP_2: *brain is a very sensitive part of the body*.
- NP_1 made of NP_2: *monuments made of stone and marble*.
- NP_1 of NP_2: *house of wood*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
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- NP_1 of NP_2: *house of wood*.
- NP_1 consists of NP_2: *the orchestra consists of ninety performers*.

Constitutive-specific construction

- N_1's N_2: *the room's wall*.
- N_2 of N_1: *the door of the car*.
- NP_2 is a part of NP_2: *brain is a very sensitive part of the body*.
- NP_1 made of NP_2: *monuments made of stone and marble*.
- NP_1 of NP_2: *house of wood*.
- NP_1 consists of NP_2: *the orchestra consists of ninety performers*.
- NP_1 containing NP_2: *a forest containing dead trees*.

Hidden events and the Telic

- The Telic relation (T) encodes information about the intended use or function of an object.

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Hidden events and the Telic

- The Telic relation (T) encodes information about the intended use or function of an object.
- It expresses the relation that allows us to grasp what an entity is by knowing what it is used for.
- It encodes a potential activity of the object.
- First sistematic mention of Telic in Pustejovsky and Anick (1988) as hidden event.

Default values for Telic relation

- Any chocolate? Not after that cake!

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.

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- Any chocolate? Not after that cake!
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Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.

Default values for Telic relation

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- I prefer cake to biscuits.
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- We skipped the cake and settled for another coffee.
- ([T = eat])

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.
- ([T = project])

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.
- ([T = project])
- This is a difficult problem.

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.
- ([T = project])
- This is a difficult problem.
- ([T = solve])

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.
- ([T = project])
- This is a difficult problem.
- ([T = solve])
- This is a difficult question.

Default values for Telic relation

- Any chocolate? Not after that cake!
- ([T = eat])
- I prefer cake to biscuits.
- ([T = eat])
- We skipped the cake and settled for another coffee.
- ([T = eat])
- the next customer.
- ([T = take_care_of])
- the next slide.
- ([T = project])
- This is a difficult problem.
- ([T = solve])
- This is a difficult question.
- ([T = solve])

Updating Telic values in composition

When the Telic activity being expressed does not correspond to the Telic value specified in the noun, we say that the expression updates the Telic information associated with the noun in composition.

$$\begin{bmatrix} \textit{shopping bag} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{container} \\ \text{T} = \textbf{shopping} \end{bmatrix} \end{bmatrix}$$

Telic-specific constructions

- an NP to V: *a book to read*.

Telic-specific constructions

- an NP to V: *a book to read*.
- an NP worth V-ing: *a question worth asking*.

Telic-specific constructions

- an NP to V: *a book to read*.
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- the NP merits/deserves V-ing: *This book deserves reading.*.

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- an NP to V: *a book to read*.
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- enjoy/prefer V-ing NP: *enjoy listening to music / prefer watching television*.

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- an NP to V: *a book to read*.
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- an Adj NP to V: *a difficult question to ask*.

Telic-specific constructions

- an NP to V: *a book to read*.
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- the NP merits/deserves V-ing: *This book deserves reading.*.
- enjoy/prefer V-ing NP: *enjoy listening to music / prefer watching television*.
- an Adj NP to V: *a difficult question to ask*.
- an NP (used) for V-ing: *a spade (used) for digging*.

Natural Telic

- The Telic of a natural kind (T_N), (*human*, *dog*, *water*, and so forth) encodes information about the actions and properties that the object engages in, but that are not intentional or purposive.

Natural Telic

A *river* does not intentionally flow, but this is a necessary property of a body of water if it is to qualify as a river (as in a fast / rapid / slow / lazy river).

$$\begin{bmatrix} \textit{river} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{space} \\ \text{C} = \textbf{water} \\ \text{T}_N = \textbf{flow} \end{bmatrix} \end{bmatrix}$$

The Agentive

- The Agentive quale (A) encodes information about the origin of the object denoted by N.
- It provides a mechanism for discriminating those objects that present themselves to us (occurring naturally) from the various artifacts that we create through our own activities and intentional behavior.
- Differently from the value of T, A introduces an existentially bound or existentially quantified event, that precedes the existence of the object.

Agentive-Telic Pairing

- Inherent in this is an association between the Agentive and Telic of the object, i.e., the object is made for a purpose (Agentive-Telic pairing).
- Natural kinds lack this association, as they do not encode an Agentive value.

Default values for Agentive

- He just finished and published his first novel.

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.
- ([A = sew])

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.
- ([A = sew])
- fresh coffee

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.
- ([A = sew])
- fresh coffee
- ([A = brew])

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.
- ([A = sew])
- fresh coffee
- ([A = brew])
- fresh water

Default values for Agentive

- He just finished and published his first novel.
- ([A = write])
- Woody Allen has started a new movie.
- ([A = direct, film])
- John began a large oil painting yesterday.
- ([A = paint])
- Mary made a cake.
- ([A = bake)
- Her mother made her a dress.
- ([A = sew])
- fresh coffee
- ([A = brew])
- fresh water
- (in contrast to "salt water")

Artifactual Types with an Agentive (coffee)

$$\begin{bmatrix} \textit{water/coffee} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{liquid} \\ \text{T} = \textbf{drink} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{coffee} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{liquid} \\ \text{T} = \textbf{drink} \\ \text{A} = \textbf{brew} \end{bmatrix} \end{bmatrix}$$

CA and conventionalized commonsense knowledge

- A conventionalized attribute (CA) is a property typically associated with an object through our experiencing of it.

CA and conventionalized commonsense knowledge

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CA and conventionalized commonsense knowledge

- A conventionalized attribute (CA) is a property typically associated with an object through our experiencing of it.
- Only the most conventional activities associated with an object are coded in the noun's meaning as CAs.
- They can be identified through empirical testing.

CA and conventionalized commonsense knowledge

$$\begin{bmatrix} \textit{competition} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{event} \\ \text{C} = \textbf{rules} \\ \text{T} = \textbf{win} \\ \text{A} = \textbf{oppositional\_activity(x,y)} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{game} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{competition} \\ \text{C} = \textbf{rules} \\ \text{T} = \textbf{pleasure} \\ \text{A} = \textbf{oppositional\_activity(x,y)} \end{bmatrix} \end{bmatrix}$$

Conventionalized Attributes

- They heard the village dog in the distance.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.
- ([SMELL = scent])

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.
- ([SMELL = scent])
- The repairman smelled gas in the kitchen.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.
- ([SMELL = scent])
- The repairman smelled gas in the kitchen.
- ([SMELL = odor])

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.
- ([SMELL = scent])
- The repairman smelled gas in the kitchen.
- ([SMELL = odor])
- Mary woke up and smelled coffee.

Conventionalized Attributes

- They heard the village dog in the distance.
- ([SOUND = barking])
- Ann was listening to the birds.
- ([SOUND = singing])
- He could hear the rain in the garden.
- ([SOUND = falling])
- John can smell the flowers in his garden.
- ([SMELL = scent])
- The repairman smelled gas in the kitchen.
- ([SMELL = odor])
- Mary woke up and smelled coffee.
- ([SMELL = aroma])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])
- John was the fastest boy in the school.

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])
- John was the fastest boy in the school.
- ([CA = running])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])
- John was the fastest boy in the school.
- ([CA = running])
- I could hear a car behind me.

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])
- John was the fastest boy in the school.
- ([CA = running])
- I could hear a car behind me.
- ([CA = driving])

Conventionalized Attributes

- Mary sat out and enjoyed the sun.
- ([CA = warming up])
- It's a great place to enjoy the sea.
- ([CA = viewing, swimming, walking])
- The tuna is one of the fastest fish in the sea.
- ([CA = swimming])
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- ([CA = running])
- I could hear a car behind me.
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- We do occasionally hear an airplane.

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CAs as projective manifestations of Qualia

- CAs in GL are interpreted as projective manifestations of specific Qualia.

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- The representation of CAs in GL is always mediated through a Quale.

Projective operations over T values

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Projective operations over T values

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- (there is no departing)

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- I left in time to catch the early train.
- (departing early)
- Heavy foods such as dairy products and meat.

Representation of Conventionalized Attributes

$$\begin{bmatrix} \textit{dog} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \begin{bmatrix} \text{F} = \textbf{animal} \\ \text{CA} = \textbf{bark} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{fish} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \begin{bmatrix} \text{F} = \textbf{animal} \\ \text{CA} = \textbf{live\_in(water), swim} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{car} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{vehicle} \\ \text{T} = \begin{bmatrix} \text{T} = \textbf{drive} \\ \text{CA} = \textbf{make\_noise} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Type Composition Logic (Asher and Pustejovsky, 2006)

1. e the general type of entities; t the type of truth values.
   (σ, τ range over all simple types, and subtypes of e.)
2. If σ and τ are types, then so is $\sigma \rightarrow \tau$.
3. If σ and τ are types, then so is $\sigma \otimes_R \tau$; R ranges over A or T.
4. If σ and τ are types, then so is $\sigma \bullet \tau$.

Qualia Types

$$\begin{bmatrix} x: & \alpha \\ & \otimes_c \beta \\ & \otimes_t \tau \\ & \otimes_a \sigma \end{bmatrix}$$

with an unlabeled qualia value

$$\begin{bmatrix} x: & \alpha \\ & \otimes \ \tau \\ & \end{bmatrix}$$

Natural Types

Entities formed from the application of the FORMAL and/or CONST qualia roles:

1. For the predicates below, e_N is structured as a join semi-lattice, $\langle e_N, \sqsubseteq \rangle$;
2. *physical*, *human*, *stick*, *lion*, *pebble*
3. *water*, *sky*, *rock*

Natural Predicate Types

Predicates formed with Natural Entities as arguments:

1. *fall*: $e_N \rightarrow t$
2. *touch*: $e_N \rightarrow (e_N \rightarrow t)$
3. *be under*: $e_N \rightarrow (e_N \rightarrow t)$

a. $\lambda x{:}\, e_N[\ \mathit{fall}(\mathrm{x})]$

b. $\lambda y{:}\, e_N \lambda x{:}\, e_N[\ \mathit{touch}(\mathrm{x},\mathrm{y})]$

c. $\lambda y{:}\, e_N \lambda x{:}\, e_N[\ \mathit{be\text{-}under}(\mathrm{x},\mathrm{y})]$

Artifactual Entity Types

Entities formed from the Naturals by adding the AGENTIVE or TELIC qualia roles:

1. Artifact Entity: $x : e_N \otimes_a \sigma$
   x exists because of event σ
2. Functional Entity: $x : e_N \otimes_t \tau$
   the purpose of x is τ
3. Functional Artifactual Entity: $x : (e_N \otimes_a \sigma) \otimes_t \tau$
   x exists because of event σ for the purpose τ

a. *beer*: $(liquid \otimes_a brew) \otimes_t drink$
b. *knife*: $(phys \otimes_a make) \otimes_t cut$
c. *house*: $(phys \otimes_a build) \otimes_t live\_in$

Artifactual Predicate Types

Predicates formed with Artifactual Entities as arguments:

1. *spoil*: $e_N \otimes_t \tau \rightarrow t$
2. *fix*: $e_N \otimes_t \tau \rightarrow (e_N \rightarrow t)$

a. $\lambda x{:}\, e_A[\ \mathit{spoil}(\mathrm{x})]$
b. $\lambda y{:}\, e_A \lambda x{:}\, e_N[\ \mathit{fix}(\mathrm{x},\mathrm{y})]$

- The beer spoiled.
- Mary fixed the watch.

Complex Entity Types

Entities formed from the Naturals and Artifactuals by a product type between the entities, i.e., the dot, •.

1. a. Mary doesn't believe the book.
   b. John sold his book to Mary.
2. a. The exam started at noon.
   b. The students could not understand the exam.

Motivating Dot Objects

When a single word or phrase has the ability to appear in selected contexts that are contradictory in type specification.

If a lexical expression, α, where $\sigma \sqcap \tau = \bot$:

1. [___] $_{\sigma}$ X
2. [___] $_{\tau}$ Y

are both well-formed predications, then α is a dot object (complex type).

Dot Object Inventory: 1

1. Act•Proposition: promise, allegation, lie
   - I doubt John's promise of marriage.
   - John's promise of marriage happened while we were in Prague.
2. Attribute•Value: temperature, weight, height, tension, strength
   - The temperature is rising.
   - The temperature is 23.

Dot Object Inventory: 2

1. Event•Information: lecture, play, seminar, exam, quiz, test
   a. My lecture lasted an hour.
   b. Nobody understood my lecture.
2. Event•Music: sonata, symphony, song, performance, concert
   a. Mary couldn't hear the concert.
   b. The rain started during the concert.

Dot Object Inventory: 3

1. Event•Physical: lunch, breakfast, dinner, tea
   a. My lunch lasted too long today.
   b. I pack my lunch on Thursdays.
2. Information•Physical: book, cd, dvd, dictionary, diary, mail, email, mail, letter
   a. Mary burned my book on Darwin.
   b. Mary believes all of Chomsky's books.

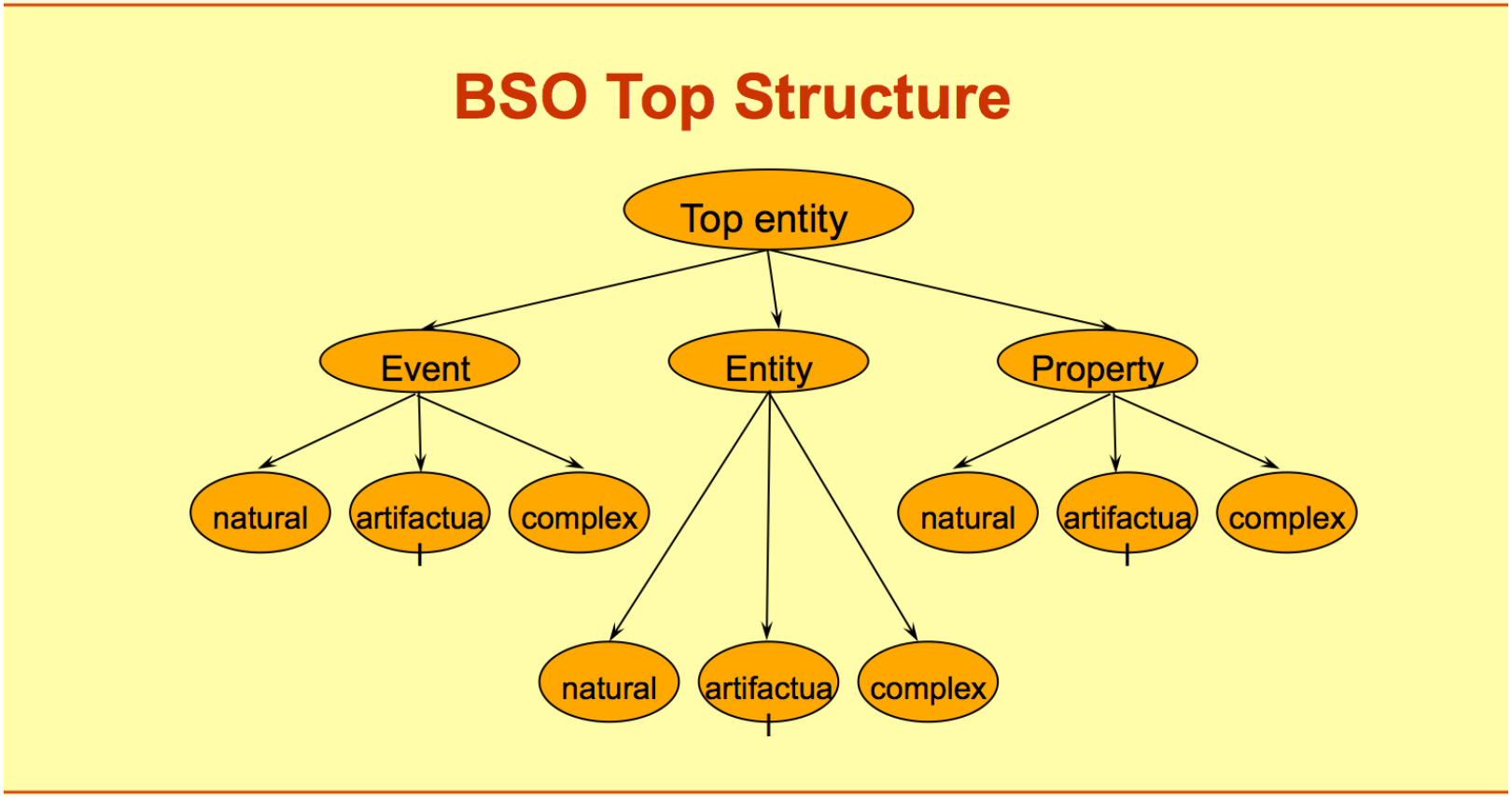
Complex Predicate Types

Predicates formed with a Complex Entity Type as an argument:

1. *read*: $phys \bullet info \rightarrow (e_N \rightarrow t)$
2. Expressed as typed arguments in a λ-expression:
   $\lambda y{:}\, phys \bullet info\ \lambda x{:}\, e_N[read(x,y)]$
3. Mary read the book.

Brandeis Semantic Ontology 1/5

Pustejovsky et al (2006)



Brandeis Semantic Ontology 2/5

- **Qualia** are defined for **Entity** types
- **Argument types** are specified for **Events**
- Type inheritance principles:
  - Inheritance is typed
  - A simple type may inherit its qualia from different supertypes
  - Inheritance for **Entities** follows **qualia** links
  - Inheritance for **Events** mirrors **argument** type inheritance
- Entity hierarchy:
  - **Natural types**
    - Inherit formal quale of supertype
  - **Artifactual types**
    - Inherit telic quale of supertype
    - Formal quale is inherited through **formal mapping**
  - **Complex types**
    - "dot types" (e.g. *building, book, lecture*)
    - very shallow hierarchy

Type Inventory from BSO 3/5

- The type of an argument is a value selected from an inventory of types in the language (Asher and Pustejovsky 2006, Pustejovsky 2011).
- In addition to the Montague types, *e* and *t*, GL assumes a richer subtyping over the entity domain than is typically assumed in type theory.
- Among these we find: *human*, *physical_object*, *artifact*, *material*, *substance*, *information*, *location*.

GL Types for Composition 4/5

ABSTRACT ENTITY, ANIMATE, ARTIFACT, ATTITUDE, DOCUMENT, DRINK, EMOTION, ENTITY, EVENT, FOOD, HUMAN, HUMAN GROUP, IDEA, INFORMATION, LOCATION, OBLIGATION, ORGANIZATION, PATH, PHYSICAL OBJECT, PROPERTY, PROPOSITION, RULE, SENSATION, SOUND, SUBSTANCE, TIME PERIOD, VEHICLE

Brandeis Semantic Ontology 5/5

Ontology 253 semantic types

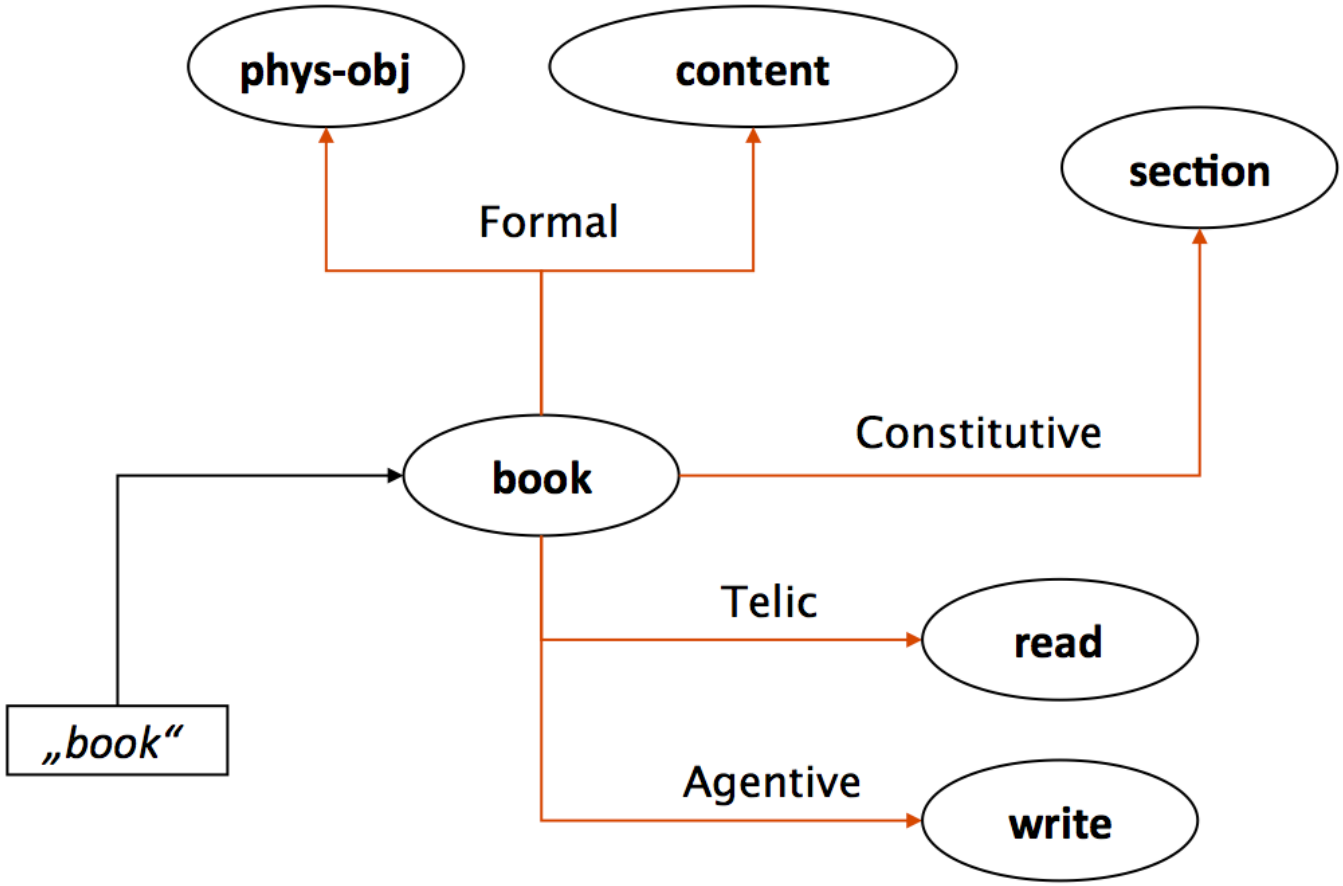
Search Shrink

- Anything details
  - Entity details
    - Abstract_Entity details
      - Concept details
        - Proposition details
          - Narrative details
        - Rule details
          - Permission details
        - Dispute details
        - Information details
      - Information_Source details
        - Document details
          - Agreement details
        - Language details
          - Number details
        - Broadcast details
        - Medium details
        - Radio_Program details
        - Recording details
        - TV_Program details
      - Numerical_Value details
        - Money_Value details
        - Quantity details
      - Psych details
        - Attitude details
        - Emotion details
        - Goal details

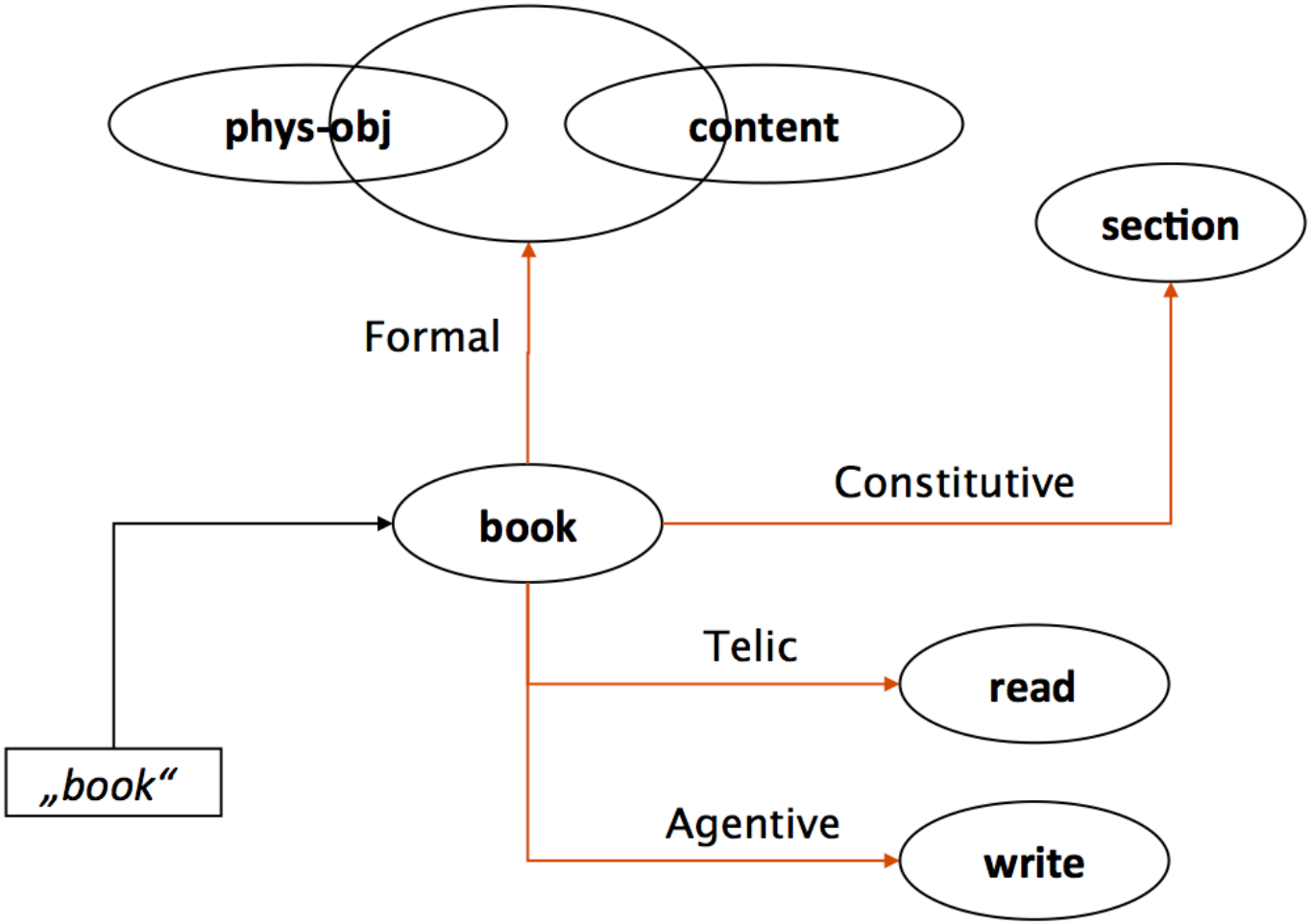
GL and CoreLex

- Lexical semantics Analysis and representation of word meaning
- A generative model of lexical semantics Representation of word meaning that enables dynamic creation of word meanings ('senses') on demand
- An empirical foundation of the generative model Analysis of sense distribution across a large-scale semantic lexicon
- An ontological view of lexical semantics Reasoning over the ontology enables sense derivation

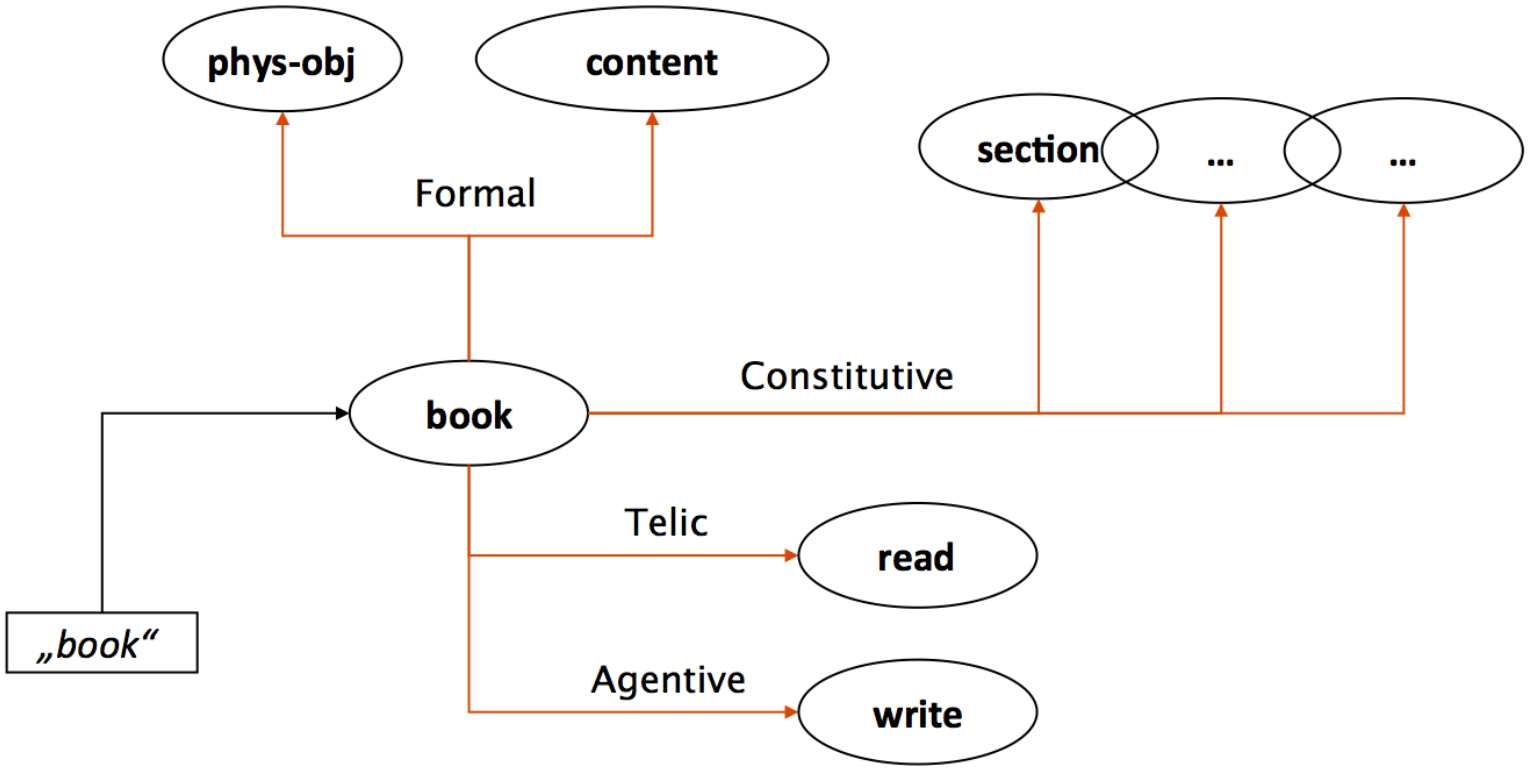
Qualia Structure for book



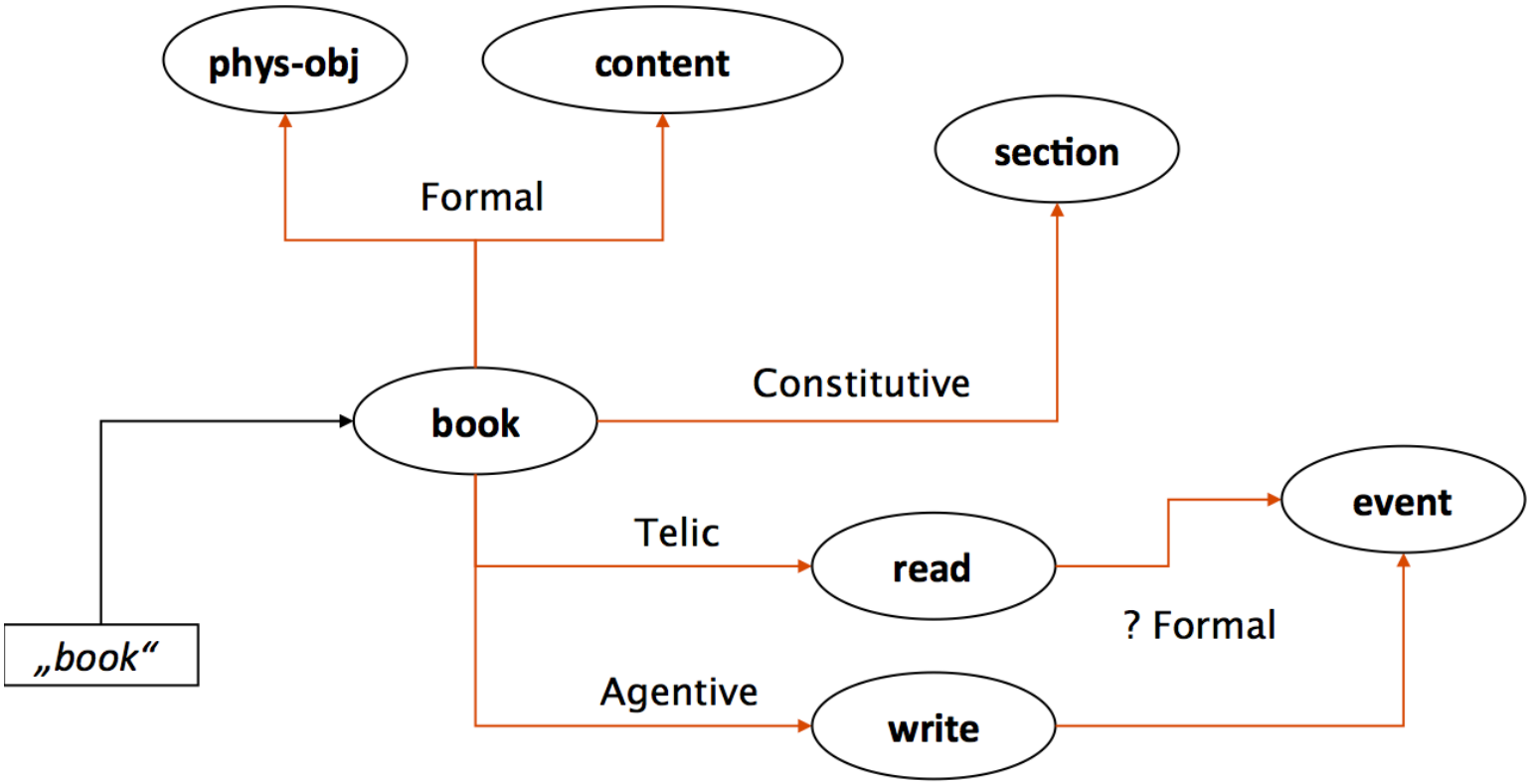
Problems with Formal



Problems with Constitutive



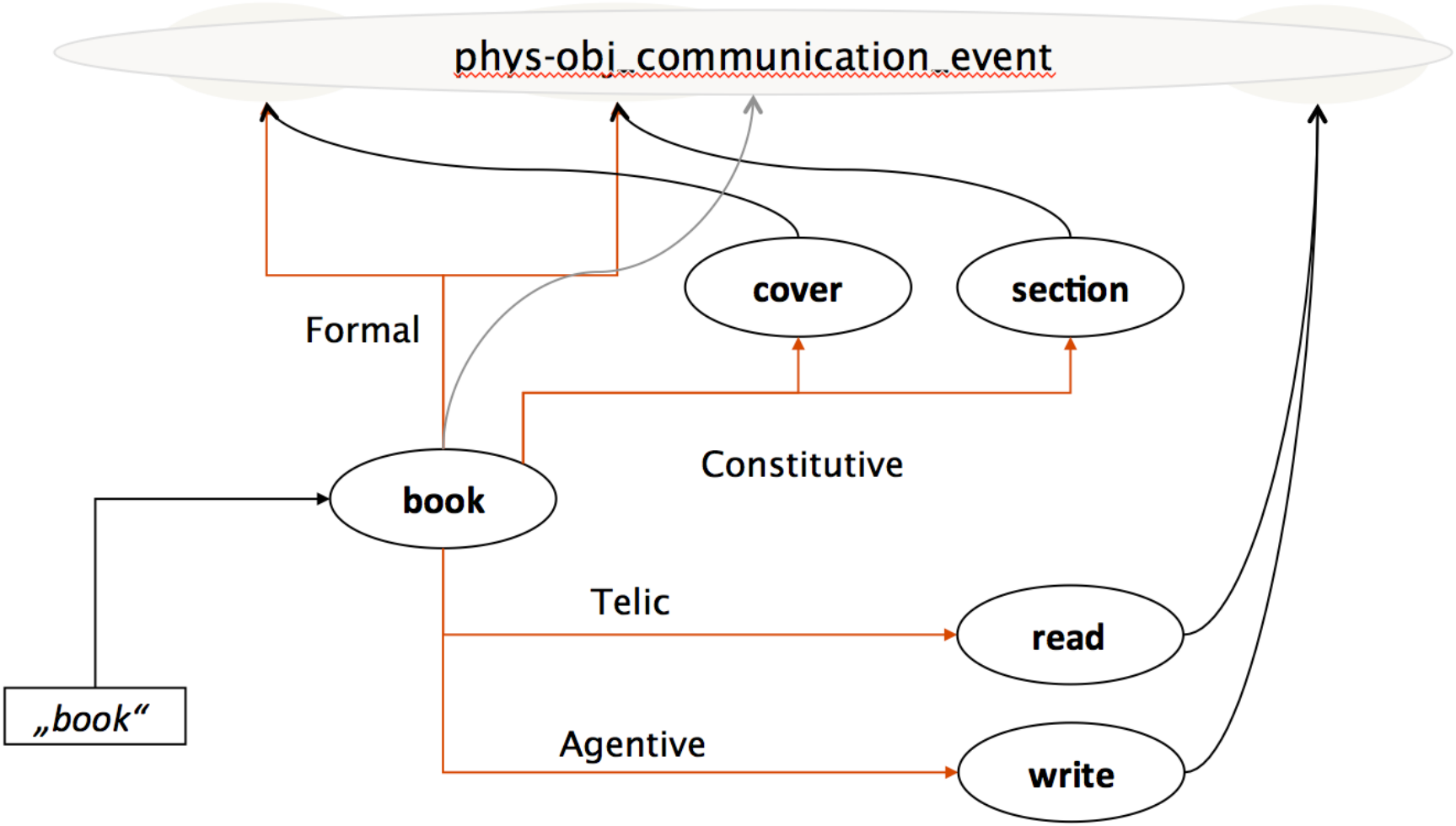
Problems with Telic/Agentive



Two Approaches

- Treat QS as a condensed ontology
  - QS provides a gateway in meaning potential
  - QS roles as shortcuts for ontology inference paths
- Condense QS even further into a complex class
  - Aggregate all types that can be reached through the QS (ontology) into a 'systematic polysemous class'
  - Each systematic polysemous class introduces a set of underspecified lexical semantic objects
  - CoreLex approach ('sense clustering')

QS as Condensed Ontology



Lab on Qualia Identification

- Select one target noun among the following categories (one noun for each category max):
  - Artifactual entities: car, knife, letter, house, table
  - Natural kinds: sea, sun, river, fish, water
  - Functional locations: *library*, *gym*, *church*, *school*.
  - Professions: *doctor*, *teacher*, *lawyer*.
  - Agentive nominals (individuals engaged in an activity, either habitually or occasionally): *passenger*.

Lab on Qualia Identification

- Use the WordSketch function of SkE. Look at full concordances if you need to. Use the patterns if you think they help.
- Identify Qualia Triggers and Qualia Values for the target nouns. Identify Conventional Attributes.
- Compile Qualia structures for the target noun

Qualia Structure for .....

$$\begin{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{C} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{T} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{A} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{bmatrix} \end{bmatrix}$$

Conventionalized attributes for .....

$$\begin{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \begin{bmatrix} \text{F} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{CA} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{bmatrix} \\ \text{T} = \begin{bmatrix} \text{T} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{CA} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Formal-specific Constructions

- [tag="N.*"][lemma="such"][lemma="as"][tag="N.*"]
- [lemma="such"][tag="N.*"][lemma="as"]
- [tag="N.*"][lemma="and"][lemma="other"][tag="N.*"]
- [tag="N.*"][lemma="or"][lemma="other"][tag="N.*"]
- [tag="N.*"][word="including"][tag="N.*"]
- [tag="N.*"][lemma="especially"][tag="N.*"]
- [word="favorite"][tag="N.*"][word="is"][tag="N.*"]

Constitutive-specific constructions

- [tag="N.*"][word="is"][]{0,2}[word="part"][lemma="of"][]{0,2}[tag="N.*"]
- [tag="N.*"][word="made"][lemma="of"][tag="N.*"]
- [tag="N.*"][word="consists"][lemma="of"][]{0,1}[tag="N.*"]
- [tag="N.*"][word="containing"][]{0,2}[tag="N.*"]

Telic-specific constructions

- [lemma="a"][tag="N.*"][word="worth"][tag="VVG"]
- [tag="N.*"][lemma="deserve"|lemma="merit"][tag="VVG"]
- [lemma="enjoy"|lemma="prefer"][tag="VVG"]
- [lemma="a"][tag="N.*"][word="for"][tag="VVG"]
- [lemma="a"][tag="N.*"][word="used"][word="for"] [tag="VVG"]

Agentive-specific constructions

- [tag="N.*"][tag="V.*D"][tag="V.*N|V.*D"]