Compositionality and the Theory of Argument Selection

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Lecture 2. Generative Lexicon as a Theory of Selection
Natural Entities

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

For the predicates below, $e_N$ is structured as a join semi-lattice, $\langle e_N, \sqsubseteq \rangle$;

(1)a. physical, human, stick, lion, pebble
   b. water, sky, rock
Natural Entity Types as a Lattice

(2)

Entity
  ├── Physical
  │    └── Stuff
  │         ├── inanimate
  │         └── animate
  └── Abstract
      ├── Mental
      └── Ideal
Natural Entities

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

For the predicates below, \( e_N \) is structured as a join semi-lattice, \( \langle e_N, \sqsubseteq \rangle \);

(3)a. physical, human, stick, lion, pebble
   b. water, sky, rock
Natural Entity Types as a Lattice
Natural Predicate Types

Predicates formed with Natural Entities as arguments:

(5)a. \textit{fall}: \ e_N \rightarrow t \\
b. \textit{touch}: \ e_N \rightarrow (e_N \rightarrow t) \\
c. \textit{be under}: \ e_N \rightarrow (e_N \rightarrow t) \\

Expressed as typed arguments in a \texttt{\lambda}-expression:

(6)a. \lambda x: e_N[\textit{fall}(x)] \\
b. \lambda y: e_N \lambda x: e_N[\textit{touch}(x,y)] \\
c. \lambda y: e_N \lambda x: e_N[\textit{be-under}(x,y)]
Artifactual Entity Types: \( e_A \)

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

(7) Expressed as types:

a. **Artifact Entity**: \( x : e_N \otimes a \sigma \)
   
   \( x \) exists because of event \( \sigma \)

b. **Functional Entity**: \( x : e_N \otimes t \tau \)
   
   the purpose of \( x \) is \( \tau \)

c. **Default Artifactual Entity**: \( x : (e_N \otimes a \sigma) \otimes t \tau \)
   
   \( x \) exists because of event \( \sigma \) for the purpose \( \tau \)
Artifactual Entity Types

Examples of types in $e_A$.

(8)a. beer: liquid $\otimes_t$ drink
    (liquid $\otimes_a$ brew) $\otimes_t$ drink (expressing Agentive)

b. knife: phys $\otimes_t$ cut
    (phys $\otimes_a$ make) $\otimes_t$ cut (expressing Agentive)

c. house: phys $\otimes_t$ live_in
    (phys $\otimes_a$ build) $\otimes_t$ live_in (expressing Agentive)
Human Functional Entity Types

(9) **TELIC** and **AGENTIVE** constraints on the Natural Type **HUMAN**:
   a. *boss, friend*;
   b. *dancer*:
      \[
      \text{human} \otimes_t \text{dance}
      \]
   c. *wife, husband*:
      \[
      \text{human} \otimes_a \text{marry}
      \]
Artifactual Predicate Types

Predicates formed with Artifactual Entities as arguments:

(10)a. $\text{spoil}: e_N \otimes t \tau \rightarrow t$

b. $\text{fix}: e_N \otimes t \tau \rightarrow (e_N \rightarrow t)$

Expressed as typed arguments in a $\lambda$-expression:

(11)a. $\lambda x : e_A[\text{spoil}(x)]$

b. $\lambda y : e_A \lambda x : e_N[\text{fix}(x,y)]$

(12)a. The beer spoiled.

b. 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, •.

(13)a. Mary doesn’t believe the book.

(14)a. John wrote the exam last night in under 10 minutes.
    b. The exam lasted more than three hours this morning.
(15) Expressed as types:

a. Complex Entity: $x : e_i \bullet e_j$, for $i, j$ of any level

b. Complex Predicate: $P : x : e_i \bullet e_j \rightarrow t$
• When a single word or phrase has the ability to appear in selected contexts that are contradictory in type specification.

(16) If a lexical expression, $\alpha$, where $\sigma \sqcap \tau = \bot$:
   a. $[\_\_]_{\sigma} \ X$
   b. $[\_\_]_{\tau} \ Y$

are both well-formed predications, then $\alpha$ is a dot object (complex type).
Dot Object Inventory

1. **Act•Proposition**: promise, allegation, lie

   a. I doubt John’s promise of marriage.

   b. John’s promise of marriage happened while we were in Prague.
Dot Object Inventory

2. **State** • **Proposition**: belief

   a. Nothing can shake John’s belief.

   b. John’s belief is obviously false.
Dot Object Inventory

3. **Attribute-Value**: temperature, weight, height, tension, strength

   a. The temperature is rising.

   b. The temperature is 23.
Dot Object Inventory

4. Act•Proposition: promise, allegation, lie

a. I doubt John’s promise of marriage.

b. John’s promise of marriage happened while we were in Prague.
Dot Object Inventory

5. **Event●Information**: lecture, play, seminar, exam, quiz, test

   a. **My lecture** lasted an hour.
   
   b. Nobody understood **my lecture**.
Dot Object Inventory

6. Event●Human: appointment

a. You missed your last appointment.
b. Your next appointment is a Serbian student.
Dot Object Inventory

7. **Event**•**Music**: sonata, symphony, song, performance, concert

   a. Mary couldn’t hear the concert.
   b. The rain started during the concert.
8. **Event•Physical**: lunch, breakfast, dinner, tea

   a. *My lunch* lasted too long today.

   b. I pack *my lunch* on Thursdays.
Dot Object Inventory

9. **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.
10. **Organization**●**(Information●Physical)**: magazine, newspaper, journal

   a. The magazine fired its editor.
   
   b. The cup is on top of the magazine.
   
   c. I disagreed with the magazine.
11. **Process-Result**: construction, depiction, imitation, portrayal, reference, rendering, decoration, display, documentation, drawing, enclosure, entry, instruction, design, invention, music, obstruction, pattern, simulation, illustration, agreement, approval, recognition, damage, compensation, contribution, disbursal, disbursement, discount, donation, acquisition, deduction, endowment, gift, categorization, classification, grouping

   a. Linnaeus’s classification of the species took 25 years.
   b. Linnaeus’s classification contains 12,100 species.
Reference to different Aspects of Dot Objects


(18)a. Mary answered every question in the class.
   b. Mary repeated every question in the class.
Complex Type (Dot Object): $e_C$

Introduces a coherence relation as a product type between a Natural, Artifactual, or Complex type, and reifies this as a type.

(19)a. $phys \bullet info$: book, record, DVD;
    b. $event \bullet event$: construction, examination;
    c. $phys \bullet aperture$: door, window.
Complex Predicate Types

Predicates formed with Complex Entity Types as arguments:

(20) \textit{read}: \textit{phys} \bullet \textit{info} \rightarrow (e_N \rightarrow t)

Expressed as typed arguments in a \(\lambda\)-expression:

(21) \lambda y: \textit{phys} \bullet \textit{info} \lambda x: e_N[\textit{read}(x,y)]

(22) Mary read the book.
Enriching Compositionality

If all you have for composition is function application, then you need to create as many lexical entries for an expression as there are environments it appears in. (Weak Compositionality)

Two ways to overcome this:

(1) Type Shifting Rules: Partee-Rooth MG, CG, HPSG.
(2) Type Coercion Operations: GL, Hendriks, Moens and Steedman
Maintaining Compositionality

- Generative Mechanisms of Argument Selection:
  * Selection
  * Accommodation
  * Coercion:
    (i) Introduction
    (ii) Exploitation

- Qualia-based Type Structure:
  * Natural,
  * Artifactual,
  * Complex.
Generative Mechanisms of Argument Selection

– **Pure Selection**: The type a function requires is **directly satisfied** by the argument.
– **Accommodation**: The type a function requires is **inherited** by the argument.
– **Coercion**: The type a function requires is **imposed** on the argument type. This is accomplished by either:
  * **Exploitation**: selecting part of the argument’s type structure to satisfy the function’s typing;
  * **Introduction**: wrapping the argument with the type the function requires.
Type Coercion

– **Exploitation**: selecting part of the argument’s type structure to satisfy the function’s typing;
– **Introduction**: wrapping the argument with the type the function requires.
Two Kinds of Coercion in Language

- **Domain-shifting**: The domain of interpretation of the argument is shifted;
- **Domain-preserving**: The argument is coerced but remains within the general domain of interpretation.
Domain-Shifting Coercion

– Entity shifts to event:
  I enjoyed the beer

– Event shifts to interval:
  before the party started...

– Entity shifts to proposition:
  I doubt John.
Domain-Preserving Coercion

- **Count-mass shifting**: There’s chicken in the soup.
- **NP Raising**: Mary and every child came.
Domain-Preserving Coercion

– Count-mass shifting: There’s chicken in the soup.
– NP Raising: Mary and every child came.

Actually, they are all over the place:

– Natural-Artifactual shifting:
– Natural-Complex shifting:
– Complex-Natural shifting:
– Artifactual-Natural shifting:
– Complex-Artifactual shifting:
– Complex-Complex shifting:
– Artifactual-Artifactual shifting:
Function Application: If $\alpha$ is of type $e_N$, and $\beta$ is of type $e_N \rightarrow t$, then $\beta(\alpha)$ is of type $t$.

A natural type tree:

```
t
  /\  \
\ e_N e_N \rightarrow t
```
Pure Selection: Natural Type

The rock fell.

(23)

\[
S \\
NP: e_N \\
\lambda x: e_N[fall(x)] \\
\]

the rock

fell

V

VP

NP: e_N
Pure Selection: Natural Type

The rock fell.

(24)

\[
\begin{array}{c}
S \\
NP: e_N \\
\text{the rock} \\
V \\
fell \\
\lambda x: e_N[fall(x)]
\end{array}
\]
Function Application: If $\alpha$ is of type $e_A$, and $\beta$ is of type $e_A \rightarrow t$, then $\beta(\alpha)$ is of type $t$.

An artifactual type tree:

```
    t
   / \   / \\
 e_A  e_A \rightarrow t
```
Pure Selection: Artifactual Type

The beer spoiled.

(25)

\[
S \rightarrow \\
NP : \sigma \otimes_T \tau \\
VP \\
V \\
\lambda x : e_A[\text{spoil}(x)]
\]

\[
\text{liquid} \otimes_T \text{drink} \sqsubseteq \sigma \otimes_T \tau
\]
Pure Selection: Artifactual Type

The beer spoiled.

(26)

\[
\begin{array}{c}
S \\
NP \quad \sigma \otimes_T \tau \\
\text{liquid} \otimes_T \text{drink} : e_A \\
V \\
\text{the beer} \\
\text{spoiled} \\
\lambda x : e_A[\text{spoil}(x)]
\end{array}
\]

\[\text{liquid} \otimes_T \text{drink} \subseteq \sigma \otimes_T \tau\]
Function Application with Complex Types

Function Application: If $\alpha$ is of type $e_C$, and $\beta$ is of type $e_C \rightarrow t$, then $\beta(\alpha)$ is of type $t$.

A complex type tree:

```
  t
 /\  /
 e_C e_C \rightarrow t
```
John read the book.

Pure Selection: Complex Type

$\lambda y : p \bullet i \lambda x : e_N[read(x, y)]$
Pure Selection: Complex Type

John read the book.

(28)
Accommodation with Natural Types

Accommodation: If $\alpha$ is of type $\sigma$, and $\beta$ is of type $\tau \to t$, then, if $\sigma \sqcap \tau \neq \bot$, then $\text{Acc}(\beta, \alpha)$ is of type $\sigma \sqcap \tau \to t$. 


Type Accommodation: Natural Types

Mary wiped her hands.
Mary wiped her hands.
Type Accommodation: Natural Types

Mary wiped her hands.

(31)

\[
\text{VP} \quad \text{[surface]} \quad \text{NP:phys} \\
\text{wipe} \quad \text{Det} \quad \text{N} \\
\text{her} \quad \text{body_part} \quad \text{hands}
\]
Type Coercion: Natural to Artifactual Introduction

The water spoiled.

(32)

\[ \lambda x : e_A[spoil(x)] \]
Type Coercion: Natural to Artifactual Introduction

The water spoiled.

(33)

\[ \lambda x : e_A[\text{spoil}(x)] \]
The water spoiled.

(34)

\[ \lambda x : e_A[\text{spoil}(x)] \]
John read the rumor.

(35)

\[ \lambda y \cdot p \bullet i \lambda x \cdot e_N[\text{read}(x,y)] \]

\[ \text{read} \quad \text{Det} \quad \text{NP:info} \quad \text{VP} \quad \text{phys} \bullet \text{info} \]
John read the rumor.

\(\lambda y \cdot p \bullet i \lambda x : e_N[\text{read}(x,y)]\)
Mary enjoyed her coffee.
Type Coercion: Event Introduction

Mary enjoyed her coffee.

(38)

\[ \text{VP} \quad \lambda x. \text{Event}(x, \text{NP}) \]

\[ \text{NP: liquid} \otimes_T \text{drink} \]

\[ \text{V} \quad \text{enjoy} \]

\[ \text{Det} \quad \text{portion} \]

\[ \text{N} \quad \text{her} \]

\[ \text{N} \quad \text{coffee} \]
Type Coercion: Qualia Exploitation

Mary enjoyed her coffee.
Mary enjoyed her coffee.

(40)
Type Coercion: Complex Exploitation

The police burned the book.

(41)
Type Coercion: Complex Exploitation

The police burned the book.

(42)
Mary believes the book.

\[
\begin{align*}
&\text{VP} \\
&\text{V} \quad \text{info} \\
&\text{believe} \\
&\lambda y \text{phys} \lambda x : e_N \{ \text{believe}(x,y) \} \\
&\text{Det} \quad \text{the} \\
&\text{NP} : \text{phys} \bullet \text{info} \\
&\text{N} \\
&\text{book}
\end{align*}
\]
Mary believes the book.

\[ (44) \]

\[ \lambda y : \text{phys} \lambda x : e_N \{ \text{believe}(x,y) \} \]

\[ \text{VP} \]

\[ \text{NP: phys } \bullet \text{ info} \]

\[ \text{believe} \]

\[ \text{the} \]

\[ \text{book} \]
Types and Composition of Local Contexts

Compositionality mediated through richer selectional mechanisms:

<table>
<thead>
<tr>
<th>COMPOSITION</th>
<th>VERB TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td>die((x))</td>
</tr>
<tr>
<td>Accommodation</td>
<td>wipe((x,\text{hand}))</td>
</tr>
<tr>
<td>Coercion</td>
<td>enjoy((\text{rock}))</td>
</tr>
<tr>
<td></td>
<td>fix((x,y))</td>
</tr>
<tr>
<td></td>
<td>spill((\text{beer}))</td>
</tr>
<tr>
<td></td>
<td>spoil((\text{water}))</td>
</tr>
<tr>
<td></td>
<td>read((x,y))</td>
</tr>
<tr>
<td></td>
<td>burn((x,\text{book}))</td>
</tr>
<tr>
<td></td>
<td>read((x,\text{joke}))</td>
</tr>
</tbody>
</table>
That’s all well and good, but...
That’s all well and good, but... 

What do we actually see in the corpus?