Generative Lexicon Theory: Theoretical and Empirical Foundations

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(with Martha Palmer
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Course Outline

- Introduction: Motivation and Objectives.
- What is Generative Lexicon About? Basic Architecture of GL.
- Formal Foundations. Qualia Structure, Lexical Typing.
- Treatment of Compositionality. Selection and Coercion.
- Empirical Applications. Theory Meets Corpus.

Lecture 1

Framing the problem: Encoding meaning creation in context

Sept. 9, 2014

Outline of Lecture 1

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Questions

- How do words combine to make meanings?
- How do words meanings change in composition?
- How do we explain creative word use?

More Questions

- What conditions does a predicate impose on its arguments, and how are these conditions realized?
- How many meanings are needed for a word appearing in multiple syntactic contexts (i.e., polysemy)?
- What are the sources of polysemy? underspecified meanings?
- Where do interpretations for unarticulated constituents come from?
- Given these facts, how can we maintain a compositional semantics?

The Principle of Compositionality

1. The meaning of a complex expression is determined by its structure and the meanings of its constituents.

Starting Assumptions

- Language meaning is compositional.
- Compositionality is a desirable property of a semantic model.
- Many linguistic phenomena appear non-compositional.
- Generative Lexicon exploits richer representations and rules to enhance compositional mechanisms.
- Richer representations involve Lexical Decomposition.
- Richer rules involve Coercion, Subselection, Co-composition.

Outline of Lecture 1

Language Data

- What is the motivation for the theory? Lots of relevant data!
- Let's look at the data!

Outline of Lecture 1

Two Types of Ambiguity

- Homonymy: unrelated senses of a word
  bank vs. bank
  chair vs. chair
- Polysemy: conceptually related senses of a word
  book vs. book
  door vs. door

– How are these to be represented in the lexicon?

Lexical and Structural Ambiguity

Language is highly ambiguous, and the ambiguity is due to different factors:

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- Local high school dropouts cut in half / polysemy

Two Types of Polysemy

- Inherent polysemy: where multiple interpretations of an expression are available by virtue of the semantics inherent in the expression itself.
- selectional polysemy: where any novel interpretation of an expression is available due to contextual influences, namely, the type of the selecting expression.

1. a. John bought the new Obama book.
   b. John doesn't agree with the new Obama book. (inherent)
2. a. Mary left after her cigarette. (selectional)
   b. Mary left after her smoking a cigarette.

– We would like to represent different types of polysemy differently

Systematic (Logical) Polysemy

1. There's chicken in the salad. (GRINDING)
2. We'll have a water and two beers. (PACKAGING)
3. Roser finished her thesis. (finished doing what?)
4. Mary began the novel. (began doing what?)
5. Mary believes John's story. (PROPOSITION)
6. Mary believes John. (PROPOSITION?)

Outline of Lecture 1

Underspecification of Meaning I

How many meanings for good?

1. good car
2. a good meal
3. a good knife

What does noisy select for?

1. a noisy_1 car
2. a noisy_1 dog
3. a noisy_2 room
4. a noisy_2 cafeteria

1. a fast typist
2. a fast train
3. a fast highway

Underspecification of Meaning II

- This ironing board is flat.
- My neighborhood is flat.
- My country is flat.

- The water is boiling.
- The pot is boiling.

Language Data: Motivation for the Theory

- We are looking at a lot of very diverse examples.
- They illustrate the mutability of meaning.
- And! The representation proposed within the GL theory is capable modeling it very simply and elegantly.

Outline of Lecture 1

Flexibility of Interpretation

- Flexibility of Subject Interpretation
- Flexibility of Object Interpretation
- Flexibility of Experiencing
- Flexibility of Perceiving
- Flexibility of Aspectuals
- Flexibility of Arguments: Concealed Questions

Flexibility of Subject Interpretation

Subject of kill:

- John killed Mary.
- The gun killed Mary.
- The shot killed Mary.
- The bullet killed Mary.
- John's pulling the trigger killed Mary.
- *The trigger killed Mary.

Causation and Intention

- John rolled down the hill as fast as he could.
- John cooled off with an iced latte.

  Subject Rule (Wechsler, 2005): Optionally interpret subject as AGENTIVE.

  kill vs murder:
- John killed the flowers accidently / intentionally.
- John murdered Mary.
- *John murdered Mary intentionally / accidentally.

– This distinction can be lexicalized

Flexibility of Object Interpretation

Fillmore (1985), Levin (1993), Levin and Rappaport (1998), Jackendoff (1990), Pustejovsky and Busa (1995)

- John swept [the dirt]$_{material}$.
- John swept [the room]$_{region}$.

- The man shoveled [the snow]$_{material}$.
- The man shoveled [the driveway]$_{region}$.

Flexibility of Arguments: Experiencers

1. That book bored me terribly.
   That movie bored me terribly.
   – bore selects for EVENT in the subject position
   – reading vs. watching
2. The movie frightened Mary.
   The dog frightened Mary.
3. The newspaper article angered the Republicans.
4. Listening to Mary irritated Alice.
   The narrow streets have always irritated Alice.

Exactly how it bores, frightens, or irritates us varies depending on the subject!

Flexibility of Arguments: Perception

- The boy heard a cat / a dog.
- They heard a bang / cry / rumor / shout / rain.
- !John heard the cloud/star/light.
- The crowd listened to the poem/speaker/speech.

Flexibility of Arguments: Attitudes, Factives

- Mary believes the rumor.
- No one believes the newspaper.
- She found the book hard to believe.
- They denied the actual conditions of the prisons.
- The graduate student regrets his last homework assignment.
- The hacker acknowledged the spam.

Flexibility of Arguments: Aspectuals

The verb begin is syntactically polymorphic:

- Mary began [to eat her breakfast].
- Mary began [eating her breakfast].
- Mary began [her breakfast].

but semantically underspecified:

- Mary began her beer/thesis/dinner/class/homework/bath
- John enjoyed his coffee/movie/cigar/discussion/appointment

– The result is combinatorial explosion in the number of sense specifications!

Flexibility of Arguments: Concealed Questions

- John knows [that the earth is round].
- John told Mary [that she is an idiot].
- Mary realizes [that she is mistaken].

- Mary knows [what time it is].
- John knows [how old she is].
- Mary told John [where she lives].
- John told me [how old he is].

- Mary knows the time.
- John knows her age.
- Mary told John her address.
- John told me his age.

Outline of Lecture 1

Sense Enumerative Lexicon (SEL)

1. Different senses of a word are separate lexical entries
2. Different senses behave differently in composition

1. Lexical entry encodes both syntactic and semantic properties semantics

   love: love(θ_1,θ_2)

   θ_1: HUMAN, θ_2: HUMAN

1. John loves Mary.
2. Apply love(θ_1,θ_2) to Mary
3. $\Longrightarrow$ love(θ_1,Mary)
4. Apply love(θ_1,Mary) to John
5. $\Longrightarrow$ love(John,Mary)

Lexical ambiguity is handled through separate lexical entries 1/2

1. **bake** (change-of-state): bake(θ_1,θ_2)
2. **bake** (create) : bake(θ_1,θ_3)

1. John baked a potato.
2. Apply bake(θ_1,θ_2) to a potato
3. $\Longrightarrow$ bake(θ_1,a_potato)
4. Apply bake(θ_1,a_potato) to John
5. $\Longrightarrow$ bake(John,a_potato)

Lexical ambiguity is handled through separate lexical entries 2/2

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5. $\Longrightarrow$ bake(John,a_cake)

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Introducing Generative Lexicon Theory

- A lexical semantic theory that can to do better!
- Addresses the generative expressiveness of language
- Lexical meaning is fundamentally decompositional, i.e. based on the idea that words encode complex concepts that may be decomposed into simpler notions

Traditional View of Decomposition

- Decomposing the meaning into features/components/primitives
  e.g. table: inanimate, concrete, with-legs
- Other primitives:
  - animate, artifact, countable, portable, part-of(x)
  - act, cause, result, manner, motion
- But: does the verb like have two different meanings, and if so, how do you represent them?
  - John likes ice cream.
  - John likes my sister.

Generative Lexicon Theory

- The method adopted in GL to define the meaning of words is inverted!
- Instead of concentrating on how a word meaning may be decomposed, GL examines how a word meaning may compose with other meanings, and how it changes in the different contexts.
- 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.

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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.

Outline of Lecture 1

Lexical Data Structures

(1) a. LEXICAL TYPING STRUCTURE: giving an explicit type for a word positioned within a type system for the language;
b. ARGUMENT STRUCTURE: specifying the number and nature of the arguments to a predicate;
c. EVENT STRUCTURE: defining the event type of the expression and any subeventual structure it may have;
d. QUALIA STRUCTURE: a structural differentiation of the predicative force for a lexical item.

Event Types

STATE : John loves his mother.
ACCOMPLISHMENT : Mary wrote a novel.
ACHIEVEMENT : John found a Euro on the floor.
PROCESS : Mary played in the park for an hour.
POINT : John knocked on the door (for 2 minutes).

Accomplishment vs. achievement:

- Mary finished writing a novel.
- *Mary wrote a novel at 5 pm.

- *John finished finding a Euro on the floor.
- John found a Euro on the floor at 5 pm.

Event Structure

In order to account for some internal aspects of event, some events need to be decomposed into subevents:

1. kill:
   $\lambda yxe_1 e_2[\text{act}(e_1, x, y) \wedge \neg\text{dead}(e_1, y) \wedge \text{dead}(e_2, y) \wedge e_1 < e_2]$:
   The gardener killed the flower.

Event Headedness: A way of indicating a foregrounding and backgrounding of sub-event. The arguments of a headed event must be expressed.

1. arrive: $e' < e$
2. build: $e < e'$

Subevents can be combined into a single event in different ways:

1. accompany: simultaneous subevents
2. arrive: one subevent precedes the other

Argument Structure Types

1. True Arguments (ARG): Syntactically realized parameters of the lexical item;
2. Default Arguments (D-ARG): Parameters which participate in the logical expressions in the qualia, but which are not necessarily expressed syntactically; e.g. John built the house *with bricks*.
3. Shadow Arguments (S-ARG): Logical parameters which are semantically incorporated into the lexical item. They can be expressed only by operations of subtyping; e.g. Mary buttered her toast *with an expensive butter*.
4. Optional Arguments: Parameters which modify the logical expression, but are part of situational or propositional interpretation, not any particular lexical item's semantic representation. These include adjunct expressions of temporal or spatial modification.

Qualia Structure

(2) a. FORMAL: the basic category of which distinguishes the meaning of a word within a larger domain; encodes taxonomic information about the lexical item; *is-a* relation.
b. CONSTITUTIVE: the relation between an object and its material, constituent parts; *part-of* or *made-of* relation.
c. TELIC: the purpose or function of the object, if there is one; *used-for* or *functions-as* relation.
d. AGENTIVE: the factors involved in the object's origins or "coming into being"; *created-by* relation.

GL Feature Structure

$$
\begin{bmatrix}
\alpha \\
\text{ARGSTR} = \begin{bmatrix} \text{ARG1} = x \\ \ldots \end{bmatrix} \\
\text{EVENTSTR} = \begin{bmatrix} \text{EVENT1} = e1 \\ \text{EVENT2} = e2 \end{bmatrix} \\
\text{QUALIA} = \begin{bmatrix} \text{CONST} = \textbf{what } x \textbf{ is made of} \\ \text{FORMAL} = \textbf{what } x \textbf{ is} \\ \text{TELIC} = e_2\textbf{: function of } x \\ \text{AGENTIVE} = e_1\textbf{: how } x \textbf{ came into being} \end{bmatrix}
\end{bmatrix}
$$

Qualia at Work

- Mary began
  her beer / thesis / dinner / class / book / bath
- John enjoyed
  his coffee / movie / cigar / discussion / appointment
- Jessica started the car
  Jessica locked the car

GL Solution

- In GL, identifying the meaning of words requires a system of lexical representation that allows words to change their meaning in different contexts
- But! Maintains the distinction between word meaning and world knowledge: this is what qualia structure aims to accomplish.

Generative Lexicon Model

GL uses argument typing and qualia structure to model compositionality.

Main analytic tools:

- Qualia Structure
- Coercion Mechanisms (type shifting operations)

In GL, we look at the way the meanings are put together, and use these tools to understand analytically how it is done.

Lecture 2

Formal foundations. Argument Structure. Qualia Structure.

September 9, 2014

Outline of Lecture 2

Outline of Lecture 2

Lexical Data Structures

(3) a. LEXICAL TYPING STRUCTURE: giving an explicit type for a word positioned within a type system for the language;
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c. EVENT STRUCTURE: defining the event type of the expression and any subeventual structure it may have;
d. QUALIA STRUCTURE: a structural differentiation of the predicative force for a lexical item.

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$$\left[\begin{array}{l} \alpha \\ \text{ARGSTR} = \left[\begin{array}{l} \text{ARG1} = x \\ \ldots \end{array}\right] \\ \text{EVENTSTR} = \left[\begin{array}{l} \text{EVENT1} = e1 \\ \text{EVENT2} = e2 \end{array}\right] \\ \text{QUALIA} = \left[\begin{array}{l} \text{CONST} = \textbf{what } x \textbf{ is made of} \\ \text{FORMAL} = \textbf{what } x \textbf{ is} \\ \text{TELIC} = e_2\textbf{: function of } x \\ \text{AGENTIVE} = e_1\textbf{: how } x \textbf{ came into being} \end{array}\right] \end{array}\right]$$

Qualia at Work

- Mary began
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Main analytic tools:

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Outline of Lecture 2

Motivation for Qualia

Motivation for Qualia relations comes from the idea that there is a *hidden event* in the lexical representation associated with nouns denoting objects made for a particular purpose:

(5) a. a door is for walking through
b. a window is for seeing through
c. a book is for reading
d. a beer is for drinking
e. a cake is for eating
f. a car is for driving
g. a table is for putting things on
h. a desk is for working on
i. a pen is for writing with

Motivation for Qualia

In certain syntactic contexts an event appears to be present in the interpretation of a noun, without being expressed in the syntax:

(6) a. They finished the beer. (drinking / TELIC)
    b. They finished the house. (building / AGENTIVE)

(7) a. a comfortable chair (to sit on)
    b. comfortable shoes (to wear, to walk in)
    c. a comfortable bed. (to sleep on)

(8) a. a dinner dress (wearing)
    b. a dessert wine (drinking)
    c. the dinner table (eating at)

This event is not arbitrary, but depends on the semantics of noun.

Light Verbs and Noun-to-Verb Transformations

- Light verb specifications:
  - i. Take a tablet (TELIC = ingest)
  - ii. Take a train (TELIC = travel with)
- Noun-to-Verb transformations:
  - a. fax a document: (TELIC = send)
  - b. microwave the chicken: (TELIC = cook)
  - c. lace the shoes: (TELIC = tie)

Required Adjuncts?

Required adjuncts in short passives, middles and past participle constructions:

(9) Short passives (AGENTIVE(picture) = paint):
a. *This picture was painted.
b. This picture was painted in 1604.

(10) Middles (TELIC(book) = read):
a. *This book reads.
b. This book reads easily.

(11) Adjectival Use of Past Participles (AGENTIVE(house) = build):
a. *a built house;
b. a recently built house.

Qualia Structure

Qualia roles capture different properties of objects insofar as they are reflected in the language:

(12) a. FORMAL: taxonomic information, i.e. information about its basic conceptual category.
b. CONSTITUTIVE: information about material and parts of objects.
c. TELIC: information about the purpose and function of the object.
d. AGENTIVE: information about the origin / creation of the object.

World Knowledge vs. Lexical Specification

Not world knowledge, but just the knowledge relevant for understanding linguistic expressions:

- Our knowledge that bread as something that is brought about through baking is considered a Quale of the word bread;
- This knowledge is exploited in our understanding of linguistic expressions, such as fresh bread, meaning bread which has been baked recently.

Unspecified Qualia Roles

Not all lexical items carry a value for each qualia role:

- Some are left unspecified
- Others are populated with more than one value.

Natural objects (e.g., rock, fish, air, sea) typically do not have a value for the Agentive Quale, since the objects they reference are not products of human creation.

Qualia Roles for Artifactuals

Artifacts are created by humans, for a purpose:

(13) $\begin{bmatrix} \textit{letter} \\ \text{QUALIA} = \begin{bmatrix} \text{T} = \textbf{read} \\ \text{A} = \textbf{write} \end{bmatrix} \end{bmatrix}$

Qualia Roles for house

(14) a. He owns a two-story house. (house as artifact (F))
b. Lock your house when you leave. (part of house, door (C))
c. We bought a comfortable house. (purpose of house (T))
d. The house is finally finished. (origin of house (A))

$$\begin{bmatrix} \textit{house} & \\ \text{QUALIA} = & \begin{bmatrix} \text{F} = \textbf{building} \\ \text{C} = \{\textbf{door, rooms, ...}\} \\ \text{T} = \textbf{live\_in} \\ \text{A} = \textbf{build} \end{bmatrix} \end{bmatrix}$$

Constitutive Quale for car

(15) a. John started the car. / engine
b. You should warm your car up in winter. / engine
c. Did you lock the car? / door
d. The car screeched down the road. / tires
e. I'm going to fill up the car. / tank

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

Criteria for Identifying Qualia Value

Distribution of nouns in context is the key:

(16) a. The rock shattered the window.
b. Wooden windows are prone to rotting.

$$\begin{bmatrix} \textit{window} \\ \text{QUALIA} = \begin{bmatrix} \text{C} = \{\textbf{pane, frame, ...}\} \end{bmatrix} \end{bmatrix}$$

What's Encoded in Lexical Entry?

When language accesses the component parts of a word's meaning with systematic regularity, there is reason to think that those parts are encoded in the lexical semantics for that word.

E.g. Car in subject position occurs with verbs denoting human actions:

(17) a. The car is waiting in the driveway.
b. A car honked from behind.

Cars and Drivers

- Sense extension from the car to its driver (*metonymy*) suggests that this information is not only part of our world knowledge but is in fact encoded in the lexical entry (as an argument to the the Telic) and available for syntactic selection:

$$\begin{bmatrix} \textit{car} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{vehicle} \\ \text{T} = \textbf{drive(human,vehicle)} \end{bmatrix} \end{bmatrix}$$

Lexically Encoded Metonymy

House and café ar often used to refer to the people who live in or work there:

(18) a. Do you want to wake up the whole house?
b. The rest of the house was sleeping.
c. You had the whole café laughing.

Such data provide evidence for specific TELIC values for these noun concepts:

- live_in(human,building)
- eat_in(human,building).

$$\begin{bmatrix} \textit{house} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{building} \\ \text{T} = \textbf{live\_in(human, building)} \end{bmatrix} \end{bmatrix}$$

Relevant Linguistic Phenomena

- Contextual modulations of noun meaning: start/lock the car
- Implicit predicates in syntactic constructions:
  Verb-Noun: finish the beer/house
  Adjective-Noun: comfortable chair/shoes
  Noun-Noun: dinner dress/table
- Flexibility of light verbs support verb constructions:
  take a tablet/a train
- Noun-to-Verb transformations:
  microwave = cook
- Required adjuncts in short passives, middles and past participle constructions

Formal Quale

Formal quale establishes a relation between the entity denoted by a word (e.g., dog) and the category it belongs to (i.e., ANIMAL):

Lexical Type Taxonomy

taxonomy-eps-converted-to.pdf

Formal Attributes for Concrete Entities

Salient properties of the entity are inherited along the *is-a* relations in this lexical hierarchy:

(19) a. Spatial characteristics, intrinsic orientation;
b. Size and dimensional properties;
c. Shape and form;
d. Color.

Const / part-of Relation

CONST Quale specifies only those parts of an entity that are relevant for the linguistic behavior of the noun:

(20) a. John was going to paint his room ([CONST = walls]).
b. She has swept the room ([CONST = floor]).

$$\begin{bmatrix} \textit{room} & \\ \text{QUALIA} = & \begin{bmatrix} \text{F} = \textbf{space} \\ \begin{bmatrix} \text{C} = \{\textbf{walls, floor, ceiling, ...}\} \\ \text{C}_{I} = \textbf{building} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

a. Parts are available in discourse as individual units;
b. Parts make a functional contribution to the entity;
c. Parts are cognitively salient.

Genitive Construction for part-of Constitutive Quale

Nouns may express one of the default values of CONST syntactically, as in a genitive construction:

a. John was going to paint the room's walls.

b. John was going to paint the walls of the room.

Constitutive material / made-of Relation

FORMAL role can be both modified and referenced by spatial predicates:

(21) a. They crossed the river. ([FORMAL = space])
b. The river is wide. ([FORMAL = space])

The CONSTITUTIVE value can be referenced directly:

(22) a. The river had frozen during the severe weather.
CONST = water
b. The river became polluted.
CONST = water

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

Expressing made-of Constitutive Quale

Adjectival modifiers:

(23) a. a golden ring;
b. a wooden floor;
c. a metallic paint.

Nominal compounds:

(24) a. plastic bag
b. paper cup
c. leather shoes
d. milk chocolate

$$\begin{bmatrix} \textit{plastic bag} & \\ \text{QUALIA} = & \begin{bmatrix} \text{F} = \textbf{bag} \\ \text{C} = \textbf{plastic} \end{bmatrix} \end{bmatrix}$$

Telic Quale

Information about intended use of objects (potential, characteristic activity) is encoded in the noun:

(25) a. This pen does not work well. (does not write)
b. Can I use your pen? (for writing)
c. We skipped (eating) the cake and settled for (drinking) another coffee.

(26) a. This is a difficult problem (to solve)
b. This is a difficult question (to answer)

(27) a. Your lunch is ready (to eat).
b. Your car is ready (to drive).

Telic Quale with -able Adjectives

-able adjectives to impose a specific interpretation on the Telic activity of the noun:

(28) a. There is no drinkable water here. (good for drinking)
b. This is a very readable text-book. (easy to read)

– NB: Not water than can be drunk!

Natural Telic

Telic of nouns like human, dog, water, encodes information about the properties and actions they engage in, not intension or purpose:

(29) a. Humans breathe/think.
b. Rivers flow.
c. The heart pumps blood.

– It is not the intentional purpose of a heart to pump blood, but it is a necessary activity for the object so defined. Likewise, 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.

(30) a fast/rapid/slow/lazy river (flowing)
a slow/lazy student

Agentive Quale

Distinguishes between created and naturally occurring objects:

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

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

a. fresh coffee (AGENTIVE = brew)
b. fresh water (in contrast to "salt water")

Agentive Quale for Abstract Entities

$$\begin{bmatrix} \textit{idea} \\ \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{proposition} \\ \text{A} = \textbf{think} \end{bmatrix} \end{bmatrix}$$

Redundancy of Modification by Quale

Modifications of a noun by its quale is ungrammatical due to redundancy:

(31) a. *baked bread (AGENTIVE = bake) / a freshly baked bread
b. *a built house (AGENTIVE = build) / a well-built house
c. *a written book (AGENTIVE = write) / a beautifully written book

This effect is similar to the effect of properties inherited via the is-a hierarchy of FORMAL relations:

(32) a. *a male bachelor
b. *a female woman

Extended Qualia

- Telic
  - Direct telic: the entity is the object of activity
    e.g. beer is the object of drinking
  - Indirect telic: the entity is not a direct object
    - Instrument telic:
      e.g. One cuts with a knife
    - Agentive noun telic (natural telic?):
      e.g. drummer is someone who plays drums
- Constitutive
  - Constitutive: *has-part, made-of* relation
    e.g. spoon is made out of silver
    e.g. crowd consists of people
  - Inverse constitutive: *is-part* relation
    e.g. engine is part of a car

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    e.g. engine is part of a car

Qualia Exploitation in Direct Object Position

- chi dawan 'eat a big bowl'
  use a big bowl to eat
  – INSTRUMENT TELIC
- chi shitang 'eat the dining hall'
  eat at the dining hall
  – INDIRECT TELIC

Conventionalized attributes

Conventionalized attributes (CA) extend qualia structure:

- Conventional, prototypical use; conventional way of experiencing something.
  e.g. water is used for drinking; but it's not its function

Customary, habitual, stereotypical activities:

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

Telic Quale vs. Conventionalized Attribute

TELICS:

a. Mary is a fast typist. (TELIC = type)

b. This Porsche is a fast car. (TELIC = drive)

Conventionalized or customary activities:

a. The tuna is one of the fastest fish in the sea. (swimming)

b. John was the fastest boy in the school. (running)

Perception predicates exploit CA

- hear the dog (barking)
- hear the rain (falling, hitting the roof)
- hear the wind (blowing)
- listen to the birds (singing)
  – but they are not FOR singing; cf. weak quale by Busa
- hear the car (pull in, making noise)
- hear the door (doorbell ring)

Outline of Lecture 2

Argument Structure

Argument types:

- true, default, shadow arguments

Type of the predicate is defined by virtue of the arguments it selects.

Argument structure specification:

- Predicates and predicative nouns:
  - number, type, syntactic expression of the arguments
- Non-predicative nouns: no argument structure specified.
- Sortal nouns would take referential arguments:

  chair(x)

Compositionality as a Function Application

1. What is the nature of the function?
2. What does it apply to; i.e., what can be an argument?

- John loves Mary. *John loves.
- love(Arg_1,Arg_2)
- Apply love(Arg_1,Arg_2) to Mary
  $\Longrightarrow$ love(Arg_1,Mary)
- Apply love(Arg_1,Mary) to John
  $\Longrightarrow$ love(John,Mary)

Lambda notation

- Meaning for John loves Mary $\Longrightarrow love(John, Mary)$
- Meaning for love $\Longrightarrow \lambda xy.love(x, y)$

Selection in a Compositional Theory

1. What elements can select?
2. What is an argument?
3. What does it mean for a predicate to select an argument?
4. How does selection relate to composition and lexical decomposition?

Verb Meaning

(1) a. Verb: V How do we decompose the meaning?
b. Arguments: x, y, z, ...

(2) a. Body: the predicate, with bound variables.
b. Arguments: the parameter list.

$$\overbrace{\lambda x_i}^{Args}\ \overbrace{[\Phi]}^{Body}$$

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$$\overbrace{\lambda x_i}^{Args}\ \overbrace{[\Phi]}^{Body}$$

Decomposition Strategies

1. atomic predication: do nothing, $P(x_1)$
2. add arguments: $P(x_1) \Longrightarrow P(x_1, x_2)$
3. split the predicate: $P \Longrightarrow P_1, P_2$
4. add and split: $P(x_1) \Longrightarrow P(x_1, x_2), P_2(x_2)$

Atomic Predication

Syntax mirrors argument structure:

$$\text{Verb}(\text{Arg}_1, \ldots, \text{Arg}_n) \iff \lambda x_n \ldots \lambda x_1[\Phi]$$

1. $\lambda x[\text{die}(x)]$
   The flower died.
2. $\lambda y \lambda x[\text{hit}(x, y)]$
   The car hit the wall.

Add Arguments

Parameter structure adds additional arguments for interpretation in the model:

$$\lambda x_m \ldots \lambda x_{n+1} \lambda x_n \ldots \lambda x_1 [\Phi] \Longrightarrow \text{Verb}(\text{Arg}_1, \ldots, \text{Arg}_n)$$

1. $\lambda y \lambda x \lambda e[\text{kill}(e, x, y)]$: (Davidson, 1967)
   The gardener killed the flower.
2. $\lambda l_2 \lambda l_1 \lambda x \lambda e[\text{go}(e, x, l_1, l_2)]$: (Hobbs, 1993)
   Nicholas went to China.
3. $\lambda t_2 \lambda t_1 \lambda l \lambda y \lambda x[\text{teach}(x, y, t_1, t_2, l)]$: (TimeML'07)
   Graham taught for an hour in Boston.

Split The Predicate

P is defined as a complex expression of subpredicates over the parameter:

$$\text{Verb}(\text{Arg}_1) \Longrightarrow \lambda x[\Phi_1, \ldots \Phi_k]$$

1. die: $\lambda x[\text{alive}(x) \wedge \text{Become}(\neg\text{alive}(x))]$
   The flower died.
2. bachelor: $\lambda x[\text{male}(x) \wedge \text{person}(x) \wedge \text{adult}(x) \wedge \neg\text{married}(x)]$

Add and Split

Parameter structure is enhanced, and P is defined as a complex of subpredicates:

$$\text{Verb}(\text{Arg}_1, \ldots, \text{Arg}_n) \implies \lambda x_m \ldots \lambda x_{n+1} \lambda x_n \ldots \lambda x_1 [\Phi_1, \ldots \Phi_k]$$

1. kill:
   $\lambda y x e_1 e_2 [\text{act}(e_1, x, y) \wedge \neg \text{dead}(e_1, y) \wedge \text{dead}(e_2, y) \wedge e_1 < e_2]$:
   The gardener killed the flower.

Argument Typing as Abstracting from the Predicate

Richer typing for arguments:

1. Identifies specific predicates in the body of the expression that are characteristic functions of an argument;
2. pulls this subset of predicates out of the body, and creates a *pretest* to the expression as a restricted quantification over a domain of sorts, denoted by that set of predicates.

Types from Predicative Content

$$\lambda x_2 \lambda x_1 [\Phi_1, \ldots \overbrace{\Phi_{x_1}}^{\tau}, \ldots \overbrace{\Phi_{x_2}}^{\sigma}, \ldots, \Phi_k]$$

$$\lambda x_2 : \sigma \; \lambda x_1 : \tau [\Phi_1, \ldots, \Phi_k - \{\Phi_{x_1}, \Phi_{x_2}\}]$$

σ and τ have now become reified as types on the arguments.

A Flexible Strategy of Selection

Arguments can be viewed as encoding pretests for performing the action in the predicate.

> If the argument condition (i.e., its type) is not satisfied, the predicate either:
>
> - fails to be interpreted (strong selection);
> - coerces its argument according to a given set of strategies.

Lecture 3

Formal foundations. The notion of types

September 12, 2014

Outline of Lecture 3

Outline of Lecture 3

Outline of Lecture 3

Function Application

(1) a. Verb: V How do we decompose the meaning?
b. Arguments: x, y, z, ...

(2) a. Body: the predicate, with bound variables.
b. Arguments: the parameter list.

$$\overbrace{\lambda x_i}^{Args} \overbrace{[\Phi]}^{Body}$$

λ-Function Formalism

- $\lambda y : p \bullet i \lambda x : e_N[\textit{read}(\mathrm{x,y})]$
- $\lambda x : f(x)$
- $\lambda x : x^2$
- $\lambda x > 0 : \sqrt{(x)}$
- $\lambda x \lambda y : x < y$
- MEANING(read) = $\lambda y : p \bullet i \lambda x : e_N[\textit{read}(\mathrm{x,y})]$

λ-Function Formalism

- $\lambda y : p \bullet i \lambda x : e_N$[*read*(x,y)]
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- MEANING(read) = $\lambda y : p \bullet i \lambda x : e_N[read(\text{x,y})]$

λ-Function Formalism

- $\lambda y: p \bullet i \lambda x: e_N[$*read*$(x,y)]$
- $\lambda x : f(x)$
- $\lambda x : x^2$
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λ-Function Formalism

- Function typing:
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- We want a similar representation for
  - sleep = $\lambda y : e_N[sleep(x)]$
  - love Mary = $\lambda y : e_N[love(x, Mary)]$

– both are functions of one argument, typed e_N.

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λ-Function Formalism

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Outline of Lecture 3

Formal Quale

Formal quale specifies an is-a relation between the entity denoted by a word (e.g., dog) and the category it belongs to (i.e., ANIMAL).

- The basic category associated with the word (i.e., its semantic type);
- The position of the word in the hierarchy of types following from this association;
- The salient properties which enter into the definition of the type, which are inherited by the word along the Formal role.

Formal Attributes for Concrete Entities

Salient properties of the entity are inherited along the *is-a* relations in this lexical hierarchy:

(33) a. Spatial characteristics, intrinsic orientation;
b. Size and dimensional properties;
c. Shape and form;
d. Color.

Each attribute may be filled with a value
– e.g. long red dress

Formal Subsumption Relations Expressed in Language

FORMAL–specific Constructions:

(34) a. NP such as NP: events such as lectures, walks, tours and meetings;
b. such NP as NP: such areas as children's playground;
c. NP and other NP: rum and other spirits;
d. NP or other NP: insects or other animals
e. NP, including NP: recyclable materials including glass;
f. NP, especially NP: cool temperate countries especially Europe and North America;
g. favorite NP is NP: Mario's favorite food is pasta.

Inheritance of Formal Attributes

- Lexical meaning often provides default values for the different Formal factors or attributes.
- Default values are inherited properties of entities, that distinguish them within larger domain:

→ Size value associated with the noun ant is small, when evaluated relative to the superordinate class for the noun insect.

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$\rightarrow$ Size value associated with the noun ant is small, when evaluated relative to the superordinate class for the noun insect.

Update of Default Formal Attribute Values

Default values may be updated from discourse context in composition:

> large ant, context makes us update the value of the Size factor from small (default) to large (for an ant)

Category and ontological classification information specified in the Formal role gives us a way to constrain the interpretation of relative interpretations of Size:

> a large ant vs. a small dog,

Outline of Lecture 3

Outline of Lecture 3

Lexical Data Structures

(35) a. LEXICAL TYPING STRUCTURE: giving an explicit type for a word positioned within a type system for the language;
b. ARGUMENT STRUCTURE: specifying the number and nature of the arguments to a predicate;
c. EVENT STRUCTURE: defining the event type of the expression and any subeventual structure it may have;
d. QUALIA STRUCTURE: a structural differentiation of the predicative force for a lexical item.

Qualia Structure

(36) a. FORMAL: the basic category of which distinguishes the meaning of a word within a larger domain; encodes taxonomic information about the lexical item; *is-a* relation.
b. CONSTITUTIVE: the relation between an object and its material, constituent parts; *part-of* or *made-of* relation.
c. TELIC: the purpose or function of the object, if there is one; *used-for* or *functions-as* relation.
d. AGENTIVE: the factors involved in the object's origins or "coming into being"; *created-by* relation.

GL Feature Structure

$$
\begin{bmatrix}
\alpha \\
\text{ARGSTR} = \begin{bmatrix} \text{ARG1} = x \\ \ldots \end{bmatrix} \\
\text{EVENTSTR} = \begin{bmatrix} \text{EVENT1} = e1 \\ \text{EVENT2} = e2 \end{bmatrix} \\
\text{QUALIA} = \begin{bmatrix} \text{CONST} = \textbf{what } x \textbf{ is made of} \\ \text{FORMAL} = \textbf{what } x \textbf{ is} \\ \text{TELIC} = e_2\textbf{: function of } x \\ \text{AGENTIVE} = e_1\textbf{: how } x \textbf{ came into being} \end{bmatrix}
\end{bmatrix}
$$

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

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

Outline of Lecture 3

Three Categories of Types

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Typing for Major Categories

1. Noun
   N: rock, water, woman, tiger, tree
   A: knife, beer, husband, dancer
   C: book, lunch, university, temperature
2. Verb
   N: fall, walk, rain, put, have
   A: donate, spoil, quench
   C: read, perform
3. Adjective
   N: red, large, flat
   A: useful, good, effective

Outline of Lecture 3

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 taxonomy:
2. *physical*, *human*, *stick*, *lion*, *pebble*
3. *water*, *sky*, *rock*

Taxonomy of Natural Entity Types

taxonomy-eps-converted-to.pdf

Motivating the Notion of Natural Kind

a. Nominal Predication: How the common noun behaves predicatively;
b. Adjectival Predication: How adjectives modifying the the common noun can be interpreted;
c. Interpretation in Coercive Contexts: How NPs with the common noun are interpreted in coercive environments.

Motivating Evidence

Natural kinds seem to behave similarly to to artifactuals in adjectival constructions or as nominal heads:

a. Mary saw every dog/pet.

b. John visited a man/doctor.

c. Birds/planes can fly.

a. a sick dog/pet

b. an American man/doctor

c. white birds/planes

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Predicative Uniqueness

Natural kinds appear to require predicative uniqueness:

a. Otis is a dog.

b. Otis is a poodle.

b. Eno is a cat.

a. ?Otis is a dog and and an animal.

b. !That is a dog and a cat.

c. Otis is a dog and therefore an animal.

– *and-therefore* construction is acceptable for sortal terms of which the first is a subcategory of the second.

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Predicative Uniqueness Elsewhere

For adjectives, restriction on co-predication is only present for terms in the same domain:

a. !This box is large and small. (size)

b. !Your gift is round and square. (shape)

c. bright and red; long and thin; flat and smooth

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Co-Predication in Artifactuals

Artifactuals, occupational terms, agentive nominals co-predicate easily:

a. This is both a pen and a knife.
b. The substance is a stimulant and an anti-inflammatory.

a. Mary is a housewife and a doctor.
b. Bernstein was a composer and a conductor.

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Predicative Uniqueness

This restriction on co-predication suggests that natural kind terms are structured in a taxonomy, obeying a complementary partitioning of the conceptual space.

1. !That is a dog and a cat.

Multiple Inheritance

Subsumption constructions indicate multiple inheritance:

a. This object is a knife and therefore a weapon.
b. Emanuel Ax is a pianist and therefore a musician.
c. Emanuel Ax is a pianist and therefore a human.

Multiple Inheritance for Naturals and Artifactuals

Ambiguity of Adjectival Modification

For artifactuals and agentives, adjectival modification can be ambiguous (e.g. between physical and non-physical attribute):

a. a blue pen (ink or material? CONST or FORMAL?)
b. a bright bulb
c. a long CD

a. a very old friend
b. a good professor
c. such a beautiful dancer

No such ambiguity is possible for natural kinds:

a. very old gold
b. a new tree
c. a young tiger
d. such a beautiful flower

Availability of Default Interpretation

a. Mary enjoyed drinking her beer.
b. Mary enjoyed her beer.

a. John began to write his thesis.
b. John began writing his thesis.
c. John began his thesis.

a. !John finished the tree.
b. !Mary began a tiger.

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*: $e_N \rightarrow (e_N \rightarrow t)$

Expressed as typed arguments in a lambda-expression:

a. $\lambda x : e_N[$*fall*$(\text{x})]$

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

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

Outline of Lecture 3

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*: $(phys \otimes_a build) \otimes_t live\_in$

Human Functional Entity Types

TELIC and AGENTIVE constraints on the Natural Type HUMAN:

a. boss, friend;

b. dancer: *human* $\otimes_t$ *dance*

c. wife, husband: *human* $\otimes_a$ *marry*

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

- The beer spoiled.
- Mary fixed the watch.

Outline of Lecture 3

Complex Entity Types

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

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:

> We had a delicious leisurely lunch.

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 • Phys): 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.

Dot Object Inventory: 4

1. 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.
2. Process•Result: construction, depiction, imitation, portrayal, reference
   a. Linnaeus's classification of the species took 25 years.
   b. Linnaeus's classification contains 12,100 species.

Distinct Principles of Individuation in Dot Objects

1. a. John read every book in the library.
   b. John stole every book in the library.
2. a. Mary answered every question in the class.
   b. Mary repeated every question in the class.

Copredication with Dot Objects: 1

1. Today's lunch$_2$ was longer than yesterday's [___]$_1$.

lunch2-eps-converted-to.pdf

Copredication with Dot Objects: 2

1. Today's lunch$_2$ was longer than yesterday's [__]$_1$.

lunch-eps-converted-to.pdf

Copredication with Different Dot Object Elements

1. !Today's lunch$_2$ was longer than yesterday's [___]$_1$.

lunch3-eps-converted-to.pdf

Complex Predicate Types

Predicates formed with a Complex Entity Type as an argument:

1. *read*: $phys \bullet info \to (e_N \to t)$
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.

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Lecture 4

Mechanisms of Compositionality

September 12, 2014

Outline of Lecture 4

Outline of Lecture 4

Three Categories of Types

- Natural Types: Carry only FORMAL and CONST qualia specifications;
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Three Categories of Types

- Natural Types:
  - Entities: formed from the application of the FORMAL and/or CONST qualia roles:
    physical, *human*, *lion*, *stone*, *pebble*
  - Predicates: formed with Natural Entities as arguments:
    fall: $e_N \rightarrow t$
    touch: $e_N \rightarrow (e_N \rightarrow t)$
- Artifactual Types:
  - Entities: formed from Naturals by adding an AGENTIVE and/or TELIC qualia roles; CONST qualia roles:
    beer: $(liquid \otimes_a brew) \otimes_t drink$
    wife, husband: $human \otimes_a marry$
  - Predicates: formed with Artifactual Entities as arguments:
    spoil: $e_N \otimes_t \tau \rightarrow t$
    fix: $e_N \otimes_t \tau \rightarrow (e_N \rightarrow t)$

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    fix: $e_N \otimes_t \tau \rightarrow (e_N \rightarrow t)$

Three Categories of Types

- Natural Types:
  - Entities: formed from the application of the FORMAL and/or CONST qualia roles:
    physical, *human*, *lion*, *stone*, *pebble*
  - Predicates: formed with Natural Entities as arguments:
    fall: $e_N \rightarrow t$
    touch: $e_N \rightarrow (e_N \rightarrow t)$
- Artifactual Types:
  - Entities: formed from Naturals by adding an AGENTIVE and/or TELIC qualia roles; CONST qualia roles:
    beer: $(liquid \otimes_a brew) \otimes_t drink$
    wife, husband: $human \otimes_a marry$
  - Predicates: formed with Artifactual Entities as arguments:
    spoil: $e_N \otimes_t \tau \rightarrow t$
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Outline of Lecture 4

Dot Objects / Complex Types

1. If σ and τ are types, then so is $\sigma \bullet \tau$.
2. When a single word or phrase has the ability to appear in selected contexts that are contradictory in type specification:

   We had a delicious leisurely lunch.
3. Each component type of the dot object has its own separate qualia specification, providing available interpretations in selection.

Book

CONST for INFO: chapters, paragraphs, ..

CONST for PHYS: pages, cover, paper, ...

University

CONST for ORGANIZATION: schools, departments, faculties, ..

CONST for LOCATION: buildings, rooms, ...

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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.

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.

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.

Dot Type Inventory

Dot type	Example
ACTION • PROPOSITION	promise, allegation, lie, charge
STATE • PROPOSITION	belief
ATTRIBUTE • VALUE	temperature, weight, height, strength
EVENT•(INFO • PHYSOBJ)	lecture, play, seminar, exam, quiz, test
EVENT • (INFO • SOUND)	concert, sonata, symphony, song
EVENT • PHYSOBJ	lunch, breakfast, dinner, tea
INFO • PHYSOBJ	article, book, CD, DVD, dictionary, diary, email, essay, letter, novel, paper
ORGANIZATION • (INFO • PHYSOBJ)	newspaper, magazine, journal
ORGANIZATION • LOC • HUMANGROUP	university, city
EVENT • LOCATION • HUMANGROUP	class
APERTURE • PHYSOBJ	door, window

Dot Type Inventory

Dot type	Example
PROCESS • RESULT	construction, imitation, portrayal, reference, decoration, display documentation, drawing, enclosure, entry, instruction, invention, simulation, illustration, agreement, approval, recognition, damage, compensation, contribution, discount, donation, acquisition, deduction, endowment, classification, purchase
PRODUCER • PRODUCT	Honda, IBM, BMW
TREE • FRUIT / TREE • WOOD	apple, orange, coffee / oak, elm, pine
ANIMAL • FOOD	anchovy, catfish, chicken, eel, herring, lamb, octopus, rabbit, squid, trout
CONTAINER • CONTENTS	bottle, bucket, carton, crate, cup, flask, keg, pot, spoon

Copredication with Dot Objects: 1

1. Today's lunch$_2$ was longer than yesterday's [__]$_1$.

lunch2-eps-converted-to.pdf

Copredication with Dot Objects: 2

1. Today's lunch$_2$ was longer than yesterday's [__]$_1$.

lunch-eps-converted-to.pdf

Copredication with Different Dot Object Elements

1. !Today's lunch$_2$ was longer than yesterday's [__]$_1$.

lunch3-eps-converted-to.pdf

Gating Predicates for Complex Types

For some complex types there are gating predicates that specify a transition between two simple types that make up the complex type:

> She dictated a letter.
>
> She cooked a frog.

Dot Object Disambiguators

The verb dictate has two main senses:
(1) verbalize to be recorded, and
(2) control

Direct objects for the first sense:

(37) a. passage, story, letter, memoirs, novel
b. message, words, work, point

The nouns in (a) can not be dictated in the "control" sense.
The nouns in (b) are ambiguous between two senses.
The good disambiguators are actually dot objects of type INFO • PHYSOBJ, with dictate functioning as a gating predicate, which requires for the information to be given physical form.

Asymmetry of Dots

The use of complex types in text suggests that there is an inherent asymmetry in the way dot objects are used. This asymmetry is consistent with the systematic relation between the senses, where each sense corresponds to one of the component types. For example, for the ANIMAL • FOOD nominals, the subject position tends to disprefer the FOOD sense, whereas in the object position, such nominals occur both with the FOOD- and the ANIMAL-selecting predicates, as well as with the gating predicates. In the object position, the FOOD selectors and the gating predicates tend to dominate:

(38) chicken.n

subject

a. ANIMAL: peck, look, wander, come, cross, follow, die

object

a. ANIMAL: count, chase, kill, shoot, slaughter, skin, pluck, sacrifice, throw

b. FOOD: eat, serve, prefer, turn, dip, stuff, carve, baste, roast, simmer

c. ANIMAL • FOOD: poach, cook

Asymmetry of Dots

A similar asymmetry can be seen with respect to different argument positions for such dot types as PROCESS • RESULT, EVENT • PROPOSITION, etc. For example, adjectival modifiers for construction (PROCESS • RESULT) tend to select for RESULT, whereas the predicates that take *construction* as direct object tend to select for PROCESS. Similarly, for allegation (EVENT • PROPOSITION), the PROPOSITION interpretation is preferred in the object position.

Asymmetry of Dots

(39) construction.n

object

EVENT: finance, oversee, complete, supervise, halt, permit, recommend enable, delay, stimulate

PHYSOBJ: examine, build, inaugurate, photograph

adjectival modifier

PHYSOBJ: logical, syntactic, passive, solid, all-metal, geometric, hybrid, rugged, sturdy, artificial, cultural, imaginative

Asymmetry of Dots

(40) allegation.n
object
EVENT: face, fuel, avoid, deflect
PROPOSITION: deny, refute, counter, contain, substantiate, rebut, confirm, believe, corroborate, hear, dispute, broadcast, prove

Asymmetry of Dots

Generic asymmetry of use (i.e. the asymmetry across all argument positions) is also a common property of some dot nominals. For example, such PROCESS • RESULT nominals as building, invention, acquisition show a distinct preference for one of the types in all argument positions. For building and invention, the RESULT/PHYSOBJ interpretation is much more frequent, whereas for acquisition, the PROCESS/EVENT interpretation dominates the use in all argument positions.

NB. For building, for example, plan selects for the complex type EVENT • RESULT in the object position, while abandon may select for either of the component types.

Asymmetry of Dots

(41) invention.n

object

a. RESULT: produce, explain, protect, adopt, develop, combine, patent, license, display, neglect, export, exploit

b. PROCESS: welcome, avoid, stimulate, spark, trace, facilitate, demand

subject

a. RESULT: simplify, impress, consist, popularize, appear, comprise

adjectival modifier

a. RESULT: finest, original, comic, successful, British, latest, patented, brilliant

Asymmetry of Dots

(42) building.n

object

a. PhysObj: erect, demolish, construct, occupy, restore, enter, convert, design, destroy, lease, own, renovate, surround, damage, complete

b. Event: allow, finish, oppose, accelerate, initiate, halt, commence, stop, undertake

c. Event • Result: plan

d. Event, Result: arrange, abandon

subject

a. PhysObj: house, stand, collapse, contain, survive, belong, remain, overlook, surround, fall, replace, dominate

b. Event: begin, continue, commence

c. Event • PhysObj: date

d. Event, PhysObj: accompany

Asymmetry of Dots

(43) acquisition.n

object

a. EVENT: finance, fund, complete, announce, authorize, commence, facilitate, oversee, control, approve, undertake

b. RESULT: identify, secure, seize, store, stalk

subject

a. EVENT: occur, boost, result, strengthen, increase, depend, form, take, continue, affect, result

b. RESULT: turn out, offer, comprise, bore, allow

c. EVENT • RESULT: put, increase, mean, represent, complement

Outline of Lecture 4

Outline of Lecture 4

Compositionality in Language

Principle of Compositionality (Frege 1892):

> The meaning of an expression is a function of the meanings of its parts and the way they are syntactically combined.

Strong Compositionality: allowing no semantic operations that aren't syntactic:

> Meaning of an expression is fully determined by the meanings of its constituents and by the way they combine syntactically.

Outline of Lecture 4

Tools for introducing unexpressed meanings

How do you maintain strong compositionality in the face of phenomena such as polymorphism, underspecified meanings?

Syntactic level solutions

- Adding null-elements
  – empty verbs, agentive markers to the subject, etc.
- Syntactic movement
  - Give the book to John
  - Give John the book

  – polymorphism accounted for via transformations

Polymorphisms via transformations

- Give the book to John
- Give John the book

This is an enumerative technique: you have to put in two grammar rules, disjunctively:

VP $\rightarrow$ VP PP

VP $\rightarrow$ V NP NP

But what about

- begin to-VP
- begin NP
  - Is it the same kind of polymorphism? Do we associate semantics for NP with to-VP? Normal composition can not do that! So: you need two semantic begins, as well as two syntactic begins.

Semantic representation solutions

Weak 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.

– senses multiply infinitely to account for generative expressiveness

Two ways to overcome this:

- Type Shifting Rules: Geach rule, Rooth and Partee (1982), Partee (1987), Groenendijk and Stokhof (1989).
- Type Coercion Operations: Moens and Steedman (1988), Pustejovsky (1989), Jacobson (1992), Dölling (1992), Copestake and Briscoe (1992), Hendriks (1993), Egg (1994), Ramsey (1996), de Swart (1998).

Overcoming Infinite Multiplication of Senses

Type Shifting Rules:
Dynamically generate the sense that would otherwise be cached in the sense-enumerative lexicon.

- shift begin to something that takes an NP.

Type Coercion Operations:
Type-shift the arguments!

- coerce NP to activity relating to the object.

– interpretation arises out of the semantics of the object.

Outline of Lecture 4

A Flexible Strategy of Selection

Arguments can be viewed as encoding pretests for performing the action in the predicate.

> If the argument condition (i.e., its type) is not satisfied, the predicate either:
>
> - fails to be interpreted (strong selection);
> - coerces its argument according to a given set of strategies.

Argument Typing as Abstracting from the Predicate

Richer typing for arguments:

1. Identifies specific predicates in the body of the expression that are characteristic functions of an argument;
2. pulls this subset of predicates out of the body, and creates a *pretest* to the expression as a restricted quantification over a domain of sorts, denoted by that set of predicates.

Types from Predicative Content

$$\lambda x_2 \lambda x_1 [\Phi_1, \ldots \overbrace{\Phi_{x_1}}^{\tau}, \ldots \overbrace{\Phi_{x_2}}^{\sigma}, \ldots, \Phi_k]$$

$$\lambda x_2 : \sigma \; \lambda x_1 : \tau [\Phi_1, \ldots, \Phi_k - \{\Phi_{x_1}, \Phi_{x_2}\}]$$

σ and τ have now become reified as types on the arguments.

Outline of Lecture 4

Outline of Lecture 4

Modes of Composition

a. PURE SELECTION (TYPE MATCHING): the type a function requires is directly satisfied by the argument;
b. ACCOMMODATION: the type a function requires is inherited by the argument;
c. TYPE COERCION: the type a function requires is imposed on the argument type. This is accomplished by either:
    i. *Exploitation*: taking a part of the argument's type to satisfy the function;
    ii. *Introduction*: wrapping the argument with the type required by the function.

Direct Argument Selection

- The spokesman denied the statement (PROPOSITION).
- The child threw the ball (PHYSICAL OBJECT).
- The audience didn't believe the rumor (PROPOSITION).

Paradigm Sentences

(44) Target = Natural
- a. The <u>rock</u> fell. (Source = Natural)
- b. The <u>beer</u> fell. (Source = Artifactual)
- c. The <u>book</u> fell. (Source = Complex)

(45) Target = Artifactual
- a. The <u>water</u> spoiled. (Source = Natural)
- b. The <u>beer</u> spoiled. (Source = Artifactual)
- c. The <u>bottle</u> spoiled. (Source = Complex)

(46) Target = Complex
- a. Mary read the <u>idea</u>. (Source = Natural)
- b. Mary read the <u>rumor</u>. (Source = Artifactual)
- c. Mary read the <u>book</u>. (Source = Complex)

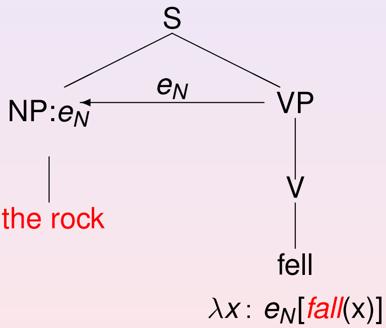
Pure Selection / Type Matching

Pure selection happens for naturals, artifactuals, and complex types alike:

- The rock fell. (NATURAL)
- The beer spoiled. (ARTIFACTUAL)
- John read the book. (COMPLEX)

Pure Selection: Natural Type

1. The rock fell.



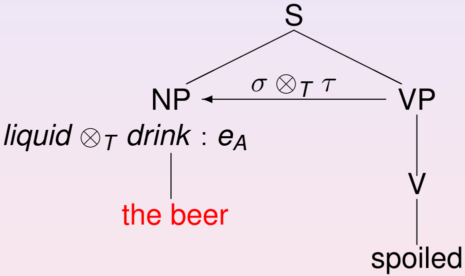
Pure Selection / Type Matching: Natural Type II

(47) a. "fall" is of type *phys* $\rightarrow$ *t*;
b. "the rock" is of type *phys* (modulo GQ type shifting);
c. Function Application (TM) applies;
$\Longrightarrow$ fall(the-rock)

(48) a. "fall" is of type *phys* $\rightarrow$ *t*;
b. "some water" is of type *liquid* (modulo GQ type shifting);
c. Accommodation Subtyping applies, *liquid* $\sqsubseteq$ *phys*:
$\Longrightarrow$ "some water" is of type *phys*:
d. Function Application (TM) applies;
$\Longrightarrow$ fall(some-water)

Pure Selection / Type Matching: Artifactual Type

1. The beer spoiled.



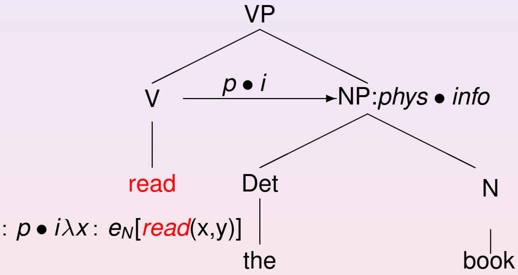
$$\lambda x : e_A[\mathit{spoil}(\mathrm{x})]$$

Pure Selection / Type Matching: Artifactual Type II

(49) a. "spoil" is of type $phys \otimes_T \tau \rightarrow t$;
b. "the beer" is of type $liquid \otimes_T drink$ (modulo GQ type shifting);
c. Accommodation Subtyping applies to the head, $liquid \sqsubseteq phys$:
$\Longrightarrow$ "the beer" has head type *phys*:
d. Accommodation Subtyping applies to the TELIC, $drink \sqsubseteq \tau$:
$\Longrightarrow$ "the beer" has TELIC type τ
e. "the beer" has type $phys \otimes_T \tau$;
f. Function Application (TM) applies;
$\Longrightarrow$ spoil(the-beer)

Pure Selection: Complex Type

1. John read the book.



Type Matching: Complex Types II

(50) a. “read” is of type $p \bullet i \rightarrow (e_N \rightarrow t)$;
b. “the book” is of type $p \bullet i$ (modulo GQ type shifting);
c. Function Application (TM) applies;
$\Longrightarrow \lambda x$ [read(x,the-book)]

Outline of Lecture 4

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

1. Entity shifts to event:
   I enjoyed the beer
2. Entity shifts to proposition:
   I doubt John.

Domain-Preserving Coercion

1. Count-mass shifting: There's chicken in the soup.
2. NP Raising: Mary and every child came.
3. Natural-Artifactual shifting: The water spoiled.
4. Natural-Complex shifting: She read a rumor.
5. Complex-Natural shifting: John burnt a book.
6. Artifactual-Natural shifting: She touched the phone.

Type Shifting in Coercion

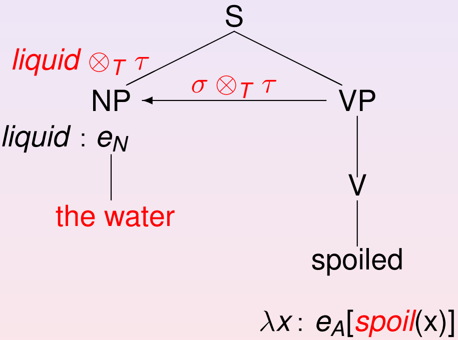
- The president denied the attack.
  EVENT $\rightarrow$ PROPOSITION
- The White House denied this statement.
  LOCATION $\rightarrow$ HUMAN
- This book explains the theory of relativity.
  PHYS • INFO $\rightarrow$ HUMAN
- The Boston office called with an update.
  EVENT $\rightarrow$ INFO

Different Kinds of Type Coercion

- The water spoiled.
  (QUALIA INTRODUCTION)
- John read the rumor.
  (NATURAL TO COMPLEX INTRODUCTION)
- Mary enjoyed her coffee.
  (EVENT INTRODUCTION)
  (QUALIA EXPLOITATION)
- The police burned the book.
  (DOT EXPLOITATION)
- Mary believes the book.
  (DOT EXPLOITATION)

Type Coercion: Qualia-Introduction on Natural Type

1. The water spoiled.

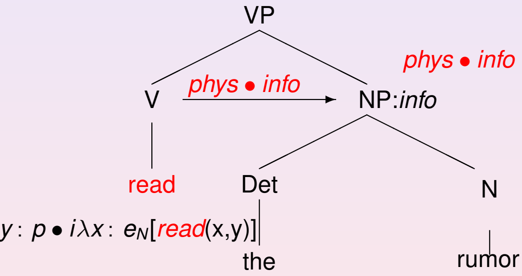


Qualia Introduction on Natural Type (II)

(51) a. “spoil” is of type *phys* $\otimes_T \tau \rightarrow t$;
b. “the water” is of type *liquid* (modulo GQ type shifting);
c. Accommodation Subtyping applies to the head, *liquid* $\sqsubseteq$ *phys*:
$\Longrightarrow$ “the water” has type *phys*;
d. Coercion by Qualia Introduction (CI-Q) applies to the type *phys*, adding a TELIC value τ:
$\Longrightarrow$ “the water” has type *phys* $\otimes_T \tau$;
e. Function Application applies;
$\Longrightarrow$ spoil(the-water)

Type Coercion: Artifactual to Complex Qualia Introduction

John read the rumor.

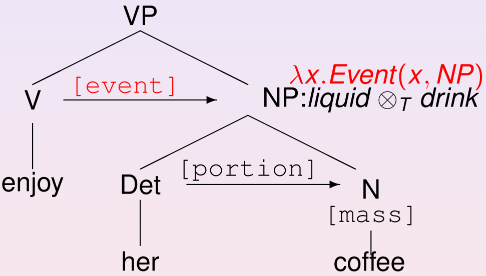


Qualia Introduction on Artifactual (II)

(52) a. "read" is of type $p \bullet i \rightarrow (e_N \rightarrow t)$;
b. "the rumor" is of type i, $i \sqsubseteq t$ (modulo GQ type shifting);
c. Coercion by Dot Introduction (CI-$\bullet$) applies to the type i, adding the missing type value, p, and the relation associated with the $\bullet$:
$\Longrightarrow$ "the rumor" has type $p \bullet i$;
e. Function Application applies;
$\Longrightarrow \lambda$x[read(x,the-rumor)]

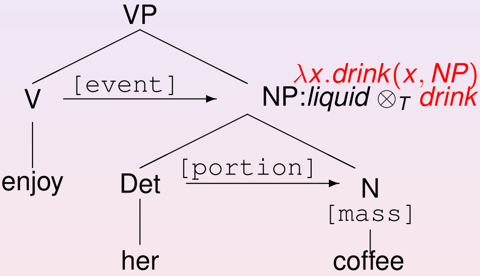
Type Coercion: Event Introduction

1. Mary enjoyed her coffee.



Type Coercion: Qualia Exploitation

1. Mary enjoyed her coffee.

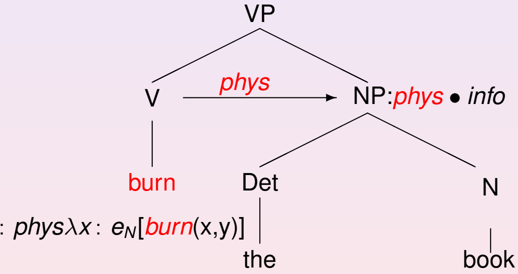


Domain-Shifting Coercion

(53) a. "enjoy" is of type *event* $\rightarrow (e_N \rightarrow t)$;
b. "her coffee" is of type *liquid* $\otimes_T$ *drink*, (modulo GQ type shifting);
c. Coercion by Introduction (CI) applies to the type *liquid* $\otimes_T$ *drink*, returning *event*:
$\Longrightarrow$ "her coffee" has type *event*;
d. Coercion by Qualia Introduction (CI-Q) applies to the type *event*, adding a value *drink* to the predicate, *P*:
$\Longrightarrow$ "her coffee" has type *event*, with *P* bound to *drink*;
e. Function Application applies;
$\Longrightarrow \lambda y$[enjoy(y,$\lambda x \exists e$[drink(e,x,her-coffee)]]

Type Coercion: Dot Exploitation

1. The police burned the book.
2. Mary believes the book.

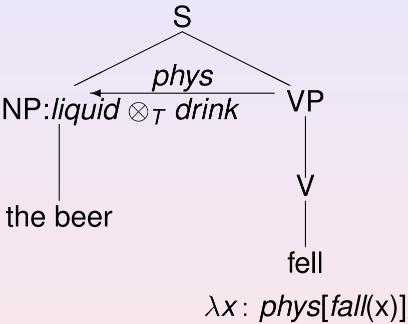


Data for Coercion by Exploitation

(54) a. The <u>beer</u> fell.
b. The <u>bottle</u> spoiled.
c. The <u>book</u> fell.
(c’. Mary bought a <u>book</u>.)

Exploitation over Artifactual 1/2

(55)

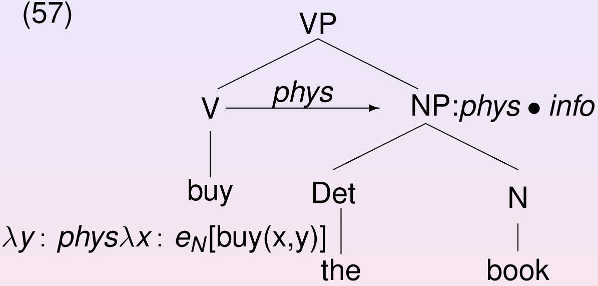


Exploitation over Artifactual 2/2

(56) a. “fall” is of type *phys* $\rightarrow$ *t*;
b. “the beer” is of type *phys* $\otimes_T \tau$ (modulo GQ type shifting);
c. Coercion by Exploitation (CE) applies to *liquid* $\otimes_T \tau$:
$\Longrightarrow$ “the beer” has type *liquid*;
d. Accommodation Subtyping (AS) applies to head, *liquid* $\sqsubseteq$ *phys*:
$\Longrightarrow$ “the beer” has type *phys*:
e. Function Application applies;
$\Longrightarrow$ fall(the-beer)

Coercion by Dot Exploitation 1/2

(57)



Coercion by Dot Exploitation 2/2

(58) a. "buy" is of type $phys \rightarrow (e_N \rightarrow t)$;

b. "the book" is of type $phys \bullet info$, (modulo GQ type shifting);

c. Coercion by Dot Exploitation (CE-•) applies to the type $phys \bullet info$, returning *phys*:

$\Longrightarrow$ "the book" has type *phys*;

e. Function Application applies;

$\Longrightarrow \lambda$x[buy(x,the-book)]

Coercion Chains

(59) The <u>bottle</u> spoiled.

(60) a. "spoil" is of type $phys \otimes_T \tau \rightarrow t$;
b. "the bottle" is of type $phys \bullet liquid$, (modulo GQ type shifting);
c. Coercion by Dot Exploitation (CE-•) applies to the type $phys \bullet liquid$, returning *liquid*:
$\Longrightarrow$ "the bottle" has type *liquid*;
d. Coercion by Qualia Introduction (CI-Q) applies to the type *liquid*, adding a TELIC value τ:
$\Longrightarrow$ "the bottle" has type $liquid \otimes_T \tau$;
e. Function Application applies;
$\Longrightarrow$ spoil(the-bottle)

Verb-Argument Composition Table

	Verb selects:		
Argument is:	**Natural**	**Artifactual**	**Complex**
Natural	Selection	Qualia Intro	Dot Intro
Artifactual	Qualia Exploit	Selection	Dot Intro
Complex	Dot Exploit	Dot Exploit	Selection

Verb-Argument Composition Table

	Verb selects:		
Arg:	**Natural**	**Artifactual**	**Complex**
N	Throw a stone	The water spoiled	Read the palm
A	Spill the beer	Drink beer	Read the opinion
C	Steal the book	Understand the book	Read the book

Functional Coercion 1/6

(61) a. The children heard a sound outside.
b. The villagers heard the bell / alarm.
c. John heard the neighbor's dog last night.

Functional Coercion 2/6

(62) a. “hear” is of type *sound* $\rightarrow (e_N \rightarrow t)$;
b. “a sound” is of type *sound* (modulo GQ type shifting);
c. Function Application (TM) applies;
$\Longrightarrow \lambda x$[hear(x,(a-sound)]

Functional Coercion 3/6

(63) a. John left Boston.
b. Mary taught before noon.

(64) a. John left the party.
b. Mary taught before the party.

Functional Coercion 4/6

(65) Attribute Functional Coercion (AFC):

a. Given an expression α, typed as: $\tau \rightarrow \beta$

b. the type τ shifts to $e \rightarrow \tau$

c. α is now typed as: $(e \rightarrow \tau) \rightarrow \beta$

Functional Coercion 5/6

(66) a. *leave*: $\lambda y{:}loc\ \lambda x{:}e_N[leave(x, y)]$
Functional Coercion: $loc \Rightarrow e \rightarrow loc$
leave: $\lambda y{:}e \rightarrow loc\ \lambda x{:}e_N[leave(x, y)]$
$(= \lambda y{:}e\ \lambda x{:}e_N[leave(x, loc(y))])$

b. $\exists e \exists y[leave(j, y) \wedge party(e) \wedge loc(e) = y]$

Functional Coercion 6/6

(67) a. "hear" is of type *sound* $\rightarrow (e_N \rightarrow t)$;
b. 'the bell" is of type *phys* $\otimes_T$ *ring* (modulo GQ type shifting);
c. Functional Coercion applies to *sound*: *sound* $\Rightarrow e \rightarrow$ *sound*
e. Function Application (TM) applies;
$\Longrightarrow \lambda x$[hear(x,(sound(the-bell))]
d. CE-Q applies to *phys* $\otimes_T$ *ring*, returning *ring*:
$\Longrightarrow \lambda x$[hear(x,(ring(the-bell))]

Composition Mechanisms

hear (Body: 'perceive with the ear', Arg: *sound*):

- hear voice, sound, whisper, thud, whistle, bang: *sound* $\subseteq$ *phys*
- hear siren, bell, alarm clock: *phys (formal) + telic = ring*
  – hear(alarm clock) is about ringing, not ticking: Qualia Exp
  – bell awakened, warned, alerted: *telic event = ringing*, Qualia Exp

mind:

- I am sure David won't mind sandwiches for a day.
  – mind event : Event Introduction
  – eat phys (sandwiches) : Qualia Exploitation

Lecture 5

Empirical Applications: from Theory to Practice

September 12, 2014

Outline of Lecture 5

Outline of Lecture 5

Outline of Lecture 5

Verb-Argument Composition Table

	Verb selects:		
Argument is:	**Natural**	**Artifactual**	**Complex**
Natural	Selection	Qualia Intro	Dot Intro
Artifactual	Qualia Exploit	Selection	Dot Intro
Complex	Dot Exploit	Dot Exploit	Selection

Verb-Argument Composition Table

	Verb selects:		
Arg:	**Natural**	**Artifactual**	**Complex**
N	Throw a stone	The water spoiled	Read the palm
A	Spill the beer	Drink beer	Read the opinion
C	Steal the book	Understand the book	Read the book

Composition Mechanisms

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mind:

- I am sure David won't mind sandwiches for a day.
  – mind event : Event Introduction
  – eat phys (sandwiches) : Qualia Exploitation

Wrapping Entity with an Attribute

(68) a. John heard the neighbor's dog last night.
b. I did not hear the alarm.
c. I did not hear the door.

(69) a. "hear" is of type *sound* $\rightarrow (e_N \rightarrow t)$;
b. Attribute becomes a function: $sound \Rightarrow e \rightarrow sound$
$\Longrightarrow \lambda y : e, \lambda x : e_{anim}$[hear(x,(sound(y))]

Attribute $\rightarrow$ Function Coercion

(70) a. John left Boston.
b. Mary taught before noon.

(71) a. John left the party.
b. Mary taught before the party.

(72) a. leave: $\lambda y{:}loc\ \lambda x{:}e_N[leave(x, y)]$

b. Attribute becomes a function: $loc \Rightarrow e \rightarrow loc$

c. leave: $\lambda y{:}e \rightarrow loc\ \lambda x{:}e_N[leave(x, y)]$
$(= \lambda y{:}e\ \lambda x{:}e_N[leave(x, loc(y))])$

d. $\exists e \exists y[leave(j, y) \wedge party(e) \wedge loc(e) = y]$

Outline of Lecture 5

Co-compositionality

- Bilateral functional application:
- Both predicate and argument act functionally to build the resulting meaning

Three Kinds of Co-composition

- Predicate Coercion:
  Subject acts functionally over its own predicate
- Predicate Cospecifcation:
  Verb and object create a new meaning
- Argument Cospecification
  Two arguments of the verb are related independently of the selecting predicate

Bi-directional Selection:

Verb: take on

Sense 1: tackle an adversary:
competition, rival, enemy, opponent, team, congress, world.

Sense 2: acquire a quality:
shape, meaning, color, form, dimension, reality, significance, identity, appearance, characteristic, flavor.

- Are you willing to take on the competition?
- Are you willing to take on the Congress?

- It is much harder to take on the opponent you know personally.
- It is much harder to take on the student you know personally.

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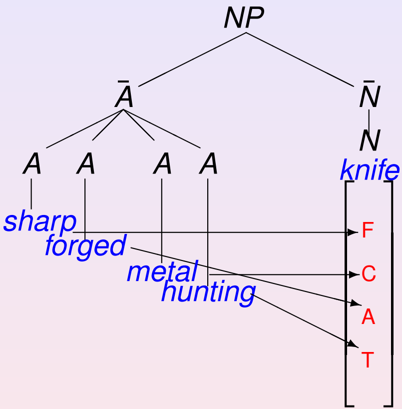
Encoding Change through Selection

1. a. Mary fixed every leaky faucet.
   b. Mary fixed every brass faucet.
2. a. John drank a full glass of milk.
   b. !John drank an empty glass of milk.
3. John closed the open door.
4. People filled the empty hall.
5. a. Mary cleaned the dirty table.
   b. Mary cleaned the glass table.
6. a. [The audience]$_i$ left the theatre.
   b. *[It]$_i$ went home.
   c. [They]$_i$ went home.

Outline of Lecture 5

Selective Binding of Adjectives



How Adjectives Bind to Qualia: Constitutive

- CONST
  a. wooden house
  b. mountainous region
  c. clay tablets

How Adjectives Bind to Qualia: Formal

- FORMAL
  heavy, red, large, sweet, raw, rough, hard, simple, responsible, happy, short, narrow, poor, bitter, new

How Adjectives Bind to Qualia: Telic

- TELIC

  a. useful table

  b. bright bulb

  c. good knife

How Adjectives Bind to Qualia: Agentive

- AGENTIVE
  a. carved figure
  b. hand-made shoes
  c. synthetic material
  d. natural light

Outline of Lecture 5

Bisetto and Scalise (2005)

Given a compound structure $[N_1\ N_2]$:

- SUBORDINATING: the head acts functionally over N_1, incorporating it as an argument.
- ATTRIBUTIVE: a general modification relation of N_1 over N_2.
- COORDINATE: the dvandva construction, with two elements without dependency holding between them.

Nominal Compounds

- Synthetic Compounds:
  Given a compound structure $[N_1\ N_2]$: N_1 is interpreted as an argument to N_2
  - bus driver
  - window cleaner
- Non-synthetic Compounds:
  - pastry chef
  - bread knife

  Qualia-based meaning derivation: chef is someone who bakes pastries, knife is something that is used for cutting bread.

Compound Modification Relations

Given a compound [A N]:
A is the TELIC value of N:

- fishing rod
- magnifying glass
- swimming pool
- shopping bag
- drinking water

Compound Modification Relations

Given a compound [N_1 N_2]:
N_1 associates with the TELIC of N_2:

- party napkins
- kitchen table
- ipod speaker
- Christmas dinner

Compound Modification Relations

Given a compound [N_1 N_2]:
N_1 is the CONST of N_2:

- paper napkins
- metal cup
- gold filling

Compound Modification Relations

Given a compound [N_1 N_2]:
N_1 is the AGENTIVE of N_2:

- food infection
- heat shock
- university fatigue
- automobile accident
- sun light

Outline of Lecture 5

Outline of Lecture 5

GL AND CPA

Merging Two Traditions in Study of Language

- Generative Lexicon:
  Encoding lexical dynamic context for richer interpretation of natural language. s
- Corpus Language Philosophy:
  Manipulation of usage situations associated with words and word tuples.

Analyzing Contexts of Usage

Consider the word treat:

- Peter treated Mary badly.
- Peter treated Mary with antibiotics.
- Peter treated Mary with respect.
- Peter treated Mary for her asthma.
- Peter treated Mary to a fancy dinner.
- Peter treated Mary to his views on George W. Bush.
- Peter treated the woodwork with creosote.

Analyzing Contexts of Usage

Consider the word treat:

- Peter treated Mary badly.
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Patterns for treat

69% [[Human 1 | Institution 1 | Animal 1]] treat [[Human 2 | Animal 2 | Entity | Event]] [Adv[Manner]]

→ [[Human 1 | Institution 1 | Animal 1]] behaves toward [[Human 2 | Animal 2 | Entity | Event]] in the [[Manner]] specified

17% [[Human 1 = Health Professional | Process = Medical | Drug]] treat [[Human 2 = Patient | Animal = Patient | Disease | Injury]] [NO ADVL]

→ [[Human 1 = Health Professional]] applies a [[Drug]] or [[Process = Medical]] to [[Human 2 = Patient]] for the purpose of curing the patient's [[Disease | Injury]]

Patterns for treat, cont'd

5% [[Human]] treat [[Inanimate]] (with [[Stuff]] | by [[Process]])

→ The chemical or other properties of [[Inanimate]] are improved or otherwise changed by [[Process]] or the application of [[Stuff]]

5% [[Human 1]] treat [[Human 2 | Self]] (to [[Eventuality = Good]])

→ [[Human 1]] gives or pays for [[Eventuality = Good]] as a benefit for [[Human 2 | Self]]

Outline of Lecture 5

Type Inheritance for Naturals and Artifactuals

Corpus-Driven Type System

- Entity
- Eventuality
- Part
- Property
- Group

Corpus-Driven Type System

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Corpus-Driven Type System

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Corpus-Driven Type System

- Entity
  - Physical Object
    - Inanimate
    - Animate
    - Plant
    - Location
  - Institution
  - Energy
  - Abstract Object
- Eventuality
- Part
- Property
- Group

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- Entity
- Eventuality
  - State
    - *Abstract*
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Corpus-Driven Type System

Eventuality $\rightarrow$ State $\rightarrow$ Abstract

- Privilege
- Psych
  - Attitude
  - Emotion
  - Goal
- Time Point
- Obligation
- Responsibility
- Power
- Uncertainty
- Concept
  - Proposition
  - Narrative
  - Information
  - Rule

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Patterns for Specific Types

Type Concept:

- accept
- apprehend
- construct
- awaken
- arrive
- dignify
- ...

It is not what you'd expect!

Patterns for Specific Types

Type Concept:

- awaken:
  44% awaken [[Emotion | Attitude | Concept | Skill]] in [[Human]]

  11% awaken [[Human]] to [[Emotion | Attitude]]

  e.g. awaken expectations, memories, feelings
- arrive:
  14% [[Human | Institution]] arrive at [[Concept = Considered Opinion]]
  e.g. arrive at opinion, conclusion, design, solution, understanding

Patterns for Specific Types

Type Building Part:

- creak
- devote
- house
- plan
- ...

Type Vehicle Group:

- ambush
- crawl

Outline of Lecture 5

Theory Meets Corpus

- Are we working with invented examples?
- Do these phenomena exist?
- Can we account for what's going on using the proposed solutions?

Let's look at the real data!

Corpus Data on Complex Types: book (as Obj)

read	772	53.51	dedicate	23	19.53
write	933	50.44	ban	27	18.52
publish	416	44.21	purchase	28	18.2
balance	76	32.65	consult	22	17.52
buy	187	29.16	finish	38	17.37
entitle	66	27.96	edit	18	17.27
borrow	43	24.94			
illustrate	65	24.38			
close	76	22.84			
produce	146	22.66			
research	26	22.34			
open	100	22.05			
rewrite	16	21.69			
sell	92	21.25			
print	34	20.74			

Complex Types: book (modified by Adjective)

concerned	61	34.79	good	18	13.2
available	65	31.21	popular	8	13.03
useful	20	22.67	encyclopaedic	2	12.69
full	30	21.91	blasphemous	2	12.53
enjoyable	8	20.99	open	9	11.67
readable	5	19.09	invaluable	3	11.56
interesting	13	18.45	impressive	4	11.2
unreadable	3	15.46	supposed	5	11.03
relevant	9	14.78	complete	9	14.59
ready	9	14.45			
up to date	4	14.29			
valuable	6	13.73			

Corpus Data on Complex Types: book (as Subj)

contain	119	30.89	consist	16	15.28
deal	51	24.3	devote	11	14.97
cover	48	19.9	trace	11	14.7
include	58	18.85	reveal	20	14.66
review	19	18.62	concentrate	15	14.59
lie	28	18.4	explain	24	14.58
provide	70	17.69	chronicle	6	18.06
publish	30	17.37	describe	28	13.93
show	65	17.07			
appear	37	17.01			
bargain	6	16.28			
help	37	15.54			

Complex Type Structure is Exploited Differently in Different Grammatical Positions

- Book in Subject position exploits the information type
- Book in Object position exploits the physical type

Corpus Data on spoil

In both BNC and Associated Press, over 80% of Direct Objects of spoil are Events. Typically, they are Events that one would expect to enjoy. The implicature is that, by spoiling an Event, one kills the enjoyability of it. One might say that spoil is a causative antonym of enjoy.

The lexical set of direct objects of spoil include:

fun, enjoyment, magic, pleasure, holiday, party, Christmas, birthday, dinner, evening, morning, day, half-hour, event, occasion, view, performance, opera, game, match, ...

Corpus Data on Selection: believe +*clause*

```
inf clause    1996 0.6
ing clause      18 1.9
that clause 13974 2.6
wh clause      486 0.5
```

Corpus Data on Selection: believe +*NP*

luck	73	33.05
ear	48	22.14
story	73	20.67
word	95	18.9
eye	74	14.78
hype	6	14.16
myth	12	14.07
truth	19	13.39
it	8	12.91
lie	10	12.57
opposite	7	12.22
tale	13	12.16
nonsense	7	11.62
propaganda	7	74

Concordance for believe $+NP$

31 percent said they'd believe the newspaper, primarily because they had "more
He seems to have made the mistake of believing his own propaganda .
Politicians are always at their most vulnerable when they believe their own propaganda .
They weren't quite so stupid as to believe wholly their own propaganda .
The trouble with the hon. Gentleman is that he believes his own propaganda .
The trouble is , the media is able to influence the public and unfortunately influential people in the trade union and labour movements , and maybe they believe the propaganda that socialism is dead and respond accordingly .

Corpus Data on Selection: doubt + NP

ability	validity
sincerity	sanity
existence	correctness
accuracy	wisdom
viability	truth
authenticity	word
feasibility	suitability
veracity	
strength	
seriousness	
faith	
value	
presupposition	
possibility	
claim	
commitment	

Corpus Data on Artifactual Selection: repair +*NP*

damage	107	42.92
roof	16	20.31
covenant	9	18.38
fence	10	18.1
road	13	12.24
gutter	5	15.89
ravages	4	15.82
hernium	4	15.6
car	23	15.39
shoe	10	15.04
leak	5	15.01
bridge	10	14.03
crack	6	14.02
fencing	4	13.91
wall	14	13.77
puncture	3	13.54
building	16	13.52
pipe	7	12.92
saddlery	2	12.79
ligament	3	11.85

Corpus Data on Complex Selection: read + NP

book	772	43.31
newspaper	205	35.76
bible	82	34.24
papers	144	32.61
article	156	31.89
letter	226	30.44
poem	85	29.39
novel	88	28.57
paper	175	28.54
text	112	26.93
passage	82	
story	148	26.03
comic	26	26.89
magazine	85	25.38
script	37	24.37
poetry	46	24.12
report	180	23.37
page	89	23.25
paragraph	38	22.92
word	162	21.85

Corpus Data on Propositional Selection: tell + NP

story
truth
lie
tale
reporter
inquest
court
Reuter
conference
fib
joke

Corpus Data on Complex Types: lunch (as Obj)

eat	93	42.49	buy	14	14.21
cook	34	34.46	arrange	8	13.18
serve	44	28.44	want	19	12.69
skip	9	23.41	host	4	12.17
finish	21	22.58	organise	6	11.1
enjoy	25	21.97	cancel	4	11.08
prepare	21	20.66	order	6	10.74
attend	15	18.54	spoil	3	9.72
miss	12	16.96	share	6	9.75
take	48	15.47			
provide	26	15.21			
bring	21	15.06			
get	40	14.98			
include	12	10.89			

Corpus Data on Complex Types: lecture (as Obj)

attend	75	38.84
deliver	65	38.02
give	226	35.18
entitle	12	19.41
organise	9	14.38
Present	13	14.16
sponsor	5	12.55
illustrate	7	12.44
finish	7	11.81
include	13	11.4
organize	5	11.21
publish	8	10.99
prepare	7	10.52
get	22	9.82
record	6	9.73
hold	12	9.55
arrange	5	9.46
read	6	8.59
write	8	8.54
begin	6	6.4

Corpus Data on Complex Types: seminar (as Obj)

attend	65	39.64	plan	7	11.98
organise	56	38.75	design	5	8.84
hold	88	32.76	present	5	8.4
host	7	18.77	aim	6	11.87
entitle	9	18.08	follow	6	7.15
run	19	17.09	convene	5	16.94
chair	6	16.83	arrange	9	15.72
sponsor	6	15.5			
conduct	8	14.93			
address	7	13.84			
give	24	12.71			

Corpus Data on Complex Types: appointment (as Obj)

make	454	35.11	hold	36	15.49
announce	71	30.09	follow	30	14.69
terminate	20	27.2	welcome	11	14.5
confirm	35	24.53	recommend	11	14.06
approve	31	24.52	receive	20	13.23
arrange	32	24.26	block	7	12.81
cancel	16	22.16	oppose	7	12.01
keep	55	20.42	veto	5	15.44
accept	32	19.64	miss	9	11.83
get	89	18.58			
secure	17	18.21			
relinquish	7	17.67			
book	9	16.21			
include	30	15.47			
ratify	6	15.32			

Outline of Lecture 5

Driving Questions

- How do words combine to make meanings?
- What are the sources of polysemy and underspecified meanings?
- Can we explain how do words meanings change in composition?

What we have done?

- Developed a model for the lexicon that allow us to explain these phenomena generatively.
- Semantic load for an utterance is distributed between different elements (predicate, arguments, modifiers).
- No need for sense enumeration!
- Accounts for very large amounts of linguistic phenomena:
  - argument selection
  - adjectival modification
  - nominal compounds
  - light verb constructions
  - implicit predicates in V-N, A-N, N-N constructions
  - required adjuncts in short passives, middles, adj. use of participles
  - co-composition
- Every mechanism should be "audited" against corpus data!

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