NP modification and relative clauses

1. Refresh

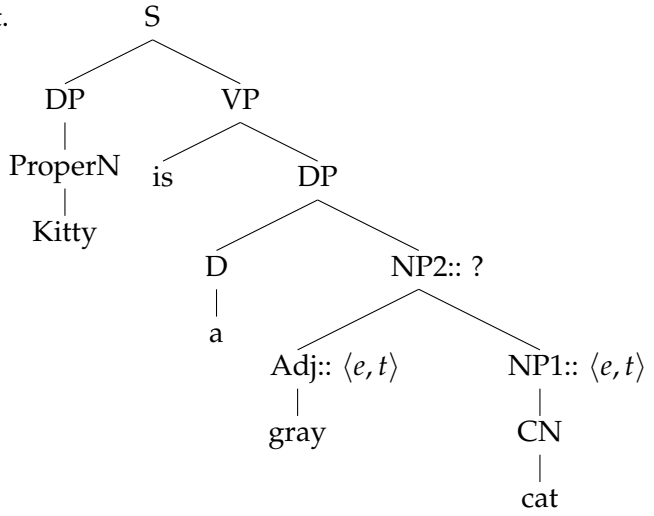
- **The principle of compositionality:** The meaning of a complex expression is determined by the meanings of its parts and the way they are syntactically combined.

  Basic composition rules: TN, NN, FA

2. Ways to interpret NP modification

- **The issue**: How can we combine two sister nodes that do not hold a function-argument relation?

(1) Kitty is a gray cat.



- **Option 1: Generalized conjunction**

  We interpret a modified NP of the form $[_{\text{NP}}\ X\ Y]$ as a generalized conjunction $X' \sqcap Y'$:

(2) **Generalized conjunction**

a. For any f and g of type $\langle e,t\rangle$, $f \sqcap g$ is a new function of type $\langle e,t\rangle$ such that for any $x \in D_e$, $[f \sqcap g](x) = f(x) \wedge g(x)$

b. η-equivalence: $f \sqcap g = \lambda y[f \sqcap g](y)$

c. Simplification rule: $\lambda y[f \sqcap g](y) = \lambda y[f(y) \wedge g(y)]$

Example:

(3) $[\![\text{gray cat}]\!]^w = [\![\text{gray}]\!]^w \sqcap [\![\text{cat}]\!]^w$
$= (\lambda x.\mathsf{gray}_w(x)) \sqcap (\lambda x.\mathsf{cat}_w(x))$
$= \lambda y[\lambda x.\mathsf{gray}_w(x) \sqcap \lambda x.\mathsf{cat}_w(x)](y)$ By η-equivalence
$= \lambda y[\mathsf{gray}_w(y) \wedge \mathsf{cat}_w(y)]$ By simplification rule

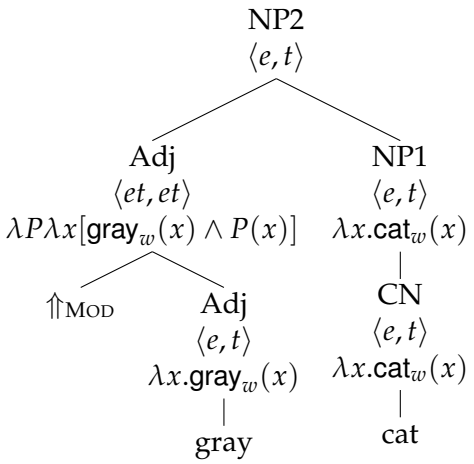
- **Option 2: Type-shifting**

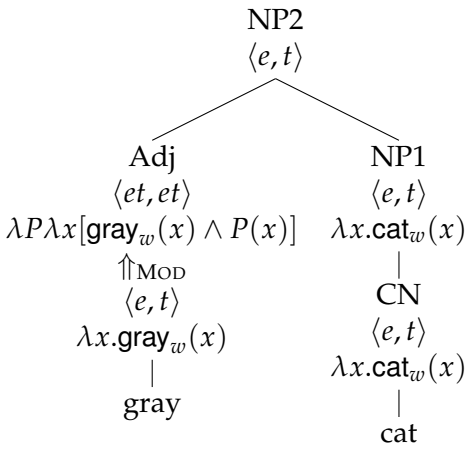
  We shift an adjective into a NP-modifier, and then combine it with an NP via functional application.

  (4) **Predicate-to-modifier shift (MOD)**
  If $[\![\alpha]\!]$ is of type $\langle e,t\rangle$, then $[\![\Uparrow_{\text{MOD}}(\alpha)]\!] = \lambda P_{\langle e,t\rangle}\lambda x_e[[\![\alpha]\!](x) \wedge P(x)]$

  In the following two tree diagrams for the complex NP "gray cat", we prefer (b) over (a) because $\Uparrow_{\text{MOD}}$ is intuitively not part of the syntax.

  (5) gray cat

  a.
  

  b.
  

  Montague assumes that all adjectives are of type $\langle et, et\rangle$. For a sentence like *Kitty is gray*, he assumes that the adjective combines with a silent noun. However, **Kitty is gray cat* is ungrammatical, which suggests that we can't always have silent nouns. So it seems necessary to assume that adjectives can at least sometimes be of type $\langle e,t\rangle$.

- **Option 3: A new composition rule — Predicate Modification**

  Alternatively, we can let go of Frege's conjecture, that Functional Application is basically the only composition rule, and accept another composition rule ...

  (6) **Predicate Modification (PM)**
  If α is a branching node, $\{\beta, \gamma\}$ is the set of α's daughters, and $[\![\beta]\!]$ and $[\![\gamma]\!]$ are both in $D_{\langle e,t\rangle}$, then $[\![\alpha]\!] = \lambda x_\sigma[[\![\beta]\!](x) \wedge [\![\gamma]\!](x)]$. (Or equivalently, $[\![\alpha]\!] = [\![X]\!]^w \cap [\![Y]\!]^w$ on the set approach)

  Compose the complex NP *gray cat* following PM:

  (7)
  $$\begin{aligned}
  [\![\text{NP2}]\!]^w &= \lambda x_e[[\![\text{Adj}]\!]^w(x) \wedge [\![\text{NP1}]\!]^w(x)] && \text{By PM}\\
  &= \lambda x_e[[\![\text{Adj}]\!]^w(x) \wedge [\![\text{CN}]\!]^w(x)] && \text{By NN}\\
  &= \lambda x_e[[\![\text{gray}]\!]^w(x) \wedge [\![\text{cat}]\!]^w(x)] && \text{By TN}\\
  &= \lambda x_e[(\lambda y_e.\text{gray}_w(y))(x) \wedge (\lambda y_e.\text{cat}_w(y))(x)] && \text{Inserting lexicons}\\
  &= \lambda x_e[\text{gray}_w(x) \wedge \text{cat}_w(x)]
  \end{aligned}$$

  Exercise: Draw tree diagrams for the following two sentences, define the meaning of each lexical expression using λ-notation, and compose the meaning of each node using composition rules.

  (8) a. New Brunswick is a city in NJ.
  b. New Brunswick is a part of NJ.

3. Restrictions and consequences of Predicate Modification

3.1. Type restriction

- Predicate Modification can only be used to combine two nodes of type $\langle e, t\rangle$.

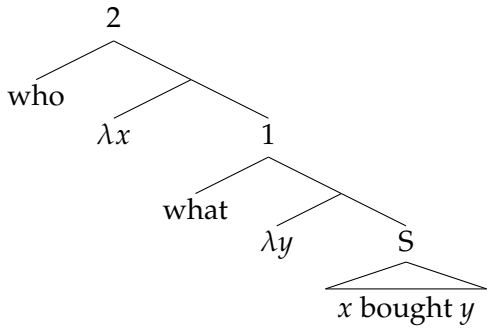
  Type-driven interpretation: Which rule applies is determined by semantic considerations. There is never any uncertainty about which rule will apply.

  In particular, given a branching node $[_\gamma\ \alpha\ \beta]$,

  - If α and β are of the form $\langle e, t\rangle$, γ is composed via Predicate Modification
  - If α is of type $\langle \sigma, \tau\rangle$ and β is of type σ, γ is composed via forward Functional Application.
  - If α is of type σ and β is of type $\langle \sigma, \tau\rangle$, γ is composed via backward Functional Application.
  - If else, the composition of γ suffers **type-mismatch**.

  Discussion: Categorial approaches of questions treat *wh*-words as λ-operators. Let's try to compose the following tree structure (intermediate nodes are omitted) while assuming the lexical entries in (9a-b). What composition rules can we use for composing Node 1? What about for Node 2?

  (9) Who bought what?
  $[\![\text{who}]\!] = \lambda P_{\langle e,t\rangle} \lambda x_e [\mathsf{human}(x) \wedge P(x)]$
  $[\![\text{what}]\!] = \lambda P_{\langle e,t\rangle} \lambda x_e [\mathsf{thing}(x) \wedge P(x)]$



3.2. Consequences

- Entailments

  (10) Kitty is a gray cat. ⇒ Kitty is a cat.
  ⇒ Kitty is gray.

  (11) Kitty is a cat & Kitty is gray ⇒ Kitty is a gray cat.

- Order of modifiers

  (12) Kitty is a cat with gray hair from UK. ⇔ Kitty is a cat from UK with gray hair.

3.3. Non-intersective adjectives

- We have two ways to compose a complex expression — by FA or by PM. Consider, in each of the following sentences, which rule shall we use to compose the involved complex NP? Why?

  (13) a. Jumbo is a [small elephant].
  b. Susi is a [beautiful dancer].
  c. John is a [fast speaker].
  d. Ann is a [former dancer].

Compare with (10):

a. Jumbo is a [small elephant].
   $\not\Rightarrow$ Jumbo is small.
b. Susi is a [beautiful dancer].
   $\not\Rightarrow$ Susi is beautiful.
c. John is a [fast speaker].
   *John is fast.
d. Ann is a [former dancer].
   *Ann is former.

– Subjective adjectives

Intuitively in (13a), what counts "small" is relative to certain comparison class. Here are two ways to capture this intuition:

(14) a. As an argument of the adjective
   $[\![\text{small}]\!]^w \approx \lambda f_{\langle e,t\rangle}.\lambda x_e.\ x$ is small in w as an f
   b. contextually specified standard
   $[\![\text{small}]\!]^w \approx \lambda x_e.\ x$ is small relative to the contextually specified standard c

– Non-predicative adjectives

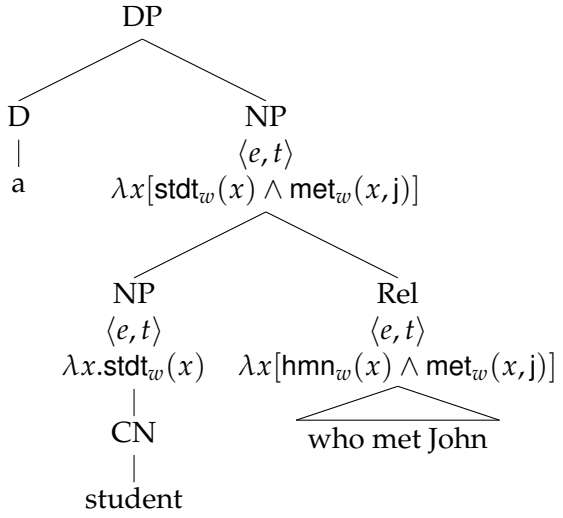
Adjectives like *fast* and *former* are not predicative. There appears to be no such thing as the set of "fast things", or as the set of "former things". (More examples: *new*, *present*)

4. Relative clauses

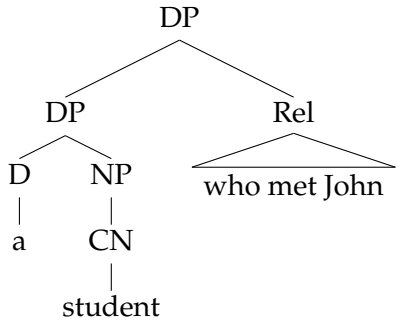
- In addition to common nouns, adjectives, and preposition phrases, relatives clauses (category label 'Rel') also have predicative interpretations. For example, the subject-headed relative clause *who met John* is a set of individuals x such that x met John.

(15) Mary is a student who met John. $\Leftrightarrow$ Mary is student, and Mary met John.

(16) a student who met John



Discussion: Why don't we assume the following syntax?



Discussion [open question]: The meaning of the relative clause *who met John* expresses the intersection of the set of human individuals to the set of entities that met John, which is seemingly close to the meaning of a complex NP. In principle, there are a few ways to compose a relative clause, such as:

- *who* is of type $\langle et, et \rangle$. It combines with *met John* via Functional Application.
- *who* is of type $\langle e, t \rangle$, semantically equivalent to the common noun *people/human*. It combines with *met John* via Predicate Modification.

What other composition methods can you think of? Which method is more plausible? Why?