Interpretation of predicates and predicate modification

1. Introduction: Common Nouns and Adjectives in Predicate Position

Expressions of type e:
⟦**Mary**⟧ = Mary

Expressions of type <e,t>:
⟦**smokes**⟧ = [λx_e.x smokes]

Expressions of type <e,<e,t>>
⟦**likes**⟧ = [λy_e.[λx_e. x likes y]]

Expressions of type <<e,t>,<<e,t>t>>
⟦**every**⟧ = $[\lambda P_{<e,t>}.[\lambda Q_{<e,t>}. \forall y[P(y)\rightarrow Q(y)]$

What about adjectives like 'small' and common nouns like 'doctor'? What sort of entries should they receive?

(1) Jumbo is small.

(2) Mary is a doctor.

We want to develop lexical entries for those lexical items that will capture the truth conditions of those sentences.

(3) ⟦**Jumbo is small**⟧= 1 iff Jumbo is small

(4) ⟦**Mary is a doctor**⟧ = 1 iff Mary is a doctor

The copula in predicative use doesn't seem to contribute to the sentence's meaning. It is semantically vacuous.

It appears in a sentence for purely syntactic reasons (e.g. to express the tense, which can't go on the noun in English).

(5) ⟦**is rich**⟧= ⟦**rich**⟧

The indefinite article in the post-copular position, as in (4), does not provide any semantic information either.

For example, in Russian the same meaning is expressed without a copular and without an article.

(6) Maša — vrač.
Masha — doctor
'Masha is a doctor'

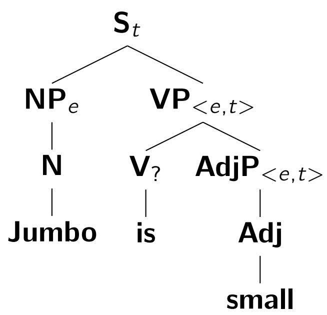
(7) ⟦**a doctor**⟧= ⟦**doctor**⟧

Many nouns and adjectives denote – like intransitive verbs – functions from individuals to truth-values.

(8) ⟦**doctor**⟧ = [λx. x is a doctor]
(9) ⟦**small**⟧ = [λx. x is small]

If 'is' and 'a' do not have any lexical entry, then how can our system compute the meaning of sentences that contain them?

(10)



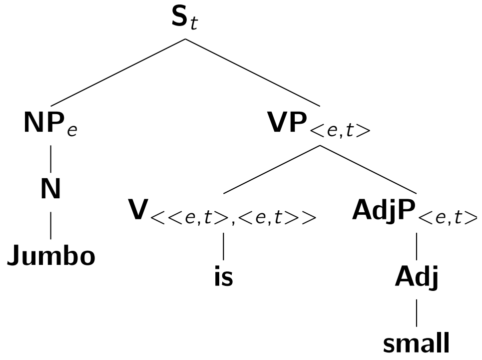
2. Semantically empty expressions

We give these expressions lexical entries, but ones that adds nothing to the meaning of the larger phrase.

We treat the meaning of the copula as an identity function.

(11) ⟦**is**⟧ = [$\lambda f_{<e,t>}.f$]

(12)



An illustration of the derivation:

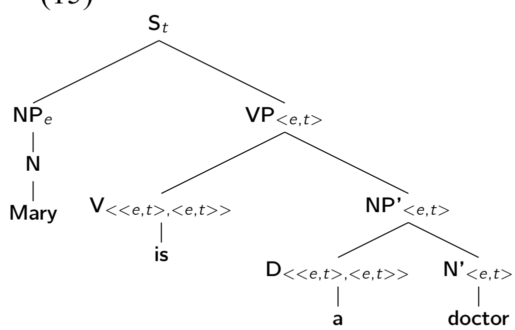
(13) ⟦**VP**⟧ = by FA
⟦**V**⟧ (⟦**AdjP**⟧) = by 4 applications of NB
⟦**is**⟧ (⟦**small**⟧) = by TN and by our lexicon
[λf.f] ([λx. x is small]) = by lambda conversion
[λx. x is small]

(14) ⟦**S**⟧ = by FA
⟦**VP**⟧ (⟦**NP**⟧) = by the computation in (13)
[λx. x is small] (⟦**NP**⟧) = by 2 applications of NB
[λx. x is small] (⟦**Jumbo**⟧) = by TN and by our lexicon
[λx. x is small] (Jumbo) = our convention
1 iff Jumbo is small

Because ⟦**is**⟧ is an identity function ⟦**is**⟧(⟦**small**⟧) = ⟦**small**⟧.

We can do the same thing for 'a', which we said is also semantically empty.

(15)



(16) ⟦**S**⟧ = by FA
⟦**VP**⟧ (⟦**NP**⟧) = by 2 applications of NB
⟦**VP**⟧ (⟦**Mary**⟧) = by TN and by our lexicon

⟦**VP**⟧ (Mary) = by the meaning of 'is'
⟦**NP'**⟧ (Mary) = by the meaning of 'a'
⟦**N'**⟧ (Mary) = by NB
⟦**doctor**⟧ (Mary) = by TN and by our lexicon
[λx. x is a doctor] (Mary) = our convention
1 iff Mary is a doctor

3. Predicate modification

3.1 Problem of composition with restrictive modifiers

We will treat some prepositions, such as 'in' in 'in Texas' as functions from individuals to functions from individuals to to truth-values (again, similarly to transitive verbs).

(17) Austin is in Texas.

(18) ⟦**in**⟧=[λx.[λy.y is located in x]]

(19) ⟦**in Texas**⟧ = by FA
⟦**in**⟧ (⟦**Texas**⟧) = by TN and lexicon
[λx.[λy.y is in x]](Texas) = by lambda conversion
[λy. y is in Texas]

This accounts for the fact that 'in Texas' like 'a doctor' can occur in the predicative position.

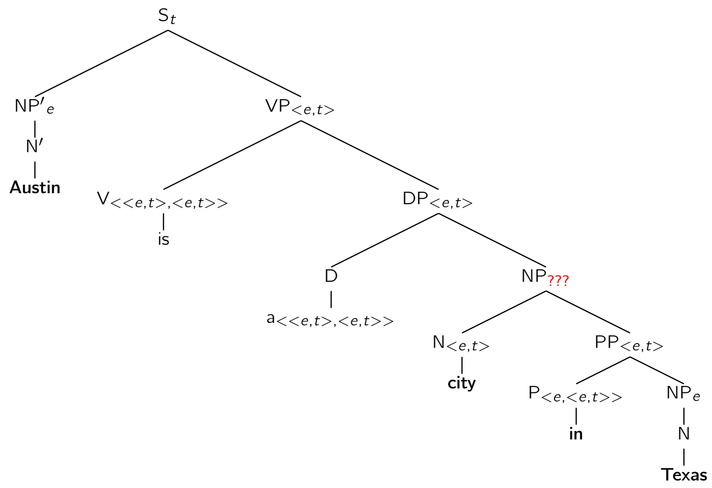
From what we said before it follows that 'city' is an expression of type <e,t>

(20) Austin is a city.
(21) ⟦**city**⟧ = λx. x is a city

We can also say (22):

(22) Austin is a city in Texas.

(23)



Our types do not go together!

Our rules cannot interpret this structure!

We have only one rule for a brunching node: FA

⟦**in Texas**⟧ is not the argument of ⟦**city**⟧

⟦**city**⟧ is not the argument of ⟦**in Texas**⟧.

We have two options here:

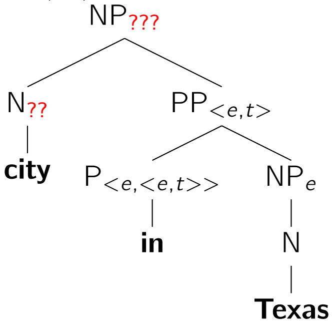
- We change the denotation of 'city' or 'in Texas' in such a way that they could combine via Functional Application.

- We add a new interpretation rule that allows 'city' and 'in Texas' to go together and retain the semantic types we said they have.

3.2 Option 1: changing the semantic types

Let's change the type of the city in such a way that it can take the PP as its argument.

(24)



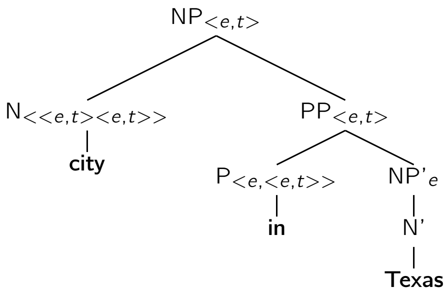
We need to think of two things:

- the semantic type
- the actual meaning of 'city in Texas'

'City in Texas' is something that is a city and something that is in Texas.

(25) ⟦**city in Texas**⟧ = λx_e.x is a city and x is in Texas

(26)



(27) ⟦**city**⟧ = [$\lambda f_{<e,t>}$.[λx_e. x is a city and f(x)=1]]

Now 'city' and 'in Texas' can compose via FA and we get the right meaning as well!

(28) ⟦**NP**⟧ = by FA
⟦**N**⟧(⟦**PP**⟧) = by NB, TN, the lexicon, the meaning of the PP (given in (29))
[$\lambda f_{<e,t>}$.[λxe. x is a city and f(x)=1]] ([λy_e. y is in Texas]) =
[λx_e. x is a city and [λy_e. y is in Texas](x)=1] = (by lambda conversion)
[λx_e.x is a city and x is in Texas] (by lambda conversion)

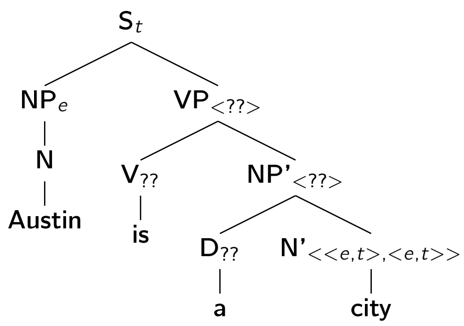
(A reminder)

(29) ⟦**in Texas**⟧ = [λy_e. y is in Texas]

Now, we are facing a problem: What about (30)?

(30) Austin is a city.

(31)



3.3 Option 2: a new interpretation rule

The idea:

- we keep the semantic types of 'city' and 'in Texas' <e,t>
- we introduce a new interpretation rule that allows them to go together.

We want to keep the number of the interpretation rules to the minimum.
We don't want to introduce a new interpretation rule for each individual case.

But in some cases if the phenomenon is systematic enough it makes sense to introduce a new interpretation rule.

A new rule: 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 $[\![\boldsymbol{\alpha}]\!] = \lambda x_e.\ [\![\boldsymbol{\beta}]\!](x) = 1$ and $[\![\gamma]\!](x) = 1$.

Comments about predicate modification:

- PM takes two functions from $D_{\langle e,t\rangle}$.
- PM creates a new function from $D_{\langle e,t\rangle}$. The dominating node inherits the type from its two daughter nodes.
- This process is also called intersective modification.
- When the sets characterized by the respective functions are considered, PM creates the characteristic function of the intersection of these two sets.

3.3.1 Intersection – some formal background

We treat expressions like $[\![$**city**$]\!]$ or $[\![$**in Texas**$]\!]$ as functions, expressions of type <e,t>.

These expressions also have a close relationship to the following sets:
(remember – a set is a collection of objects)

(32) {x: x is a city}
(33) {NYC, Moscow, Austin…}

(34) {z: z is in Texas}
(35) {Austin, Houston, Big Bend National Park, John….}

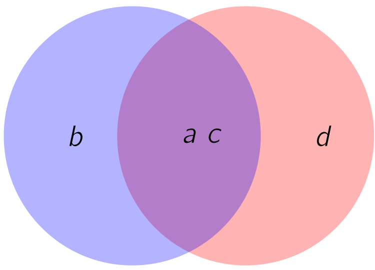
We can a function a characteristic function of a set, if we can use it to pick the right set:

⟦**city**⟧ is a characteristic function of sets of cities:
{x : ⟦**city**⟧(x) = 1}.

⟦**in Texas**⟧ is a characteristic function of sets of things that are in Taxes:
{y: ⟦**in Texas**⟧(y) = 1}.

The intersection of two sets A and B, A ∩ B, is the set C with exactly those elements which are shared by A and B. (intersection is an operation its result is a new set)

(36) {a, b, c} ∩ {a, c, d} = {a, c}



The rule of predicate modification allows us:

- To take one function F_1 that is a characteristic function of a set A
- To take another functions F_2 that is a characteristic function of a set B
- And create a new function F_3 that is a characteristic function of the intersection between A and B

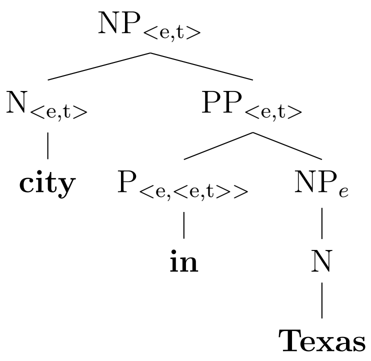
Under this approach:

⟦**in Texas**⟧ is not the argument of ⟦**city**⟧.

⟦**city in Texas**⟧ has the same denotation type as ⟦**city**⟧.

⟦**city in Texas**⟧ is a characteristic function of {x : ⟦**city**⟧(x) = 1}∩ {y: ⟦**in Texas**⟧(y) = 1}

3.3.2 Applying predicate modification



(37) $[\![\textbf{NP}]\!]$ = by PM

$[\lambda x_e.\ [\![\textbf{N}]\!](x) = 1$ and $[\![\textbf{PP}]\!](x) = 1] =$ by NB and by the meaning of the PP

$[\lambda x_e.\ [\![\textbf{city}]\!](x) = 1$ and $[\lambda y_e.$ y is in Texas$](x) = 1] =$ by TN and lexicon

$[\lambda x_e.[\lambda y \in D_e.$ y is a city$](x) = 1$ and $[\lambda z_e.$ z is in Texas$](x) = 1]\ ] =$ by 2 lambda conversions

$[\lambda x_e.$x is a city and x is in Texas$]$

(A reminder)

(38) $[\![\textbf{in Texas}]\!] = [\lambda y_e.$ y is in Texas$]$

Predicate modification with adjectives:

(39) $[\![\textbf{gray cat}]\!]$ = by PM

$[\lambda x_e.\ [\![\textbf{gray}]\!](x) = 1$ and $[\![\textbf{cat}]\!](x) = 1] =$ by TN and lexicon

$[\lambda x_e.[\lambda y_e.$y is gray$](x)=1$ and $[\lambda z_e.$z is a cat$](x)=1] =$

$[\lambda x_e.$x is gray and x is a cat$]$ (by 2 applications of lambda conversion)

A prediction: equivalence of PM and conjunction

An analysis with PM predicts that (40) and (41) are equivalent.

(40) Julius is a gray cat.

(41) Julis is gray and Julius is a cat.

PM in (40)yields the function $[\lambda x_e.\ [\![\textbf{gray}]\!](x) = 1$ and $[\![\textbf{cat}]\!](x) = 1]$, which is true of Julius iff Julius is gray and Julius is a cat.

$[\![\textbf{and}]\!]$ in (41) requires that $[\![\textbf{Julius is gray}]\!] = 1$ and $[\![\textbf{Julius is a cat}]\!] = 1$.

Intuitively this seems correct in this case!

3.3.3 A problem

Entailment vs. non-entailment

(42) does not entail (43): A small elephant is still a large animal!

(42) Jumbo is a small elephant.
(43) Jumbo is a small animal.
(44) ✓Jumbo is a small elephant, but he is not a small animal.

Compare this with the entailment below:

(45) Jumbo is an elephant.
(46) Jumbo is an animal.
(47) #Jumbo is an elephant, but he is not an animal.

No equivalence!

4. Nonintersective adjectives

The adjectives like ‘small’ are called nonintersective.

Most of the adjectives in natural languages are nonintersective. ‘Young’, ‘short’, ‘famous,’ ‘tall’, ‘old’, ‘happy’, ‘angry’ belong to this class.

(48) John is a short basketball player $\nvDash$ John is short.
(49) Billi is a huge rat $\nvDash$ Billi is huge.

Some adjectives are intersective. ‘Female’, ‘male’, ‘married’, ‘dead,’ ‘gray’, ‘blue’ are intersective.

(50) John is a male basketball player $\vDash$ John is male.
(51) Billi is a dead rat $\vDash$ Billi is dead.

The key difference between these two classes of adjectives seems to be the following:

Something can be young/short/famous/etc. in a relative sense. That is, it makes sense to say things like the following: “He is young/short/famous/etc. for an X.”

Something can’t be male/pregnant/married/dead/etc. in a relative sense. That is, it makes no sense to say things like the following: “He is male/pregnant/married/dead/etc. for an X.”

For intersective adjectives it makes a lot of sense to use the rule of Predicate modification. What about the nonintersecitve ones?

Could we use a more complex denotation for them, so that they compose with their noun and the noun provides the standard?

We could do this and it is an empirical question of whether this is the right thing to do.

(52) ⟦**small**⟧= [$\lambda f_{<e,t>}$.[λx_e. f(x) = T and x is below the average height for the entities in {y: f(y)=T}]]

(53) ⟦**small elephant**⟧= [λx_e. x is an elephant and x is below the average height for the entities in {y : y is an elephant}]

Question 1: what will we do with (54)?

(54) Jumbo is small.

One option would be to say that there is an unpronounced noun that follows 'small'.

Syntacticians actually proposed that this is true for some languages in some cases.

Question 2: is it right that the standard must always be provided by the noun that follows the adjective?

Context: An army of monsters like King Kong

(55) Jumbo doesn't have a chance. He's only a small elephant.

In (55) it is possible that Jumbo is a regular size elephant. It suffices for him to be smaller than the standard size monster.

Conclusion: the standard is not always determined by the noun. The standard size relevant for the interpretation of a predicate can be determined by the context.

The solution

We treat both nonintersective and intersective predicates as expressions of type <e,t>.

They go together with the nount via the rule of Predicate modification.

We make the meaning of nonintersective predicates dependent on the context.

Non-intersective adjectives and context dependence Adjectives like 'small' are evaluated relative to the utterance context c.

Often (but as we saw, not always) a noun sets up a context in a specific way.

(56) ⟦**small**⟧^{c} = λx_e. x's size is below the size standard in c

(57) ⟦**Jumbo is a small elephant**⟧^{c} = 1 iff Jumbo is an elephant and smaller than the size standard in c

$[\![(58)]\!]^c$ entails $[\![(59)]\!]^c$ only in case the context is held constant.

(58) Jumbo is a small elephant.
(59) Jumbo is a small animal.

Other types of nonintersective predicates

(60) John is a beautiful skater $\not\Rightarrow$ John is beautiful for a skater
(61) Mary is a former president $\not\Rightarrow$ John is a president

Something much more complex has to be said about those adjectives. At this stage we do not have the tools to get their meaning right. But this is a question semantics asks.

5. The list of rules we have now:

The Rule of Functional Application (FA):
If α is a branching node that has two daughters – β and γ – and if $[\![\boldsymbol{\beta}]\!]$ is a function whose domain contains $[\![\gamma]\!]$, then $[\![\boldsymbol{\alpha}]\!] = [\![\boldsymbol{\beta}]\!]([\![\gamma]\!])$

Non-branching nodes (NB):
If α is a non-branching node, and β is α's daughter, then $[\![\boldsymbol{\alpha}]\!]=[\![\boldsymbol{\beta}]\!]$

Terminal nodes (TN):
If α is a terminal node, $[\![\boldsymbol{\alpha}]\!]=$ is specified in the lexicon.

Predicate modification (PM):
If α is a branching node, $\{\beta,\gamma\}$ is the set of α's daughters, and $[\![\boldsymbol{\beta}]\!]$ and $[\![\gamma]\!]$ are both in $D_{\langle e,t\rangle}$, then $[\![\boldsymbol{\alpha}]\!]= \lambda x_e.\ [\![\boldsymbol{\beta}]\!](x) = 1$ and $[\![\gamma]\!](x) = 1$.