Recursive adjectival modification in CLLRS

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Abstract

This paper sketches an analysis in Lexical Resource Semantics of adverbial and adjectival modification in nominal projections which is extensible to modification of other syntactic categories. It combines insights into the syntax-semantics interface of recursive modification in HPSG with underspecified semantics and type-logical meaning representations in the tradition of Montague grammar. The analysis is phrased in such a way that it receives a direct implementation in the Constraint Language of Lexical Resource Semantics as part of the TRALE system.

1 Introduction

This paper has two main goals: (1) it presents a Montagovian semantics of recursive adjectival modification in English in LRS (Lexical Resource Semantics, Richter & Sailer (2004)) hand in hand with its implementation in CLLRS (Constraint Language of Lexical Resource Semantics, Penn & Richter (2005)), and (2) it points out that the seemingly straightforward constraint-based rendering of the semantic composition system crucially goes beyond what traditional hole semantic analyses with dominance constraints can do. The important innovation is the underspecification of the semantic functor, i.e. the predicate of a logical expression is underspecified, whereas the holes of dominance constraints into which the labels of other formulæ can be plugged are in the argument positions of functors. While LRS was always able to cover such cases, the syntax and semantics of CLLRS had to be generalized to capture them. A precursor of the present type-logical theory of recursive modification was proposed in a more traditional HPSG feature geometry by Kasper (1997).

2 Data and intended semantics

Adjectival modification has not received much attention so far in LRS or in CLLRS, with the exception of the challenging lexical item *different* in Lahm (2018) and Richter (2016). The present focus is on more ordinary adjectives and their adverbial modifiers. In Montague grammars with semantic representations in Intensional Logic and a composition system based on intensional functional application such as the fragment of English in (Gamut, 1991, p. 198), adjectives are semantically treated as functions from properties to sets of entities. In the spirit of lifting types to the most complex case necessary, this permits an account of the fact that a *former senator* is not a senator, and an *alleged senator* may not be a senator. As usual in LRS, our

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representations are stated in Two-sorted Type Theory, Ty2 (Gallin, 1975). We follow the decision in the English fragment for an automatic reasoning architecture by Hahn & Richter (2015) and add a world index to the representation of adjectives. The type of non-logical constants for adjectives then is $\langle s\langle\langle s\langle et\rangle\rangle\langle et\rangle\rangle\rangle$, with $\langle s\langle et\rangle\rangle$ being the type of nominal constants. Adverbial modifiers of adjectives such as *potentially* in *potentially controversial plan* map an adjective meaning into an adjective meaning, which makes them of type $\langle\langle s\langle\langle s\langle et\rangle\rangle\langle et\rangle\rangle\rangle\langle s\langle\langle s\langle et\rangle\rangle\langle et\rangle\rangle\rangle\rangle$. As we are not concerned with quantification in nominal phrases, we will assume syncategorematic quantifiers as translations of quantificational determiners as in the older LRS literature rather than categorematic (possibly polyadic) quantifiers for simplicity.

In the following examples, we show a few representative noun phrases with adjectival modification and their translation (omitting the translation of the determiner, which would be translated as an existential quantifier binding the variable x in each example). World variables are notated as w_n and are of type s; x, y, z are variables of type e.

(1) a. (a) controversial plan
$controversial(w, (\lambda w_2 \lambda y.(plan(w_2, y))), x)$
b. (a) potentially controversial plan
$(potential(controversial))\,(w, (\lambda w_2 \lambda y.(plan(w_2, y))), x)$
c. (an) invisible pink unicorn
$invis(w, (\lambda w_2 \lambda y.(pink(w_2, (\lambda w_3 \lambda z.(unicorn(w_3, z))), y))), x)$
d. (a) clearly potentially genuine unicorn
$(clear(potential(genuine)))\,(w, (\lambda w_2 \lambda y.(unicorn(w_2, y))), x)$

The meaning of an adjective has three arguments of type s, $\langle s\langle et\rangle\rangle$, and e, respectively. Semantically, the two lambda abstractions in (1a) are unnecessary, but they will be technically useful for defining the semantic composition principles in (CL)LRS representations, which is why they are depicted here as well. The same holds for all corresponding lambda abstractions in (1b)–(1d).

Classes of adjectives are traditionally distinguished by the inference patterns they license (Partee, 1995; Kamp & Partee, 1995). We assume that they are given by appropriate meaning postulates (shown here according to (Hahn & Richter, 2015, p. 558)):

(2) a. For every intersective adjective meaning α (*blond, female, Chinese*):
$\exists P^1_{\langle s\langle et\rangle\rangle} \forall w_s \forall P^2_{\langle s\langle et\rangle\rangle} \forall x_e (\alpha(w, P^2, x) \leftrightarrow (P^1(w, x) \wedge P^2(w, x)))$
b. For every subsective, non-intersective adjective meaning α (*tall, genuine, pink*): $\forall P_{\langle s\langle et\rangle\rangle} \forall x_e \forall w_s (\alpha(w, P, x) \rightarrow P(w, x))$

c. For every privative adjective meaning α (*fake, former*):
$\forall P_{\langle s\langle et\rangle\rangle}\forall x_e \forall w_s(\alpha(w, P, x) \rightarrow \neg P(w, x))$

In an HPSG grammar, these could either be stated as part of the representations of words in an appropriate store for meaning postulates (licensed by principles generalizing over the appropriate word classes so that individual lexical entries do not have to mention them separately) or triggered at utterance level by the presence of the respective lexical items in the utterance.

3 (CL)LRS Analysis

To keep the presentation compact, we do not separate LRS and CLLRS descriptions but render the underlying LRS specification in a syntax that loosely follows the CLLRS code of the corresponding grammar implementation. The external content is indicated by ^, the internal content is shown between curly braces ({,}), the main content is underlined, and square brackets ([,]) indicate the subterm relation. Capital letters are metavariables.

(3) pink ⇝ `^(([{`<u>*pink*</u>`}])(W, λWλX.[ 1 (W,X)], X))`
(where 1 is shared with the MOD|LOC|CONTENT|MAIN value of *pink*)

(4) potentially ⇝ `^(([{`<u>*potential*</u>`}])([ 2 ]))`
(where 2 is shared with the MOD|LOC|CONTENT|MAIN value of *potentially*)

We need a new clause of the LRS SEMANTICS PRINCIPLE which formulates the semantic combinatoric restrictions for combinations of adjectives (HEAD value *adjective*) with nominal projections and of adverbial modifiers (HEAD value *adj_ adv*) with adjectival projections.

(5) SEMANTICS PRINCIPLE, new clause for (adverbial) adjectival modification:
In a *head-adjunct* phrase with an adjective or and adverbial modifier of adjectives as non-head daughter ([HEAD *adj_ adv* ∨ *adjective*]), the internal content of the head daughter is a subterm of an argument of the internal content of the non-head daughter.

Moreover, an assumption of the LRS PROJECTION PRINCIPLE must be modified, according to which the internal content is always inherited from the head daughter of a phrase: In accordance with the insight that in adjectival modification (and related structures) syntactic head and semantic head are not the same, in these phrases the internal content is inherited by the phrase from the external content of the non-head daughter. The first two clauses of the principle in (6) are unchanged, whereas the third clause distinguishes INCONT inheritance in non-head-adjunct structures from the new case of head-adjunct structures:

(6) LRS Projection Principle
In each *phrase*,

a. the EXCONT values of the head and the mother are identical,
b. the PARTS value contains all and only the elements of the PARTS values of the daughters,
c. (i) if it's not a head-adjunct phrase, the INCONT values of the head and the mother a re identical,
(ii) if it is a head-adjunct phrase, the EXCONT value of the non-head daughter and the INCONT value of the mother are identical.

Given the lexical specifications in (3) and (4), the new clause of the Semantics Principle and the modified LRS Projection Principle for internal content inheritance, we can now investigate how the semantic representations in (1a)–(1d) are licensed.

(7) unicorn $\rightsquigarrow$ `^[{`$\underline{unicorn}$`(W, X)}]`

With the (simplified) lexical semantic specification of a noun like *unicorn* in (7), we obtain (8) for *pink unicorn*:

(8) pink unicorn $\rightsquigarrow$ `^[({`*pink* `(W, λWλX.[`$\underline{unicorn}$`(W,X)], X)})]`

The internal content of *pink unicorn* (8) is inherited from the external content of *pink* (3) (Projection Principle), the variables `X` in (3), (7) and (8) are all identical (a consequence of the lexical specification of *pink*), the predicate *unicorn* in (8) is in the scope of the two lambda abstractions due to the lexical requirement of *pink* and in accordance with the modifier clause of the Semantics Principle in (5): Since the first argument of *pink* is a world variable of type s and the last argument is a variable of type e, only the second argument can accommodate the internal content of *unicorn.* Moreover, the representation in (8) corresponds to (1a). In particular if *pink unicorn* is combined with the indefinite determiner translated as existential quantifier, we obtain ˆ$\exists x$({*pink* (W, λWλx.$\underline{unicorn}$(W, x), x)}: [x]) as representation for the full NP, since `X` in (8) is identified with the object level variable x contributed by the determiner (by lexical requirement of *unicorn* according to standard LRS analysis); and x must also occur in the scope of the quantifier ([x] after ':', separating restrictor from scope).

Now consider another adjective, *invisible*:

(9) invisible $\rightsquigarrow$ `^(([{`$\underline{invisible}$`}])(W, λWλX.[` 3 `(W,X)], X))`
(where 3 is shared with the MOD|LOC|CONTENT|MAIN value of *invisible*)

(9) is combined as non-head daughter with *pink unicorn* in (8) to form *invisible pink unicorn.* In this case, 3 is identified with the MAIN value of

the head daughter, which is the MAIN value of *unicorn*. But in addition, according to the new clause of the SEMANTICS PRINCIPLE, (5), the internal content of the head daughter (*pink unicorn*) must be a subterm of an argument of the internal content of *invisible*. This is only possible in the scope of the two lambda abstractions of its second argument. But that means that the expression shown in the constraints in (8) must be in the scope of the two lambda expressions contributed by *invisible*, leading to what is shown in (1c). In fact, it turns out the variables x, y and z of (1c) are all the same variable x according to the (CL)LRS constraints of the grammar, but they are either bound by different lambda abstractions (z, y) or unbound in the term (the last occurrence of x in (1c)).

Let's assume alternatively that we combine *potentially* (4) with *pink* (3). In the resulting phrase, *potentially* is the non-head daughter and *pink* is the head daughter. According to the clause of the SEMANTICS PRINCIPLE above, the internal content of *pink*, which is the non-logical constant *pink*, is (a subterm of) the argument of the functor *potential*. Note that the typing of the two non-logical constants fits this requirement when *pink* is the argument of *potential*. According to the LRS PROJECTION PRINCIPLE, the external content of *potentially* becomes the internal content of *potentially pink*. Overall, this leads to the following constraint for *potentially pink*:

(10) potentially pink $\rightsquigarrow$
^(([{$\mathit{potential}(\underline{\mathit{pink}})$}])(W, λWλX.[$\boxed{1}$ (W,X)], X))

The adjectival phrase *potentially pink* with the semantic representation in (10) can be combined with a noun like *unicorn* in the same way in which *pink* alone can be combined with *unicorn*. Alternatively, *potentially pink* can be combined with another adverbial modifier before it finds its nominal head (see (1d)).

A crucial feature of the analysis above is the underspecification of the functor of adjectival modification: The main relation of adjectives is potentially a subterm of the overall functor (see (3)), thus making it possible that something else takes their main relation as argument first to build a complex functor which then applies to the arguments of the adjective. This potential for combining with a modifier is preserved after a first modifier combines with an adjective, as shown in (10).

Underspecification of functors, naturally formulated in LRS, turns out to be challenging for implementation. In the tradition of term representations for expressions of first order logic, the original representation of functors in CLLRS tied predicates to their arguments, and they could not be separated. Similarly, formulations of underspecified representations in the tradition of hole semantics with dominance constraints (Bos, 1995) leave holes in argument positions which can be plugged by labels of subformulæ, but there are no holes in the position of syntactic functors. CLLRS was re-implemented with a new data structure for term representations and a new specification syntax for stating arguments of fully specified or underspecified functors.

4 Conclusion

The analysis presented above has been implemented as a component of a larger fragment of English with CLLRS semantics in TRALE. The CLLRS implementation is entirely parallel to the LRS specification. The syntax-semantics interface follows the main ideas put forth by Kasper (1997) in his seminal paper on the semantics of recursive modification in HPSG. One major difference is the semantic representation language where the present proposal chooses a classical higher-order logic. Another difference is the narrower empirical focus on modifiers in the nominal domain of the present paper. With a type-logical representation language, we expect the main ideas to be applicable in the verbal domain as well, but important details depend on the choice a particular verb semantics that require much broader considerations. The parallels to Kasper (1997) are far-reaching: There is a clear distinction between the inherent content of lexical items from the semantic combinatorics, the inherent lexical content is separated from its use in different constructions. At the same time, the combinatorial behavior of signs is projected from the lexical head of constructions, while a uniform semantic principle is responsible for regulating the essential restrictions on head-modifier constructions. Both approaches cover different kinds of modifiers (operators, intersective), captured in the present analysis by meaning postulates for classes of adjectives.

Predicative adjectival constructions were not covered in the analysis above, but they can be added by assuming a lexical rule which relates attributive forms to predicative forms, including a slightly modified lexical semantic specification. For the adjective *pink*, the semantic specification would look as shown in (11-a), where *entity* is a property of any entity in the model, and standard semantic composition principles of LRS are sufficient to then derive an adequate semantic representation for (11-b).

(11) a. pink ⇝ ^(([{*pink*}])(W, *entity*, X))
b. Few unicorns are (entirely) pink.

Adverbial modifiers apply to predicative adjectival constructions as they do in the attributive case. However, further assumptions are needed to add adverbial modifiers of adverbials to the picture, as in *a very occasionally invisible unicorn*. If *very* first modifies *occasionally* before *very occasionally* modifies *invisible*, the non-logical constant of *very* must be of a different type from the type of the constant of *occasionally*. It might be useful to consider type polymorphism for adverbials by underspecification as a possible solution. Just as an extension of the present analysis of modification to the verbal domain, this is left to future consideration.

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