LOGON

Technical Report # 2007-7

The English Resource Grammar

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Contents

1 Introduction

Generation within the LOGON pipeline employs the English Resource Grammar (ERG) to produce linguistically well-formed candidate surface realizations for each MRS presented by the transfer component. The ERG is an open-source, broad-coverage, declarative grammar implementation for English, designed within the Head-driven Phrase Structure Grammar (HPSG) framework. This linguistic framework places most of the burden of linguistic description on the lexicon, employing a relatively small number of highly schematic syntactic rules to combine words or phrases to form larger constituents. Each word or phrase (more generally, each *sign*) is defined in terms of feature structures where the values of attributes are governed by general principles such as the Head Feature Convention, which ensures the identity of a particular subset of feature-value pairs on a phrasal node and on one distinguished daughter, the head of the phrase. Many of these generalizations aim to be language-independent, constraining the space of possible analyses for linguistic phenomena. Central to the HPSG framework is the inclusion in each sign of constraints on multiple dimensions of representation, including at least syntactic and semantic properties, so that rules, lexical entries, and principles determine semantic well-formedness just as they do syntax.

Under continuous development at CSLI since 1993, the ERG provides syntactic and semantic analyses for the large majority of common constructions in written English text, and it has been augmented during the LOGON project to improve coverage of lexical entries and high-frequency constructions within the chosen LOGON development corpus of Norwegian back-country tourism texts. At the completion of the LOGON demonstrator, the ERG provided correct parses for 85 per cent of the English translations in the development corpus, and provided well-formed realizations for more than 80 per cent of the Norwegian development corpus items which succeeded in transfer. The hand-built ERG lexicon grew within LOGON to more than 27,000 lexical entries, which are augmented within the demonstrator by on-the-fly construction of entries for unknown named entities used in generator output.

Each successful input to the generator is a well-formed MRS representing the content of a phrase or sentence, expressed as a bag of elementary predications (EPs) each of which is consistent with the public semantic interface specification (the SEM-I) provided by the grammar. Within the LOGON demonstrator, each input MRS is produced by the Transfer component as described in Chapter **??**. An example of such an MRS is given in compact form in 3, the result of first parsing the simple Norwegian sentence 1 (which can be translated as 2), and then applying the transfer rules which convert Norwegian EPs to English EPs.

(1) Gjendebu ble åpnet i 1871.

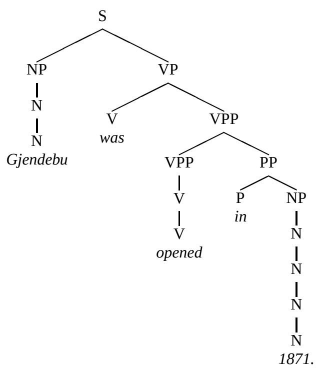
(2) Gjendebu was opened in 1871.

(3)

$$
\langle\, h_1, \\
\left|\begin{array}{l}
h_1\text{:prpstn\_m}(e_2\{\text{TENSE } \textit{past}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\},, \\
\qquad\qquad h_3, x_4, u_5) \\
h_6\text{:proper\_q}(x_4, h_7, h_8), \\
h_9\text{:named}(x_4\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\}, \textit{gjendebu}), \\
h_{10}\text{:\_open\_v\_cause}(e_2, u_{11}, x_4), \\
h_{10}\text{:\_in\_p\_temp}(e_{12}, e_2, x_{13}), \\
h_{14}\text{:proper\_q}(x_{13}, h_{15}, h_{16}), \\
h_{17}\text{:yofc}(x_{13}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\}, i_{18}, \textit{1871})
\end{array}\right| \\
\{\, h_3 =_q h_{10}, h_7 =_q h_9, h_{15} =_q h_{17} \,\}\,\rangle
$$

The generator looks up all of the lexical entries whose predicates match those found in the input MRS and then augments that bag of entries with any semantically empty lexical entries whose conditioning requirements are satisfied by the input MRS. It uses an efficient version of an exhaustive procedure which constructs all phrases containing any of these lexical entries which are admitted by the rules of the grammar and semantically consistent with the input. The generator returns as valid realizations those phrases whose MRS matches the input and which are consistent with the root condition set for the generator. For the above example, the generator returns just the one realization in 4, with its corresponding ERG analysis:

(4) *Gjendebu was opened in 1871.*



Though this example is relatively simple, it already illustrates several features of the generator and the use of the resources provided by the ERG. First, of the five lexical entries used in the preferred realization here, four are semantically contentful and could be found in the lexicon via their predicates. But the word "was" is treated in the ERG as semantically empty (apart from its constraints on the tense of the event), so its lexical entry was added to the generator's inventory of candidate lexical entries by virtue of a triggering rule, discussed in more detail in the final section of this chapter. Second, the temporal preposition "in" introduces a semantic predicate which is more specific than that of the corresponding input EP, since English imposes idiosyncratic constraints on the choice of temporal prepositions determined by the semantic class of their object NP: "in 1871" but "on Tuesday" and "at ten o'clock". By permitting as input the less specific predication temp_loc_sp, the generator attends to this idiosyncracy within the ERG, simplifying the external interface for this component. Third, the lexical entry corresponding to "1871" is a more generic lexical entry used for all numbered years, and whose orthography for realization is determined by a property of the relevant input EP. And fourth, the proper name "Gjendebu" could be generated on the fly without the need for a pre-defined lexical entry, exploiting a robust extension to the generator which is useful in name-rich domains such as ours. In this example, the syntactic rules used to admit each of the constituent phrases happen to be semantically transparent, leaving the lexical entries to account for all of the information in the input MRS; but as we will see in the next section, other commonly used rules in the ERG contribute part of the semantic content of the phrases they admit.

In the next section we present ERG analyses of some of the more frequently occurring linguistic phenomena in the English translations of the LOGON development corpus, focusing on the contributions of lexical entries and rules to the composition of the semantics for these phenomena. In the following section we review some of the linguistic phenomena for which the pre-LOGON ERG lacked coverage. And the final section describes some additional grammar resources used by the generator, aiming to find the right balance for LOGON among the competing tensions of precision, robustness, efficiency and extensibility. But first, some remarks on the notation used here.

1.1 Notational Conventions

Consistent with standard assumptions in the HPSG framework, ERG analyses reflect both syntactic and semantic constraints on well-formedness, with the bulk of these constraints expressed as properties of lexical entries which inherit from a rich hierarchy of lexical types, augmented by a modest set of productive lexical rules. The syntactic component of the ERG consists of some 180 context-free rules defined as constructions which again inherit from a hierarchy, in this case of phrasal types. These linguistic objects are all implemented as typed feature structures, with unification the sole operation for determining the well-formedness of a candidate mapping between form and meaning. The ERG has been developed using the LKB system (Copestake, 2002) [1], which provides an implementation of typed feature structures, a parser, a generator, and sophisticated inspection and debugging tools.

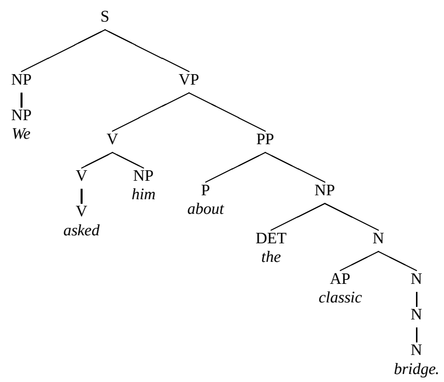
While these feature structures include rich syntactic information in addition to their semantic content, the phenomenon descriptions presented here abbreviate the syntactic properties of each constituent in a phrase, using atomic node labels for convenience in presenting the phrasal structure employed in these linguistic analyses. For example, the noun phrase "the classic bridge" is assigned the following (somewhat simplified) feature structure by the ERG:

(5)
$$\begin{bmatrix} \textit{hspec\_rule} & \\ \text{SSM} & \begin{bmatrix} \textit{canonical\_synsem} & \\ \text{LOCAL} & \begin{bmatrix} \textit{local} & \\ \text{CAT} & \begin{bmatrix} \textit{cat} & \\ \text{HEAD} & \textit{noun} \\ \text{VAL} & \begin{bmatrix} \textit{valence} & \\ \text{SUBJ} & \langle\,\rangle \\ \text{SPR} & \langle\,\rangle \\ \text{COMPS} & \langle\,\rangle \end{bmatrix} \end{bmatrix} \\ \text{CONT} & \textit{mrs} \\ \text{CONJ} & \textit{cnil} \end{bmatrix} \\ \text{LEX} & - \\ \text{NONLOC} & \textit{non-local} \\ \text{MODIFD} & \textit{lmod} \end{bmatrix} \\ \text{INFL} & + \end{bmatrix}$$

We will abbreviate this feature structure as simply an **NP**, an expression whose HEAD attribute is *noun* and whose specifier requirement has been met (the value of SPR is the empty list). Irrelevant to this abbreviation are the fact that this expression is a phrase ([LEX –]) or that the head noun has been modified on its left ([MODIFD *lmod*]), for example. These more fine-grained properties are necessary to ensure well-formedness when parsing or generating, but can be visually glossed over when viewing whole derivation trees. Similar abbreviatory mappings from syntactic category constraints to node labels are defined for most phrases admitted by the grammar, enabling compact presentation of the derivation trees for analyses assigned by the parser or the generator, such as the following:

[1] The initial work on the ERG employed the PAGE (Platform for Advanced Grammar Engineering) system developed at the DFKI in Saarbrücken, and the LKB was later adapted to accommodate the type description language TDL (Krieger & Schäfer, 1994) used in PAGE.

(6) *We asked him about the classic bridge.*



2 Core Linguistic Phenomena

Most of the core phenomena of English syntax and semantics are by definition common to most domains and genres, and the ERG analyses presented in this section largely pre-date the onset of the LOGON project. However, some of the details of the semantic representations have been revised during the course of the project, reflecting our efforts toward cross-linguistic harmonization of semantics, a topic discussed in detail in Chapter **??**.

2.1 Clauses and Sentence Fragments

In English, distinct syntactic constructions can be used to differentiate declarative, interrogative, and imperative sentences, with some variety of structure possible for each of these primary clause types. The ERG is a sentence-level grammar, or more precisely, one which licenses well-formed utterances, including both sentences and sub-sentence phrases. Either may contain embedded clauses, either as arguments or as modifiers, which exhibit some properties that contrast with matrix clauses.

6 above is an example of a simple declarative main clause, whose semantics is given in 7. Here the main predication is the three place relation _ask_v_about, with the index of _bridge_n_1 as its third argument. The top level predication for an utterance will always be a message, here the proposition EP prpstn_m, reflecting the declarative clause structure of this example. The event variable introduced by the main predication is specified with tense, mood, and aspect properties (not perfect and not progressive), while the referential indices introduced by the noun phrases are marked for person and number. For uniformity in representation, every noun phrase introduces a quantifier EP, though the quantifiers for pronouns and proper names do not exhibit any interactions with scope in LOGON.

(7) *We asked him about the classic bridge.*

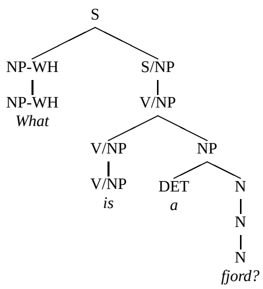
$\langle h_1,$

h_1:prpstn_m(e_2{TENSE *past*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:pron(x_7{PERS *1*, NUM *pl*, PRONTYPE *std_pron*}),
h_8:pronoun_q(x_7, h_9, h_{10}),
h_{11}:_ask_v_about(e_2, x_7, x_{13}, x_{12}),
h_{14}:pron(x_{13}{PERS *3*, NUM *sg*, GEND *m*, PRONTYPE *std_pron*}),
h_{15}:pronoun_q(x_{13}, h_{16}, h_{17}),
h_{18}:_the_q(x_{12}, h_{20}, h_{19}),
h_{21}:_classic_a_1(e_{22}, x_{12}),
h_{21}:_bridge_n_1(x_{12}{PERS *3*, NUM *sg*, DIV -})

$\{ h_3 =_q h_{11}, h_9 =_q h_6, h_{16} =_q h_{14}, h_{20} =_q h_{21} \} \rangle$

8 illustrates analyses of simple examples of the other two main clause types, for interrogatives and imperatives.

(8) *What is a fjord?*

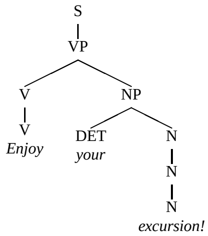


$\langle h_1,$

h_1:int_m(e_2{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_4, u_3, x_5),
h_4:prpstn_m(e_2, h_6, u_3, x_5),
h_7:thing(x_5{PERS *3*, NUM *sg*}),
h_8:which_q(x_5, h_9, h_{10}),
h_{11}:_be_v_id(e_2, x_{12}, x_5),
h_{13}:_a_q(x_{12}, h_{15}, h_{14}),
h_{16}:_fjord_n_1(x_{12}{PERS *3*, NUM *sg*, DIV -})

$\{ h_6 =_q h_{11}, h_9 =_q h_7, h_{15} =_q h_{16} \} \rangle$

(9) *Enjoy your excursion!*

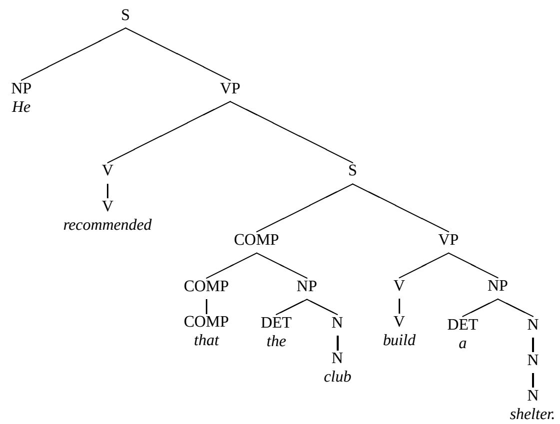


$$
\begin{array}{l}
\langle\, h_1, \\
\left|\begin{array}{l}
h_1\text{:imp\_m}(e_2\{\text{TENSE } \textit{pres}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\}, h_3, u_4, u_5), \\
h_6\text{:pronoun\_q}(x_8, h_7, h_9), \\
h_{10}\text{:pron}(x_8\{\text{PERS } \textit{2}, \text{PRONTYPE } \textit{zero\_pron}\}), \\
h_{11}\text{:\_enjoy\_v\_1}(e_2, x_8, x_{12}), \\
h_{13}\text{:def\_explicit\_q}(x_{12}, h_{15}, h_{14}), \\
h_{16}\text{:poss}(e_{18}, x_{12}, x_{17}), \\
h_{19}\text{:pronoun\_q}(x_{17}, h_{20}, h_{21}), \\
h_{22}\text{:pron}(x_{17}\{\text{PERS } \textit{2}, \text{PRONTYPE } \textit{std\_pron}\}), \\
h_{16}\text{:\_excursion\_n\_1}(x_{12}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\})
\end{array}\right| \\
\{\, h_3 =_q h_{11}, h_7 =_q h_{10}, h_{15} =_q h_{16}, h_{20} =_q h_{22} \,\} \,\rangle
\end{array}
$$

The WH-question above introduces the interrogative int_m message EP (in addition to a proposition EP which might be unnecessary), while the command introduces the imperative imp_m message EP. Both of these examples illustrate another characteristic of semantic composition in the ERG: while most lexical entries introduce just one EP each, some are semantically more complex, such as the possessive pronoun “your”, which provides both the pronoun EP pron and the two-place possessive relation poss. Similarly, WH-pronouns are given a more complex semantics, preserving the uniformity of a common quantifier which_q while including a second EP differentiating “what” from “who” (person_n), “where” (place_n), etc.

While embedded complement clauses exhibit somewhat distinct structural properties compared to main clauses, their semantic representations are nearly indistinguishable, except that the label of the outermost message EP in the complement clause is identified with an argument position in another EP, and in addition the mood of the EP may be *subjunctive*, as in the following example:

(10) *He recommended that the club build a shelter.*



$\langle\, h_1,$

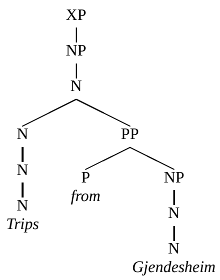
h_1:prpstn_m(e_2{TENSE *past*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:pron(x_7{PERS *3*, NUM *sg*, GEND *m*, PRONTYPE *std_pron*}),
h_8:pronoun_q(x_7, h_9, h_{10}),
h_{11}:_recommend_v_1(e_2, x_7, h_{12}),
h_{12}:prpstn_m(e_{14}{TENSE *tensed*, MOOD *subjunctive*, PROG -, PERF -}, h_{13}, u_{16}, u_{15}),
h_{17}:_the_q(x_{19}, h_{20}, h_{18}),
h_{21}:_club_n_1(x_{19}{PERS *3*, NUM *sg*, DIV -}),
h_{22}:_build_v_1(e_{14}, x_{19}, x_{23}),
h_{24}:_a_q(x_{23}, h_{26}, h_{25}),
h_{27}:_shelter_n_1(x_{23}{PERS *3*, NUM *sg*, DIV -})

$\{\, h_3 =_q h_{11}, h_9 =_q h_6, h_{13} =_q h_{22}, h_{20} =_q h_{21}, h_{26} =_q h_{27} \,\}\,\rangle$

Here the label of the embedded message is identified with the last argument of the _recommend_v_1 EP, and the event variable of the complement clause's _build_v_1 EP is marked as subjunctive.

In addition to complete sentences, the ERG also analyzes sub-sentence utterances consisting of one or two constituents which we will refer to here as sentence fragments, following (Schlangen, 2003). An example is the following section heading within a text.

(11) *Trips from Gjendesheim*

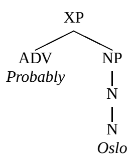


$\langle h_1,$
h_1:prop-or-ques_m($e_2$$\{$TENSE *untensed*, MOOD *indicative*, PROG -, PERF -$\}$, h_3, u_5, u_4),
h_6:unknown(e_2, x_7),
h_8:udef_q(x_7, h_9, h_{10}),
h_{11}:_trip_n_of($x_7$$\{$PERS *3*, NUM *pl*, DIV +$\}$, u_{12}),
h_{11}:_from_p(e_{13}, x_7, x_{14}),
h_{15}:proper_q(x_{14}, h_{16}, h_{17}),
h_{18}:named($x_{14}$$\{$PERS *3*, NUM *sg*, DIV -$\}$, *gjendesheim*)
$\{ h_3 =_q h_6, h_9 =_q h_{11}, h_{16} =_q h_{18} \} \rangle$

As noted above, for uniformity, fragments too introduce a top-level message EP, here the underspecified prop-or-ques_m, though it might be reasonable to assume that the absence of an utterance-final question mark will typically license interpretation as a declarative proposition. Again following (Schlangen, 2003), NP fragments also introduce an underspecified one-place relation unknown which might later be identified with the relevant discourse-supplied relation for which the NP is an argument.

Some non-sentence utterances, like "probably Oslo" are not single constituents, but a sequence of two, each of which bears some independent grammatical relation to the implicit main verb, further motivating our introduction of the unknown EP for fragments. The syntax and semantics of this expression are as follows.

(12) *Probably Oslo*



$\langle h_1,$
h_1:prop-or-ques_m(e_2 {TENSE *untensed*, MOOD *indicative*, PROG -, PERF -}, h_3, u_5, u_4),
h_6:unknown(e_2, x_7),
h_8:_probable_a_1(e_9, h_{10}),
h_{11}:proper_q(x_7, h_{12}, h_{13}),
h_{14}:named(x_7 {PERS *3*, NUM *sg*, DIV -}, *oslo*)
$\{ h_3 =_q h_8, h_{10} =_q h_6, h_{12} =_q h_{14} \} \rangle$

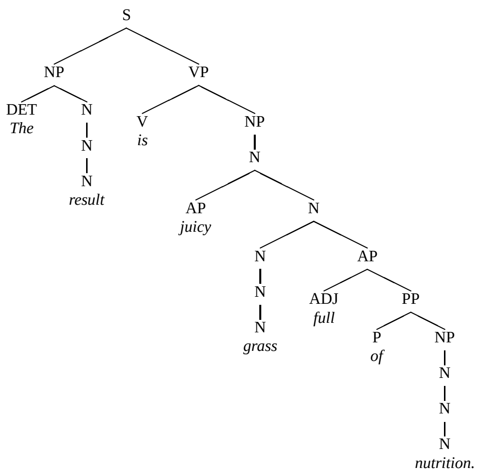
This MRS presents an underspecified representation which we can interpret as a proposition or question whose content consists of some discourse-supplied relation of which “Oslo” is an argument, and which is in the scope of the adverb “probably”.

2.2 Modification

Much of the complexity in naturally occurring English text derives from a wide variety of modification structures, including at least adjectives, adverbs, prepositional phrases, degree modifiers, subordinating conjunctions, and relative clauses. We present examples of each of these independently, and in some of their possible combinations, together with sketches of the dimensions of variation supported in the ERG.

Adjectives in English typically appear as modifiers before their target noun if they are lexical (more or less), and after the noun if they head phrases of their own. In the ERG all adjectives are uniformly treated semantically as intersective modifiers, so we defer for now the issue of whether the class of adjectives including “probable”, “former” and “fake” would be better represented as scopal modifiers. While most adjectives introduce simple one-place relations taking the index of the noun they modify as their sole argument, English has a rather wide variety of complement patterns for adjectives, only a few of which can be illustrated here. We have already seen an example of a simple attributive adjective in 6, and in the corresponding MRS in 7 we can see that, as with every intersective modifier, the labels of the _classic_a_1 EP and the _bridge_n_1 EP are identified, and further, the ARG1 of _classic_a_1 is identified with the ARG0 of _bridge_n_1.

(13) *The result is juicy grass full of nutrition.*

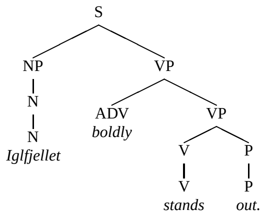


$$
\begin{array}{l}
\langle\, h_1, \\
\quad h_1\text{:prpstn\_m}(e_2\{\text{TENSE } \textit{pres}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\}, h_3, u_4, u_5), \\
\quad h_6\text{:\_the\_q}(x_8, h_9, h_7), \\
\quad h_{10}\text{:\_result\_n\_of}(x_8\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\}, i_{11}), \\
\quad h_{12}\text{:\_be\_v\_id}(e_2, x_8, x_{13}), \\
\quad h_{14}\text{:udef\_q}(x_{13}, h_{15}, h_{16}), \\
\quad h_{17}\text{:\_juicy\_a\_1}(e_{18}, x_{13}), \\
\quad h_{17}\text{:\_grass\_n\_1}(x_{13}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV +}\}), \\
\quad h_{17}\text{:\_full\_a\_of}(e_{19}, x_{13}, x_{20}), \\
\quad h_{21}\text{:udef\_q}(x_{20}, h_{22}, h_{23}), \\
\quad h_{24}\text{:\_nutrition\_n\_1}(x_{20}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{GEND } \textit{n}, \text{DIV +}\}) \\
\;\{\, h_3 =_q h_{12}, h_9 =_q h_{10}, h_{15} =_q h_{17}, h_{22} =_q h_{24} \,\}\,\rangle
\end{array}
$$

In this example, the two-place relation _full_a_of identifies its label with that of _grass_n_1 and that EP's ARG0 with its own ARG1, in addition linking its other argument with the ARG0 of _nutrition_n_1. Note that since all nominal modifiers are treated as intersective, it is convenient when there are both prenominal and postnominal modifiers to avoid spurious ambiguity by consistently favoring low attachment on one side or the other. As shown in 13, the ERG currently attaches post-head modifiers before pre-head ones.

Intersective adverbs have a similar semantic relationship to their targets, identifying their label with that of the highest EP in the phrase they modify, and identifying that EP's ARG0 with their ARG1, as shown in 14.

(14) *Iglfjellet boldly stands out.*



$\langle\, h_1,$

$\big|\; h_1$:prpstn_m($e_2\{$TENSE *pres*, MOOD *indicative*, PROG -, PERF -$\}$, h_3, u_4, u_5),

h_6:proper_q(x_8, h_7, h_9),

h_{10}:named($x_8\{$PERS *3*, NUM *sg*, DIV -$\}$, *iglfjellet*),

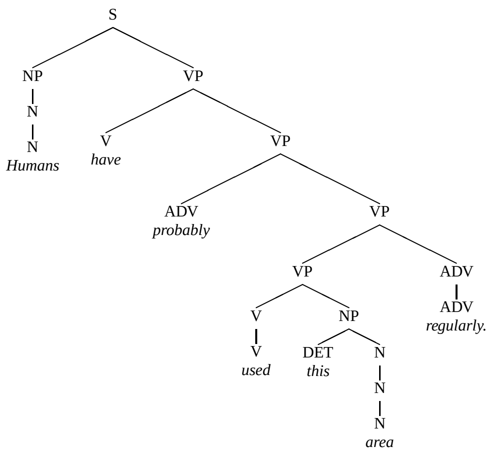
h_{11}:_bold_a_1(e_{12}, e_2),

h_{11}:_stand_v_out(e_2, x_8) $\;\big|$

$\{\, h_3 =_q h_{11}, h_7 =_q h_{10}\,\}\,\rangle$

Scopal adverbs like “probably”, illustrated in 15, do not identify their EP’s label with that of their target’s EP, instead making that target EP’s label the value of their ARG1 (mediated as usual with a *qeq* as presented earlier). This representation is to be interpreted as having the adverb’s semantics outscoping the semantic content of the phrase it modifies.

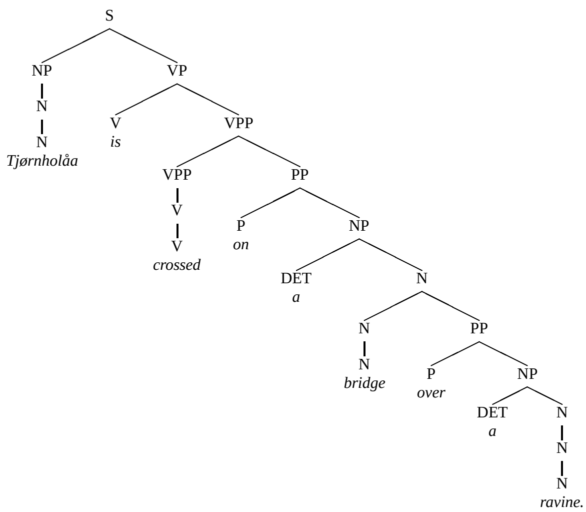
(15) *Humans have probably used this area regularly.*



$$
\begin{array}{l}
\langle\, h_1, \\
\quad h_1\text{:prpstn\_m}(e_2\{\text{TENSE } \textit{pres}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF +}\}, h_3, u_4, u_5), \\
\quad h_6\text{:udef\_q}(x_8, h_7, h_9), \\
\quad h_{10}\text{:\_human\_n\_1}(x_8\{\text{PERS } \textit{3}, \text{NUM } \textit{pl}, \text{DIV +}\}), \\
\quad h_{11}\text{:\_probable\_a\_1}(e_{12}, h_{13}), \\
\quad h_{14}\text{:\_use\_v\_1}(e_2, x_8, x_{15}), \\
\quad h_{16}\text{:\_this\_q\_dem}(x_{15}, h_{18}, h_{17}), \\
\quad h_{19}\text{:\_area\_n\_of}(x_{15}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}\}, i_{20}), \\
\quad h_{14}\text{:\_regular\_a\_1}(e_{21}, e_2) \\
\ \{\, h_3 =_q h_{11}, h_7 =_q h_{10}, h_{13} =_q h_{14}, h_{18} =_q h_{19} \,\}\,\rangle
\end{array}
$$

Prepositional phrase modifiers usually consist of a preposition and its noun phrase complement, where the preposition semantically introduces a two-place relation with that complement's semantic index as its ARG2 and the target phrase's semantic index as its ARG1. Ordinary PPs are treated in the ERG as intersective modifiers, so the label of the preposition's EP is identified with the label of the target semantic head's EP, just as with adjectives and intersective adverbs.

(16) *Tjørnholåa is crossed on a bridge over a ravine.*



$\langle\, h_1,$

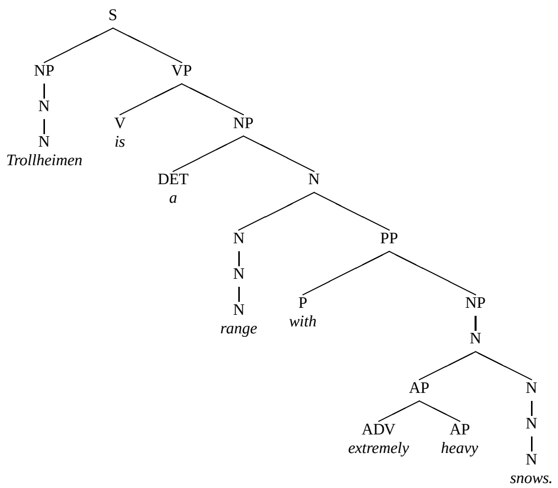
h_1:prpstn_m($e_2\{$TENSE *pres*, MOOD *indicative*, PROG -, PERF -$\}$, h_3, x_4, u_5),
h_6:proper_q(x_4, h_7, h_8),
h_9:named($x_4\{$PERS *3*, NUM *sg*, DIV -$\}$, *tjørnholåa*),
h_{10}:_cross_v_1(e_2, u_{11}, x_4),
h_{10}:_on_p(e_{12}, e_2, x_{13}),
h_{14}:_a_q(x_{13}, h_{16}, h_{15}),
h_{17}:_bridge_n_1($x_{13}\{$PERS *3*, NUM *sg*, DIV -$\}$),
h_{17}:_over_p(e_{18}, x_{13}, x_{19}),
h_{20}:_a_q(x_{19}, h_{22}, h_{21}),
h_{23}:_ravine_n_1($x_{19}\{$PERS *3*, NUM *sg*, DIV -$\}$)

$\{\, h_3 =_q h_{10}, h_7 =_q h_9, h_{16} =_q h_{17}, h_{22} =_q h_{23} \,\}\,\rangle$

We can see in the above example that the PP headed by “on” modifies the VP headed by “cross”, while the PP “over a ravine” modifies the nominal phrase headed by “ravine”: in each case the label of the EP introduced by the preposition is identified with that of the target phrase main EP’s label, and the external argument of each preposition’s EP is identified with its target’s semantic index.

Degree modifiers, which exhibit an impressive range of syntactic and semantic variety in English, fall into two broad classes: the majority which behave semantically like intersective adverbs, and all the rest, which resist easy generalization. The most typical kind appears as a degree specifier of an adjective:

(17) *Trollheimen is a range with extremely heavy snows.*

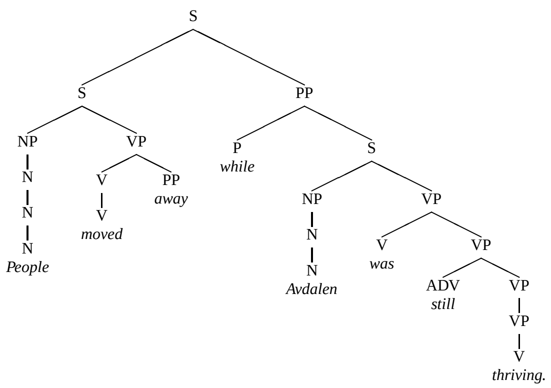


$$
\begin{array}{l}
\langle\, h_1, \\
\quad h_1\text{:prpstn\_m}(e_2\{\text{TENSE } pres, \text{MOOD } indicative, \text{PROG -}, \text{PERF -}\}, h_3, u_4, u_5), \\
\quad h_6\text{:proper\_q}(x_8, h_7, h_9), \\
\quad h_{10}\text{:named}(x_8\{\text{PERS } 3, \text{NUM } sg, \text{DIV -}\}, trollheimen), \\
\quad h_{11}\text{:\_be\_v\_id}(e_2, x_8, x_{12}), \\
\quad h_{13}\text{:\_a\_q}(x_{12}, h_{15}, h_{14}), \\
\quad h_{16}\text{:\_range\_n\_of}(x_{12}\{\text{PERS } 3, \text{NUM } sg, \text{DIV -}\}, i_{17}), \\
\quad h_{16}\text{:\_with\_p}(e_{18}, x_{12}, x_{19}), \\
\quad h_{20}\text{:udef\_q}(x_{19}, h_{21}, h_{22}), \\
\quad h_{23}\text{:\_extremely\_x\_deg}(e_{24}, e_{25}), \\
\quad h_{23}\text{:\_heavy\_a\_1}(e_{25}, x_{19}), \\
\quad h_{23}\text{:\_snow\_n\_1}(x_{19}\{\text{PERS } 3, \text{NUM } pl, \text{DIV +}\}) \\
\{\, h_3 =_q h_{11}, h_7 =_q h_{10}, h_{15} =_q h_{16}, h_{21} =_q h_{23} \,\}\,\rangle
\end{array}
$$

As with ordinary adverbs, the degree modifier "extremely" introduces an EP whose label is identified with its target, and whose ARG1 is the same as its target's ARG0.

Subordinating conjunctions like "while" or the conditional "if" share many syntactic characteristics with ordinary prepositional phrases, but their semantic representation is quite distinct, since they must relate the contents of two clauses: their complement subordinate clause, and the target clause which they modify. Since each of these clauses can include scopal predications (such as negation or modality), the EP introduced by the subordinating conjunction takes not the event variable but the highest scoping label of each clause for one of its two arguments. This construction is illustrated in the following

(18) *People moved away while Avdalen was still thriving.*

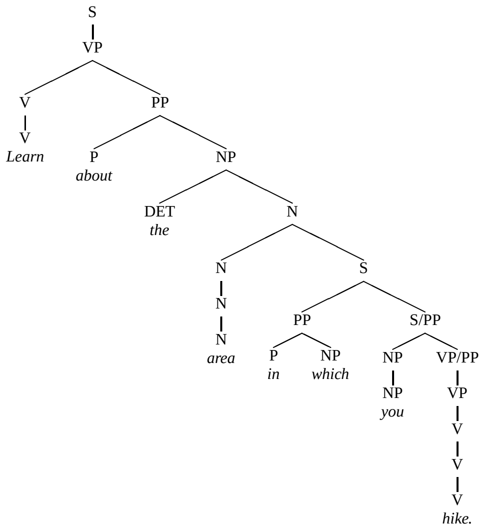


$$
\begin{array}{l}
\langle\, h_1, \\
\quad h_1{:}\text{prpstn\_m}(e_2\{\text{TENSE } \textit{past}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\}, h_3, u_4, u_5), \\
\quad h_6{:}\text{udef\_q}(x_8, h_7, h_9), \\
\quad h_{10}{:}\text{\_people\_n\_of}(x_8\{\text{PERS } \textit{3}, \text{NUM } \textit{pl}, \text{DIV +}\}, i_{11}), \\
\quad h_{12}{:}\text{\_move\_v\_1}(e_2, x_8), \\
\quad h_{12}{:}\text{\_away\_p\_dir}(e_{13}, e_2), \\
\quad h_{14}{:}\text{\_while\_x}(e_{16}, h_{12}, h_{15}), \\
\quad h_{17}{:}\text{prpstn\_m}(e_2, h_{19}, u_4, u_{18}), \\
\quad h_{15}{:}\text{prpstn\_m}(e_{21}\{\text{TENSE } \textit{past}, \text{MOOD } \textit{indicative}, \text{PROG +}, \text{PERF -}\}, h_{20}, u_{23}, u_{22}), \\
\quad h_{24}{:}\text{proper\_q}(x_{26}, h_{25}, h_{27}), \\
\quad h_{28}{:}\text{named}(x_{26}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\}, \textit{avdalen}), \\
\quad h_{29}{:}\text{\_still\_a\_1}(e_{30}, e_{21}), \\
\quad h_{29}{:}\text{\_thrive\_v\_1}(e_{21}, x_{26}) \\
\;\{\, h_3 =_q h_{17}, h_7 =_q h_{10}, h_{19} =_q h_{14}, h_{20} =_q h_{29}, h_{25} =_q h_{28} \,\}\,\rangle
\end{array}
$$

The two-place relation introduced by “while” identifies its first argument with the label of the message for the main clause which it modifies, and its second argument with the label of the complement clause’s message, ensuring that any scopal relations within each of these clauses are retained. Since the labels of the two clause-specific messages both appear as arguments, an additional top-level message is introduced in these constructions, in order to preserve the convenient uniformity that every utterance presents the label of a message as its highest-scoping element.

Finally for our inventory of ordinary modifiers, we illustrate the ERG analysis of relative clauses, which as usual come in a pleasing variety of syntactic forms, but present a largely uniform semantic representation. As with any clause, a relative clause introduces a message as its highest-scoping EP, and identifies that message’s label with the label of the noun that the relative clause modifies. In addition, relative clauses preserve the identity of the relativized element within the clause, and identify that element with the semantic index of the modified noun.

(19) *Learn about the area in which you hike.*



$\langle\, h_1,$

h_1:imp_m(e_2{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:pronoun_q(x_8, h_7, h_9),
h_{10}:pron(x_8{PERS *2*, PRONTYPE *zero_pron*}),
h_{11}:_learn_v_about(e_2, x_8, x_{12}),
h_{13}:_the_q(x_{12}, h_{15}, h_{14}),
h_{16}:_area_n_of(x_{12}{PERS *3*, NUM *sg*}, i_{17}),
h_{18}:_in_p(e_{19}, e_{20}, x_{12}),
h_{16}:prpstn_m(e_{20}{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_{21}, u_{23}, u_{22}),
h_{24}:pron(x_{25}{PERS *2*, PRONTYPE *std_pron*}),
h_{26}:pronoun_q(x_{25}, h_{27}, h_{28}),
h_{18}:_hike_v_1(e_{20}, x_{25})

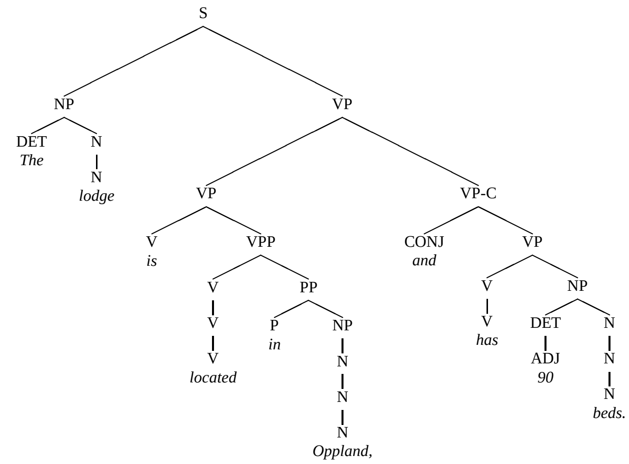
$\{\, h_3 =_q h_{11}, h_7 =_q h_{10}, h_{15} =_q h_{16}, h_{21} =_q h_{18}, h_{27} =_q h_{24} \,\}\,\rangle$

Crucially here, the ARG0 of _area_n_of is identified both with the second argument of the EP for "learn" and with the second argument of the EP for the locative preposition"in". And as advertised, the label of the message for the relative clause is the same as that of the EP for "area".

2.3 Coordination

The most common kind of conjoined structure is constituent coordination, where each of the two or more conjuncts belongs to the same category (at some relevant level of abstraction) as the others. The ERG provides analyses of most coordinate phrases of this kind in binary structures, combining the conjunction first with the conjunct to its right, and then the one to the left. Phrases consisting of more than two conjuncts and only one overt conjunction have similarly binary right-branching structure. The conjunction typically introduces a relation which takes as semantic arguments both the label and the semantic index of each of the conjuncts, though not when conjoining quantified noun phrases, since quantifier labels remain unconstrained.

(20) *The lodge is located in Oppland, and has 90 beds.*

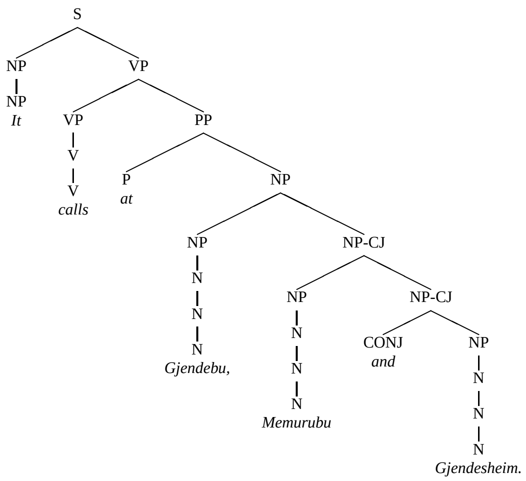


$\langle h_1,$
h_1:prpstn_m(e_2{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:_the_q(x_8, h_9, h_7),
h_{10}:_lodge_n_1(x_8{PERS *3*, NUM *sg*, DIV -}),
h_{11}:_locate_v_1(e_{12}{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, u_{13}, x_8),
h_{11}:_in_p(e_{14}, e_{12}, x_{15}),
h_{16}:proper_q(x_{15}, h_{17}, h_{18}),
h_{19}:named(x_{15}{PERS *3*, NUM *sg*, DIV -}, *oppland*),
h_{20}:_and_c(e_2, h_{11}, e_{12}, h_{22}, e_{21}{}),
h_{22}:_have_v_1(e_{21}{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, x_8, x_{23}),
h_{24}:udef_q(x_{23}, h_{25}, h_{26}),
h_{27}:card(e_{28}{TENSE *untensed*, MOOD *indicative*, PROG -, PERF -}, x{}, *90*),
h_{27}:_bed_n_1(x_{23}{PERS *3*, NUM *pl*, DIV +})
$\{ h_3 =_q h_{20}, h_9 =_q h_{10}, h_{17} =_q h_{19}, h_{25} =_q h_{27} \} \rangle$

The conjoined verb phrase here introduces a new event which is intended to group the events of the two conjuncts, leaving underspecified just how they are to be interpreted; and the conjunction EP _and_c takes as arguments the labels of the highest-scoping EP in each of the two VP conjuncts (along with their event variables). Hence the conjunction EP becomes the highest-scoping EP for this sentence.

Conjoined noun phrases are treated analogously, but the conjunction EP only takes the semantic index of each as arguments, as illustrated in the multiple conjunct example in 21.

(21) *It calls at Gjendebu, Memurubu and Gjendesheim.*



$\langle\, h_1,$

h_1:prpstn_m($e_2\{$TENSE *pres*, MOOD *indicative*, PROG -, PERF -$\}$, h_3, u_4, u_5),
h_6:pron($x_7\{$PERS *3*, NUM *sg*, GEND *n*, PRONTYPE *std_pron*$\}$),
h_8:pronoun_q(x_7, h_9, h_{10}),
h_{11}:_call_v_1(e_2, x_7, i_{12}),
h_{11}:_at_p(e_{13}, e_2, x_{14}),
h_{15}:udef_q(x_{14}, h_{16}, h_{17}),
h_{18}:proper_q(x_{20}, h_{19}, h_{21}),
h_{22}:named($x_{20}\{$PERS *3*, NUM *sg*, DIV -$\}$, *gjendebu*),
h_{23}:udef_q(x_{25}, h_{24}, h_{26}),
h_{27}:implicit_conj($x_{14}\{$PERS *3*, NUM *pl*$\}$, u_{28}, x_{20}, u_{29}, x_{25}),
h_{30}:proper_q(x_{32}, h_{31}, h_{33}),
h_{34}:named($x_{32}\{$PERS *3*, NUM *sg*, DIV -$\}$, *memurubu*),
h_{35}:_and_c($x_{25}\{$PERS *3*, NUM *pl*$\}$, u_{37}, x_{32}, u_{38}, x_{36}),
h_{39}:proper_q(x_{36}, h_{40}, h_{41}),
h_{42}:named($x_{36}\{$PERS *3*, NUM *sg*, DIV -$\}$, *gjendesheim*)

$\{\, h_3 =_q h_{11}, h_9 =_q h_6, h_{16} =_q h_{27}, h_{19} =_q h_{22}, h_{24} =_q h_{35}, h_{31} =_q h_{34}, h_{40} =_q h_{42} \,\}\,\rangle$

Since both the syntactic structures and the semantic representations for coordination are binary, each new conjunct in an implicit multiple coordinate structure corresponds to an additional conjunction EP, the implicit_conj relation, which behaves semantically just like the EP introduced by an overt conjunction word. Just as a new grouping event is introduced for conjoined VPs, so a new semantic index is introduced for each pair of conjoined nominal phrases, again leaving underspecified whether the coordinate phrase should be interpreted, say, distributively or collectively.

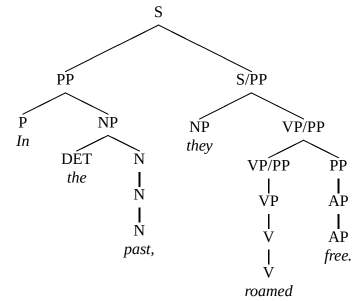
The phenomena described in this section represent core phenomena, all of which are common in the LOGON corpus, both in the humanly provided English translations and in the semantic representations produced by the Transfer component as input to the generator. In the next section we review some more interesting phenomena which are also common in the LOGON corpus, but for which the pre-LOGON ERG did not yet include analyses.

3 LOGON-Driven Grammar Extensions

Prior to LOGON, development of the ERG was driven by applications in the domains of meeting scheduling, speech prosthesis, and automated customer email response, all of which focused on roughly conversational English. The LOGON development corpus consists of largely descriptive or instructional content, with somewhat longer and syntactically more complex utterances. Not surprisingly, the linguistic phenomena we encountered included several for which the ERG initially lacked satisfactory analyses, and which appeared with sufficient frequency that augmentation of the grammar was justified. One of these, where multiple prepositional phrase modifiers interact with each other semantically, receives discussion in Chapter **??**.

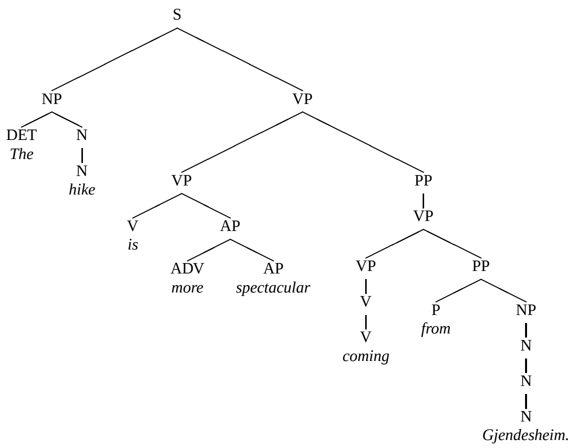
A second phenomenon we addressed involves depictive modifiers where a predicative phrase appears as a modifier of a sentence or a verb phrase, such as the adjective "free" in "predators roamed free", or the verb phrase headed by "coming" in "the hike is more spectacular, coming from Gjendesheim". Our analysis treats these semantically as a kind of non-finite subordinate clause, with the semantics introducing essentially the same subord predication that is used for ordinary subordination as with "if-then" constructions. Here the second argument of that relation is the highest-scoping element of the semantics for the predicative phrase, which serves as the subordinate "clause". Two examples are given in 22 and 23.

(22) *In the past they roamed free.*



$$\langle h_1,$$
$$h_1\text{:prpstn\_m}(e_2\{\text{TENSE } past, \text{MOOD } indicative, \text{PROG -}, \text{PERF -}\}, h_{11}, u_{10}, e_4),$$
$$h_3\text{:\_in\_p}(e_4, e_2, x_5),$$
$$h_6\text{:\_the\_q}(x_5, h_8, h_7),$$
$$h_9\text{:\_past\_n\_1}(x_5\{\text{PERS } 3, \text{NUM } sg, \text{DIV -}\}),$$
$$h_{12}\text{:pron}(x_{13}\{\text{PERS } 3, \text{NUM } sg, \text{GEND } m\text{-}or\text{-}f, \text{PRONTYPE } std\_pron\}),$$
$$h_{14}\text{:pronoun\_q}(x_{13}, h_{15}, h_{16}),$$
$$h_3\text{:\_roam\_v\_1}(e_2, x_{13}, i_{17}),$$
$$h_{18}\text{:subord}(e_{21}, h_{19}, h_{20}),$$
$$h_{20}\text{:prpstn\_m}(e_{22}, h_{24}, u_{23}, u_{25}),$$
$$h_{19}\text{:prpstn\_m}(e_2, h_{26}, u_{10}, u_{27}),$$
$$h_{28}\text{:\_free\_a\_1}(e_{22}, i_{29})$$
$$\{ h_8 =_q h_9, h_{11} =_q h_{18}, h_{15} =_q h_{12}, h_{24} =_q h_{28}, h_{26} =_q h_3 \} \rangle$$

(23) *The hike is more spectacular coming from Gjendesheim.*



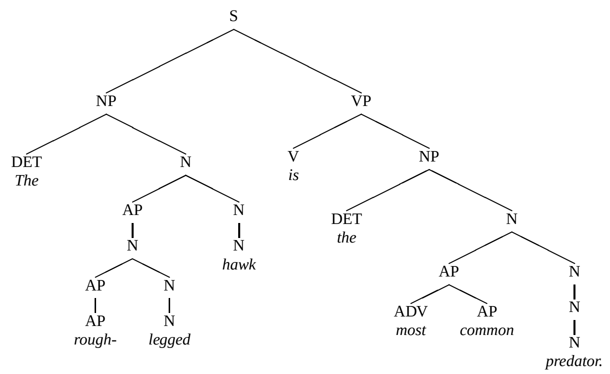
$\langle h_1,$

h_1:prpstn_m(e_2{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:_the_q(x_8, h_9, h_7),
h_{10}:_hike_n_1(x_8{PERS *3*, NUM *sg*, DIV -}),
h_{11}:comp(e_{12}, e_2, u_{13}),
h_{11}:_spectacular_a_1(e_2, x_8),
h_{14}:subord(e_{17}, h_{15}, h_{16}),
h_{16}:prpstn_m(e_{18}{TENSE *untensed*, MOOD *indicative*, PROG +, PERF -}, h_{20}, u_{19}, u_{21}),
h_{15}:prpstn_m(e_2, h_{22}, u_4, u_{23}),
h_{24}:_come_v_1(e_{18}, i_{25}),
h_{24}:_from_p(e_{26}, e_{18}, x_{27}),
h_{28}:proper_q(x_{27}, h_{29}, h_{30}),
h_{31}:named(x_{27}{PERS *3*, NUM *sg*, DIV -}, *gjendesheim*)

$\{ h_3 =_q h_{14}, h_9 =_q h_{10}, h_{20} =_q h_{24}, h_{22} =_q h_{11}, h_{29} =_q h_{31} \} \rangle$

A third extension to the grammar provides an analysis of adjective phrases derived from a noun bearing an "-ed" suffix, either with an adjective as in "rough-legged hawk" or with another noun as in "the knife-edged Besseggen". These modifier phrases are analyzed using a lexical rule which relates the basic lexical entry for a noun belonging to a particular class (including for example body parts) to a derived entry with an "-ed" suffix, where this derived entry can then combine with an adjective or a noun to its left to form a phrase with the distribution of an ordinary adjective, either attributive or predicative. We illustrate both variants in 24 and 25.

(24) *The rough-legged hawk is the most common predator.*

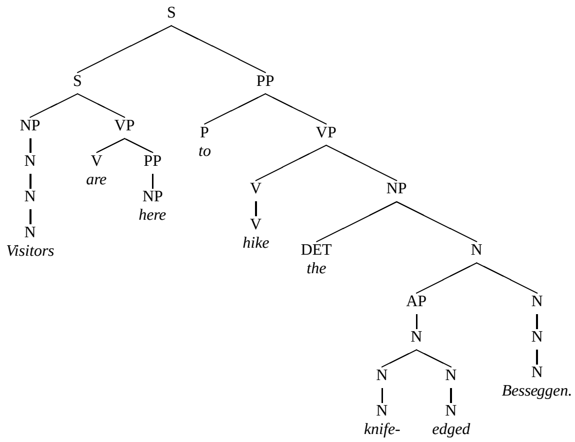


$\langle\, h_1,$

h_1:prpstn_m(e_2{TENSE *pres*, MOOD *indicative*, PROG -, PERF -}, h_3, u_4, u_5),
h_6:_the_q(x_8, h_9, h_7),
h_{10}:unspec_mod(e_{11}, x_8{PERS *3*, NUM *sg*, DIV -}, x_{12}),
h_{13}:udef_q(x_{12}, h_{14}, h_{15}),
h_{16}:_rough_a_1(e_{17}, x_{12}),
h_{16}:_leg_n_1(x_{12}),
h_{10}:_hawk_n_1(x_8),
h_{18}:_be_v_id(e_2, x_8, x_{19}),
h_{20}:_the_q(x_{19}, h_{22}, h_{21}),
h_{23}:superl(e_{24}, e_{25}),
h_{23}:_common_a_1(e_{25}, x_{19}),
h_{23}:_predator_n_1(x_{19}{PERS *3*, NUM *sg*, DIV -})

$\{\, h_3 =_q h_{18}, h_9 =_q h_{10}, h_{14} =_q h_{16}, h_{22} =_q h_{23} \,\}\,\rangle$

(25) *Visitors are here to hike the knife-edged Besseggen.*



$$
\begin{array}{l}
\langle\, h_1, \\
\quad h_3\text{:prpstn\_m}(e_2\{\text{TENSE } \textit{pres}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\}, h_6, u_4, u_5), \\
\quad h_7\text{:udef\_q}(x_9, h_8, h_{10}), \\
\quad h_{11}\text{:\_visitor\_n\_of}(x_9\{\text{PERS } \textit{3}, \text{NUM } \textit{pl}, \text{DIV +}\}, i_{12}), \\
\quad h_{13}\text{:unspec\_loc}(e_2, x_9, x_{14}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}\}), \\
\quad h_{15}\text{:place\_n}(x_{14}), \\
\quad h_{16}\text{:def\_implicit\_q}(x_{14}, h_{17}, h_{18}), \\
\quad h_{15}\text{:\_here\_a\_1}(e_{19}, x_{14}), \\
\quad h_{20}\text{:\_in+order+to\_x}(e_{22}, h_3, h_{21}), \\
\quad h_1\text{:prpstn\_m}(e_2, h_{23}, u_4, u_5), \\
\quad h_{21}\text{:prpstn\_m}(e_{24}\{\text{TENSE } \textit{untensed}, \text{MOOD } \textit{indicative}, \text{PROG -}, \text{PERF -}\}, h_{26}, u_{25}, u_{27}), \\
\quad h_{28}\text{:\_hike\_v\_1}(e_{24}, i_{30}, x_{29}), \\
\quad h_{31}\text{:\_the\_q}(x_{29}, h_{33}, h_{32}), \\
\quad h_{34}\text{:unspec\_mod}(e_{35}, x_{29}, x_{36}), \\
\quad h_{37}\text{:udef\_q}(x_{36}, h_{38}, h_{39}), \\
\quad h_{40}\text{:compound}(e_{42}, x_{36}, x_{41}), \\
\quad h_{43}\text{:udef\_q}(x_{41}, h_{44}, h_{45}), \\
\quad h_{46}\text{:\_knife\_n\_1}(x_{41}), \\
\quad h_{40}\text{:\_edge\_n\_of}(x_{36}), \\
\quad h_{34}\text{:named}(x_{29}\{\text{PERS } \textit{3}, \text{NUM } \textit{sg}, \text{DIV -}\}, \textit{besseggen}) \\
\{\, h_6 =_q h_{13}, h_8 =_q h_{11}, h_{17} =_q h_{15}, h_{23} =_q h_{20}, h_{26} =_q h_{28}, h_{33} =_q h_{34}, h_{38} =_q h_{40}, h_{44} =_q h_{46} \,\}\, \rangle
\end{array}
$$

In each of these examples, lexical rule forming the *-ed*-marked noun introduces into the semantics an unspec_mod predication which relates the index of that noun to the index for the head of the noun phrase it modifies. Within the binary phrase combining the *-ed*-marked noun with the word to its left, the construction is a normal adjective-noun or noun-noun-compound phrase with the expected semantics.

4 Grammar Resources for Generation

In order to generate felicitous translations with this grammar with a reasonable level of efficiency, some additional resources must accompany the lexical entries and rules which comprise the bulk of the grammar. These include (1) a set of constraints on which subset of parsable structures will be generated, and (2) a mechanism to accommodate lexical entries which do not introduce any elementary predications into the semantics.

Because the ERG is designed for use across multiple domains, both for parsing and for generation, many of the lexical entries and rules include a constraint which distinguishes coarsely among two levels of formality. Words like "gonna" (for "going to") are acceptable as input for parsing, but not so useful for the kind of translations we aim at in LOGON; and similarly, not all variations of punctuation or spelling encountered in text need to be generated. The generator can be configured to exclude these informal or redundant elements, whether lexical or syntactic, so they will not be included as part of any analysis produced by the generator.

The ERG's lexicon includes a number of lexical entries like the auxiliary verb "do" or the sentential complementizer "that" which do not introduce an elementary predication into the semantics, even though such entries often impose constraints on values of semantic attributes such as tense or number. Since the generator uses a chart-based algorithm, described in (Carroll, Copestake, Flickinger, & Poznanski, 1999), where the chart is initialized by looking up lexical entries and rules indexed by their semantic predicates, some accommodation must be made for semantically empty entries such as the ones for the auxiliary"do". Hence the grammar includes a set of "trigger" rules which define a conditioning property of the input semantics which, if satisfied, licenses the addition of a semantically empty lexical entry into the generator's initialized chart. For example, the entry for "did" is added if the input semantics includes a negation relation with scope over a relation whose ARG0 is an past tense event.

The first of these two mechanisms provides a useful level of control over the variety of outputs produced by the generator, while the second enables the generator to maintain reasonable efficiency when using a grammar like the ERG which includes semantically empty lexical entries.

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