THE ROLE OF PRED IN LFG+GLUE

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Abstract

In this paper, I argue that standard, co-descriptional glue semantics provides no clear and satisfactory role for the traditional PRED-features of LFG, due to the fact that the linear logic of glue semantics does the work of the Completeness and Coherence Constraints. But then I show that a reduced but significant role for PRED-features can be found in an alternative 'Description-by-Analysis' (DBA) formulation, proposed in Andrews (2007a).[1] The DBA formulation is argued to be superior in various respects, and some constraints are proposed to cause the DBA approach to approximate some of the empirically justifiable aspects of the behavior of the co-descriptional formulation.

The standard way to combine LFG with glue-semantics has been with a 'co-descriptional' architecture in which lexical entries introduce the usual grammatical features in the usual way, together with 'meaning-constructors' that account for the meanings, both of the PRED-feature associated with the lexical item, and any semantically intepretable grammatical features that it might introduce, either inherently or due to the inflectional morphology. Typical examples would be the following entries for the verb form *went* and the noun-form *feet*:[2]

(1) a. *went*:V, $(\uparrow\text{PRED}) = \text{`Go}_{motion}\text{<}(\uparrow\text{SUBJ})\text{>'}$, $(\uparrow\text{TENSE}) = \text{PAST}$,
$\lambda x.go(x) \ :\ (\uparrow\text{SUBJ})_e \multimap\ \uparrow_p$,
$\lambda P.Past(P) \ :\ \uparrow_p \multimap\ \uparrow_p$

b. *feet*:N, $(\uparrow\text{PRED}) = \text{`Foot'}$, $(\uparrow\text{NUM}) = \text{PL}$,
$\lambda x.Foot(x) \ :\ \uparrow_p$,
$\lambda P.Past(P) \ :\ \uparrow_p \multimap\ \uparrow_p$

Co-description was introduced and motivated in Halvorsen and Kaplan (1988) as an alternative to the earlier (and overall more often used) 'description-by-analysis' (DBA) architecture, in which the f-structure is the primary input to the semantics.[3]

Although the norm in glue-semantics, co-description raises a puzzle with respect to the role of PRED-features, namely, why they are there at all. The problem is that, as pointed out in Kuhn (2001), the linear logic resource management employed in glue is in itself sufficient to account for the phenomena of Completeness, Coherence, and Predicate Uniqueness, which comprise the major special properties of PRED-features. This leaves us with no clear reason why these features couldn't just be omitted from the lexical entries of (1). Even if absence of the PRED-features caused some

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[1] And, independently developed for XLE (Crouch, p.c.), although no longer used.

[2] Using p 'proposition' for the type of propositions rather than the usual t, and a clearly oversimplified Priorian operator treatment for tense.

[3] See for example Halvorsen (1983), Wedekind and Kaplan (1993), Frank and Semecky (2004), Crouch and King (2006), Crouch (2006).

subtle problems, putting them back in would still constitute an explanatory problem, since there isn't any principle that requires LFG lexical entries to introduce PRED-values. If the benefits of co-description were sufficiently impressive, one could presumably deal with this issue, but I will first show that the original motivation for it is insufficient, and point out that it creates various problems, one of which was noted by Andrews (2007a). Then I will describe a DBA architecture for glue, and show it it provides a role for PRED-features. But this is not the same as in pre-glue LFG, since glue will be doing the work of Completeness and Coherence (but not Predicate Uniqueness). So the last step is to propose some constraints which will cause meaning-constructors in the DBA architecture to act in a way that is similar in certain empirically justifiable respects to standard PRED-features controlling Completeness and Coherence, but avoiding the problems with co-description.

1 Problems and Non-benefits of Co-Description

The main proposed benefit of co-description was that it could make available for semantic interpretation information not present in f-structure (Halvorsen and Kaplan 1988:284, 1995 version).[4] But this ignores the fact that, thanks to the inverse of the ϕ projection, anything accessible from c-structure is also accessible from f-structure. Andrews (2007b), for example, proposes constraints involving c-structure in a DBA glue framework. However, it might still be the case that co-description is the best approach, either for all, or only for some, kinds of linguistic phenomena. Here I will argue that it isn't best for what would be traditionally regarded as the interpretation of features and lexical items (by contrast, co-description seems very well suited for the properties of information-structure, c.f. Mycock (2006)).

Perhaps the most immediate problem, pointed out in Andrews (2007a), is that it becomes an accident that the occurrences of features and their traditionally ascribed meanings are quite closely correlated, with only limited exceptions, such as *pluralia tantum*, which I'll discuss later. There would for example be nothing obviously wrong with a variant of (1b) in which the plural meaning-constructor was present but not the plural feature-equation. But this doesn't happen, even with the exotic plurals that English is so fond of borrowing from other languages:

(2) a. These seraphim are annoyed

b. This seraph is annoyed

c. *This seraphim is annoyed (plural meaning, singular syntax)

[4] "Every interpretation scheme based on description-by-analysis requires that all semantically relevant information be encoded in the functional structure."

But agreement, the main motivation for having features at all, leads to a further problem with the meaning-constructors.

This is that one has to decide which of the various lexical entries introducing a given feature-value occurrence is the one that is introducing the constructor. Consider an Italian example such as:

(3) (le ragazze) vengono
the(FEM.PL) girl(FEM.PL) come(3.PL)
The girls/they are coming

If the subject is present, one would presumably want the noun to introduce the plural meaning-constructor, and the verb not to (since not all NPs are in positions where there is a verb to agree with them and provide their number constructors), but if the subject is omitted, then the verb would presumably be the provider of the constructor. It is certainly not impossible to come up with grammars that will work properly, but it involves delicate choices with considerable scope for stipulation, which it would be good to reduce to the greatest extent possible.

Another problem resides in the overlapping powers and responsibilities of the PRED-features, with their argument-lists, and those of the meaning-constructors that refer to grammatical functions. This is that, although the PRED-features control what governable grammatical functions can and must appear, they no longer say anything about what their semantic contributions are, since this is done by the meaning-constructors. But, left unconstrained, meaning-constructors can do all sorts of peculiar things in the way of rearranging the semantics of the grammatical functions. Below, for example, (a) interchanges the semantic role of subject and object, while (b) creates an unspecified causee agent causative:

(4) a. $\lambda Pxy.P(y,x) : ((\uparrow \mathrm{OBJ})_e \multimap (\uparrow \mathrm{SUBJ})_e \multimap \uparrow_p) \multimap (\uparrow \mathrm{SUBJ}) \multimap (\uparrow \mathrm{OBJ}) \multimap \uparrow_p$

b. $\lambda Px.(\exists z)(\mathit{Cause}(x, P(z,y))) : ((\uparrow \mathrm{SUBJ})_e \multimap \uparrow_p) \multimap (\uparrow \mathrm{SUBJ})_e \multimap \uparrow_p$

Without some further constraints, these meaning-constructors could be introduced by inflections or grammatical particles, thereby undoing the kinds of work people have been trying to accomplish with Lexical Mapping Theory and its competitors over the last several decades.

The most obvious and direct solution to the overlap problem is to drop the PRED-features entirely, since, as noted above, the resource management provided by linear logic can do all of the syntactic work of the PRED-features, and of course the meaning constructors also take over their informal role of encoding the meaning. Therefore, the natural consequence of adopting co-description is to abandon PRED-features. This might of course be the right thing to do, but I will argue in the remainder of the paper that glue-by-DBA would be a good thing to try first for certain aspects of semantic interpretation, especially, morphology and the lexicon. However, note that the use of meaning-constructors introduced by the PS rules, for example by Asudeh and Crouch (2002) and Sadler and Nordlinger (2008), is not implicated in any of the problems raised here, and is consistent with what I will be proposing.

2 Glue by DBA

The basic idea of DBA glue is to introduce meaning-constructors on the basis of what is in the f-structure. A fundamental requirement is that this be done in a resource-sensitive manner, so that the semantically interpretable aspects of an f-structure be interpreted once, and once only. For example if we have a [POLARITY NEG] feature in a negative sentence, we must be prevented from reading the sentence as non-negative by either failing to interpret the feature at all, or interpreting it twice.

Most implementations of DBA semantics in LFG are conceptually 'destructive', in that aspects of f-structure are removed and replaced by semantic material. This is explicit in the f-structure rewriting approach described by Crouch and King (2006) and Crouch (2006), where f-structure facts are deleted as semantic information is added, and also in the restriction-based proposal of Wedekind and Kaplan (1993).

Andrews (2007a) proposes a conceptually different, correspondence-based view (which however might well not be empirically distinct), in which semantic information is added monotonically to the structure. An essential component of this system is that the functions of the standard LFG lexicon are split between two distinct ones, a 'Morphological Lexicon' that is essentially equivalent to the standard one, but with a reduced role for PRED-features, and a 'Semantic Lexicon' which is responsible for giving the meanings of interpretable features and their combinations, including PRED-values.

Semantic Lexicon Entries (SLEs) pair f-descriptions with meaning-constructors. Here are some sample SLEs, using the more readable and compact 'f-structure fact' notation from XLE rather than the equations originally used by Andrews:

(5) a. TENSE(f, PAST) $\Leftrightarrow$ $\mathit{Past} : f_p \multimap f_p$

b. PRED(f, 'Go'), SUBJ(f, g) $\Leftrightarrow$ $\mathit{Go} : g_e \multimap f_p$

c. PRED(f, 'Marvin') $\Leftrightarrow$ $\mathit{Marvin} : f_e$

The bidirectional $\Leftrightarrow$ symbol is used because the relationship is meant to be conceived of as inherently bi- or a- directional; note that it is *not* a linear bi-implication, because an SLE can be used as often as desired (it needs to consume a resource, but is not itself consumed).

A possibly more readable notation for the f-structure side is to use AVMs with labels:

(6) a. $f{:}\begin{bmatrix}\text{TENSE} & \text{PAST}\end{bmatrix} \;\Leftrightarrow\; \mathit{Past} : f_p \multimap f_p$

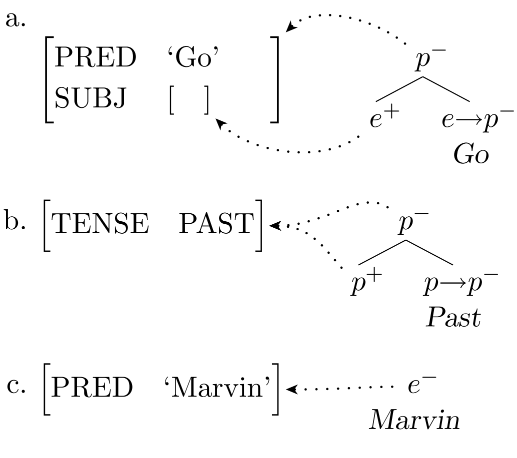
b. $f{:}\begin{bmatrix}\text{SUBJ} & g{:}[\;\;] \\ \text{PRED} & \text{`Go'}\end{bmatrix} \;\Leftrightarrow\; \mathit{Go} : g_e \multimap f_p$

c. $f{:}\begin{bmatrix}\text{PRED} & \text{`Marvin'}\end{bmatrix} \;\Leftrightarrow\; \mathit{Marvin} : f_e$

The f-structure labels in the meaning-constructors are to be thought of as defining a 'reversed semantic projection' (essentially Kaplan's (1987) σ going from the semantic representation to the f-structure rather than in the opposite direction, as usually assumed). Later we'll propose constraints that give some significance to the AVM notation.

This idea can be made more vivid, and some other structural relationships usefully exposed, by representing the meaning-constructors in the 'prefab glue' notation introduced in Andrews (2007b), which is essentially the dynamic graph of de Groote (1999), supplemented with one additional kind of arc, which we'll introduce when we need it. The labels are replaced with dotted arrows depicting the reversed semantic projection, and the way in which the trees are built from the meaning-constructors, and the +/− polarities assigned, is discussed in Andrews (2007b). In the prefab notation, we will also replace the $\multimap$ -symbol with $\rightarrow$, since these are supposed to represent functional semantic types, for which $\rightarrow$ is one of the standard symbols. So the SLEs above become:

(7)

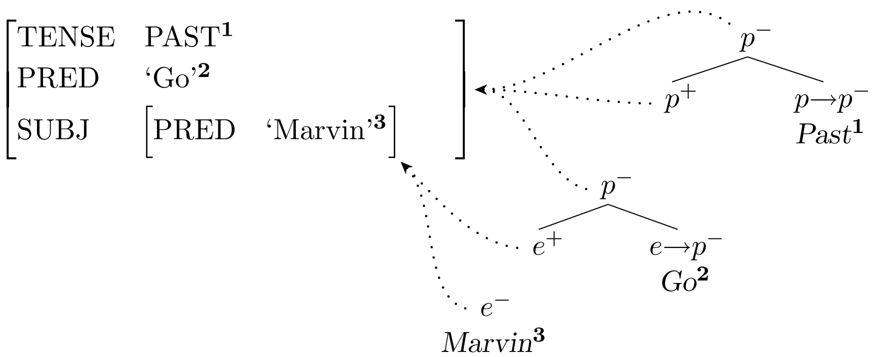


The meaning-constructors in this notation can be regarded as pieces of the logical forms into which the meaning-sides are to be inserted (with predicates on the right), supplemented with syntactic correspondence information.

So the next step is to explain how SLE's and an f-structure can be used to produce a collection of meaning-constructors, suitable for assembly. The method will need to account for the resource-sensitivity discussed at the beginning of this section. Andrews (2007a) proposes to use a correspondence relation, implemented by co-indexing, subject to some constraints.[5] Suppose that, when an SLE is chosen from the Semantic Lexicon, the feature value(s) (we'll soon see that there is in general more than one) that it mentions get an index, unique to that instantiation (similar to the instantiation of PRED-features, but happening at a different place, following slightly different rules).

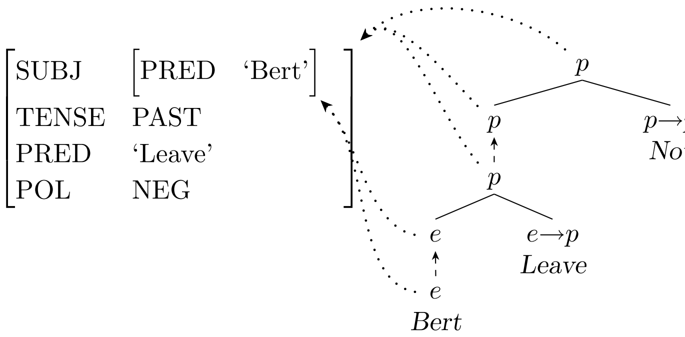
Then, when the instantiated SLE is used, we can suppose that its index is applied to the feature-values in the part of the f-sturcture that it's applying to. Now, a principle that each 'interpretable' feature must receive a unique index will account for the resource-sensitivity. We need the qualification 'interpretable', because there appear to be some features, such as structural case, that don't get interpreted by meaning-constructors in this way (topic and focus markers might well be the same, if they are taken to reflect the presence of inherently meaningful GFs, without introducing further explicit content of their own). And these indexes can also be applied to the meaning-constructors themselves, implementing a correspondence relation (which, unfortunately, does not appear to be a function in either direction).

Consider for example the f-structure for *Marvin went.* Selecting, instantiating, and 'applying' some SLEs to the f-structure will produce a result like this:

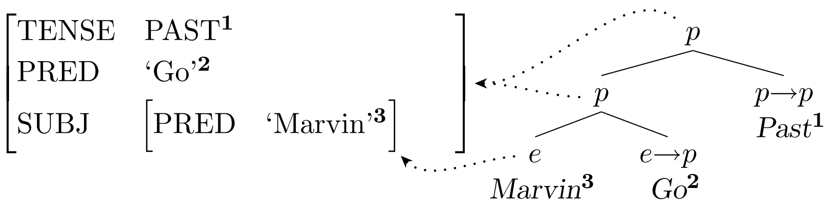
(8)


Each meaning-constructor has correspondence relations going from its atom-labelled nodes ('literals') to f-structures, as mandated by the SLEs. Then, assembly of the logical form is achieved by connecting these atomic nodes with 'axiom-links', subject to the proof-net rules as discussed in Andrews (2007b), and the constraint that axiom-linked nodes share their f-structure correspondent. The only acceptable assembly is then:

[5]Crouch and van Genabith (1999) and Asudeh and Crouch (2002) make use of a correspondence of this nature, without saying much about its properties.

(9) 

If we 'contract' along the axiom-links, the logical form becomes completely banal:

(10) 

One might hope that the correspondence relation expressed by the features could be a function, but a reason for not trying to do this in the f-structure-to-meaning direction is provided by various kinds of idioms, including *pluralia tantum* and similar phenomena that create issues for the idea that intepretable features are always intepreted.

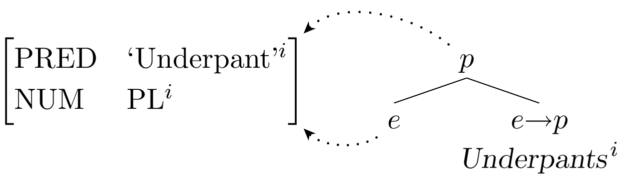
The problem of *pluralia tantum* is that there appears to be a syntactically active plural feature (inducing agreement), which is not semantically interpreted:

(11) These underpants/bikini bottoms are clean [said holding one intact piece of cloth]

The agreement shows that a syntactic plural feature is present in f-structure, so what permits it to escape interpretation?

What I propose is that it does not actually escape intepretation, but rather is jointly interpreted with the PRED. An SLE to do this is:[6]

(12)



To suppress independent interpretation of the NUM-feature, we can simply have it share the semantic instantiation index with the PRED-value and the meaning-side, as indicated by the superscripting in (12).

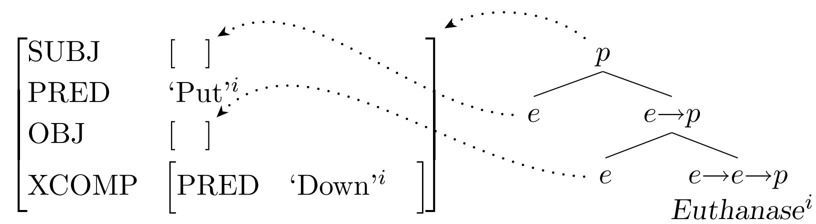
[6]Assuming the standard glue analysis of common nouns as properties applying to type *e*. The possibly unsettling absence of VAR and RESTR attributes will be discussed below.

Therefore, the co-superscripting does not define a function in the meaning-to-f-structure direction, and the evidence in Dalrymple (2001) that adjectives introduce two meaning-constructors (originally due to Kasper 1995) suggests that it doesn't in the opposite direction either, although this possibility deserves further consideration. Putting the superscript somewhere in the meaning-constructor allows for various kinds of scope-related constraints to be formulated, as discussed in Andrews (2007b) and Andrews (2007a), and the meaning-specification seems like the most obvious place to put it.

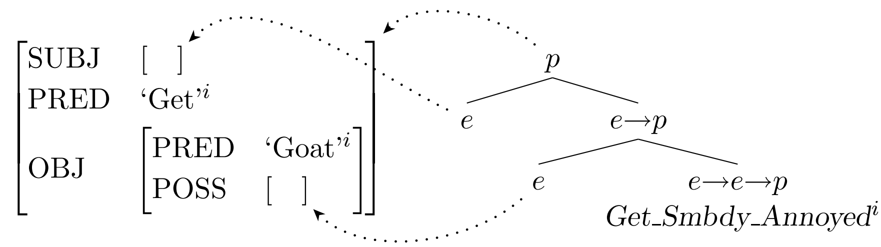
Pluralia tantum may in fact be seen as a sort of idiom composed of a lexical stem and an inflectional feature that are normally each interpreted independently, but here fail to be, since they are instead interpreted jointly. A similar analysis can be applied to grammatical gender features, which are usually interpreted 'idiomatically' with their stems, but sometimes not, such as with third-person pronouns.

This general approach seems to extend smoothly to more traditional types of idioms, of the type that Egan (2008) calls CHUNKS, such as *put* [some animal] *down*, or *get* [somebody] *'s goat*. These consist of two or more parts with at least some degree of syntactic autonomy, but which appear to be intepreted jointly. They can be given SLEs such as these:

(13) a.



b.



We will henceforth omit the superscripts, since they are managed by general convention. The idiom *get up X's nose*, meaning 'annoy X' appears to combine the directional XCOMP of (a) and the possessive of (b) in a single construction, with an unusually long path to the semantic argument.

Our treatment so far leaves us with a general question, which is whether there is really any reason to retain the PRED-features. If a wide range of features can be interpreted, why not instead have meaningful elements introduce a variety of features, such as perhaps KIND for nouns, EVENT_TYPE for dynamic verbs, SITUTION_TYPE for stative verbs, etc., whose values encode the meaning? In the following sections, we will try to answer this question and defend (a version of) the PRED-feature by proposing and motivating a variety of constraints in which it plays a special role.

3 The Properties and Role of PRED

A first argument is that in the DBA glue system, we will still need feature-value instantiation to implement uniqueness (that is, inability for values introduced in different places to unify) for the features representing the meanings of open-class items. For, without uniqueness, such a feature could be introduced multiple times, and then unified, just as does happen with number features and others that participate in agreement (and 'concord', for those who postulate a difference between these). This is something that isn't needed in a co-descriptional architecture, since resource sensitivity will account for the data, but it is needed in DBA.

It is then reasonable to suggest that full, open class lexical meanings must be expressed by PRED-feature values, and that these are by default instantiated (there may be limited exceptions, as discussed in Andrews (1990); Tariana 'repeaters' (Aikhenvald 2003) might well be an interesting example).

One potential exception is FORM-features, as used in the standard LFG analysis of idioms, but we have already dispensed with these. Another, suggested by an abstract-referee, might be the PCASE or PFORM features that are sometimes used for the analysis of oblique arguments, but it can be argued that it is only a relatively small collection of prepositions that are actually used in this way, as opposed to constituting semantic cases. Furthermore, it seems quite plausible to reanalyse these as involving oblique grammatical functions together with PRED-features. But the treatment of oblique arguments raises various issues that I can't go into here. I should also point out that in some languages, the PRED features for parts of speech such as Verb and Adjective are not an open set (Dixon 1977, Pawley 2006).

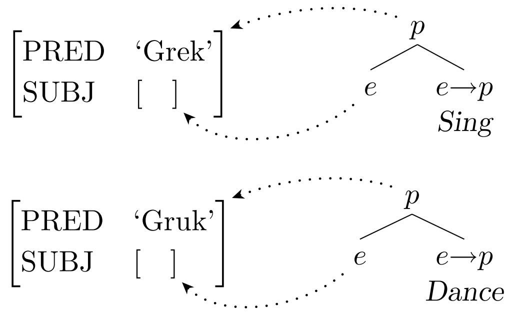
Another characteristic of PRED-features, pointed out in Andrews (2007a), is that they seem to have a special role in inflectional morphology, that of designating what might be called the 'stem'. For example, when an irregular verb has multiple meanings and/or participates in multiple idioms, it normally preserves its irregularities across all of its different senses. Triggering stem selection therefore appears to be another distinctive function for PRED-features.

A more complex kind of motivation from PRED comes from the fact that we need to impose some constraints on SLEs, in which the PRED-feature appears to play a special role.

4 A Need for Constraints

Consider the following SLE, which allows a pair of PRED-values to be jointly interpreted if and only if both appear somewhere in the same structure, with no constraints on their relationship:

(14)



This is theoretically quite undesireable, and it is to the credit of the co-descriptional approach that it is at least difficult to get effects like this (although some fairly strange things can be done by playing around with constraining equations and (io)fu designators).

A plausible program for ruling such things out would be to impose constraints requiring that the effects of SLEs be quite similar to those of standard lexical entries with their PRED-features, combined with additions such as constraining equations for FORM and other feature values. After all, this mechanism has seemed largely adequate from the beginning of LFG, appearing to meet only rather localized difficulties with complex predicates (e.g., Alsina (1996), Andrews and Manning (1999) and work cited there), and remain on the whole satisfactory for purely syntactic work.

It is a property of the kinds of lexical entries that have been proposed in standard LFG that the feature-values they fix all seem to involve short, determinate (and therefore downward; upward paths would involve uncertainty) paths composed of governable GFs from the f-structure designated by ↑ in the lexical entry (potential exceptions, such as negative polarity environments, clearly involve semantico-logical factors that can't be adequately captured by f-descriptional constraints). This provides motivation for an 'Arboriform Constraint' on SLEs:

(15) Arboriform Constraint: the set of f-(sub)structure labels in an SLE for which the SLE specifies an atomic feature-value must form a tree, with governable GF's (from source to target of the GF) as the links (oriented down the tree, so that all tree members are accessible by a path from the root).

(15) immediately excludes (14), while allowing all of the SLEs which we have proposed so far., and explains why the AVM notation is useful, since it directly reflects the tree-structure.

It also accounts for why conventional lexical entries work pretty well, since a conventional LFG lexical entry can specify the values of all of the features mentioned in the SLE by downward paths of the usual kind, from a c-structure node corresponding to an f-structure node at or above the SLE ‘root’.

But there is a terminological issue with calling this node a ‘root’ of the SLE, which is that, as we will see shortly, SLEs can involve f-structures for which they don’t specify any feature-values, which appear to be subject to different constraints, as we shall see. So we instead use the term ‘center’:

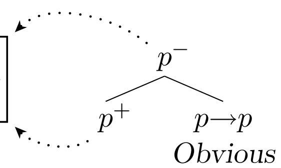
(16) Center: the center of an SLE is the unique f-structure label serving as the root of the tree mandated to exist by (15).

A further constraint emerges from the fact that there appears to have been very little pressure in the development of LFG to allow any features other than PRED to ‘subcategorize’ for arguments. A proposition such as ‘only PRED-values subcategorize’ is not really empirical, since LFG workers are trained to deploy PRED-values in situations where subcategorization seems to be a useful idea, but it is significant that following this training doesn’t seem to lead to serious problems, except perhaps in the previously-mentioned area of complex predicates and serial verb constructions, where there certainly are problems with PRED-features, but merely allowing other features to subcategorize doesn’t solve them.

A first attempt to formulate a constraint to capture this apparent restriction might be to say that the f-substructures of an SLE that correspond to ‘argument’ positions on the semantic side must be accessible by deterministic paths made of governable GFs from the center. The SLEs we’ve looked at so far obey this constraint, but there are important examples that don’t. A relatively simple one is this constructor for sentence-adverbials such as *obviously*:

(17)

$$\left[\text{ADJUNCTS}\left\{\left[\text{PRED} \quad \text{‘Obvious’}\right]\right\}\right]$$



The meaning introduced by this constructor applies not at the center, but at something gotten by following a iofu path from the center: if the center is designated as $*$, then the meaning applies at (ADJUNCT $\in *$).

It is possible that this example might be dissolved by the use of constructors introduced by the PS rules, which have been proposed by Asudeh and Crouch (2002), and recently used by Sadler and Nordlinger (2008). But the issues involved here are complex, and it is probably best to set up the theory to allow SLEs such as (17).

Especially because harder-to-avoid examples are provided by quantifiers, in which the scope is not only above the center, but, in general, unboundedly so. The general nature of quantifier constructors needs some preliminary discussion. Originally, quantifiers constructors were supposed to involve universal linear quantifiers, but these have sometimes been omitted (for example by Fry (1999) and Lev (2007)), on the basis that they are implicit for free variables. This gives us a format like this:

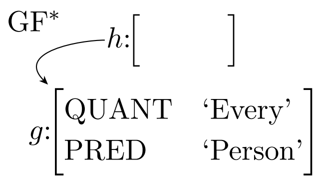
(18) $\lambda P.Every(x, Person(x), P(x))\ :\ (g_e \multimap H) \multimap H$

The idea here is that H can be instantiated (by UI in the glue-derivation) as any literal, and the constraints on glue derivations will suppress various kinds of absurd readings that naive quantifier scope assignment mechanisms tend to allow (Dalrymple et al. 1997).

But there needs to be a restriction that these variables can only instantiate to type p. In the correspondence-based DBA system proposed here, a straightforward way to achieve this is to think of the variable as being an LFG local name (Dalrymple 2001:146-148), accompanied by a type-subscript, so that the variable instantiation is LFG instantiation rather than linear UI. This can be viewed as a further development of Kokkonidis' (2008) First Order Glue system, simplifying it to merely propositional rather than quantificational linear logic, as discussed further in Andrews (2008).

On this basis, we can formulate a sample quantifier constructor for *everybody* as follows, using the AVM notation for the f-structure side, and a standard meaning-constructor format on the glue side:

(19)

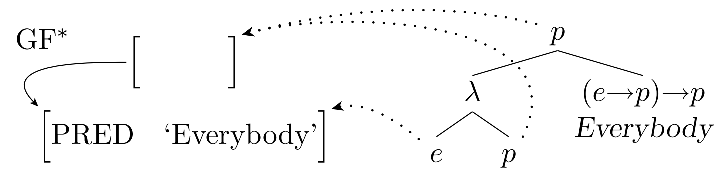


$\Leftrightarrow\ Everybody : (g_e \multimap h_p) \multimap h_p$

To express the f-structure side as a formula in the f-structure fact notation, we'd need to add some sort of functional uncertainty predicate, or else just admit equations such as $(h\,\mathrm{GF}^*) = \mathrm{g}$ as such.

And to express the glue-side in the prefab format, we need to know what to do with an argument that is an implication rather than a basic type. In the procedure for converting standard format meaning-constructors to the prefab format, these arguments become positive polarity implications, which are expanded into a (left) 'pseudo-daughter' of negative polarity, labelled with the antecedent of the mother, and connected to it with a dotted arc, and a (right) daughter of positive polarity, connected to it with a solid line. And, since the formula labelling the implicational argument is so easily readable from those of its daughters, and is essentially a lambda-abstraction (corresponding to an implication introduction in the Natural Deduction version of the glue proof), it is convenient just to label the node with λ. The resulting structure is:

(20)



It is clear from this structure that not every f-structure linked to a positive literal needs to be accessible by a determinate path from the center.

However, the positions in the SLE that are problematic for our proposed constraint turn out to have the property of being connected to 'modifier' rather than 'skeleton' literals in the meaning-constructor, in the sense of Gupta and Lamping (1998). This distinction can be relatively easily explained in terms of the prefab format we have introduced, using the formulation of the Correctness Criterion for proof-nets presented in de Groote (1999). This can be concisely expressed in terms of the notion of 'dynamic graph', which is constituted by the tree-links in the meaning-constructors that we've been writing as solid lines, oriented upwards, together with the axiom-links, in the direction of the arrows.

The Correctness Criterion for implicational intuitionistic proof-nets can then be formulated as:

(21) a. The dynamic graph must form a tree.

b. where every path that starts at the left daughter of a λ-node (positive implication) must pass through that node (or equivalently, its right daughter).

(a) is basically a constraint that the assembly be a single coherent structure (and is similar in spirit to the standard Coherence Constraint), while (b) amounts to the requirement that variables be properly bound.

With this in place, we can define the concept of 'skeleton' and 'modifier' literal in a meaning-constructor, as follows:

(22) a. A 'modifier' literal is one that occurs in a pair (in an instantiated meaning-constructor) that satisfies the type and polarity restrictions for being axiom-linked, but can't be so-linked, without producing a violating the Correctness Criterion.

b. A 'skeleton' literal is any non-modifier literal.

If we look at the proposed constructors for tense or number, quantifiers, or the sentence adverb *obviously*, we see that they have only modifier positions, because connecting their (top) negative to one of their argument positions would prevent an assembly of constructors from forming something whose dynamic paths would be a tree.

But in the SLE's for various verbs discussed earlier, all of the literals in the meaning-constructors are skeleton. Regular noun SLEs are also skeleton, because the two literals are of different semantic types (e and p). On the other hand, the positions associated with normal 'subcategorized' arguments are all skeleton, because they fail to match in either f-structure correspondence or semantic type with anything else in them, so no dynamic path loops can be formed.

We can now formulate a proposed constraint on the f-structure side positions in an SLE that skeleton literals can correspond to under σ:

(23) Skeleton literal constraint: The f-structure correspondent of a skeleton literal must be on a deterministic governable GF-path (in the f-description of the SLE) from the center.

The center of the quantifier constructor (19) is the f-structure labelled g, while that of the adverbial constructor (17) is the set-member with the PRED-value. The positions in the f-description that aren't accessible from the center by a deterministic governable GF-path correspond to modifier rather than skeleton positions, so that (23) is obeyed.

Adjectival and the other adverbial meaning-constructors as discussed in Dalrymple (2001:ch.11) also obey (23), but space forbids going through them all here. There are however some potential counterexamples to (23), such as the English 'Verb X's way' construction discussed in Asudeh et al. (2008). Discussion of these will have to be left for some other occasion; suffice it to say that (a) such constructions don't appear to be very common (b) there are a variety of possibilities for analysing them, such as with a lexical rule.

A further property that meaning-constructors plausibly have is that if the 'Final Output' (literal node at the top of the tree) as defined in Andrews (2007b) is a skeleton position, then it is linked to the center. Verb meanings, for example, appear to always provide a semantic predication for the f-structure that their top PRED-value is an attribute of. It might be possible to extend this to all skeleton negative polarity literals, but obligatory control verbs in Serbo-Croation as analysed by Asudeh (2005:496) provide a counterexample. In the present approach, a functional control verb such as *pokušao* 'try' would require a meaning-constructor of the following form:

(24) $\lambda Px.\mathit{Try}(x, P(x)) \;:\; (i_e \multimap h_p) \multimap g_e \multimap f_p$
where $(f\,\text{XCOMP SUBJ}) = i$ and $g \neq i$

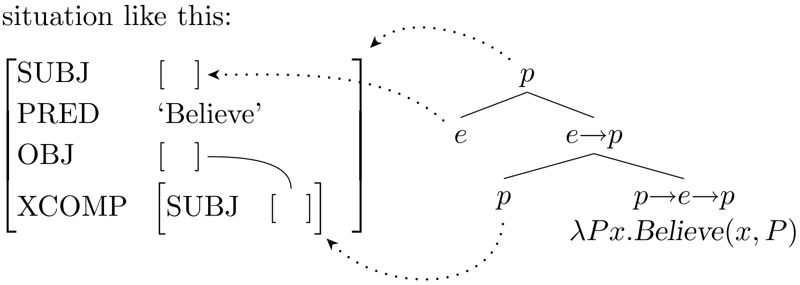
The fact that the matrix and complement subjects aren't the same f-structure prevents the positive and negative type e terms from being modifiers.

We now have a constraint on the handling of skeletal positions in SLEs which makes them function very similarly to the argument-lists and traditional informal semantic interpretation of PRED-features, But we still don't have anything that requires the PREDs to be there, leaving us without an account of why subcategorization appears to be a property of PRED-features (since, so far, any feature could have a meaning-constructor with skeleton SLE positions).

For this, I propose the following constraint:

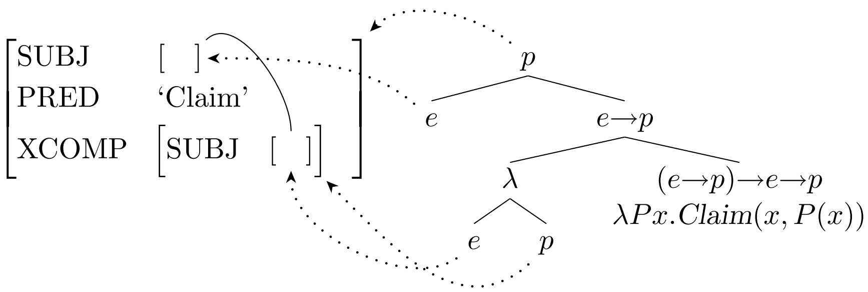
(25) Argument Path PRED-Constraint: If a skeleton literal is positive, it can be gotten to from the center by a governable GF-path such that for each $<f_i, \mathrm{GF}, f_{i+1}>$ in that path, the SLE specifies a PRED-value for f_i.

It is worth working through how (24) applies to functional control verbs, as analysed by Asudeh (2005). When the controller is not an argument, we get a situation like this:

(26)


No PRED-value is mentioned as sister to SUBJ in the <XCOMP SUBJ> path, but the constraint is not violated because this path does not lead to something corresponding to a literal in the meaning-constructor.

When the controller is an argument, we get a situation like this:

(27)


Here, the <XCOMP SUBJ> path does lead to something corresponding to a literal, but to a negative rather than a positive one, so the constraint is still not violated. Note that the f-structure identity of the two SUBJ-values is required by the 'Functional Consistency' principle of Andrews (2007b). This might well lead to a contradiction with the interesting proposals of Alsina (2008), which would need to be sorted out.

5 AVMs and Part-of-Speech-based Constraints

The constraints introduced above can be used to motivate the AVM-based notatation, with limited extensions connected to the system of Part-of-Speech categories. In particular, the arboriform constraint (15) implies that the skeletal positions of the meaning-side will be linked to a tree-structure that can be represented as an AVM, which the argument-path constraint (25) requires to be populated with PRED-features, if the constructor specifies any argument GFs. (Note, however, that if there are no arguments, we don't have any principle to require there to be a PRED, if the Part of Speech is not open in the language. This could be correct, but in any event is something that needs more work.)

All of the conventional 'subcategorization' phenomena are connected to this structure, which can be called the 'central tree', because it is rooted to the center. What else is there? One thing that there appears to be is functional control, which involves a limited range of additional path equations.

The rest of what there is appears to be a limited range of additional material, closely linked to the Part-of-Speech system. This material seems able to be described as the (not necessarily atomic) 'final conclusion' of a meaning-constructor, constrained to involve certain kinds of upward paths from the center. For sentence-adverbs, for example, the final conclusion and constraints appear to be:

(28) $(< g_e \multimap > f_p) \multimap \; < g_e \multimap > f_p$
$<g = (f\,\mathrm{GF}),> f \in (\mathrm{ADJ}\uparrow)$

where ↑ is used to refer to the center, and the angle brackets enclose material that may be present or absent (all simultaneously, as in SPE phonology). Without the brackets, the result is the final conclusion (and entire glue side) of *obviously*, with them, *skillfully*, as analysed in Dalrymple (2001:270-274).

A sentence adverb with no complement (the majority) would then have a central tree of the form [PRED '*X*'], with ↑ in the meaning-constructor automatically linking to the outer brackets, while those few adverbs that take complements (*unfortunately for us*; *skillfully for an undergraduate*) will take additional material in the central tree, such as for example:

[PRED 'Unfortunate', OBL [PRED 'For', OBJ *h*:[ ]]]

where h will link to an antecedent of the final conclusion of the form h_e. Given Dalrymple's account of attributive adjectives, the same constructors that work for sentence adverbs will also work for those modifying adjectives (*an obviously insane proposal*). Scoping adjectives such as *former*, and other kinds of adverbs such as degree adverbs will be different, but it seems likely that the range of variety is limited.

The details of how to treat the other parts of speech are uncertain, but it seems clear that only a limited number of options for the material other than the central tree will be required. Possibly for example just p for nouns, adjectives and verbs (leaving the sorts of differences pointed out for example by Wierzbicka (1986) and Baker (2003) unexplained, for now). The association between different types of parts of speech and different forms of final conclusion is a somewhat unexpected feature in the DBA scheme, although it is natural in co-description, but this needs to be set against the other problems with the co-descriptional approach. Such relationships can be stated using inverse projections.

An important consequence of the constraints is that if an SLE involves only one PRED-feature, its syntactic effects can be simulated with a conventional PRED-feature with an argument-list, obeying the Completeness and Coherence Constraints. Furthermore, if additional features are involved, as with idioms and *pluralia tantum*, the effects can be simulated with FORM-features and constraining equations, in a compileable way. This does not constitute a reason for reverting to co-description, due to the problems discussed earlier in the paper, but it does mean that even if the proposals made here are correct in all respects, there's no reason to drop conventional PRED-features from LFG implementations, as long as they support efficient processing.

Another point that is worth making is that SLEs are well-suited to serve as inputs to lexical rules, under various kinds of formulations, such as OT-LFG (Andrews 2007a), conventional LMT, or classic LFG grammatical function reassignment, as in the original LFG analysis of the passive (Bresnan 1982). They furthermore would not seem to create any gratuitous obstacles to formulating inheritence-based accounts of phenomena such as idiomatic preposition selection in English or case-frame determination in Icelandic, as proposed in construction grammar. For example, a partial SLE such as [SUBJ g:[CASE ACC], OBJ j:[CASE ACC]] for verbs expressing 'lacking' in Icelandic is not significantly different from the form of representation for case-frames used in Barðdal (2001). We can therefore follow Asudeh et al. (2008) in using lexical inheritance to get some very useful properties of Construction Grammar within the formalism of LFG.

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