Gluing Meanings and Semantic Structures

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In this paper I explore the use of s(emantic)-structures in LFG and propose that lexical meanings can be associated with s-structures of complex types.

The glue expressions on the right-hand side of meaning constructors (MCs) in glue semantics control semantic composition, determining how meanings are combined in a semantic derivation. They also have another function that is often overlooked but that is architecturally vital. As described by e.g. Dalrymple (2001), MCs associate a meaning with an s-structure: the meaning appears on the left-hand side of the MC, and the s-structure is defined by the glue expression that appears on the right-hand side. For example, a meaning constructor like $anna{:}\uparrow_\sigma$ pairs the meaning *anna* with the s-structure $\uparrow_\sigma$. S-structures provide a mediation between syntax and meaning, and are therefore the means by which semantics is integrated into the LFG architecture.

Dalrymple and Nikolaeva (2011) propose that s-structures are the locus for expressing discourse-relevant properties of the elements of meaning in a sentence. So they rewrite the MC $john{:}\uparrow_\sigma$, appearing in a particular linguistic context where it is identifiable and topical, as in (1).

(1)
$$john{:}\begin{bmatrix}\text{ANIMATE} & + \\ \text{HUMAN} & + \\ \text{STATUS} & \text{IDENTIFIABLE} \\ \text{ACTV} & \text{ACTIVE} \\ \text{DF} & \text{TOPIC}\end{bmatrix}$$

The proposal that such features be represented in s-structure is an important development, permitting the representation and use of discourse-relevant features without the need for a separate discourse structure or mechanism to track meanings and features across sentences. Dalrymple and Nikolaeva use the s-structure attribute DF, with values such as TOPIC or FOCUS, as the basis for the categorization of MCs at i(nformation)-structure, and it is likely that there are many further potential uses for such s-structure features awaiting research.

However, in the present mainstream approach to glue, s-structures are all of type e or t; there are no complex-type structures. Complex meanings (those involving lambda-abstraction) are associated not with any one s-structure, but with a complex glue expression that usually involves linear implication between simple-type (e/t) structures; for example a simple verbal meaning:

(2) $\lambda y.\lambda x.hit(x,y) : (\uparrow \text{SUBJ})_{\sigma\langle e\rangle} \multimap (\uparrow \text{OBJ})_{\sigma\langle e\rangle} \multimap \uparrow_{\sigma\langle t\rangle}$

This means that most (if not all) lexical meanings have no s-structure with which they and they alone are associated and in which semantic features of the type proposed by Dalrymple and Nikolaeva (2011) can be represented. This is not a problem for Dalrymple and Nikolaeva's i-structure model as they present it, because they treat the DF feature as a label that categorizes the meaning associated with the head of the projecting f-structure, not necessarily the meaning associated with the s-structure itself. However, this requires the assumption of two sorts of s-structure feature, one sort semantically contentful and directly applicable to the meaning associated with the s-structure in which the feature appears, and one sort with no semantic content and not directly related to the associated meaning. I show that more detailed treatments of i-structure require contentful semantic features more primitive than DF, and argue that all s-structure features should be semantically contentful and directly applicable to the meaning associated with the s-structure in which the feature appears.

Moreover, even assuming the Dalrymple and Nikolaeva (2011) model, it is not possible to distinguish the i-structure categorization of different elements of the meaning of a single word. So, in (3), it is presupposed in the answer, on the basis of the question, that Anna did something, but what she did is new information. Assuming a decomposition of TOPIC and FOCUS according to the binary features ±PROM and ±NEW, as per Butt and King (1996) and Choi (1999), the event itself is −NEW, and therefore cannot be in focus (focus being +NEW, +PROM) while the event type is +NEW and, indeed, part of the focus. In an event-based semantics these two parts of the verbal meaning can be distinguished and so potentially categorized separately at i-structure; this is shown in (5), in which boldface words represent MCs. But in Dalrymple and Nikolaeva's model they cannot be categorized separately, because neither has a distinct s-structure in which features such as DF can be represented (the s-structure in which the DF feature for the verb appears, in their model, is the s-structure for the clause). Similarly, in (4) it is presupposed in the answer that an entity of some sort hit Norman, but the fact that that entity is Anna is new and focused. It is possible to assume two meaning constructors for a proper name like *Anna*, one expressing the existence of an entity, the other its identity, but under the Dalrymple and Nikolaeva (2011) i-structure model both will be associated with the same $\uparrow_\sigma$, and so cannot be put into different sets at i-structure.

(3) Q: What did Anna do?
A: Anna hit Norman.

(4) Q: Who hit Norman?
A: Anna hit Norman.

(5) $\begin{bmatrix} \text{TOPIC} & \{\textbf{Anna}, \textbf{event}\} \\ \text{FOCUS} & \{\textbf{hit}, \textbf{Norman}\} \end{bmatrix}$

I propose that the solution to both these problems is to decompose MCs of the 'traditional' form into two separate MCs. The first contains the contentful meaning and associates it with a specific semantic structure of the appropriate complex type. We can now specify discourse relevant properties for this meaning, and this meaning alone, by reference to this structure. The second MC has an identity function on the meaning side, while the glue side consumes the complex-type structure and produces a 'traditional' style glue expression that determines how a meaning be combined with other meanings. For example, for a basic verbal meaning such as $\lambda y.\lambda x.hit(x, y)$:

(6) a. $\lambda y.\lambda x.hit(x, y) : (\uparrow_\sigma \text{REL})_{\langle e \to \langle e \to t \rangle \rangle}$
b. $\lambda P.P : (\uparrow_\sigma \text{REL})_{\langle e \to \langle e \to t \rangle \rangle} \multimap (\uparrow \text{SUBJ})_{\sigma\langle e \rangle} \multimap (\uparrow \text{OBJ})_{\sigma\langle e \rangle} \multimap \uparrow_{\sigma\langle t \rangle}$

Basic lexical meanings are associated with a single s-structure $(\uparrow_\sigma \text{REL})$. The type of such structures is not limited to e or t, but reflects the type of the meaning. So $\lambda y.\lambda x.hit(x, y)$ is associated with an s-structure $(\uparrow_\sigma \text{REL})$ of type $\langle e \to \langle e \to t \rangle \rangle$, whereas a meaning such as $\lambda x.sleep(x)$ will be associated with an s-structure $(\uparrow_\sigma \text{REL})$ of type $\langle e \to t \rangle$. Glue expressions such as that in (6a), however, contain no direct information on how to combine with other meanings; they must therefore be converted into glue expressions that do include such information, and this is the purpose of the second MC, as in (6b). The result of composing (6a) and (6b) is the MC in (7), i.e. one of the 'traditional' form.

(7) $\lambda y.\lambda x.hit(x, y) : (\uparrow \text{SUBJ})_{\sigma\langle e \rangle} \multimap (\uparrow \text{OBJ})_{\sigma\langle e \rangle} \multimap \uparrow_{\sigma\langle t \rangle}$

Every complex meaning (at least those that we may want to express semantic properties of) must be specified in this way in the lexicon. So for a basic noun meaning like $\lambda x.student(x)$:

(8) a. $\lambda x.student(x) : (\uparrow_\sigma \text{REL})_{\langle e \to t \rangle}$
b. $\lambda P.P : (\uparrow_\sigma \text{REL})_{\langle e \to t \rangle} \multimap (\uparrow_\sigma \text{VAR})_{\langle e \rangle} \multimap (\uparrow_\sigma \text{RESTR})_{\langle t \rangle}$

In order to express distinct properties of different MCs associated with the same word, it is necessary to project multiple complex-type structures. So, assuming a very basic event semantics, the verb *hit* (as in 3) contributes two pairs of MCs, as in (9) and (10); (9a) will correspond to **hit** in (5), and (10a) will correspond to **event** in (5).

(9) a. $\lambda e.hit(e) : (\uparrow_\sigma \text{REL})_{\langle e \to t \rangle}$
b. $\lambda P.P : (\uparrow_\sigma \text{REL})_{\langle e \to t \rangle} \multimap (\uparrow \text{EV})_{\sigma\langle e \rangle} \multimap \uparrow_{\sigma\langle t \rangle}$

(10) a. $\lambda P.\exists e.P(e) : (\uparrow_\sigma \text{EVENT})_{\langle \langle e \to t \rangle \to t \rangle}$
b. $\lambda P.P : (\uparrow_\sigma \text{EVENT})_{\langle \langle e \to t \rangle \to t \rangle} \multimap (((\uparrow \text{EV})_{\sigma\langle e \rangle} \multimap \uparrow_{\sigma\langle t \rangle}) \multimap \uparrow_{\sigma\langle t \rangle})$

Under this model, we can distinguish two types of MC. The first contains the lexical meaning, and represents the 'pure' projection of meaning from lexical items through the f-structure. The second can be understood as representing the instantiation of the association between syntax and semantics: they specify how, given a syntactic context, meanings can be combined.
One criticism of this approach may be that it proposes new s-structures in which semantic features can be represented, but retains many s-structures that have no specific meaning associated with them and so will never contain semantic features (e.g. $(\uparrow_\sigma \text{VAR})$, $(\uparrow_\sigma \text{EV})$, etc.). An alternative implementation of the same proposal will also be considered, in which complex-type glue expressions are mapped to 'first-order' glue expressions (Kokkonidis, 2008), permitting us to retain the necessary structures but eliminate the unnecessary ones. This would mean retaining the MCs such as (6a), but replacing those such as (6b) with functions to first-order expressions.

References: Butt, Miriam and Tracy Holloway King (1996). 'Structural Topic and Focus without Movement'. In Miriam Butt and Tracy Holloway King (eds.), *Proceedings of the LFG96 Conference*, Stanford, CA: CSLI Publications. • Choi, Hye-Won (1999). *Optimizing Structure in Context*. Stanford, CA: CSLI Publications. • Dalrymple, Mary (2001). *Lexical Functional Grammar*. San Diego, CA: Academic Press. • Dalrymple, Mary and Irina Nikolaeva (2011). *Objects and Information Structure*. Cambridge: Cambridge University Press. • Kokkonidis, Miltiadis (2008). 'First-Order Glue'. *Journal of Logic, Language and Information 17*, pp. 43–68.