Gluing Meanings and Semantic Structures

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LFG14 Conference, Ann Arbor, Michigan
18 July 2014

1 Associating meanings with structures

(1) Henry slept.

(2) a. $henry : \uparrow_\sigma$
b. $\lambda x.sleep(x) : (\uparrow \text{SUBJ})_\sigma \multimap \uparrow_\sigma$

(3) $s{:}\begin{bmatrix} \text{PRED} & \text{`sleep}\langle\text{SUBJ}\rangle\text{'} \\ \text{SUBJ} & h{:}\begin{bmatrix}\text{PRED} & \text{`Henry'}\end{bmatrix} \end{bmatrix}$

The basic elements of glue expressions are formulae like $\uparrow_\sigma$ or $(\uparrow \text{SUBJ})_\sigma$; these formulae refer to *semantic structures*. These semantic structures are projected from f-structures via the projection function σ, and thus provide the means by which semantics is integrated into the projection architecture.

Dalrymple et al. (1999), Dalrymple (2001), Dalrymple and Nikolaeva (2011: 72) etc.: meanings are associated with semantic structures, or with relations between semantic structures, by virtue of the glue expressions with which a meaning constructor pairs them.

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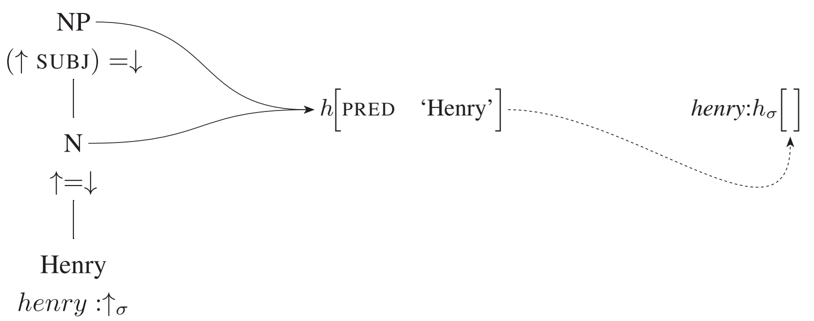


In most works that utilize glue, all semantic structures are related to meanings of type e or t. Only meanings of type e or t, then, can be associated with a single structure of the appropriate type. More complex meanings are not associated with a single semantic structure, but with a relation, usually involving linear implication, between two or more structures. So $\lambda x.sleep(x)$ is of type $\langle e \rightarrow t\rangle$, and the glue expression accordingly expresses a linear implication from an s-structure of type e (i.e. h_σ in 4) to an s-structure of type t, which is the semantic structure for the clause.

2 Information structure and granularity

S-structures introduced as a point of mediation between f-structure and meaning by Dalrymple et al. (1996), "because in general semantic projections carry more information than just the association to the meaning for the corresponding f-structure." (Internally complex s-structures for nouns, with s-structures embedded under the attributes

VAR and RESTR). Other arguments for embedding in s-structure: treatments of tense and aspect in glue (e.g. Fry 2005, Haug 2008, Lowe forthcoming), and the argument structure proposals of Asudeh and Giorgolo (2012). Besides this no other features are traditionally assumed to appear in s-structure, so any semantic derivation will necessarily involve a number of empty s-structures.

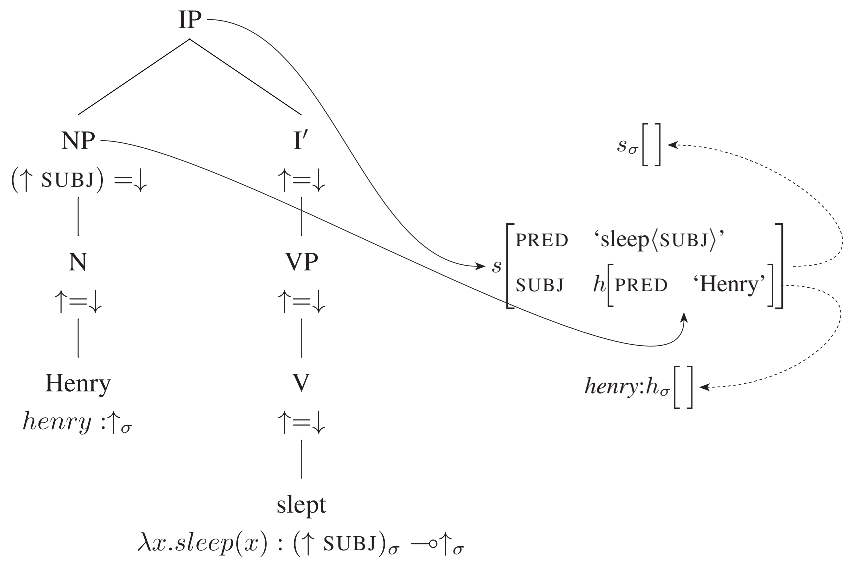
2.1 IS features in s-structure

Dalrymple and Nikolaeva (2011) challenge the emptiness of s-structures: semantic structures are the locus for expressing information structural and discourse-relevant properties of the elements of meaning in a sentence. Dalrymple and Nikolaeva (2011: 79) rewrite the meaning constructor *john*:$\uparrow_\sigma$, appearing in a particular linguistic context where it is identifiable and topical, as follows:

(5)
$$john: \begin{bmatrix} \text{ANIMATE} & + \\ \text{HUMAN} & + \\ \text{STATUS} & \text{IDENTIFIABLE} \\ \text{ACTV} & \text{ACTIVE} \\ \text{DF} & \text{TOPIC} \end{bmatrix}$$

But there are limitations to the use of s-structures in this way: more complex meanings are not directly associated with a single structure. In (6), the meaning $henry$ is directly associated with h_σ, but there is no structure with which $\lambda x.sleep(x)$ is directly associated. The meaning associated with s_σ is $sleep(henry)$, since this is the structure/meaning of the clause.

(6)



Dalrymple and Nikolaeva (2011) set up their model in such a way that verbal meanings of similar form to that in (2b) can be categorized at i-structure on the basis of the DF feature in the *clausal* s-structure. They would assume an i-structure such as in (8), based on meaning constructors / s-structures as in (7).

(7) a. $henry : h_\sigma[\text{DF TOPIC}]$

b. $\lambda x.sleep(x) : h_\sigma \multimap s_\sigma[\text{DF FOCUS}]$

(8) $\begin{bmatrix} \text{TOPIC} & \left\{ henry : h_\sigma \right\} \\ \text{FOCUS} & \left\{ \lambda x.sleep(x) : h_\sigma \multimap s_\sigma \right\} \end{bmatrix}$

The meaning constructor $\lambda x.sleep(x) : h_\sigma \multimap s_\sigma$, and by implication the meaning $\lambda x.sleep(x)$, is categorized in the focus set at i-structure by virtue of the feature DF FOCUS appearing in the s-structure s_σ. The rule that achieves this is the rule of i-structure categorization associated with all meanings in the lexicon:

(9) **meaning-constructor** $\in (\uparrow_{\sigma\iota}\ (\uparrow_\sigma\ \text{DF}))$

In the sentence under discussion, s is the f-structure for the clause, with PRED 'sleep⟨SUBJ⟩'. The s-structure $\uparrow_\sigma$ for the verb is therefore s_σ, and so the feature DF FOCUS in s_σ means that, by (9), the verbal meaning constructor is correctly categorized in the FOCUS set at i-structure.

The analysis given by Dalrymple and Nikolaeva (2011: 91) implies the following meaning constructor, even though there is no sense in which the full clausal meaning is in 'focus'.

(10) *sleep(henry)*:$\begin{bmatrix} \text{DF} & \text{FOCUS} \end{bmatrix}$

2.2 The eternal problem of information structure: granularity

"The granularity problem" refers originally to the fact that f-structure is not fine-grained enough to be used as a basis for i-structure distinctions, since there is no f-structure that contains the verb and not also all of its arguments and adjuncts (King 1997).

King (1997) and Butt and King (2000) propose that i-structure be projected from c-structure, since c-structure does have sufficient granularity to distinguish a verb from its dependents. But the formalization of this is never particularly explicit, and it does not reflect the fact that i-structure is closely related to semantic structure and meaning (Mycock 2009). In addition, even c-structure is not fine-grained enough (see below).

Dalrymple and Nikolaeva's model uses s-structure as the basis of i-structure categorization. S-structure is a projection of f-structure, so is (under normal assumptions) no more fine-grained. But their model is set up in such a way as to get round the granularity problem regarding the distinction of a verb from its arguments, as described above.

But the granularity problem still exists: Dalrymple and Nikolaeva's use of DF implies that there can be only one information structure categorization for all meanings (or meaning constructors) projected from a single f-structure. Since σ is a function, an f-structure can be associated with at most one s-structure, and since there can be only a single DF feature in any one s-structure, all meanings associated with an f-structure must share the same information structure categorization. This causes no problem when dealing with simplified verbal meanings like $\lambda x.sleep(x)$ and with proper names like $Henry$ or $John$. However, problems arise under attempts to treat more complex semantic analyses.

Under an event semantic approach to verbal meanings, a word like *slept* would have not the single meaning constructor in (2b), but could have the four in (11): (11a) represents the basic verbal meaning; (11b) represents perfective aspect; (11c) represents past tense; and (11d) represents finiteness, functioning to close off the open temporal variable.[1]

[1]This assumes, for the sake of argument, that the English simple past is a past perfective category. The meanings constructors here are based on Haug (2008) and Lowe (forthcoming).

(11) a. $\lambda x.\lambda e.sleep(e) \wedge experiencer(e,x) : (\uparrow \textsc{subj})_\sigma \multimap (\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma$

b. $\lambda P.\lambda t.\exists e.P(e) \wedge \tau(e) \prec t : ((\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma) \multimap ((\uparrow_\sigma \textsc{rt}) \multimap \uparrow_\sigma)$

c. $\lambda P.\lambda t'.\exists t.P(t) \wedge t \subseteq t' : ((\uparrow_\sigma \textsc{rt}) \multimap \uparrow_\sigma) \multimap ((\uparrow_\sigma \textsc{pt}) \multimap \uparrow_\sigma)$

d. $\lambda P.\exists t.P(t) : ((\uparrow_\sigma \textsc{pt}) \multimap \uparrow_\sigma) \multimap \uparrow_\sigma$

All these meanings are part of the lexical meaning of the verb: they must be introduced in the lexical entry of the verb. They will all be projected from the same f-structure, i.e. the f-structure for which the verb provides the PRED. Same is true of periphrastic verb forms. According to Falk (2003), supportive *do*, perfective *have*, and the modals *will*, *shall* and *would* are feature-carriers that do not head their own f-structures. So for all the sentences in (12) there will be only two f-structures, one for the clause/verb, and one for the subject, just as in (3) and exemplified in (13) for (12d).

(12) a. Henry did sleep.

b. Henry has slept.

c. Henry will sleep.

d. Henry will have slept.

(13)
$$\begin{bmatrix} \textsc{pred} & \text{`sleep}\langle\textsc{subj}\rangle\text{'} \\ \textsc{tense} & \textsc{future} \\ \textsc{aspect} & \textsc{perfective} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{`Henry'} \end{bmatrix} \end{bmatrix}$$

Problem with Dalrymple and Nikolaeva's (2011) use of DF: since there is only a single f-structure corresponding to a periphrastic verb form like *will have slept*, all elements of the verb's meaning, including the basic verbal meaning and tense and aspect, must be categorized in the same set at i-structure.

(14) Q. Have you found it?

A. I *had* found it (but I lost it again).

(15) Q. Have you read my paper?

A. I *will* have read it by tomorrow.

Even on a more simple model that ignores tense and aspect, it is necessary to be able to distinguish the part of a verb's meaning that expresses the occurrence of an event from the part that expresses the event type (the basic verbal meaning). The answer in (16) is about Anna doing something; the fact that Anna did something is therefore not part of the focused material in the clause. What is focused is the nature, the kind, of the event that Anna undertook.

(16) Q. What did Anna do?

A. Anna hit Norman.

(17) a. **hit**: $\lambda y.\lambda x.\lambda e.hit(e) \wedge agent(e,x) \wedge patient(e,y) : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap (\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma$

b. **event**: $\lambda P.\exists e.P(e) : ((\uparrow_\sigma \textsc{ev}) \multimap \uparrow_\sigma) \multimap \uparrow_\sigma$

The required i-structure, in Dalrymple and Nikolaeva's (2011) formulation, is given in (18). But under Dalrymple and Nikolaeva's model, this is impossible.

(18)
$$\begin{bmatrix} \textsc{topic} & \left\{\textbf{anna}, \textbf{event}\right\} \\ \textsc{focus} & \left\{\textbf{hit}, \textbf{norman}\right\} \end{bmatrix}$$

Not only verbs: in (19), the answer is about the fact that someone hit Norman, and the focused meaning, which supplies the information requested in the question, is who that someone is.

(19) Q. Who hit Norman?
A. The student hit Norman.

Necessary to distinguish the part of the meaning of *the student* that refers to the existence of an entity from the part that refers to what kind of entity we are dealing with. In the case of *the student*, it might be possible to make this distinction by associating the former meaning component with (the f-structure of) the determiner, and the latter with (the f-structure of) the noun itself.[2]

Same principle would apply to singular nouns with the indefinite determiner. But indefinite plural noun phrases in English have no determiner, so there will be no SPEC feature in the f-structure of such a noun phrase, and therefore no separate f-structure from which the entity meaning can be projected.

(20) Q. Who ruined the economy?
A. Socialists ruined the economy.

Just as with verbs, then, there is only one s-structure projected from the f-structure of *Socialists*. Under Dalrymple and Nikolaeva's (2011) proposals all meaning constructors associated with this word must be categorized in the same way at i-structure, despite the information structural differences between the entity and entity-kind parts of the word's meaning.

3 Proposal: uniquely labelled (complex-typed) structures

Problem derives from the dual function of glue expressions: glue expressions state constraints on semantic composition, but they do this by associating meanings with semantic structures or with relations between semantic structures. If the association with structures is treated merely as a feature of the architecture, as little more than a book-keeping device, this dual functionality is unproblematic. But if we use semantic structures for other things, a conflict arises.

Proposal - decompose meaning constructors of the traditional sort into two expressions, one of which functions to associate a meaning with a single semantic structure and the other of which states the necessary constraints on semantic composition. Instead of a meaning constructor like (21), we in fact have two meaning constructors, as in (22).

(21) $\lambda x.sleep(x) : (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$

(22) a. $\lambda x.sleep(x) : (\uparrow_\sigma \textsc{rel})$
b. $\lambda P.P : (\uparrow_\sigma \textsc{rel}) \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$

This proposal requires the assumption of s-structures that are related to meanings of complex type (or if s-structures themselves are typed, that s-structures can have complex types).

The uniquely labelled structure for a verbal meaning cannot be $\uparrow_\sigma$. I use instead the s-structure attribute REL: the uniquely labelled structure for verbal meanings will be $(\uparrow_\sigma \textsc{rel})$.

Not only for verbs: $(\uparrow_\sigma \textsc{rel})$ can be used for the basic lexical meaning of all words that head their own f-structure.

[2]This would work only if SPEC takes as its value an f-structure, rather than an atomic label.

(23) a. $\lambda x.student(x) : (\uparrow_\sigma \text{ REL})_{\langle e \to t\rangle}$

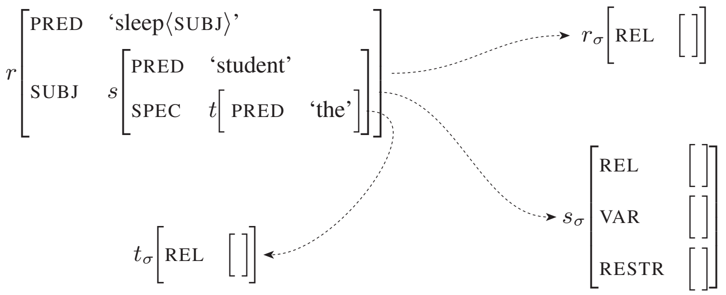
b. $\lambda P.P : (\uparrow_\sigma \text{ REL})_{\langle e \to t\rangle} \multimap (\uparrow_\sigma \text{ VAR})_{\langle e\rangle} \multimap (\uparrow_\sigma \text{ RESTR})_{\langle t\rangle}$

(24) a. $\lambda P.\lambda Q.\iota x.P(x) \wedge Q(x) : (\uparrow_\sigma \text{ REL})_{\langle\langle e\to t\rangle \to \langle\langle e \to t\rangle \to t\rangle\rangle}$

b. $\lambda P.P : \forall \alpha.(\uparrow_\sigma \text{ REL})_{\langle\langle e\to t\rangle \to \langle\langle e \to t\rangle \to t\rangle\rangle} \multimap (((\text{SPEC} \uparrow)_\sigma \text{VAR})_{\langle e\rangle} \multimap ((\text{SPEC} \uparrow)_\sigma \text{RESTR})_{\langle t\rangle}) \multimap ((\text{SPEC} \uparrow)_{\sigma\langle e\rangle} \multimap \alpha_{\langle t\rangle}) \multimap \alpha_{\langle t\rangle}$

(25) The student slept.

(26)



4 Multiple meanings per word

We can assume as many complex-typed structures as necessary for a particular word, i.e. as many as the number of meaning constructors assumed. We just need unique labels for each meaning. For example, if we assume a four-way division of verbal meaning into event-kind (i.e. the basic lexical meaning), aspect, tense and finiteness, as in (11), the four meanings concerned can be associated with the structures $(\uparrow_\sigma \text{ REL})$, $(\uparrow_\sigma \text{ ASP})$, $(\uparrow_\sigma \text{ TEN})$ and $(\uparrow_\sigma \text{ FIN})$ respectively. The four meaning constructors in (11) can then be treated as compositions of the eight meaning constructors in (27).

(27) a. i. $\lambda x.\lambda e.sleep(e) \wedge experiencer(e,x) : (\uparrow_\sigma \text{ REL})$

ii. $\lambda P.P : (\uparrow_\sigma \text{ REL}) \multimap (\uparrow \text{ SUBJ})_\sigma \multimap (\uparrow_\sigma \text{ EV}) \multimap \uparrow_\sigma$

b. i. $\lambda P.\lambda t.\exists e.P(e) \wedge \tau(e) \prec t : (\uparrow_\sigma \text{ ASP})$

ii. $\lambda P.P : (\uparrow_\sigma \text{ ASP}) \multimap ((\uparrow_\sigma \text{ EV}) \multimap \uparrow_\sigma) \multimap (\uparrow_\sigma \text{ RT}) \multimap \uparrow_\sigma$

c. i. $\lambda P.\lambda t'.\exists t.P(t) \wedge t \subseteq t' : (\uparrow_\sigma \text{ TEN})$

ii. $\lambda P.P : (\uparrow_\sigma \text{ TEN}) \multimap ((\uparrow_\sigma \text{ RT}) \multimap \uparrow_\sigma) \multimap (\uparrow_\sigma \text{ PT}) \multimap \uparrow_\sigma$

d. i. $\lambda P.\exists t.P(t) : (\uparrow_\sigma \text{ FIN})$

ii. $\lambda P.P : (\uparrow_\sigma \text{ FIN}) \multimap ((\uparrow_\sigma \text{ PT}) \multimap \uparrow_\sigma) \multimap \uparrow_\sigma$

A two-way division of verbal meaning (event and event-kind) would require only two uniquely labelled structures. In order to capture the two parts of meaning of an indefinite plural like *Socialists* in (20b), we require two structures, $(\uparrow_\sigma \text{ REL})$ for the basic meaning, and $(\uparrow_\sigma \text{ ENT})$ for the existence of one or more entities.

(28) a. i. $\lambda x.Socialist(x) : (\uparrow_\sigma \text{ REL})$

ii. $\lambda P.P : (\uparrow_\sigma \text{ REL}) \multimap (\uparrow_\sigma \text{ VAR}) \multimap (\uparrow_\sigma \text{ RESTR})$

b. i. $\lambda P.\lambda Q.\exists x.P(x) \wedge Q(x) : (\uparrow_\sigma \text{ ENT})$

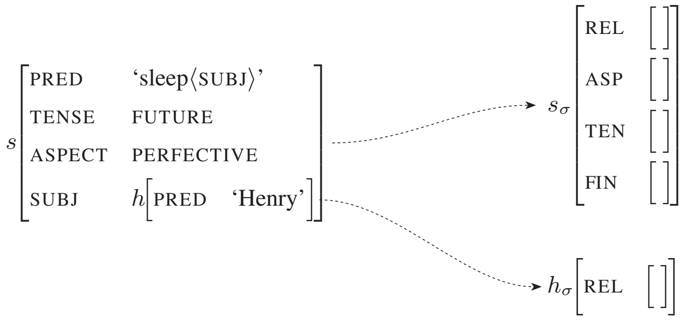
ii. $\lambda P.P : \forall \alpha.(\uparrow_\sigma \text{ ENT}) \multimap ((\uparrow_\sigma \text{ VAR}) \multimap (\uparrow_\sigma \text{ RESTR})) \multimap (\uparrow_\sigma \multimap \alpha) \multimap \alpha$

Figure 1: Glue proof for (25), based on (22), (23) and (24)

$$\dfrac{\dfrac{\lambda x.student(x) : (s_\sigma \text{REL}) \qquad \lambda P.P : (s_\sigma \text{REL}) \multimap (s_\sigma \text{VAR}) \multimap (s_\sigma \text{RESTR})}{\lambda x.student(x) : (s_\sigma \text{VAR}) \multimap (s_\sigma \text{RESTR})} \qquad \dfrac{\lambda P.\lambda Q.\iota x.P(x) \wedge Q(x) : (t_\sigma \text{REL}) \qquad \lambda P.P : (t_\sigma \text{REL}) \multimap ((s_\sigma \text{VAR}) \multimap (s_\sigma \text{RESTR})) \multimap (s_\sigma \multimap r_\sigma) \multimap r_\sigma}{\lambda P.\lambda Q.\iota x.P(x) \wedge Q(x) : ((s_\sigma \text{VAR}) \multimap (s_\sigma \text{RESTR})) \multimap (s_\sigma \multimap r_\sigma) \multimap r_\sigma}}{\lambda Q.\iota x.student(x) \wedge Q(x) : (s_\sigma \multimap r_\sigma) \multimap r_\sigma}$$

$$\dfrac{\lambda x.sleep(x) : (r_\sigma \text{REL}) \qquad \lambda P.P : (r_\sigma \text{REL}) \multimap s_\sigma \multimap r_\sigma}{\lambda x.sleep(x) : s_\sigma \multimap r_\sigma}$$

$$\dfrac{\lambda Q.\iota x.student(x) \wedge Q(x) : (s_\sigma \multimap r_\sigma) \multimap r_\sigma \qquad \lambda x.sleep(x) : s_\sigma \multimap r_\sigma}{\iota x.student(x) \wedge sleep(x) : r_\sigma}$$

(29) 

5 Conclusion

- Semantic structures: architecturally important, but rarely considered.
- Using s-structures for i-structure categorization is promising on various levels, but still suffers from the granularity problem.
- Proposal: meaning constructors of the ‘standard’ form be ‘split’, and considered compositions of two separate meaning constructors, one of which associates the lexical meaning with an s-structure of the appropriate type, and another which converts the glue expression of the former into a glue expression of the ‘standard’ form.
- This proposal effectively resolves the granularity problem, introducing into s-structure sufficient granularity for whatever distinctions are required.
- The ‘split’ proposed correlates neatly with the two components required for semantic composition: meaning and realization. One sort of meaning constructor introduces lexical meaning, while the other introduces the information necessary for composition of lexical meaning.

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