Towards a Discourse-Oriented Representation of Information Structure in HPSG

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1 A Syntax-Oriented Representation

A representation for information structure in HPSG was proposed by Engdahl & Vallduví (1996). Arguing that information structure is a distinct dimension, which should not be associated only with phonology, only with syntax, or only with semantics, they propose that a feature INFO-STRUCT (which includes FOCUS and GROUND, the latter including LINK and TAIL) should be located within the CONTEXT feature in the HPSG framework.

However, the specific representation which they use is syntactic: LINK and FOCUS are equated with the syntactic constituents (NPs and VPs) which realize the topic concept and the focus information. As the primary concern of Engdahl & Vallduví (1996) is with information *packaging*, this has the advantage of facilitating the description of the realization of information structure (by intonation in English, by word order in Catalan), but it has the major disadvantage that the packaging is only indirectly tied to the information which is packaged, which is itself part of the semantic content.[1]

This syntax-based representation of information structure enables the distinction between narrow focus and wide focus to be represented. Example (1) can be interpreted either with narrow focus on the object noun phrase or with wide focus on the whole verb phrase.

(1) The president [F hates [F the Delft china set]].

To represent these alternatives, the value of FOCUS at higher nodes (S and VP) is equated with the smaller syntactic constituent (the object NP) to represent the narrow focus reading, or with the larger syntactic constituent (the whole VP) to represent the wide focus reading, as shown by examples (17) and (18) of Engdahl & Vallduví (1996).

This would be an elegant way to capture the narrow and wide focus readings. However, there are a number of cases where informational partitioning does not correspond to syntactic constituency. Among the examples given by Engdahl & Vallduví are subject-verb focus (3) and complex focus (4):

[1] In a footnote, Engdahl and Vallduví themselves suggest that it would be more appropriate for the value of INFO-STRUCT to be structure-shared with the CONTENT information.

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(2) What happened to the china set? [F The BUTLER BROKE] the set.

(3) Who did your friends introduce to whom?
John introduced BILL to SUE, and **Mike**...

To handle these examples, Engdahl & Vallduví change the representation so that set values will be used: the value of FOCUS will not be a single syntactic constituent which exactly spans the focus scope, but an otherwise arbitrary set of syntactic constituents which together make up the relevant sequence of words. The representation thereby loses its initial elegance. With this change, examples (1) and (2) will have a singleton set value for FOCUS, and set values will also be used for LINK and TAIL.

2 A Semantics-Oriented Representation

We now examine a different approach to information structure, based on the practical requirements of dialogue modelling in robust dialogue system projects. These requirements appear to support a closer link between the information structure representation and the semantic representation. Dialogue responses need to be generated from the semantic information. Old and new discourse referents need to be distinguished, and referents are usually identified by indices in the semantic representation. In addition, topic continuities and topic shifts need to be tracked, and the topics are also identified by semantic indices, even when a topic is some kind of event.

As an example of this approach we take the dialogue modelling framework used in PLUS (Pragmatics-based Language Understanding System), described by Jokinen (1994). In PLUS, the semantic representation consists of flat quasi-logical forms with simple indices for discourse referents. The dialogue manager component takes account of information structure and decides what semantic representations to supply to the generator. Jokinen defines **Topic** as a distinguished discourse entity which is talked about, and which is an instantiated World Model concept. **NewInfo** is a concept or property value which is *new* with respect to some Topic. The representation for both is based directly on the semantic representation. Jokinen gives an example from PLUS (Topics are in italics, NewInfo bold-faced):

(4) User: *I need a car.*
System: Do you want to **buy or rent** *one*?
User: **Rent**. (topic: *car*)
System: **Where**? (topic: *rent*)
User: In **Bolton**. (topic: *rent*)
...

Jokinen (1994) explains that in the first system contribution in (4), NewInfo is the disjunction 'buy or rent', which has the representation:

(5) Goal: know(s,[wantEvent(w,u,d),disj(d,b,r),
buyEvent(b,u,c,_),hireEvent(r,u,c,_),car(c),user(u)])
NewInfo: disj(d,b,r)

Compared with the syntax-oriented representation of information structure, this semantics-oriented representation appears to have the advantage of facilitating topic tracking and distinguishing old and new referents, due to the direct use of semantic indices (c = *car*, r = *rent*, etc.). Further examples of its use in practical dialogue modelling are described by Jokinen (1994).

Although many examples of narrow and wide focus could be elegantly represented in this approach, simply by NewInfo taking the appropriate index value, other examples cannot be represented by a single semantic index: if *hates* has semantic index h, the wide VP focus reading in (1) would need NewInfo to be both h and s. It is not possible to unify these indices, because the hating event (h) and the china set (s) are ontologically distinct items. The conclusion is that the value of NewInfo should be a *set* of indices, giving representations like those sketched in (6) (narrow NP focus) and (7) (wide VP focus):

(6) Semantics: hateEvent(h,p,s),president(p),Delft(s),china(s),set(s)
NewInfo: {s}

(7) Semantics: hateEvent(h,p,s),president(p),Delft(s),china(s),set(s)
NewInfo: {h,s}

The kind of flat quasi-logical form used in PLUS has the disadvantage that it lacks an adequate treatment of quantifier scope. An approach has been developed in Minimal Recursion Semantics (Copestake, Flickinger & Sag 1997) in the HPSG framework to provide a solution to this problem. Basically, MRS is a flat indexed quasi-logical form like the one used in PLUS, but MRS has typed feature structures as used throughout HPSG.

The representation for quantifier scoping in MRS is achieved by the use of *handles*, extra identifiers that are unified with the role arguments of other relations. This technique not only enables recursive embedding to be simulated, but also allows quantifier scope to be either fully resolved or underspecified. We give an example from Copestake et al. (1997) using their linear notation to save space. The unscoped representation of *every dog chased some cat* is:

(8) 1:every(x,3,n), 3:dog(x), 7:cat(y), 5:some(y,7,m), 4:chase(e,x,y)
top handle: p

Here 1, 3, 4, 5, 7 are handles and m, n and p are variables over handles. This unscoped representation can be further instantiated to give scoped representations by unifying m, n and p with the appropriate handles:

(9) 1:every(x,3,4), 3:dog(x), 7:cat(y), 5:some(y,7,1), 4:chase(e,x,y)
top handle: 5 (wide scope *some*)

(10) 1:every(x,3,5), 3:dog(x), 7:cat(y), 5:some(y,7,4), 4:chase(e,x,y)
top handle: 1 (wide scope *every*)

The top handle allows the clause to be embedded in a longer sentence. In the scoped representations, it is unified with the widest scoped quantifier.

3 Towards a Discourse-Oriented Representation

We have described both a syntax-oriented approach and a semantics-oriented approach, but our aim is to move towards a discourse-oriented approach to information structure. If information structure is a distinct dimension, as argued by Engdahl & Vallduví (1996), its representation should not be too closely tied to either syntax or semantics. This has long been a fundamental assumption in functionally-oriented approaches such as Systemic Functional Grammar.

For example, Teich (1998) illustrates how focus scope is handled by SFG. In the *function structures* in (10) and (11) there is a syntax-oriented layer (Subject-Finite-Object), a semantics-oriented layer (Actor-Process-Goal), and **two** other layers of discourse-oriented information.

(11)

Actor	Process	Goal
Theme	Rheme	
Given	New	
Subject	Finite	Object
Fred	*ate the beans*	

(12)

Actor	Process	Goal
Theme	Rheme	
Given		New
Subject	Finite	Object
Fred ate		*the beans*

However, we noted that the semantics-oriented approach had advantages in topic-tracking and distinguishing old and new referents due to its direct use of semantic indices. A representation for use in practical dialogue systems, while not directly tied to either syntax or semantics, should nevertheless be relatively close to the semantic information. We therefore take the MRS representation as a starting point for a representation of information structure in HPSG, but follow Engdahl & Vallduví (1996) in locating INFO-STRUCT in CONTEXT.

To avoid confusion, we also follow Engdahl & Vallduvi's feature terminology: INFO-STRUCT includes FOCUS and GROUND, and GROUND includes LINK and TAIL. However, the values of FOCUS, LINK and TAIL will not be syntactic constituents, they will be variables over handles. These variables will be unified with particular handles in the semantics in order to represent specific focus scopings and topic interpretations. An advantage of handles is that they can be unified with each other without implying that semantic entities lose their distinct identities. However, we will follow the earlier approaches and use set values. In our representation, these will be sets of handles.

We start by adding information structure to the MRS quantifier example of Copestake et al. (1997), *every dog chased some cat*. If we assume a context (perhaps *what did every dog chase?*) in which *every dog* is interpreted as link, and *some cat* has narrow focus, we can use a representation such as:

(13) 1:every(x,3,4), 3:dog(x), 7:cat(y), 5:some(y,7,1), 4:chase(e,x,y)
TOP-HANDLE:5, LINK:{1}, TAIL:{4}, FOCUS:{5}

By contrast, if we assume a context (perhaps *what did every dog do?*) in which there is wide focus across *chased some cat*, we need to include handles 4 and 5 in the value of FOCUS, giving:

(14) 1:every(x,3,5), 3:dog(x), 7:cat(y), 5:some(y,7,4), 4:chase(e,x,y)
TOP-HANDLE:1, LINK:{1}, FOCUS:{4,5}

We now sketch new representations of some of the examples of Engdahl & Vallduví (1996). The alternative focus scope readings of example (1) can be represented by (15) (narrow focus) and (16) (wide focus):

(15) 1:the(x,2), 2:president(x), 3:the(y,4), 4:china(y), 4:set(y), 5:hate(e,x,y)
TOP-HANDLE:5, LINK:{1}, TAIL:{5}, FOCUS:{3} (narrow focus)

(16) 1:the(x,2), 2:president(x), 3:the(y,4), 4:china(y), 4:set(y), 5:hate(e,x,y)
TOP-HANDLE:5, LINK:{1}, FOCUS:{3,5} (wide focus)

Example (21) of Engdahl & Vallduví (1996), *The president* [F HATES] *the Delft china set*, is of course:

(17) 1:the(x,2), 2:president(x), 3:the(y,4), 4:china(y), 4:set(y), 5:hate(e,x,y)
TOP-HANDLE:5, LINK:{1}, TAIL:{3}, FOCUS:{5}

The problematic subject-verb focus in example (2), [F *The* BUTLER BROKE] *the set*, can be represented by:

(18) 1:the(x,2), 2:butler(x), 3:the(y,4), 4:set(y), 5:break(e,x,y)
TOP-HANDLE:5, TAIL:{3}, FOCUS:{1,5}

Using the NAME relation of Copestake et al. (1997), the complex focus in example (3) can be represented by:

(19) 1:NAME(x,John), 2:NAME(y,Bill), 3:NAME(z,Sue), 5:introduce(e,x,y,z)
TOP-HANDLE:5, LINK:{1}, TAIL:{5}, FOCUS:{2,3}

Finally, the PLUS example in (4), *Do you want to* **buy or rent** *one?* might possibly be represented by:

(20) 1:want(w,u,2) 2:or(3,4) 3:buy(b,u,c) 4:rent(r,u,c) 5:car(c), 6:user(u)
TOP-HANDLE:1, LINK:{1}, TAIL:{5}, FOCUS:{2}

References

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