Linking from the outside in *

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1 Introduction

Two issues divide theories of argument structure: how many macro-roles are necessary, and how much of subcategorization is semantically determined? Current semantically-based theories of linking often assume that two macro-roles are needed (Foley and Van Valin, 1984; Dowty, 1991), and that lexical semantic properties alone suffice to determine subcategorization (Pinker, 1989).

In this paper, we first suggest that only one generalized role—“actor”—is needed to state linking constraints. Instead of rules referring to other roles, we invoke an independently motivated relationship of one situation being a part of another, represented by the embedding of of one semantic structure within another. We propose two principles that account for the linking of direct arguments. First, within semantic relations, actor participants are distinguished from others, and NPs denoting actors must precede other NPs in argument structure. Second, NPs linked to semantically more embedded roles follow those linked to less deeply embedded ones. These proposals capture the special status of actors or proto-agents that underlies more syntactic notions such as external or distinguished argument. We combine this analysis with work described in more detail elsewhere (Davis, 1996; Davis and Koenig, in press) advocating a model of linking based on a multiple inheritance hierarchy of word classes. In this model linking rules are treated as constraints on certain word classes, which are inherited by their subclasses. The semantic basis of linking in this model results from two properties of this word-class hierarchy. The first is that word classes can be defined in terms of semantic content. The second is that types of semantic content

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can also be hierarchically arranged, with those denoting more specific situation types treated as subtypes of more general ones. We require this arrangement of semantic relations to be mirrored in the hierarchy of (semantically-defined) word classes. Thus more semantically specific word classes inherit the linking constraints of their more general superclasses.

In section 2 we present the necessary apparatus of Head-Driven Phrase Structure Grammar (henceforth HPSG), described in depth in Pollard and Sag (1987, 1994). We then discuss the lexical semantic representations we employ, the two hierarchies mentioned above, and the status of linking constraints. The heart of our proposal consists of two such constraints, which we term Actor Priority and Outer Priority. In section 3 we first state these informally, and then more rigorously in a version of typed feature logic from Keller (1993). We show how these constraints account for the linking of direct arguments. For oblique arguments, such as PPs, we turn in section 4 to the mechanisms of Minimal Recursion Semantics (Copestake, Flickinger, and Sag, 1997)), treating these arguments as contributing a semantic relation to an interlinked list of such relations.

2 Types, semantic relations, and linking constraints

The lexicon is viewed in HPSG as a type hierarchy of word classes, with each type inheriting information from its supertypes and possibly adding other information (Flickinger, Pollard, and Wasow, 1987; Pollard and Sag, 1987). The information pertaining to each type is represented by means of a typed feature structure (Aït-Kaci, 1984; Carpenter, 1992; Keller 1993), typically depicted as a set of attributes and values (which can themselves be feature structures with their own attributes and values). Here we are concerned primarily with information about the semantic content and subcategorization of a word class (i.e., of the words that belong to it). In figure 1, for instance, we show some relevant pieces of information for transitive verbs referring to ingestion, including 'devour', 'consume', 'ingest', and transitive 'eat' and 'drink'. The names of types appear in the upper left corner of our feature structure descriptions, the attributes below them on the left-hand side, and the value of each attribute to its right. The boxed numerals are tags or pointers; identically-numbered tags indicate that the tagged values in two different places are one and the same piece of information.

\[
\begin{array}{c}
\text{ingest-vb} \\
\text{CAT} [\text{HEAD verb}] \\
\text{ARG-ST} \langle \text{NP} [\text{N}] \text{ NP} [\text{N}] \rangle \\
\text{ingest-rel} \\
\text{CONTENT} \langle \text{ACT} [\text{E}] \text{ ARG2} [\text{E}] \rangle \\
\end{array}
\]

Figure 1: A partial description of the type ingest-vb

Here three attributes of ingest-vb and their values are shown. CAT(EGORY) has a feature structure as its value; within this feature structure the attribute HEAD has a value
of type verb. CONTENT also has a feature structure as its value; it is of type ingest-rel and contains two attributes, ACT(OR) and ARG(UMENT)2. This structure is used to represent the semantic content of a verb, and we will refer to types of CONTENT values as semantic relations. ARG(UMENT)-ST(RUCTURE) has a list of feature structures as its value. In (1) each element of the list is denoted by NP; followed by a tag (NP is a conventional shorthand for a feature structure representing a noun phrase). The first NP on the ARG-ST list of a verb is its subject, the second (if there is one) is the object.1

Whatever follows the colon in this shorthand notation is the value of the NP’s CONTENT. Thus the value of the the first NP’s CONTENT (which is whatever the subject NP contributes semantically) is the same feature structure as the value of ACT, and the second NP’s CONTENT is identical to the value of ARG2. This equation of values of an attribute within a verb’s CONTENT and the CONTENT of an element of its ARG-ST list expresses the linking of a semantic role to a syntactic argument. As a concise way of describing this structure-sharing, we will say that in figure 1 the ACT is linked to the subject and the ARG2 to the direct object.

Assuming that the description in figure 1 holds of all instances of ingest-vb, we can think of this information as constraints on this type. This includes the presence of particular attributes, the kinds of values they have, and the sharing of information indicated by tags. Some of these constraints are inherited from supertypes of ingest-vb; for example, all transitive verbs have two NPs on their ARG-ST list, so this information is stated as a constraint on the type transitive-vb, of which ingest-vb is a subtype. Other information is particular to the type ingest-vb, such as the requirement that the value of CONTENT be of the type ingest-rel.

Linking rules can equally be viewed as constraints on types in the hierarchy of wordclasses. Linking constraints concern the relationship between the values of attributes within semantic relations (which we will refer to as semantic role attributes) and the CONTENT values of elements of ARG-ST, as indicated by the tags in figure 1. For transitive verbs of ingestion, linking constraints must ensure that the subject denotes the ingester (the value of ACT) and the object the ingested thing (the value of ARG2), rather than the reverse. For this kind of linking model to be meaningful and predictive, we need to answer three questions:

1. What principles semantically ground attributes like ACT so that we can know which participants in a situation their values denote?

   What architecture is required for the word-class hierarchy so that lexical items inherit the proper linking constraints? What form do the linking constraints take, and what types are they associated with in the word-class hierarchy?

We answer the first question by associating a semantic role attribute such as ACT with

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1This statement applies to active verbs in nominative-accusative constructions. Passive verbs and ergative-absolutive constructions are discussed briefly below, but raise many issues beyond the scope of this paper. See Davis and Koenig (in press a) and Manning and Sag (1998) for further discussion.
a set of characteristic entailments, much like the proto-role entailments of Dowty (1991). These are properties that hold of participant roles in many types of situations. Associated with ACT, for instance, are entailments like being volitionally involved in a situation or causally affecting another participant in a situation. The latter is true of ingesters, which necessarily causally affect ingested things, providing the grounds for denoting them by the value of ACT. In (2) is a list of the characteristic attributes associated with ACT. These entailments select participants that control the unfolding of the situation (either by initiating it or the ability to terminate it).

(2) Characteristic entailments of ACT:
- Causally affects or influences other participant(s) or event(s)
- Volitionally involved in situation
- Has a notion or perception of another participant in situation
- Possesses another participant in situation

One of our claims in this paper is that semantic role attributes other than ACT are alike as far as linking is concerned. Thus there is no need to provide characteristic entailments for them, and we name them with arbitrary labels such as ARG2, ARG3, and so on. Apart from parsimony, there are two motivations for our claim. First, whereas the set of characteristic entailments of ACT seems to form a natural class, there seems to be no clear semantic natural class that describes the entailments characterizing an UND role, calling its semantic basis into question. Second, binding-theoretic considerations independently motivate the notion of “situation embedding” (Jackendoff, 1992), which allows us to dispense with an UND macro-role and other semantic role attributes, as discussed later. In contrast, the notion of UND is limited in its application to linking theory.

The ACT attribute may appear in the semantic representation of a situation type only if its value denotes a participant playing a role in a situation of that type entailing that at least one of the characteristic entailments holds of that participant. Feeding something to someone, to take another example, is a kind of situation in which the participant playing the role of feeder necessarily causally initiates an ingestion event. Accordingly, the feeder may be denoted by the value of ACT in the type feed-rel. Ingesters, as noted above, are also entailed to causally affect another participant. But only a single participant may be denoted by the value of ACT. One way this restriction can be overcome is by representing feeding as involving a subevent of ingesting. The feeder is the actor in the “main event”, while the ingester is the actor in the ingesting subevent. Our representation of feed-rel

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2Contrary to what Dowty (1991) advocates, we do not propose to state linking constraints directly in terms of number of proto-role entailments. Rather, we reify proto-roles; that is, we introduce attributes such as ACT as a mediating level between semantic entailments and syntactic arguments. See Davis and Koenig (in press a) for motivations.

3A word of caution is needed here. Van Valin and Lapolla (1997) adduce many syntactic arguments in favor of an UND macro-role, some of which are binding-theoretic or non-linking related in nature. Space considerations prevent us from examining their arguments; however, we believe that the UND of Role and Reference Grammar corresponds to the notion of "second position on the ARG-ST list" in HPSG, allowing us to restate their generalizations in that way.
appears in figure 2. Embedding representations of sub-situations (a resulting event, in this case) allows more than one ACT attribute to appear within a semantic relation.

\[
\begin{align*}
\text{feed-rel} \\
\text{ACT} & \quad \text{[]} \\
\text{ARG2} & \quad \left[ \begin{array}{c}
\text{ingest-rel} \\
\text{ACT} \\
\text{ARG2} \end{array} \right]
\end{align*}
\]

Figure 2: The representation of the semantic content of feed

To conclude our answer to the first question in 1, and begin answering the second, we address the status of the ARG2 attribute within ingest-rel and feed-rel. What properties of semantic relations will cause its value to denote the ingested thing in ingest-rel and the resulting subevent in feed-rel? This arises from inheritance relationships among semantic relations, which, like word-classes, are organized in a multiple inheritance hierarchy. Both ingest-rel and feed-rel are subtypes of a general affect-rel relation, which has ACT and ARG2 attributes. The value of ARG2 in affect-rel is stipulated to denote an entity or situation affected or influenced by the value of ACT. As a species of affect-rel, ingest-rel and feed-rel share this property. Feed-rel is in addition a subtype of cause-rel, which requires that this affected/influenced participant be a situation resulting from the actor’s action. For semantic relations that are not subtypes of affect-rel, such as possess-rel, the non-ACT attribute (for which we might use the name ARG2 or some other name) there will be a different stipulation—its value in possess-rel and its subtypes, for example, denotes the possessed entity.

Effectively, the hierarchy of semantic relations obviates independently defined semantic role attributes (e.g., “undergoer” or “patient” in many models of linking). But it also finds a use in ensuring that the appropriate linking constraints apply to a word, because the structures of the semantic relations hierarchy and the word-class hierarchy (where linking constraints are stated) are related. We posit a homomorphism from the semantic relations hierarchy to the word-class hierarchy, expressed in the following Semantic Subtype Condition, which provides the final piece needed to ground this model of linking semantically.

(3) Semantic Subtype Condition:

If \( s \) is a type in the semantic relations hierarchy and there exists a type in the word-class hierarchy with CONTENT of type \( s \), then there exists a type \( s-p \) in the word-class hierarchy with CONTENT of type \( s \) such that every type in the word-class hierarchy with CONTENT a subtype of \( s \) is a subtype of \( s-p \).

Informally, among all the types in the word-class hierarchy specifying a given semantic content, there is a most general type in the word-class hierarchy specifying that semantic content, with all others its subtypes. This also guarantees that if there are two such most general types, \( s-p \) and \( t-p \), specifying semantics of types \( s \) and \( t \) respectively, then if \( t \) is a
subtype of $s$, $t$-pis a subtype of $s$-$p$. This follows immediately from 3 because anything of type $t$ is also of type $s$.

We exploit this parallelism between the two hierarchies to answer the third question in 1, concerning the form of linking constraints and their location in the word-class hierarchy. To ensure that a constraint applies to all words that have a particular semantics, we can place it on the most general type in the word-class hierarchy having that semantics (which must exist, given the Semantic Subtype Condition).

One constraint is that if there is a “top-level” ACT attribute (that is, one that is not embedded in another semantic relation) in the semantics of a word, then it should be linked to the first element of the ARG-ST list (for active verbs, the subject). So that this constraint applies to all the appropriate words, it is stated on the type act-$p$, the most general type in the word-class hierarchy that specifies a semantics containing an ACT attribute. In figure 3 is the statement of this constraint in feature structure terms.

$$
\begin{bmatrix}
\text{act-$p$} \\
\text{ARG-ST} (\text{NP} [\ldots]) \\
\text{CONTENT} [\text{ACT} [\ldots]]
\end{bmatrix}
$$

Figure 3: The act-$p$ verb class

This constraint provides a partial mapping from semantic roles to syntactic arguments. For verbs like ‘eat’ and ‘feed’, it accounts for the eater or feeder being linked to the subject. Linking of the other roles in the semantics of these verbs is left unspecified. If we postulated an UNDERGOER or PATIENT semantic role attribute, we might posit a constraint similar to the one in figure 3, as we have done in Davis and Koenig (in press). But we claim here that such attributes are superfluous.

The simplest solution would be to propose that no other constraints are needed. Because nothing prevents other semantic roles from being linked to other elements of the ARG-ST list, we simply no constraints regarding the linking of, say, the ingested entity. For verbs like ‘eat’ and ‘drink’ this linking is optional, while for transitive verbs such as ‘ingest’ and ‘devour’, their transitivity must be specified, but which role the object is linked to need not be, as the only role available is the ingested thing. However, such a model falls short in the following respects. It permits free variation among ditransitive verbs of the kind exhibited in (4), which in fact does not seem to occur.

(4) a. Marge showed/fed/gave/got Homer a chocolate donut.

b. Marge shmowed a chocolate donut Homer.

Verbs like “schmow”, in which the first object is linked to the “theme” and the second to the eventual possessor or perceiver, appear not to exist, at least in English (we assume that word order reflects order on the ARG-ST list; in other languages, case or verb agreement

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4 For independent reasons related to binding theory in HPSSG, it would not be possible to link the same role to both subject and object, so the ingester cannot be linked to both.
morphology would show this). But allowing semantic roles to be freely linked as described above would not rule out such predicates. Similar points could be made about possible ditransitive causative verbs in many languages.

Secondly, linking patterns of verbs of motion are insufficiently restricted. The following examples, based on a pair in Jackendoff (1990), illustrate the problem.

(5) a. Smoke entered the room.
   b. *The room bented smoke.

There is no ACT attribute in the semantics of 'enter', as neither the entering entity nor the entered location necessarily bears any of the ACT characteristic entailments in (2). But if linking of non-actor roles were free, nonoccurring verbs like 'benter' should be possible. But reversals similar to those in (5) do seem to be possible if the entire path is expressed as an NP, as in these Chichewa and Chinese sentences (Bresnan and Kanerva, 1989, ex. 1b; and Wechsler, 1995, ex. 11).

(6) Ku-mu-dzi ku-na-bwër-á a-lendë-wo.
   17-3-village 17SB-REC.PST-come-IND 2-visitor-2 those
   “To the village came those visitors.”

(7) a. shui jin le wu (li).
    water enter ASP house (-inside)
    “The water entered the house.”

b. wu-li jin le shui.
   house-inside enter ASP water
   “The water entered the house.”

c. *wu jin le shui.
    house enter ASP water

In (6), 'ku-mu-dzi' is an NP denoting a location, as Bresnan and Kanerva (1989) have shown. It is linked to the entire value of the path, not to an attribute within it. Likewise, wu-li in (7b) appears to denote the entire path, but without the localizer 'li', 'wu' cannot be the subject, as (7c) shows.

In light of these examples, and many similar ones we must conclude that linking of semantic roles other than top-level ACT is not free; some additional constraints must be stated. What should they be? An empirically adequate approach, at least for this small amount of data, is to posit the following two constraints (here $A$ stands for any semantic role attribute).

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5The possible occurrences of raised and expletive arguments must also be addressed. Lack of space prevents us from doing so here, but it is possible to extend the account in the following section by adding subtypes of arg-linking to those in (6).
\[
\begin{align*}
\text{ARG-ST} \langle \text{NP}, \text{NP:} \ldots \rangle & \quad \text{CONTENT}[A[\text{ACT:} \ldots ]] \\
\text{ARG-ST} \langle \text{NP:} \ldots \rangle & \quad \text{CONTENT}[A] 
\end{align*}
\]

(a) \quad (b)

Figure 4: Priority constraints (preliminary)

One constraint requires an ACT attribute embedded in another attribute to be linked to the second element of the ARG-ST list. This will rule out verbs like ‘schmow’. The other requires that the first element of an ARG-ST list be linked to a top-level semantic role attribute. This rule out verbs like ‘benter’ if we assume, like Jackendoff, that the entered location is represented as the value of an attribute embedded in a structure representing the trajectory of the moving object.

The first constraint is theoretically unsatisfying. Why should the second position on the ARG-ST list be reserved for an ACT attribute embedded one level, rather than some other semantic role attribute in some other position? Why are there not four or five other, similar constraints? Furthermore, both of these constraints are empirically inadequate. Causative verbs in many languages have a CONTENT with an embedded ACT attribute like the one in figure 4, but the embedded ACT attribute may not be linked directly to the verb at all. Subject raising verbs counterexample this constraint requiring the first element of ARG-ST to be linked to a top-level semantic role attribute, because there subjects are not linked to any semantic role.

3 The Priority Constraints

More general and adequate constraints are needed, and we state them informally in (8). While these informal versions are not difficult to state, rendering them in the description language of typed feature logic presents some complications, which we explore below.

(8) Actor Priority

Elements of the ARG-ST list linked to an ACT attribute precede elements that are not.

(9) Top-level Priority

Some element of the ARG-ST list linked to a top-level attribute precedes each element that is linked only to an embedded attribute.

A verb like ‘schmow’ in (4b) fails to satisfy the Actor Priority constraint because the second object (denoting the recipient), represented by the value of an embedded ACT attribute, follows the first object, which is not linked to any ACT attribute. In attested verbs like ‘give’, ‘feed’, ‘get’, and ‘show’, the first object denotes the recipient. It is preceded
on the ARG-ST list only by an NP linked to the top-level ACT attribute. In the case of ‘benter’, in (5b), the first NP violates the Top-level Priority constraint in (9)). It is not linked to a top-level attribute and no element linked to a top-level attribute precedes it. In contrast, both arguments in the Chichewa sentence in (6) and the Chinese sentence in (7b) are linked to top-level attributes, so that either may be realized as the subject in these cases.

The implementation makes use of the following types, attributes, and constraints. First, an additional attribute, LINKED-ARGS, is posited within the lexical entries of predicators.\(^6\) It takes as its value a structure of type arg-linking, which has the features shown in figure 5, along with the types of their values.

![Figure 5: The type arg-linking](image)

The attribute ARG-LIST is simply the familiar ARG-ST list, but without PP complements or other oblique arguments (these will be discussed briefly later). Thus the value of ARG-LIST is an initial sublist of ARG-ST. We will see additional incarnations of the ARG-LIST attribute within the recursively embedded arg-linking structures we will need to state the priority constraints. The value of LINKED-ARGS | REL is structure-shared with the value of CONTENT.

The type arg-linking has several subtypes, shown in the inheritance hierarchy in figure 6.

![Figure 6: The subtypes of arg-linking](image)

The immediate subtypes partition arg-linking in two ways: actor-arg-linking and non-actor-arg-linking constitute one partition, and recursive-arg-linking and last-arg-linking constitute the other. The subtypes of these in figure 6 are the unique most general types required for instances of arg-linking. The function of each type in figure 6 will become clear as we proceed. To begin, the type recursive-arg-linking licenses a third attribute, WORKSPACE, which takes another arg-linking structure as its value.

\(^6\)Technically, within the SYNSEM | LOCAL values of predicators, the only part of lexical entries that we show in this paper.
Figure 7: The type recursive-arg-linking

A cascade of WORKSPACE attributes provides a place where successive arguments on
the top-level ARG-LIST list are linked to successively more embedded roles in the predi-
cator’s CONTENT.

The type actor-arg-linking is intended to link an initial subsequence of the top-level
ARG-LIST list to successively more embedded ACT attributes in CONTENT. It requires
that the first element of ARG-LIST be linked to the top-level ACT in REL (thus REL in
actor-arg-linking must be of type act-ref). This is shown in figure 8.\textsuperscript{7}

Figure 8: The type actor-arg-linking

This means that in this case the first element of LINKED-ARGS | ARG-LIST is linked
to the top-level ACT attribute in CONTENT. Thus we can replace the linking constraint
in figure 3 with the following constraint, which states that a predicator with a CONTENT
of type act-ref (that is, act-p) has a LINKED-ARGS value of type actor-arg-linking. As we
will soon see, the constraint in figure 9, in conjunction with the other types and constraints
we present, will also account for Actor Priority.

Figure 9: The type act-vb

The type non-actor-arg-linking is intended to link non-actor roles in CONTENT. In
figure 10 this is indicated by linking the first element of ARG-LIST to a non-actor attribute
in REL. The variable N in figure 10 stands for any semantic role attribute except ACT.

\textsuperscript{7}In this section, we use a FIRST/REST notation for some lists, but they are no different conceptually
from the lists we depict in angle brackets. Clarity guides our choice of notation in each case.
Now we will turn to linking subsequent elements of LINKED-ARGS — ARG-LIST, for which the type recursive-arg-linking and the value of its WORKSPACE attribute come into play. The following constraints hold of the type recursive-arg-linking.

\[
\begin{bmatrix}
\text{recursive-arg-linking} \\
\text{ARG-LIST} \\
\text{REL (x)} \\
\text{WORKSPACE}
\end{bmatrix}
\begin{bmatrix}
\text{REST [REL] [ARG-LIST]} \\
\text{arg-linking [REL] [ARG-LIST]}
\end{bmatrix}
\]

Figure 11: The type recursive-arg-linking

The embedded ARG-LIST list structure-shares its value with the REST of the outer ARG-LIST list, and the embedded REL structure shares its value either with the outer REL or with the value of one of its attributes (the \(X\) in figure 11 is a variable whose value can be any semantic role attribute). Since we have stipulated that the type arg-linking is partitioned by actor-arg-linking and non-actor-arg-linking, every instance of recursive-arg-linking is also an instance of actor-arg-linking or of non-actor-arg-linking. This means that one or the other of the constraints in figure 8 and 10, linking the first element of ARG-LIST to an attribute in REL, holds of the value of WORKSPACE. If the entire relation is structure-shared, then the first element of the embedded ARG-LIST (which is the second element of the outer ARG-LIST) is linked to a semantic role attribute at the same level as the one linked to the first level of the outer ARG-LIST. If a subpart of the relation is structure-shared, then the first element of the embedded ARG-LIST is linked to a semantic role attribute embedded one level in the outer REL value.

Thus each successively embedded arg-linking attribute links a succeeding element on the (outer) ARG-LIST. So far, however, nothing requires elements linked to an ACT attribute to precede other elements. To enforce this ordering, a constraint is required on the type recursive-n-a-arg-linking, stating that its WORKSPACE value must be of the type non-actor-arg-linking, as shown in figure 12.

\[
\begin{bmatrix}
\text{recursive-n-a-arg-linking} \\
\text{WORKSPACE}
\end{bmatrix}
\begin{bmatrix}
\text{non-actor-arg-linking}
\end{bmatrix}
\]

Figure 12: The type recursive-n-a-arg-linking

Once one non-actor is constrained to be linked to an element of ARG-LIST, all succeeding elements of ARG-LIST are likewise constrained. An instance of recursive-n-a-arg-linking
“trips a switch”, limiting more embedded arg-linking structures to linking non-actors.

The type last-arg-linking (and its subtypes) terminates the cascade of linking. This type lacks the WORKSPACE attribute, and constrains its ARG-LIST to a single element, as shown in figure 13.

\[
\begin{array}{c}
\text{last-arg-linking} \\
\text{ARG-LIST} \\
\text{rest empty-list}
\end{array}
\]

Figure 13: The type last-arg-linking

Actor Priority follows from the constraint in figure 12, as mentioned above. A version of Top-level Priority follows from the constraints in figures 8 and 10, which ensure that the first element of LINKED-ARGS | ARG-LIST will be linked to a top-level role. In fact, a more stringent condition is embodied in the current formulation; successive elements of an ARG-LIST are linked to equally embedded or more deeply embedded roles, due to the constraint in figure 10. Here is an example of the workings of these constraints, using the linking of arguments in the ditransitive verb 'give' as an illustration. The CONTENT and ARG-ST of 'give' appear in figure 14 along with the LINKED-ARGS structure that constrains the relationship between them.

\[
\begin{align*}
\text{give-p} \\
\text{ARG-ST} & \begin{array}{c}
\text{NP:} \\
\text{NP:} \\
\text{NP:}
\end{array} \\
\text{cause-possess-rel} \\
\text{ACT} & \\
\text{ARG2} & \begin{array}{c}
\text{ACT} \\
\text{ARG2}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{ARG-LIST} & \begin{array}{c}
\text{FIRSTXP:} \\
\text{REST}
\end{array} \\
\text{REL} & \\
\text{ARG-LIST} & \begin{array}{c}
\text{FIRSTXP:} \\
\text{REST}
\end{array} \\
\text{REL} & \begin{array}{c}
\text{ACT}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{ARG-LIST} & \begin{array}{c}
\text{FIRSTXP:} \\
\text{REST}
\end{array} \\
\text{REL} & \begin{array}{c}
\text{ARG2}
\end{array}
\end{align*}
\]

\[
\begin{align*}
\text{ARG-LIST} & \begin{array}{c}
\text{FIRSTXP:} \\
\text{REST}
\end{array} \\
\text{REL} & \begin{array}{c}
\text{ARG2}
\end{array}
\end{align*}
\]

Figure 14: The type corresponding to ditransitive ‘give’
4 PPs and MRS

Finally, we briefly discuss the representation of (some) PPs. Many PPs and other oblique complements are not linked in accordance with the recursive argument-linking procedure we have outlined. Instead, they follow the recursively-linked arguments on the ARG-ST list, as noted in passing above. The constraint in figure 15 states that the ARG-ST list contains the recursively-linked arguments as an initial sublist (the small circle denotes list concatenation).

\[
\begin{array}{c}
\text{ARG-ST} \\
\text{LINKED-ARGS [ARG-LIST]}
\end{array}
\]

Figure 15: The Direct Argument Priority constraint

We use instrumental ‘with’ as an example in this section. Consider the sentences in (10) and (11).

(10) a. They covered the body with a blanket.

    b. They eat ice-cream with a knife.

(11) a. They used a blanket to cover the body.

    b. They use a knife to eat ice-cream.

All these sentences describe events involving the use of an entity that helps in performing an action (an instrument). But whereas covering something implies (in the use exemplified in (10a) the use of an instrument, eating does not. How do we represent the lexico-semantic structure of the two verbs so that we have a unified representation for the semantic contribution of instrument phrases? One possible way to represent instruments semantically is to add an attribute whose value describes the instrument. Another possibility is to follow Lakoff (1963) and take into account the near paraphrase relation between the sentences in (10) and (11). Following this semantic lead, we could then introduce an additional use-rel in the semantic structure of the two verbs. However, Lakoff’s original proposal leads to a model invoking abstract syntax to treat uniformly cases like ‘cover’, for which the use-rel is part of the lexical semantics of the verb, and cases like ‘eat’, in which this same relation is added (either via lexical rules or syntactic adjunction). Our solution is to use Minimal Recursion Semantics (henceforth MRS) to keep Lakoff’s basic insights without resorting to an abstract syntactic model of the similarity of (10a) and (10b). Copestake, Flickinger, and Sag (1997) provide an introduction to MRS and independent motivations for this type of semantic representation. For our purposes, two facets of MRS are relevant. The first is that our old semantic content is now the value of the KEY attribute. The second is that the value of the KEY attribute now constitutes one element of the value of a LISZT attribute (whose value is a list of semantic relations, including relations for generalized quantifiers).
The LISZT attribute allows us to model the contribution of an additional semantic relation from a PP like 'with a knife', without unmotivated alterations to the semantics of 'cover' or 'eat'. Figures in 16 illustrate the semantic content of these verbs as they are used in (10). Note that cover-rel is regarded as a subtype of use-rel. It is therefore possible for 'with' in (10a) to share its CONTENT value with that of 'cover', rather than contributing a distinct element to LISZT. But eat-rel is not unifiable with use-rel, so 'with' in (10b) necessarily adds a distinct element to the LISZT value of 'eat'.

![Diagram](image.png)

Figure 16: CONTENT values of 'cover (with)' and 'eat with'

‘With’ in both cases has the same lexical entry, whose semantics contains a LISZT value in which a use-rel is one element.

This very brief description of MRS and the representation of semantically potent prepositions illustrates our approach to the linking of oblique complements. Its main benefit lies in avoiding the multiplication of unmotivated attributes within the representation of a semantic relation such as eat-rel while maintaining a maximally uniform representation of instrumental PPs.

## 5 Conclusion

Our goal in this paper has been to argue for a linking theory that is at the same time semantically grounded and semantically parsimonious. We have proposed that the two proto-roles suggested by Foley and Van Valin (1984) and Dowty (1991) can be reduced to one-actor or proto-agent–with non-actor participant roles remaining unclassified semantically. We have instead proposed constraints on linking that rely on the basic notion of sub-situation, represented by embedding one semantic relation within another, and have implemented them within the typed feature logic of HPSG. Finally, we have suggested a mechanism whereby the semantic contribution of oblique complements can be either unified with their head’s semantics or added to it.
References


