「언어연구」, 제15권(1997), 19~42

HPSG: An Overview and Some Work in Progress
Head-Driven Phrase Structure Grammar

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In an earlier talk, I tried to convey something of the nature of constraint-based grammar, a general approach to theoretical and computational linguistics that has been emerging since the mid-to-late 1970's. In doing so I identified a set of characteristics that are common to constraint-based theories and systems, repeated here in (1). The key thing to keep in mind in understanding these characteristics is that the grammar is a set of constraints, and that the relationship between the constraints and linguistic structures is essentially the same as the relationship between a logical theory and a model-theoretic interpretation of that theory.

(1) Characteristics of Constraint-Based Grammar

A. Generativity: It is determinate what are the candidate structures and what are the constraints; and it is decidable whether a candidate structure satisfies the constraints.

B. Expressivity: the language in which the theory is formulated is richly expressive, since constraints are imposed BY the theory, not UPON the theory.

C. Empirical Adequacy: the theory must be able to capture empirical generalizations accurately (get the facts right).

D. Psycholinguistic Responsibility: theories should lend themselves to interfacing with plausible processing models.

E. Nondestructiveness: grammars do not make reference to operations that destructively modify existing structure.

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1) This feature article was presented for the 11th Pacific Asian Conference on Language, Information and Computation held at Kyung Hee University on December 20 -22. 1996.

F. Locality: satisfaction of constraints by a structure depends only on that structure, not on "competitors".

G. Parallelism: the levels of representation are not sequentially derived; they are mutually constrained parallel structures.

H. Radical Nonautonomy: syntax has no distinguished status; instead syntactic representations are just one (or more) of the parallel structures.

In this talk I will try to convey something of the flavor of work in constraint-based grammar by briefly sketching the outlines of the constraint-based framework most familiar to me, head-driven phrase structure grammar (HPSG), and then describing some work in progress.

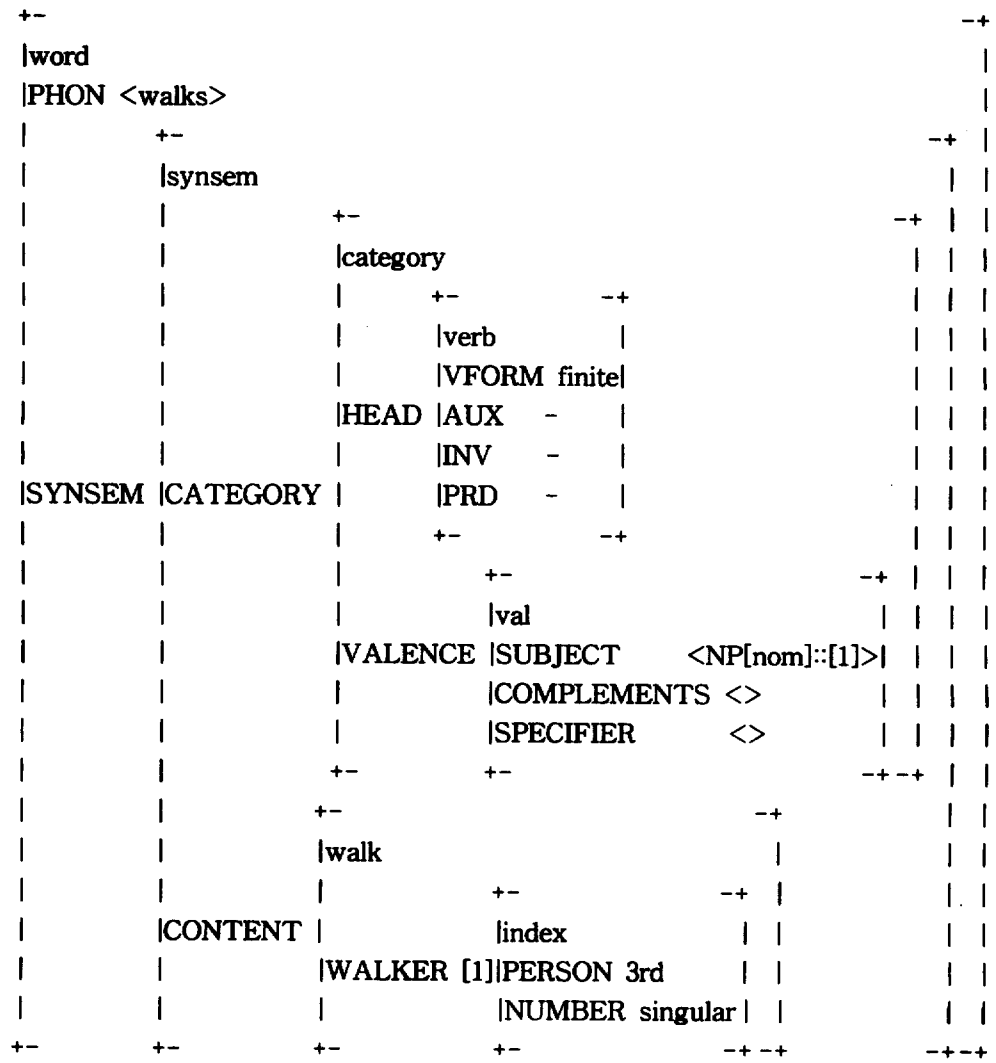
The development of HPSG began in at Stanford University and Hewlett-Packard Laboratories in the early to mid 1980s. It started out as an attempt to revise an earlier theory, GPSG, but also incorporated many insights and analytic techniques from other frameworks and research traditions, including categorial grammar, LFG, GB, situation semantics, datatype theory, and knowledge representation. Most of the effort in HPSG so far has been devoted to syntax and semantics, but in recent years HPSG work has gradually extended into other areas, such as morphology, phonology, and pragmatics. In addition to theoretical linguistic work in HPSG, there has also been a great deal of activity connected with establishing correct formal foundations and developing efficient computer implementations, but today I'll limit my attention to mostly to syntax, semantics, and the interface between them.

Since its inception, HPSG theory has undergone continual revision. Just to give myself a stationary target, I'm going to take as my point of reference a version of the theory sometimes called HPSG3, which is essentially the version of HPSG sketched in the final chapter of the book HPSG (Pollard and Sag 1994). Since HPSG is constraint-based, the first thing you need to know about in order to understand it are what the candidate structures look like, and what the constraints look like.

In HPSG, the structures are TYPED FEATURE STRUCTURES, which are a kind of rooted, connected, directed graph. The edges are labelled with symbols

called FEATURES, and the nodes are labelled with symbols called TYPES. The type tells what kind of linguistic object the node represents, and the features tell what parts the object has. Since feature structures are hard to display, usually what we show instead is a certain kind of description of a feature structure called an ATTRIBUTE-VALUE MATRIX or AVM. For example, the AVM shown in (2) is the lexical entry for the verb WALKS.

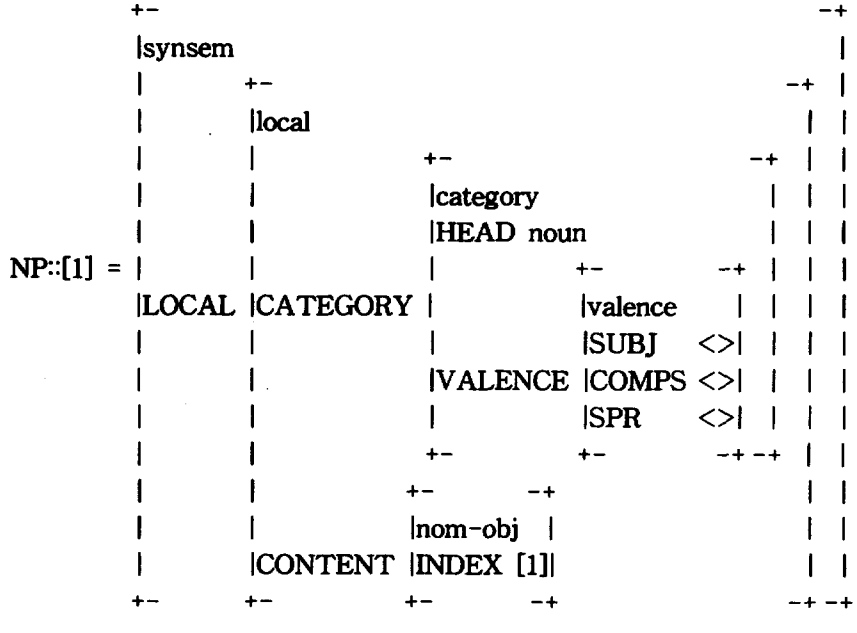
(2) attribute-value matrix description of a feature structure representing (a token of) the word WALKS (slightly simplified)

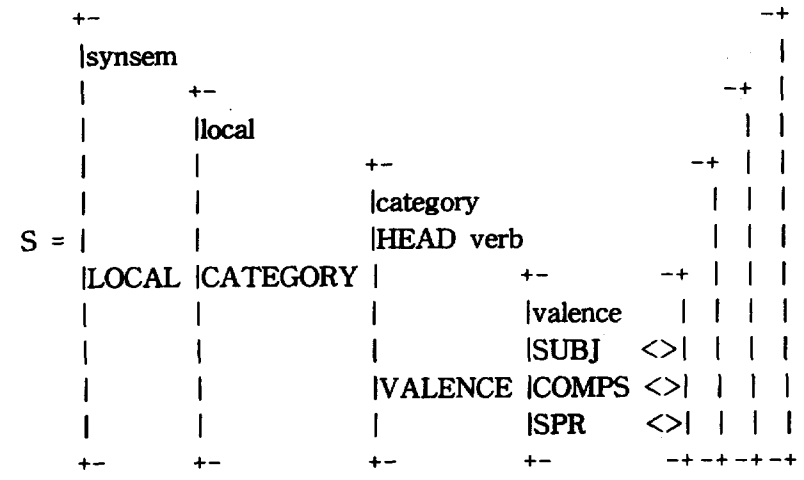


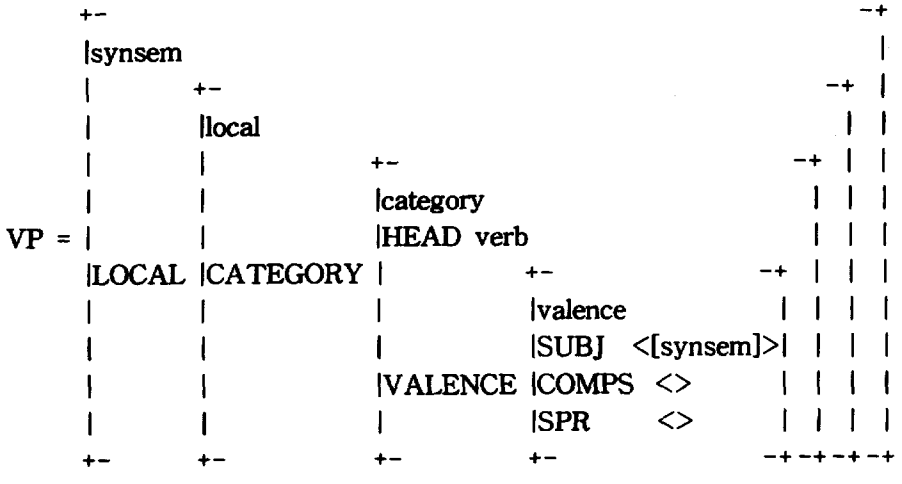
Here, as in all AVM descriptions, type symbols are given in lower-case and feature symbols in upper-case. Here the symbol "NP[nom]::[1]" given as the value of the SUBJECT feature is actually shorthand for another AVM description, shown in (3)a. (I'll come back to this shortly.) The lexical entry in (2) tells us, among other things, that WALKS is pronounced /wɔ́ks/, that it is a finite nonauxiliary verb, that it selects as its subject a 3rd-singular nominative NP, and that it refers to the semantic walk relation. Also note the two occurrences of the tag [1], which indicate structure sharing. This means that two paths in the feature structure lead to the same node. In this case the structure sharing means that the referential index of the subject NP is assigned to the semantic role of WALKER in the walk relation. This is a typical HPSG lexical entry. Any instance of the word WALKS will be a feature structure that satisfies this description.

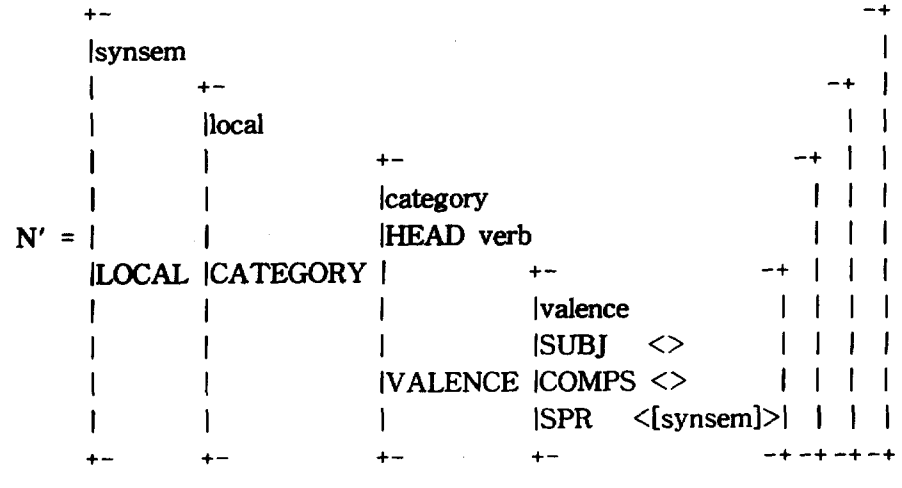
As I just mentioned, in HPSG, syntactic category symbols are just abbreviations for certain feature descriptions, as shown in (3).

(3) Some category symbols in HPSG




S =
synsem
local
LOCAL
CATEGORY
category
HEAD verb
VALENCE
valence
SUBJ <>
COMPS <>
SPR <>


VP =
synsem
local
LOCAL
CATEGORY
category
HEAD verb
VALENCE
valence
SUBJ <[synsem]>
COMPS <>
SPR <>


N' =
synsem
local
LOCAL
CATEGORY
category
HEAD verb
VALENCE
valence
SUBJ <>
COMPS <>
SPR <[synsem]>

Thus, an NP is an expression whose head feature -- essentially its part of speech -- is nominal and all of whose valence requirements are satisfied, whereas an S is a verbal expression whose valence requirements are satisfied. But a VP is a verbal expression whose subject valence is unsatisfied, while an N′ is a nominal expression whose specifier valence is unsatisfied.

In HPSG, as in many constraint-based theories, a lot of the action is in the lexicon. This can be seen by considering a few simplified lexical entries (here many of the features and type symbols are omitted for simplicity):

(4) Some HPSG lexical entries (simplified)

```
          +-            +-
          |             |HEAD verb
          |             |          +-
          |CATEGORY     |          |SUBJ  <NP::[1]>
WALK      |             |VALENCE   |COMPS <>
          |             +-         +-
          |           +-
          |CONTENT    |walk
          |           |WALKER [1]
          +-          +-

          +-            +-
          |             |HEAD verb
          |             |          +-
          |CATEGORY     |          |SUBJ  <NP::[1]>
SEE       |             |VALENCE   |COMPS <NP::[2]>
          |             +-         +-
          |           +-
          |           |see
          |CONTENT    |SEER [1]
          |           |SEEN [2]
          +-          +-
```

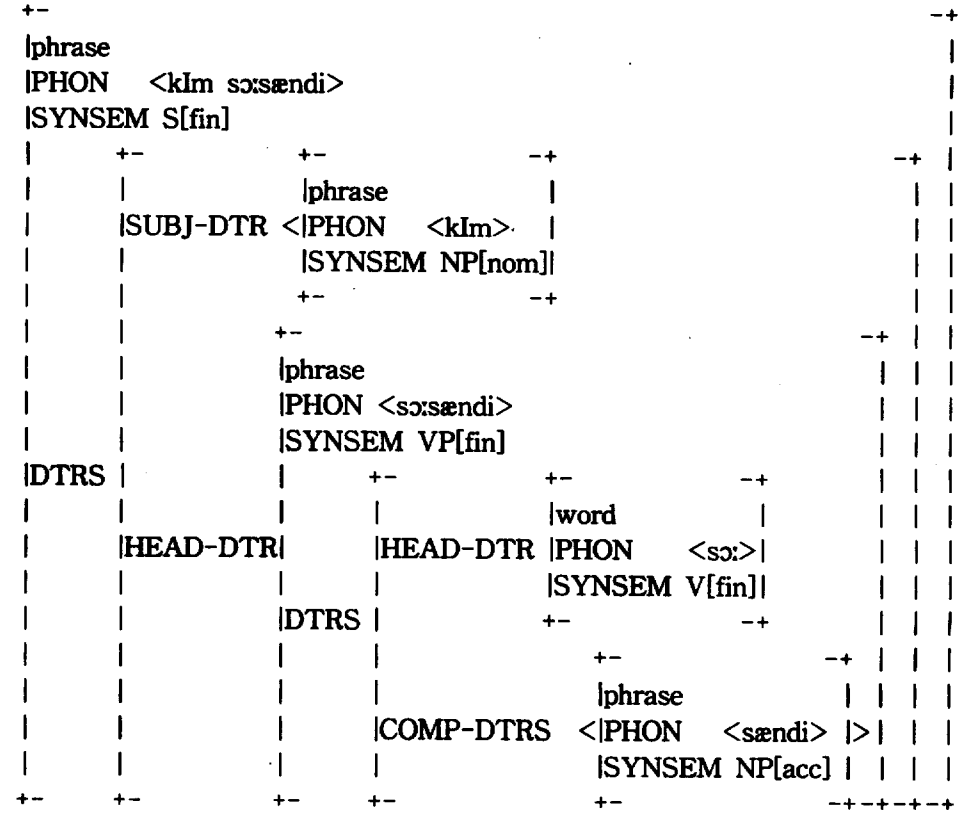
```
        +-            +-
        |             |HEAD verb
        |             |          +-
        |CATEGORY     |          |SUBJ   <NP::[1]>
GIVE    |             |VALENCE   |COMPS  <NP::[2],PP[to]::[3]>
        |             +-         +-
        |           +-
        |           |give
        |CONTENT    |GIVER [1]
        |           |GIVEN [2]
        |           |RECIPIENT [3]
        +-          +-

        +-            +-
        |             |HEAD verb
        |CATEGORY     |          +-
        |             |          |SUBJ   <NP::[1]>
 TRY    |             |VALENCE   |COMPS  <VP[SUBJ <NP::[1]>]:[2]>
        |             +-         +-
        |           +-
        |CONTENT    |try
        |           |TRYER [1]
        |           |TRIED [2]
        +-          +-

        +-            +-
        |             |HEAD verb
        |CATEGORY     |          +-
        |             |          |SUBJ   <[1]>
SEEM    |             |VALENCE   |COMPS  <VP[SUBJ <[1]>]:[2]>
        |             +-         +-
        |           +-
        |CONTENT    |seem
        |           |ARGUMENT [2]
        +-          +-
```

Here the WALK entry is just a simplification of the entry given in (2); the SEE entry is a typical transitive verb entry, with the subject index assigned to the

SEER role and the object index to the SEEN role; and the GIVE entry is a typical ditransitive verb entry, which assigns three roles. The TRY entry is typical for a subject- control verb: the verbal complement is treated as a VP (not an S), whose unrealized subject is required to be coindexed with the matrix subject. And finally, the SEEM lexical entry typifies raising-to-subject verbs: the entire complex of syntactic and semantic features of the matrix subject is constrained to be identical with those of the unrealized complement subject.

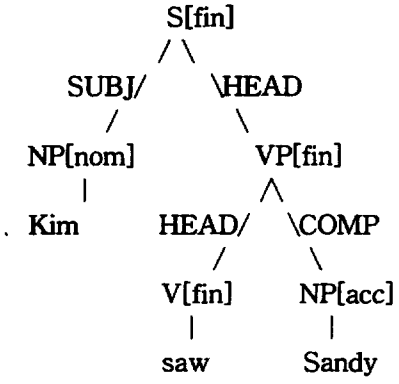
In HPSG the representation of phrases is similar to the representation of words, except that phrases have an additional feature that words lack, namely the DAUGHTERS feature, whose value is a feature structure called a constituent-structure that encodes information about the phrase's immediate constituents. For example, a very partial AVM description of the phrase KIM SAW SANDY has the form shown in (5):

(5) AVM description of a feature structure representing the sentence KIM SAW SANDY



To make phrase descriptions easier to read, we usually use a tree-like notation, so that (5) comes out looking like (6):

(6)



However, it is important to keep in mind that in the structure described by (6) is actually a feature structure, not a tree.

Of course, not just any old feature structure is a legal linguistic object. To be well-formed, a feature structure has to satisfy the constraints imposed by the grammar. Now technically speaking, constraints in HPSG are expressed in a special formal language called feature constraint logic, but since I don't have time to explain that, I'll just express whatever constraints we need to discuss in a combination of pictures and (I hope) plain English.

To start with, we need a set of constraints that are usually called FEATURE GEOMETRY CONSTRAINTS, as described in (7):

(7) Feature geometry constraints specify:

a. what the types are;
b. which types are subtypes of other types;
c. for each type, what features are appropriate for that type;
d. for each type and each feature appropriate for that type, what types are appropriate for the value of that feature.

One convenient way to present the feature geometry constraints is by using TYPE DECLARATIONS, like the ones shown in (9). The way to read these is explained in (8):

(8) How to read HPSG type declarations

type0
  type1 "The type type0 has the subtypes type1 and type2."
  type2

type0: [FEAT1: type1, FEAT2: type2]

"The type type0 has the features FEAT1 and FEAT2,
with values of type type1 and type2 respectively."

(9) Some HPSG type declarations

sign: [PHON: list[phonstring], SYNSEM: synsem]
  word
  phrase [DTRS: constit-struc]

synsem: [CAT: category, CONTENT: content]

category: [HEAD: head, VALENCE: valence]

valence: [SUBJ: list[synsem], COMPS: list[synsem], SPR: list[synsem]]

content
  state-of-affairs
    walk: [WALKER: index]
    see: [SEER: index, SEEN: index]
  nom-obj: [INDEX: index]

index: [PER: per, NUM: num, GEND: gend]

constit-struc
  coord-struc
  headed-struc

bool
  plus
  minus

head
  noun: [CASE: case]
  verb: [VFORM: vform, AUX: boolean, INV: boolean]
  prep: [PFORM: pform]
  adjective
  marker
  determiner

vform
  fin
  inf
  ger
  psp
  prp
  pas

case
  nom
  acc

gend
  masc
  fem
  neut

num
  sing
  plur

per
  1st
  2nd
  3rd

Very often, an important part of a new analysis in HPSG is revising one or more feature geometry constraints. For example, in his recent research on relative clauses, Ivan Sag eliminates the DTRS feature for phrases. This sounds trivial, but one of the results is that subtypes of phrase can now be used to cross-classify phrases along the lines of construction grammar. (Jong-Bok Kim and Byung-Soo Park's paper on free relatives at this conference adopts this approach.)

In addition to the feature geometry constraints, we also need constraints to tell us what the well-formed words and phrases are. For words, this is simple (10):

(10) Wellformedness constraint for words:

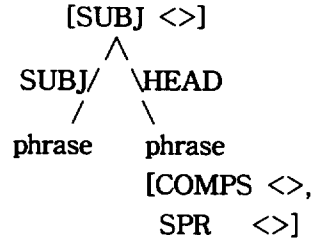
Every word must satisfy one of the lexical entries.

For phrases, things are more complicated, since there are several different constraints that must be satisfied. Some of the most important ones are given in (11-13):

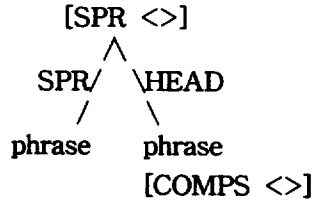
(11) Immediate Dominance Constraint

Every phrase has to satisfy one of the following descriptions (order irrelevant):

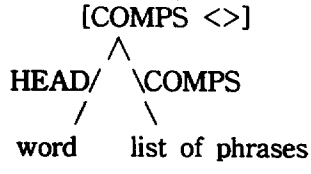
a. head-subject schema



b. head-specifier schema



c. head-complement schema



d. ...

Basically this constraint offers a handful of options for what a local tree can look like. Thus it is roughly analogous to X-bar theory.

(12) Head Feature Constraint

> For every headed phrase, the head features must be the same as those of the head daughter.

This guarantees that the head features of any word also show up on all the phrasal projections of that word.

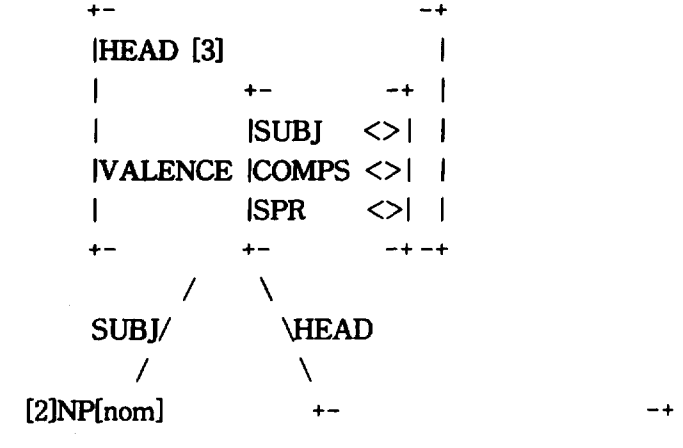
(13) Valence Constraint

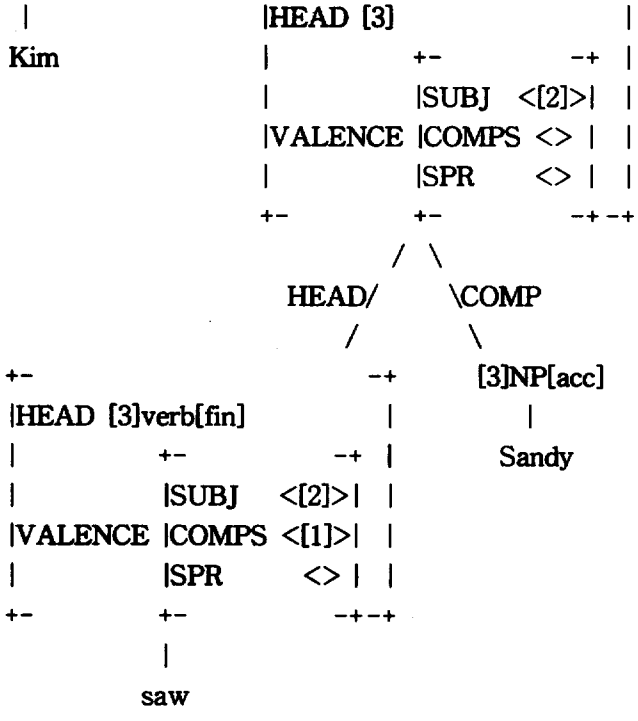
> For each of the valence features (SUBJECT, COMPLEMENTS, SPECIFIER), the value of that feature on a headed phrase must be the value on the head daughter minus those valence requirements satisfied by one of the nonhead daughters.

In essence, this constraint is analogous to functional application in categorial grammar: it serves to check off valence requirements of lexical heads as they are satisfied.

Together, all these constraints on phrasal wellformedness will have the effect that the sentence KIM SAW SANDY in (6) actually looks like the picture in (14):

(14) KIM SAW SANDY revisited





We can summarize all of this as in (15):

(15) Wellformedness in HPSG

A **feature structure** is well-formed just in case:

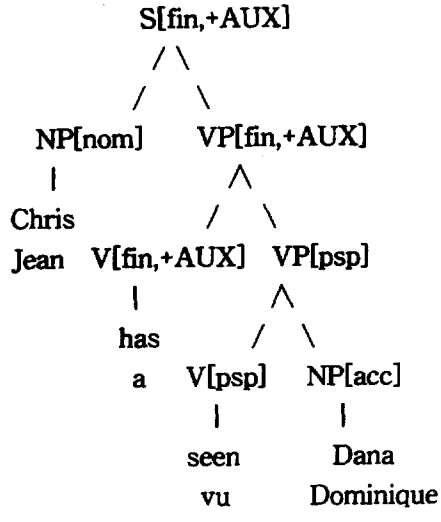
a. Every node satisfies the feature geometry constraints;
b. Every word node satisfies one of the lexical entries;
c. Every phrase node satisfies the immediate dominance constraint, the head feature constraint, the valence constraint, etc.

That is the end of the overview. Now let's take a quick look at a couple of representative works in progress.

First, a look at some important work by Abeille and Godard on French auxiliaries. This is part of a larger project on French syntax, which also includes Ivan Sag, Philip Miller, and Jong-Bok Kim. Most work in HPSG, as in other syntactic theories, has assumed that the complement of an auxiliary is a phrase,

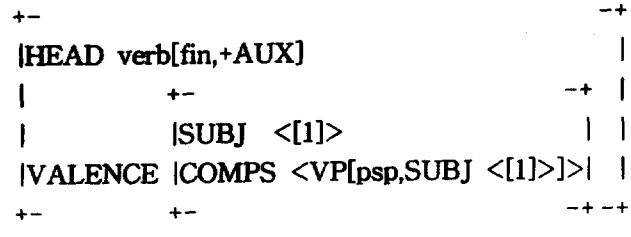
usually a verb phrase, as shown in (16):

(16) Chris has seen Dana. (Fr. Jean a vu Dominique)



In HPSG, auxiliaries have standardly been analyzed as verbs that are positively specified for the feature AUX, and which have the same valence as a typical raising-to-subject verb:

(17) category of auxiliary HAS



Here the VALENCE value is essentially the same as for the raising verb SEEM given in (4). Roughly the same kind of auxiliary analysis (a single verbal phrasal complement) has been standardly assumed for French, for example in the influential work on French negation and adverb placement by Pollock in the GB framework. However, there are some mysterious facts about the so-called tense auxiliaries AVOIR 'have' and ETRE 'be' in French that are not explained by this analysis. I'll mention just two kinds of relevant facts here. First, consider the facts in (18):

(18) a. Paul a bruyamment ri et chante. [Adverb can scope
Paul has loudly laughed and sung over both verbs]

b. Jean a immediatement pense a une reponse et
Jean has immediately thought of an answer and

contre-attaque. [Adverb can only scope over
counter-attacked the first verb.]

These facts seem difficult to explain if the conjoined complements of the auxiliary are verb phrases. Next, consider the facts in (19), adapted from a recent paper French and English negation by Jong-Bok Kim and Ivan Sag:

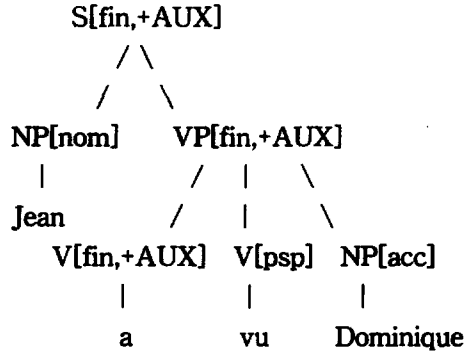
(19)a. Nous n'allons pas ne pas [aller en vacances cette ete].
We NE go not NE not NE not go on vacation this summer
'We're not going to not go on vacation this summer.'

b.*Nous ne sommes pas ne pas alles en vacances cette ete.
We NE are not NE not gone on vacation this summer
'We didn't not go on vacation this summer.'

As Kim and Sag argue on the basis of other facts unrelated to these, the French negative word PAS can be either an adjunct to a nonfinite VP, or else a complement to a finite verb. Thus in (19)a, we have two different cases of PAS adjoining to the VP complement ALLER EN VACANCES CETTE ETE. Then why is (19)b bad? Well, the first PAS is a complement to the finite auxiliary SOMMES. Since complements cannot repeat, the only option for the second PAS would be to adjoin to the VP complement. The fact that this is impossible strongly suggests that the auxiliary has no VP complement for the negation to adjoin to.

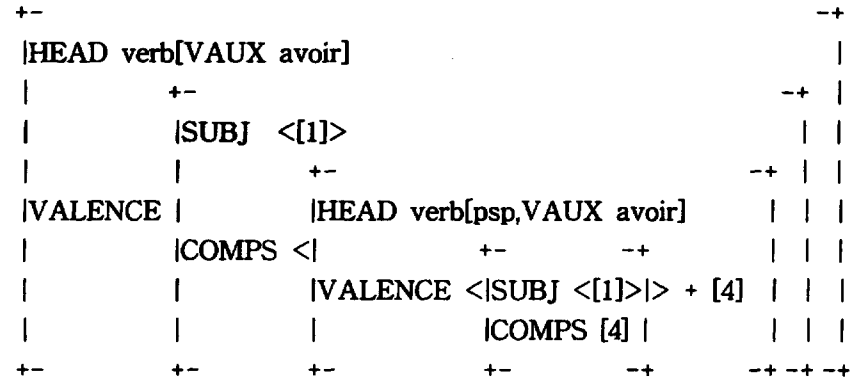
In order to explain these and other facts, Abeille and Godard assume that the correct structure for French auxiliary complementation is NOT as in (16), but rather as shown in (20):

(20)



But how can a verb, even an auxiliary, take a lexical verb, not a VP, as its complement? And how does DOMINIQUE, which is intuitively the object of the participle VU, become a complement of the auxiliary? In order to explain this, Abeille and Godard make use of an idea first proposed by Hinrichs and Nakazawa for the analysis of German, and also employed in the analysis of many other languages, such as the account of Korean complex predicates in Chan Chung's recent dissertation. This idea, variously known as argument composition or argument attraction, is embodied in the lexical entry for the French tense auxiliary given in (21):

(21) tense auxiliary AVOIR (simplified from Abeille & Godard)



Here the + sign should be read as list concatenation. What this says in essence is that the complements of AVOIR are a past-participle verb plus whatever complements the participle subcategorized for. Given this lexical entry, the structure in (20) is generated by already-existing constraints. The only thing we have to change is the head-complement schema in (11)c: we have to eliminate the requirement that complements always be phrasal.

Next, let's take a quick look at some work in the area of binding theory. Binding theory is concerned with the question of which NPs in a sentence may or may not be the antecedents of different kinds of pronouns. In a 1992 paper, Ivan Sag and I proposed a binding theory for English along the following lines. First of all, we divide referential NPs into three basic types as in (22):

(22) Referential types for NPs (adapted from Pollard & Sag 1992)

nom-obj
  nonpronoun (npro)
  pronoun (pron)
    personal-pronoun (ppro) [e.g., SHE, HIM]
    anaphor (ana) [e.g. HIMSELF, EACH OTHER]

The theory depends crucially on a relationship called OBLIQUENESS, defined in (23):

(23)a. The OBLIQUENESS relation is defined on the valents of a head as follows:
1. The subject is less oblique than the specifier and complements.
2. The specifier is less oblique than the complements.
3. A complement is less oblique than another complement that occurs later on the COMPS list.

Notice that according to this definition, obliqueness is defined purely in terms of grammatical relations, not on the basis of tree configurations or linear order. Thus, for example, order of obliqueness is determined as in (24):

(24) Order of obliqueness

a. Kim_1 gave the books_2 to Sandy_3.
b. Kim's_1 picture of Sandy_2

Next, we define the relationship called O-COMMAND as follows:

(25) O-command

Given two referential phrases XP and YP,

a. XP LOCALLY O-COMMANDS YP provided they are valents of the same head and XP is less oblique than YP.

b. XP O-COMMANDS YP provided XP locally o-commands YP, or a phrase containing YP.

In essence this says that you bind things which are, or are contained in things which are, more oblique than you.

Next, binding is defined as in (26):

(26) Binding

Given two referential phrases XP and YP, XP (LOCALLY) BINDS YP provided:

a. XP (LOCALLY) o-commands YP, and
b. XP and YP are coindexed.

Finally, the binding theory is as stated in (27):

(27) Binding theory (for American English)

a. An anaphor (ana) which is locally o-commanded must be locally bound.
b. A personal pronoun (ppro) must not be locally bound.

This theory explains the basic facts about English pronoun binding, as in (28), as well as a great many other facts that are unexplained by the so-called standard binding theory of Chomsky 1985, such as the ones in (29):

(28) Basic predictions of Pollard & Sag's binding theory

a. John_i admires himself_i.
b. *John_i admires him_i.
c. John_i thinks Bill_j admires him_i.
d. *John_i thinks Bill_j admires himself_i.

(29) Predictions of Pollard and Sag's binding theory unexplained by Chomsky 1985

a. [John and Mary]_i hoped that the journal would reject [each other's]_i papers.
b. John suggested that tiny portraits of [each other]_i would make ideal gifts for [the twins]_i.
c. The agreement that [Iran and Iraq]_j reached guaranteed [each other's]_j fishing rights until the year 2010.
d. John's_i campaign requires that pictures of himself_i be placed all over town.
e. Mary couldn't decide on birthday presents for [the twins]_i. Maybe tiny portraits of [each other]_i would do.
f. Iran_i agreed with Iraq_j that [each other's]_k fishing rights must be respected. (k = i+j)
g. John_i asked Mary_j to send reminders to everyone except themselves_k. (k = i+j)

The basic idea in explaining the facts in (29) is that these are all anaphors that are not locally o-commanded. Therefore, condition a of the binding theory in (27) does not apply to them, and they are not required to have locally o-commanding binders. For such "exempt" anaphors, we assume that the antecedent is determined by nonsyntactic factors, such as narrative point of view.

However, this theory does not work very well when we look at certain British and literary dialects, where we commonly find examples like the ones in (30):

(30) "Lit/Brit" binding facts unexplained by Pollard & Sag's binding theory (after Zribi-Hertz 1989)

a. because Desiree ... had undoubtedly explained to them the precise nature of her relationship with himself [himself = Philip]
b. his_i wife ... suspected himself_i to be the cause of her distress
c. But Rupert_i was not unduly worried about Peter's opinion of himself_i

These facts show that under appropriate discourse conditions, involving such factors as logophoricity, point of view, and emphasis, in these dialects even a locally o-commanded reflexive pronoun need not be locally bound.

Turning next to Chinese, we find still a different situation. First of all, in the absence of special discourse conditions, the Chinese reflexive ZIJI is bound by a subject, either the local one or a higher one:

(31) Basic Chinese binding facts: subject binding

a. Zhangsan_i zhidao Lisi_j xihuan ziji_i/j.
Zhangsan know Lisi like self

b. Ta_i zhidao tamen_j dui ziji_i/j mei xinxin.
S/he know they toward self lack confidence

c. Zhangsan_i gei-le Lisi_j yizhang ziji_i/*j de xiangpian.
Zhangsan gave-ASP Lisi one-CL self DE photo

However, there are some unexplained exceptions to this, as shown in (32):

(32) ZIJI contained in an adjunct clause (after Xue & Pollard ms.)

a. Zhangsan_i shuo [Wangwu_j bu hui qu, [yinwei Lisi_k
Zhangsan say Wangwu not will go because Lisi

mei yaoqing ziji_i/*j/k
have-not invite self

b. Zhangsan_i shuo [ruguo Lisi_j piping ziji_i/j/*k,
Zhangsan say if Lisi criticize self

[Wangwu_k jiu bu hui qu.
Wangwu jiu not will go

c. Lisi_i zhidao [Zhangsan_j bu xihuan [neixie
Lisi know Zhangsan not like those

[e_k piping ziji_i/j/k] de ren_k].
criticize self DE person

Here the mystery is why the ZIJI in the relative clause in (32)c can be bound by the next subject up, but not the ZIJI in the adjunct clauses in (32)a-b.

We also have to consider facts like those in (33), which show that sometimes ZIJI can have an antecedent which is not a superordinate subject:

(33) a. [Zhangsan_i de jiaoao]_j hai-le ziji_i/*j.
Zhangsan DE pride harm-ASP self

b. [Zhangsan_i de xin]_j biaoming Lisi hai-le ziji*i/*j/k.
Zhangsan DE letter indicate Lisi harm-ASP self

c. Ziji_i de xiaohai mei de jiang de xiaoxi shi Lisi_i
self DE child have-not get prize DE news make Lisi

hen nanguo.
very sad

Here (33)a-b are examples of so-called "subcommanding" antecedents, while in (33)c the antecedent is an experiencer object of a causative.

Now let me sketch an analysis of these facts, which is based partly on some ongoing work on Chinese with Ping Xue, and partly on some work in progress on English by Karin Golde.

The first step is to eliminate the classification of NP types in (22) and replace it with the new one in (34):

(34) Referential types for NPs (After Golde in progress)

nom-obj
nonpronoun (npro)
pronoun (pron)
personal-pronoun (ppro) [e.g., SHE, HIM, TA]
self-pro [e.g. HIMSELF, ZIJI]

As before, pronouns are divided into two subtypes, but the new classification is based on morphological properties, not binding properties. The binding theory for English, both American and Lit/Brit, now takes the form in (35):

(35) Binding theory for English (American and Lit/Brit)

a. Self-pronouns which are not locally bound are subject to certain discourse constraints [which remain to be specified].

b. A personal pronoun (ppro) must not be locally bound.

This permits examples like the ones in (30), as long as the appropriate discourse conditions are satisfied. But American English has the further constraint in (36):

(36) Additional constraint for American English

Self-pronouns which are locally o-commanded must be locally bound.

Because of (36), examples like (30) are excluded in American English. Thus in American English, the only self-pronouns which are REQUIRED to satisfy discourse constraints are the ones that are NOT locally o-commanded.

And finally, the binding theory we propose for Chinese is as shown in (37):

(37) Binding theory for Chinese

a. Self-pronouns which are not bound by a subject are subject to certain discourse constraints [which remain to be specified].

b. [same as for English]

This reanalysis reveals a striking similarity between Chinese and English, especially "Lit/Brit" English. The key difference is that in English, the only way a self-pronoun can escape the discourse constraints is to be locally bound. In Chinese, by contrast, it is sufficient to be bound, but the binder must be a subject; otherwise, as with examples (33a,c), further discourse conditions must be present.

The only thing left to explain is the mysterious contrast in (32): why can't WANGWU be the antecedent of ZIJI in (32)a? The answer is that WANGWU fails to o-command ZIJI, because the subordinate clause is an adjunct, not a valent. By contrast, in (32)c, ZHANGSAN can be the antecedent of ZIJI because it o-commands ZIJI. This is because ZIJI is contained is contained in the direct

object of the lower clause, which IS a valent.

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