

Feature Indeterminacy and the Coordination of Unlikes in a Totally Well-Typed HPSG

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1 Introduction

This paper is an attempt to reconcile facts regarding two difficult issues in formal syntax—the *coordination of unlikes*, and *feature indeterminacy*—with formal modeling assumptions in Head-Driven Phrase Structure Grammar (HPSG; Pollard and Sag 1994), in particular that feature structures are *totally well-typed* (Carpenter, 1992). I argue that the problems presented by the combination of these two phenomena cannot be solved solely with the structural tools made available by HPSG’s type hierarchy, and propose a lattice that can model both phenomena at once, without admitting unmotivated structural descriptions.

The first section of the paper briefly introduces the nature of the formal problem presented by feature indeterminacy and the coordination of unlikes; the second section reviews proposed solutions to the problem in another constraint-based formalism, Lexical-Functional Grammar (LFG; Kaplan and Bresnan 1982), and in Lambek Categorical Grammar (LCG; Lambek 1958). The next sections of the paper examine possible solutions in HPSG, and presents a novel lattice and with it an account of single-feature indeterminacy and unlike coordination on the lattice. Another section is devoted to problems regarding case concord within the NP, previously unexamined in this context, and proposes a treatment based on the same formal apparatus.¹

¹I am extremely in the debt of and grateful to Samuel Bayer, Jim Blevins, Joan Bresnan, Mary Dalrymple, Adam Przepiorkowski, Ashwini Deo, Chris Manning, Peter Sells, Arnold Zwicky, and in particular Ivan Sag, for discussions and comments regarding my work on this topic. The suggestions of Carl Pollard, who showed me how the formalism introduced in this work can be situated and extended in domain theory, have been especially important for this paper. I have also had the good fortune to receive valuable feedback on a previous draft of this paper from the participants in a seminar on coordination at Ohio State

2 The Problem

In constraint-based grammatical formalisms, agreement and concord among different elements of a syntactic construct are modeled as the integration of information carried by these elements about a particular *feature value*. In practice, the nature of information about any given feature is assumed to be the same for all relevant elements. In languages with case, for example, the constraints that

- (1) i. a particular verb form selects for an accusative object; and that
- ii. a particular noun form's case is accusative;

are modeled in a fundamentally identical way: that some feature CASE must have exactly the value ACC. Disjunctive specifications are permitted, but the formal representation of disjunction is formally identical for feature values selected by verbs and specified by nouns. Furthermore, it is generally assumed that all disjunctions are actually resolved in well-formed linguistic objects (see, for example, discussions in Kaplan and Bresnan (1982), where disjunctions are not permitted in functional structure, and total well-typedness in Pollard and Sag (1994)).

There is considerable evidence, however, that there *is* a difference between (1i) and (1ii), and that apparent disjunctions are *not* always resolved. This evidence is most acute in a wide variety of coordination phenomena, as discussed by Zaenen and Karttunen (1984); Ingria (1990); Bayer and Johnson (1995); Bayer (1996); and Dalrymple and Kaplan (2000), among others. Examples include:

- (2) Pat is a Republican and proud of it. (Sag et al. 1985)
- (3) Kogo/*Co Janek lubi a Jerzy nienawidzi?
(ACC/GEN)/(NOM/ACC) OBJ.ACC OBJ.GEN
who John likes and George hates
"Who/*What does John like and George hate?" (Polish: Dyla 1984, (10))
- (4) Er findet und hilft Frauen.
 OBJ.ACC OBJ.DAT
 He finds and helps women

University. Finally, I would like to thank the native Russian speakers who generously let me work with them on Russian data, and in particular Natalia Roudakova, who worked closely with me on Russian data, and Adam Przepiorkowski for data on Polish and Ashwini Deo for data on Marathi. Any mistakes remain my sole responsibility.

“He finds and helps women.”

- (5) I certainly will, and you already have, {*clarify/*clarified the situation} {set the record straight} with respect to the budget. (Pullum and Zwicky 1986)

Each of the above sentences includes an element one of whose feature values is an apparently unresolved disjunction. In (2), an NP and an AP are coordinated under the copula *is*, which in general can accept either category, and in this case, both at the same time. In (3), the fronted *kogo* simultaneously satisfies accusative and genitive case requirements of governing verbs, while nominative/accusative-syncretized *co* cannot. In (4), the shared object, syncretized for all cases, also satisfies simultaneously two different case requirements. Finally, in (5), the verbform *set* can satisfy both demands of base and past-participial verbforms from prior auxiliaries. There is also similar evidence from the domain of case on free relative pronouns (see Section 7). In this paper I will distinguish between *selectional values*, such as those specified by a verb for its object, and *inherent values*, such as those specified by a noun for itself, which I claim, following Bayer (1996), behave asymmetrically.

Surface-oriented accounts of coordination typically assume that at least some kinds of phrasal coordination are instantiations of a rule of the form $X \rightarrow X \text{ } c_j \dots X$ but it is also recognized that the output conjuncts of this rule need not be strictly identical. On the other hand, both surface and transformational accounts of coordination make great use of the intuition that the grammaticality of $W X \text{ and } Y Z$ usually has as a prerequisite the grammaticality of both $W X Z$ and $W Y Z$. These approaches might be integrated by saying that, in a surface-oriented syntactic account of constituent coordination,

- (6) all constraints that apply to a coordinate mother also apply to each conjunct daughter.²

With treatments of certain classes of symmetric non-constituent coordination, such as those proposed by Milward (1994) and Maxwell and Manning (1996), grammaticality patterns in examples such as (5) can also be subsumed under this constraint. The challenge facing all syntactic theories of constituent coordination is how to insure that this general constraint is met.

²There are certain clear exceptions to this constraint, the resolution of agreement features in coordinate NPs being one, so this statement must actually be qualified to apply to certain classes of constraints in (perhaps) certain classes of coordination environments.

In the next section I review approaches to this problem in LFG and LCG, and a more general proposal by Blevins; subsequently I explore the space of possible HPSG solutions before making a specific proposal. A preliminary caveat, however, is necessary. Feature indeterminacy and the coordination of unlikes, in the sense defined by (2), are an abstraction of a particular subclass of empirically observed coordination patterns. Alternative patternings are common; for example, many judgements show that a form shared as an argument among conjunct members of a coordinated verb structure is acceptable even if the form meets the selectional requirements of only the *nearest* verb. Some speakers judge *clarified* in (5), for example, as acceptable, even though it quite clearly fails to match constraint (2):

(7) *I certainly will clarified the situation with respect to the budget.

From the perspective of language variation, these alternative—and likely quite common—patterns should not be ignored. But insofar as they pattern as the identity of a particular selectional requirement on the coordinate mother with the requirement on a single conjunct daughter, picked out by certain linear ordering constraints, they do not present the same formal challenge as those examples patterning according to (2). The present paper is strictly limited to the treatment of this problem.

3 Previous approaches

3.1 LFG: sets for both coordinate and indeterminate structures

Kaplan and Maxwell (1988) presented a solution for constituent coordination in LFG which permitted functional structures to alternatively be *sets* of attribute-value matrices. Correspondingly, a constraint present in c-structure that is operational on a set-valued functional structure is satisfied iff it is satisfied for all members of the set. Crucially, constraints that have more than one possible satisfaction can be satisfied differently in each conjunct. This immediately solved the problem of properly characterizing the relation between extraction and the Coordinate Structure Constraint, as in:

(8) The robot that Bill gave Mary and Jack said Jill gave a ball to (c.f. Kaplan and Maxwell 1988, (23))

In (8), the head of the relative clause fills different grammatical functions in the two conjuncts, and is at a different level of embedding. Kaplan

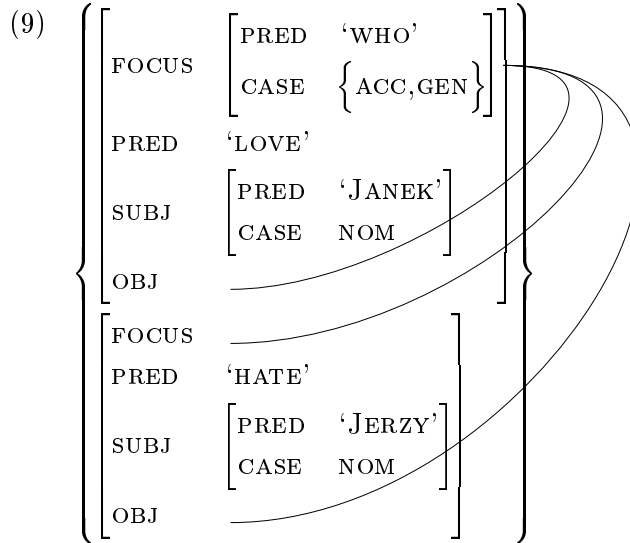
and Maxwell assume that the functional equation constraining the relative clause head here is $(f_1 \text{ COMP}^* \text{ GF}) = f_2$. Since this functional equation can be realized with any number of COMPS, and GF can stand for any valid grammatical function, the relative clause head can fill different grammatical functions in the different conjuncts.

Dalrymple and Kaplan (2000) have shown that many problematic aspects of feature indeterminacy can be elegantly solved in LFG by treating certain features, including case, as set-valued. In general, they take a noun form syncretized for cases $\{a_1, \dots, a_n\}$ as having a CASE value equal to $\{a_1, \dots, a_n\}$. An ordinary accusative noun, for example, would have CASE value $\{\text{ACC}\}$, while an accusative-genitive syncretized noun such as Polish *kogo* would have a lexical entry of $(\uparrow \text{CASE}) = \{\text{ACC}, \text{GEN}\}$, in LFG's notation. This value, as Dalrymple and Kaplan explain, is a *set designator*—it exhaustively stipulates that both and only ACC and GEN are members of the value of CASE.

Verbs in their account, on the other hand, stipulate the case values of their arguments non-exhaustively. A verb governing an accusative object, such as *lubi* in Polish, has a case requirement in its lexical entry of the form $\text{ACC} \in (\uparrow \text{OBJ CASE})$, requiring only that ACC is a member of the object's CASE (set) value, and places no restrictions on the further membership of that set. This formalizes the crucial observation that the case requirements of multiple verbs on a single argument need not be checked against each other, while allowing full structural identity of the argument of the two verbs. The grammaticality of the Polish (3), for example, follows from its unproblematic functional structure (c-structure omitted):

findet	und	hilft	Frauen
$VP/RNP[ACC]$	$(\alpha/L\alpha)/R\alpha$	$VP/RNP[DAT]$	$NP[NOM]\wedge NP[ACC]\wedge NP[DAT]\wedge NP[GEN]$
$VP/R(NP[ACC]\wedge NP[DAT])$	$VP/RNP[ACC]\wedge NP[DAT]$	$VP/R(NP[ACC]\wedge NP[DAT])$	$NP[ACC]\wedge NP[DAT]$
$VP/RNP[ACC]\wedge NP[DAT]$			
VP			

Figure 1: Partial LCG derivation of (4), following Bayer (1996).



3.2 LCG: coordination and indeterminacy through logical conjunction and disjunction

Bayer (1996); Bayer and Johnson (1995) argue that both indeterminacy and the coordination of unlikes can be handled in Lambek Categorical Grammar (LCG) in one fell swoop, through augmenting the set of category constructors with MEET and JOIN constructors, following Morrill (1994). Indeterminate case on nouns is taken as a conjunction of all individual case values. When such a noun is shared between coordinated categories specifying different for their argument, the coordinated categories undergo Antecedent Strengthening, whereby the selectional requirements S on an argument are replaced with the conjunction of S with other requirements, to produce a coordinate mother that selects an argument with the meet (conjunction) of the two case values specified by the daughter. Because conjunct verbs or VPs can be matched for their argument selection, apparently conflicting requirements for an argument do not result in incompatibility but rather in a pooled selectional requirement on the argument.

Figure 1 shows a LCG analysis of (3), following Bayer (1996), beginning with the conjunction of verb phrases. In the first step, each verb undergoes *argument strengthening*, allowing it to take an argument with more properties than just the selected case. The syncretized *Frauen* undergoes weakening of its category. In the next step, the argument-strengthened verbs, which now are of identical category, are coordinated, and finally the coordinated verb combines with the object *Frauen* to form a verb phrase. The coordination of unlike categories proceeds similarly, except that since the coordinated element is an argument and not a functor, *join introduction* weakens the conjuncts to the same category. All these category-changing operations are derived from rules of logical inference.

3.3 Case indeterminacy as subsumption

It may be instructive to contrast D&K’s approach with a like-minded but somewhat more radical proposal by Blevins (2000). Capitalizing on the paradigmatic nature of case syncretism across many languages, Blevins shows that the set-based model can be replaced with a decomposition into Jakobsonian distinctive features, which can be represented in constraint-based frameworks as complex, multiple-featured attribute-value matrices. This permits an arguably more compact representation of case than D&K’s set notation; following the analysis of Jakobson (1958), the six to eight Slavic cases, for example, seems to succumb to just three binary features, without losing any generalizations about syncretism.³ This representation alone, however, does not solve the feature-indeterminacy problem. For that, Blevins relies on widely replacing structural identity requirements with looser subsumption requirements. The case requirements of a verb on its argument, in Blevins’s proposal, do not unify with the argument, but rather are subsumed by it. The non-conflict between differing argument case requirements in coordinated VPs is modeled with a set-based approach to VP coordination similar to that introduced in Kaplan and Maxwell (1988) for LFG. Both subsumption and set-based modeling of coordinated VPs are crucial to Blevins’s treatment of feature indeterminacy.⁴

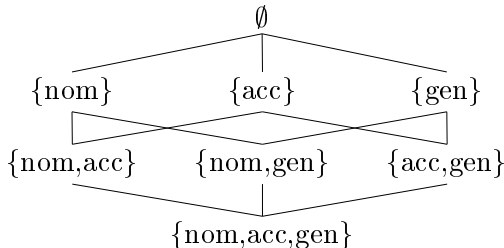
³Neidle (1988) also uses Jakobson’s decomposition to encode generalizations about Russian case in LFG.

⁴There are even more crucial details that I have omitted here. Blevins’s analysis requires a strictly “upward” flow of information (subsumption is always of syntactically higher elements by lower elements) to ensure that the proper subsumption relations hold in the proper directions. Furthermore, all the subsumption relations between attribute-value matrices in Blevins’s analyses arise from stipulations on phrase structure rules (as opposed to tie information within lexemes). Finally, Blevins models coordination with

4 Shortcomings of the power set lattice

At first glance it appears that the use of sets introduced by Dalrymple and Kaplan can be readily adapted to HPSG for feature indeterminacy and coordination. To see how this might be accomplished, let us consider the structure of the lattice defined by the powerset $\mathcal{P}(B)$ over a set B , ordered by reverse inclusion.

Figure 2: Powerset lattice for $\{nom, acc, gen\}$, ordered by inclusion

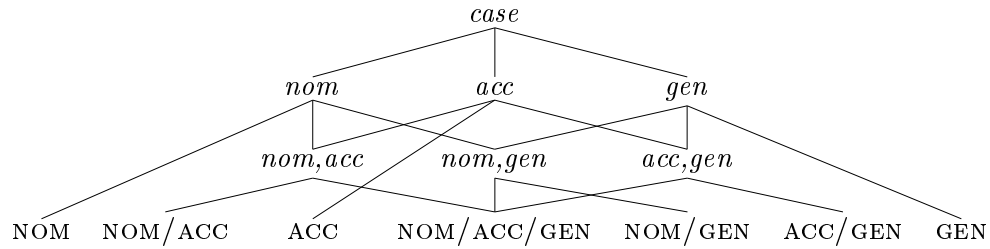


The subset relation among sets in $\mathcal{P}(B)$ is determined by *precedence* on the lattice. In D&K's set-based approach, for example, the case-marking constraint on objects of verbs is taken to be of the form $x \in (\uparrow\text{OBJ CASE})$. This is equivalent to the constraint $\{x\} \subseteq (\uparrow\text{OBJ CASE})$, so a selecting value can be thought of as an *upper bound* on the powerset lattice for possible case values of the governed noun, satisfied only if the noun specifies an equal or lower value. A noun governed by multiple verbs is simply subject to multiple upper bounds.

In HPSG, this treatment could straightforwardly be adopted by making similar assumptions about the (set-based) form of lexical entries for nouns and verbs. Alternatively, the structure of the powerset lattice could be adapted to fit within HPSG's *sort hierarchy* for individual features. In this theory, all linguistic structures are populated with *maximal sorts*, which dominate no other node in the sort semilattice. A sort hierarchy with the appropriate properties can easily be constructed from the powerset lattice by extending for each node N on the powerset lattice a maximal sort M such that N and only N dominates M (except for the topmost and bottommost nodes, for which it is unnecessary):

sets of AVM's, as do D&K. This array of assumptions serves well for the coordination examples such as (3) and (4), but may be problematic for free-relative examples, where the subsumption ordering needs to flow downward (into the relative clause) for proper results.

Figure 3: Sort hierarchy for $\{nom, acc, gen\}$, based on powerset lattice

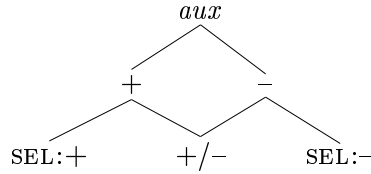


Assuming this sort hierarchy, selectional requirements of verbs specify non-maximal nodes for the value, and the values of nouns specify maximal values. The empirical coverage of such a system is identical to that of Figure 2.⁵

As noted by Bayer (1996), the coordination of unlikes can be thought of as the mirror image of feature indeterminacy, and either of these powerset-based constructions could be adopted for a treatment of the coordination of unlikes. For example, following Pollard and Sag (1994) and assuming that verb phrases are specified for a binary AUX feature corresponding to the status of the head verb, we can enrich the sort hierarchy for AUX, as shown in Figure 4. It has been proposed that the English auxiliary *do* subcategorizes for a VP complement that is [AUX -] (Sag, p.c.). In this case, the necessary assumption is that the lexical entries of verbs specify non-maximal binary values, and that *do* specifies a maximal value [AUX SEL:-] for its VP complement. Assuming token identity between AUX values in conjunct VPs and coordinate mother gives the proper results for the following set:⁶

⁵Levine et al. (2001) propose just such a sort hierarchy for the treatment of case in English parasitic gaps.

Figure 4: Powerset lattice-based sort hierarchy for AUX



- (10) a. She loves this kind of movie and is planning to see it.
 b. * Does she love this movie and be planning to see it?
 c. Does she love this kind of movie and want to see it?

Note that the duality between feature indeterminacy and the coordination of unlike categories is realized by the inverted relative positions of inherent vs. selecting values: in feature indeterminacy, inherent values are lower than selecting values, while in the coordination of unlikes, selecting values are lower than inherent values. From this perspective, the coordination of unlikes is simply indeterminacy of selecting feature values.

This picture is incomplete, as is shown by the following data. Recall from (3), repeated below, that Polish case exhibits feature indeterminacy, in particular between accusative and genitive. However, objects of unlike case can also be coordinated in Polish, precisely when each conjunct could individually serve as object of the verb:

- (3) Kogo Janek lubi a Jerzy nienawidzi?
 (11) Dajcie wina i ca"l"na "swini"e! (Przepiórkowski 1999)
 give wine.GEN and whole.ACC pig.ACC
 "Serve some wine and a whole pig!"

This is also true of Russian (also see Franks 1993):⁷

⁶However, it introduces a spurious ambiguity for sentences such as

She loves this movie and plans on seeing it.

whose AUX value in the coordinate VP could be either +/- or SEL:-. This ambiguity results from the unselected status of the AUX value.

⁷These are by no means marginal cases. Object case marking alternation is typologically widespread, typically correlated with variability in animacy and definiteness of the object. Comrie (1978) provides a cross-linguistic survey of the phenomenon. In every language with object case marking alternation that I have checked, including Russian, Polish, Turkish, Tatar, and Marathi, the conjunction of objects with alternate case is possible. Pragmatic constraints do exist on this conjunction, but they follow directly from the differing conjuncts.

- (12) Kogo ja iskal ne bylo doma.
 who.ACC/GEN I sought.OBJ-ACC not was.SUBJ-GEN home.
 “The person who I was looking for wasn’t at home.”
- (13) Včera vec’ den’ on proždal [NP svoju podругu Irinu]
 yesterday all day he expected self’s.ACC girlfriend.ACC Irina.ACC
 i [NP zvonka [PP ot svoego brata Grigorija]]. (Russian)
 and call.GEN from self’s brother Gregory
 “Yesterday he waited all day for his girlfriend Irina and for a call
 from his brother Gregory.”

Since Polish and Russian case show indeterminacy in (3) and (12), inherent values must be taken to be maximal types in a sort hierarchy based on the powerset. Therefore, case on the coordinate NP objects in (11) and (13) cannot be taken to be the token-identity of the conjunct daughter cases. Nor could their coordination be taken as their meet (equivalently, generalization) on the sort hierarchy, however, as this would permit the coordinated object to be admissible if *either* of its conjuncts satisfies the governing verb’s requirements. In short, on a lattice based on the powerset it is impossible to preserve the necessary information in coordination of both governed and governing phrases.⁸

In the next section, I present a lattice that allows for the simultaneous representation of indeterminacy and the coordination of unlikes, one in which feature values are modeled with *sets of sets* of symbols. The remainder of the paper is devoted to an initial account of both phenomena.

5 Defining double-set lattices

This section presents a lattice constructed set-theoretically, on which every possible coordination of both inherent values and selecting values has a unique representation. This lattice serves as the foundation for the theory of coordination and NP-internal case concord developed in the remainder of the paper.

Let $B = \{b_1, \dots, b_n\}$, and note that the relations of union and intersection are defined over members of $\mathcal{P}(B)$, the *power set* of B . Define two relations over *double-set* members of the *double power set* of B , $\mathcal{P}(\mathcal{P}(B))$, as follows:

- (14) Given double sets $S_1, S_2 \in \mathcal{P}(\mathcal{P}(B))$:

⁸Bayer and Johnson (1995) make an equivalent point with regard to the GPSG account of coordination proposed by Sag et al. (1985), although it does not address an account in which NP and VP coordination rules are distinct.

- i. The *double union* of S_1 and S_2 , written as $S_1 \vee S_2$, is equal to the set $S' = S_1 \cup S_2$, minus the set of all $e_i \in S'$ such that there is some $e_j \in S_1 \cup S_2$ such that $e_j \subset e_i$.
- ii. The *double intersection* of S_1 and S_2 , written as $S_1 \wedge S_2$, is equal to the set S' of all elements e such that for some $s \in S_1$ and $t \in S_2$, $e = s \cup t$, minus the set of all $e_i \in S'$ such that there is some $e_j \in S'$ such that $e_j \subset e_i$.
- iii. S_1 *suffices for* S_2 , written as $S_1 \supseteq S_2$ iff $S_1 \vee S_2 = S_1$ (and, hence, $S_1 \wedge S_2 = S_2$).

Now consider the set $\mathcal{C} \subset \mathcal{P}(\mathcal{P}(B))$, which contains every one of and only the elements of $\mathcal{P}(\mathcal{P}(B))$ with cardinality 0 or 1. For example, if $B = \{a, b\}$, then \mathcal{C} will be $\{\{\{a\}\}, \{\{b\}\}, \{\{a, b\}\}, \{\emptyset\}, \emptyset\}$.

- (15) The *double-set lattice* \mathcal{L}^B of B is the closure of \mathcal{C} over \wedge and \vee , ordered by \supseteq .

This results in a distributive lattice for any B . Figure 5 is a diagram of the double-set lattice of $\{A, B, C\}$. Fortunately, for any set B , the lattice $\mathcal{L}^{B'}$ is a sublattice of \mathcal{L}^B for any set $B' \subset B$. Figure 6, which is a diagram of the double-set lattice of $\{A, B\}$, a sublattice of the lattice in Figure 5. This simplifies discussion of the behavior of members of $\mathcal{L}^{B'}$ on \mathcal{L}^B , as all the ordering relations among elements of $\mathcal{L}^{B'}$ also hold in \mathcal{L}^B .

Importantly, in general some members of $\mathcal{P}(\mathcal{P}(B'))$ will not be present in \mathcal{L}^B . For the lattice in Figure 6, these include: $\{\{A\}, \{A, B\}\}, \{\{B\}, \{A, B\}\}, \{\emptyset, \{A\}\}, \{\emptyset, \{B\}\}, \{\emptyset, \{A, B\}\}, \{\emptyset, \{A, B\}, \{A\}\}, \{\emptyset, \{A, B\}, \{B\}\}, \{\emptyset, \{A, B\}, \{A\}, \{B\}\}$. This is a reflection of the property of all double-set lattices that

- (16) For any element S of a double-set lattice, no two nonidentical singleton subsets of S are ordered by \supseteq .⁹

⁹As Carl Pollard has shown (p.c.), the double-set lattice can be constructed, up to isomorphism, more generally using domain theory. For a set \mathcal{B} , the double-set lattice of \mathcal{B} is equivalent to $\text{Hoare}(\text{Smyth}(\mathcal{B}))$, where $\text{Smyth}(X)$ is the Smyth powerdomain of X and $\text{Hoare}(X)$ the Hoare powerdomain of X . For unordered X , the Smyth powerdomain of X is simply $\mathcal{P}(X)$ ordered by reverse inclusion; the Hoare powerdomain of X , in turn, is the lattice in which for $A, B \subset X$, $A \leq B$ iff for every $a \in A$, some $b \in B$ is such that $a \leq b$ on X .

I retain the definition of the double-set lattice as presented here, however, because it remains closed under ordinary set intersection (though not under set union). I make use of set intersection in the treatment of NP-internal case concord (Section 9).

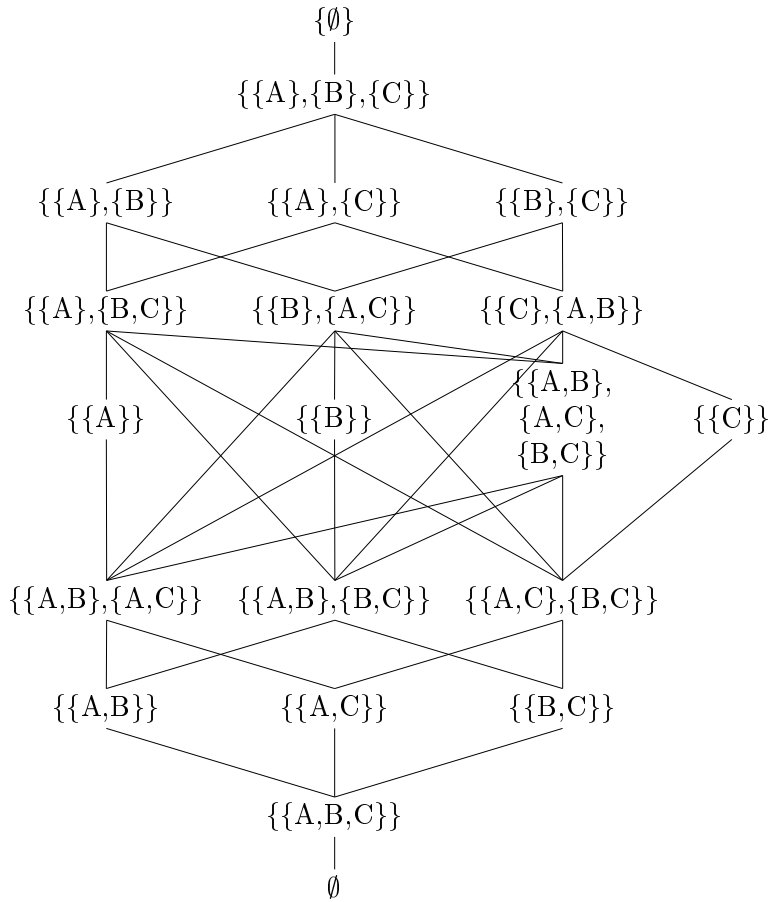


Figure 5: Double-set lattice ordered by \supseteq over $\{A, B, C\}$.

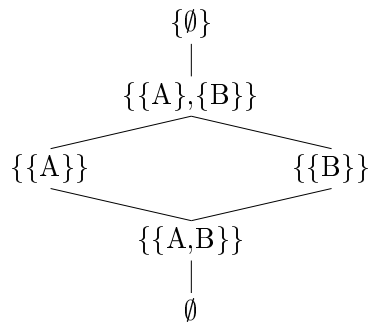


Figure 6: Double-set lattice over $\{A, B\}$. A sublattice of Figure 5.

6 A theory of coordination with double-set-valued features

In this section, I will show how double-set lattices can be used to model the asymmetry between feature values and selection requirements on those features, and handle the resulting examples of both the coordination of unlikes and feature indeterminacy.

6.1 Preliminaries

To begin with, I assume that the inventory of CASE feature values is not simply a finite set of symbols, but rather the *double-set lattice* derived from that set of symbols. Features with such an inventory of values I will call *double-set-valued features*, and their values are of type *double-set value*, a subtype of *set value*. For the moment I will limit the scope of constraint to values of the CASE feature. In Section 8, I generalize constraints to hierarchically more general feature values.

The set of CASE values in Polish, for example, would be taken as the double-set lattice over the set $\{\text{NOM}, \text{GEN}, \text{ACC}, \text{DAT}, \text{LOC}, \text{PREP}\}$, which constitutes the traditionally-recognized set of possible case values of Polish NPs.¹⁰

It will follow from my formulation of lexical entries and syntactic rules that double-set values have an intuitive interpretation that can be read directly from the form of the feature value. For a double-set value $S = \{s_1, \dots, s_n\}$, each $s_i \in S$ comprised of $\{c_{i1}, \dots, c_{in}\}$, each c_{ij} can be regarded as an assertion of truth regarding the feature structure in question. A member s_i of S can be regarded as an assertion of the *disjunction* of the assertions of each of its members c_{ij} ; S itself can be regarded, in turn, as a *conjunction* of the assertions of each of its members s_i . The case value $\{\{\text{GEN}, \text{ACC}\}, \{\text{NOM}\}\}$, for example, can be interpreted as an assertion of 1) *nominative* AND 2) *genitive* OR *accusative*.

Note that from the definition presented in Section 5, it follows that if two double-set values have the same logical content under this interpretation, then they are the same feature value. $\{\{\text{GEN}\}, \{\text{GEN}, \text{ACC}\}\}$, for example, is not a double-set value, even though both $\{\text{GEN}\}$ and $\{\text{GEN}, \text{ACC}\}$ are individually possible members of double-set values. That this feature value is ill-formed can be seen from (16). Although $\text{GEN} \wedge (\text{GEN} \vee \text{ACC})$ and GEN both have the same logical content as assertions, the only double-set value with this interpretation is $\{\{\text{GEN}\}\}$.

¹⁰Momentarily ignoring debates over, for example, whether partitive case in Polish needs to be distinguished from genitive.

6.2 Lexical Entries

I model the selection requirements of **verbs** on features of their arguments as a *lower bound* on the lattice of double-set values. The Polish verb form *nienawidzi*, which demands a genitive object, would have a lexical entry specifying its object’s case as follows:

$$(17) \text{ nienawidzi: } \left[\text{ARG-ST} < \text{subj, NP}_{[\text{CASE } \square]} > \right] \wedge (\square \supseteq \{\{\text{GEN}\}\})$$

Given this treatment of verbal lexical entries, two treatments are possible for noun phrases. The CASE value for a noun phrase might be taken as an *upper bound* on the \supseteq ordering; this would correspond closely to the CG treatment of Bayer (1996), in which NP arguments of verbs can undergo Meet Elimination, weakening their category (for example, $\text{GEN} \wedge \text{ACC}$ weakens to ACC) during a derivation. In a constraint-based grammatical formalism, this approach would have the advantage that CASE in NP coordination could be treated straightforwardly with unification. The price of such an approach, however, would be the admission of multiple satisfying feature structures for some combinations of verb and NP argument—for example, in an utterance where a verb selecting an accusative object governs an accusative-genitive indeterminate noun, structures with both $\{\{\text{ACC}\}\}$ and $\{\{\text{ACC}\}, \{\text{GEN}\}\}$ as object CASE value would be admitted.¹¹

The alternative approach is for lexical entries to specify particular values for features that are “inherent” to them—case on nouns (and adjectives and determiners), for example, which is marked directly on NPs. The lexical entry for Polish *kogo*, for example, would here include the partial CASE specification:

$$(18) \text{ kogo: } [\text{CASE } \{\{\text{GEN}\}, \{\text{ACC}\}\}]$$

This second alternative forms the basis of the theory of coordination, indeterminacy, and concord presented here.

6.3 Coordinate structure syntax

Ultimately we will want to state the syntactic constraints on coordinate structures with great generality, but in this section I begin with maximally specific constraints. In Section 8, I propose a more general syntactic constraint on coordination that is consistent with the analysis presented in this section.

¹¹The lower-bound approach also renders invalid the proposal for NP-internal case concord presented in Section 9, though Footnote 17 suggests an alternative, viable approach.

I assume that constraints on argument case value are consistent with the strong version of the the Coordination Principle, restricted to feature structures of a verbal category, from Pollard and Sag (1994):

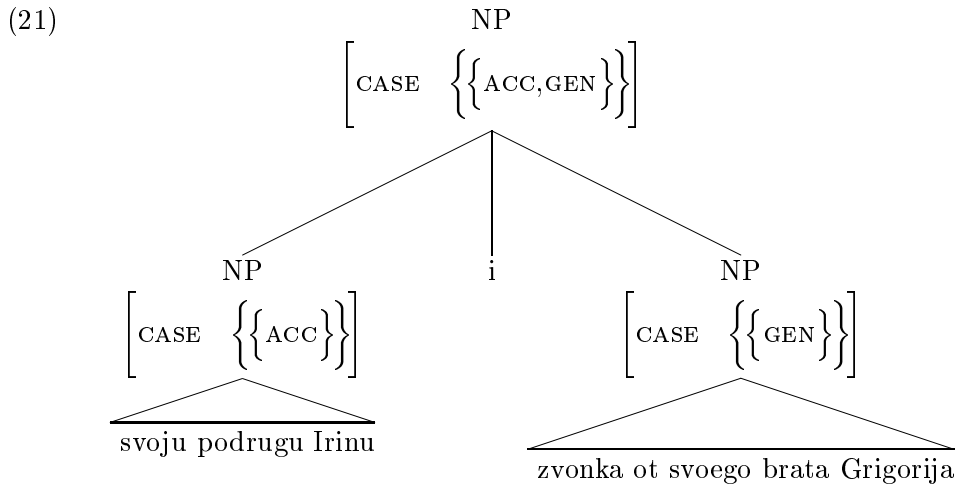
- (19) The CATEGORY and NONLOCAL values of each conjunct daughter (VP) are identical to that of the mother.¹²

In Polish (3), for example, the sentence-initial *kogo* is an object of the coordinate VP *Janek lubi a Jerzy nienawidzi*, and its case value C therefore must satisfy both $C \supseteq \{\{\text{ACC}\}\}$, from *lubi*, and $C \supseteq \{\{\text{GEN}\}\}$, from *nienawidzi*. As $A \supseteq B$ iff A is above B on the double-set lattice as oriented in Figure 5, the case value of *kogo*, $\{\{\text{ACC}\}, \{\text{GEN}\}\}$, does satisfy both these constraints; the case value of a noun not acc-gen syncretized would not.

The coordinate structure constraint I propose for noun phrases makes use of the operations on double sets defined in Section 5.

- (20) In a coordinate NP structure, the CASE value of the mother NP is the double intersection of the CASE values of all conjunct daughters.

Under (20), the structure of the NP coordinate object in example (13) is as follows:



The CASE value $\{\{\text{ACC, GEN}\}\}$ on the coordinate mother in (21) can be interpreted as a disjunction of ACCusative and GENitive values. It should be

¹²Though P&S suggest that the identity requirement is too strong, the alternative subsumption-based analysis (here considered for VPs) is susceptible to Bayer (1996)'s general critique of subsumption-based approaches. The tools presented here deal directly with the shortcomings of both the strong and weak approaches documented in P&S.

evident that this coordinate structure is a viable object only for a verb such as Russian *ždat'*, which can take either an accusative or genitive object. The lexical entry for *ždat'* would include the specification

$$(22) \quad \textit{ždat}': [\text{ARG-ST} < \textit{subj}, \text{NP}[\text{CASE } \square] >] \wedge (\square \supseteq \{\{\text{ACC}, \text{GEN}\}\})$$

As the coordinate NP *mother* in (21) satisfies the second part of the logical conjunction in the partial lexical entry for *ždat'*, it can serve as the object of this verb, as in (13).

7 Free Relative Pronouns

Groos and van Reimsdijk (1979) showed that in German, relative pronouns can be free in a sentence only if their form is consistent with the case requirements of both the governing matrix verb and the relative clause's verb:

$$(23) \quad \begin{array}{l} \text{Was} \quad \quad \quad \text{du} \quad \text{mir} \quad \text{gegeben} \quad \quad \text{hast, ist} \\ \text{what.NOM/ACC} \quad \text{you} \quad \text{me} \quad \text{given.OBJ-ACC} \quad \text{have} \quad \text{is.SUBJ-NOM} \\ \text{prächtigt.} \\ \text{wonderful.} \end{array}$$

Similar examples also exist in Russian, as shown in (12).

Ingria (1990) presented this construction as evidence, similar to the facts discussed by Zaenen and Karttunen (1984) regarding coordination, that a disjunctive specification of case value for case syncretism is untenable. As with the accounts of Bayer (1996) and Dalrymple and Kaplan (2000), the HPSG account presented here permits this construction without difficulty, if we assume that a free relative pronoun *P* syncretized for cases A and B have lexical entries including:¹³

$$(24) \quad P: \left[\text{CASE} \quad \left\{ \left\{ A \right\}, \left\{ B \right\} \right\} \right]$$

¹³The remaining difficulty is the actual syntactic structure of a free relative clause; the only crucial assumption is that both matrix and RC-internal verbs select for the same value. This is Müller (1999) advocates a distinction between case values “external” to and “internal” to the relative clause for German free relatives, and raises two criticisms of the indeterminacy approach, based on the importance of object NP case value for word order within the VP, and for certain adverbial elements in concord with the object NP. The critique is not formally damning, however, because whatever dependencies might otherwise be tied to the case value of the noun, can be tied to the selecting value of the governing verb under the indeterminacy approach.

and verbal lexical entries specify lower bounds on the double-set lattice, as in (17).

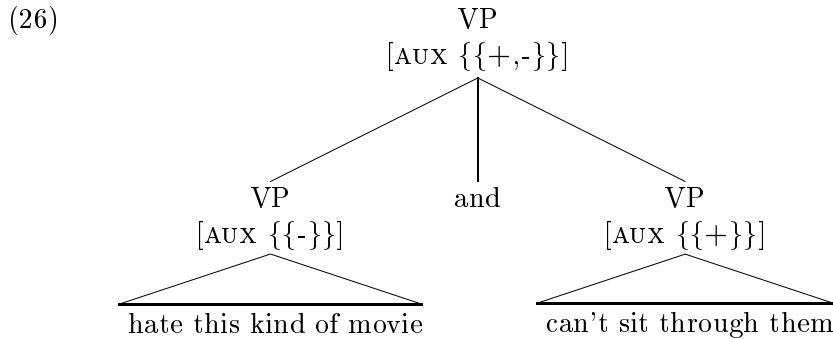
8 Generalizing coordination syntax

In Section 6.3, I stated constraints on CASE values in coordinate structures in terms specific to atomic feature values. This set of constraints on values of individual feature can, however, be generalized as a single constraint, consistent with the analysis presented thus far, and capturing a more comprehensive array of facts.

To begin with, note that the distribution of coordinated English VP's with and without auxiliaries, shown in (10), is fundamentally similar to the distribution of coordinated Polish/Russian objects in (11) and (13). If we assume that the set of possible values of AUX is not the set of symbols $\{+,-\}$, as is typically done, but rather the set of members of the *double-set lattice* over the set of symbols $\{+,-\}$, then we can develop a theory of auxiliaries VP coordination without resorting to subsumption. Suppose auxiliary verbs include in their lexical specification the constraint $[\text{HEAD} \mid \text{AUX} \{\{+\}\}]$, and non-auxiliaries $[\text{HEAD} \mid \text{AUX} \{\{-\}\}]$. Let the rule for VP coordination state that the AUX value of the coordinate mother is the double intersection of the AUX values of the conjunct daughters, just as we assumed for CASE in coordinate NPs. Finally, let the lexical entry for *do* include the constraint:

$$(25) \quad do: \left[\text{ARG-ST} < \text{subj}, \text{VP}_{[\text{AUX} \square]}, \dots > \right] \wedge \square \supseteq \{\{-\}\}$$

The above assumptions handle both (10a) and (10b) above:



The coordinate VP mother in (26) is fine in (10a), where there are no external constraints that its AUX value needs to meet. In (10b), however,

the AUX value of cannot meet the constraint imposed by the head verb *do*, which demands an AUX value $\supseteq \{-\}$ for its VP complement.

What remains is to state these coordination rules in more general terms. As P&S 94 notes, CATEGORY and NONLOCAL are the HPSG features on which coordinate structure constraints are naturally operative. Double intersection as presented in Section 6.1, however, is undefined for feature values that are not double-set lattice values. What we need is a recursive relation that can be stated on non-atomic feature values but that results in the double intersection relation for paths leading to double-set lattice values.

- (27) W is the *feature-structure coordination* of a set of values $\{V_1, \dots, V_n\}$, all of type T , when:
1. If T is feature-structure-valued: if for every feature F_j in type V , feature-structure coordination holds between the value of F_j in W and the set of values $\{v_{j1}, \dots, v_{jn}\}$ of F_j for each V_i ;
 2. If V is double-set-valued: if W is the double intersection of $\{V_1, \dots, V_n\}$;
 3. Otherwise: if W and $\{V_1, \dots, V_n\}$ are all token-identical.

We can now state the syntactic constraint on coordinate structures quite generally:

- (28) In a coordinate structure, the CATEGORY and NONLOCAL values of the coordinate mother are the *feature-structure coordination* of the respective values of the conjunct daughters.

We can show that all the relations of feature values in VP and NP coordination that we have examined so far are implied by (27-28). According to these rules, if and only if a path can be traced from CATEGORY or NONLOCAL to an atomic-valued feature F without passing into any lists or sets, and F has as its values members of double-set lattices, then in a coordinate structure, the value for F for the coordinate mother will be the double intersection of the values of F in the conjunct daughters. CASE in nominal categories can be reached from CATEGORY through the path CAT | HEAD | CASE, and AUX in verbal categories through the path CAT | HEAD | AUX; therefore the values of these features will undergo double intersection in coordination. CASE in the ARG-ST, COMPS, and/or SLASH of a verbal-category features structure, on the other hand, is embedded in a list (and possibly a set). (27) demands token identity among lists/sets for all conjuncts and the mother, so all values within the lists must be identical for all conjuncts and the coordinate

mother. This includes the value of `CASE` in members of the `ARG-ST` list, which covers (19).

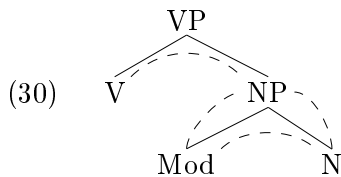
This general constraint, along with the necessary assumption that feature values, including `AUX` and `CASE`, and `HEAD`, must be modeled as double-set-valued, also covers coordination in the domain of other features, such as (2) and (5).

9 NP-internal case

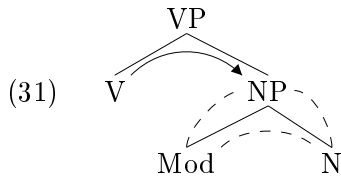
The accounts we have examined of case syncretism as feature indeterminacy also have implications for NP-internal case concord. In languages that mark case on determiners and modifiers within the noun phrase, case marking on these elements must “match” the case marking on the noun:¹⁴

- (29) Ja ljubil krasivuju/*krasivaja ženščinu. (Russian)
 I loved-OBJ.ACC beautiful-ACC/*-NOM woman-ACC.

In constraint-based formalisms, this “matching” relation has traditionally been modeled as common instantiation of a single feature value, similar to the matching of selecting and inherent values, as discussed in Section 2. Such a picture can be represented as follows, with dotted lines representing featural identity:



In the formal accounts of feature indeterminacy and the coordination of unlikes thus far reviewed and developed, however, the relation between `CASE` on V and NP nodes above changes from a symmetrical sharing relation to an asymmetrical *bounding* relation, represented below as a solid line with an arrow:

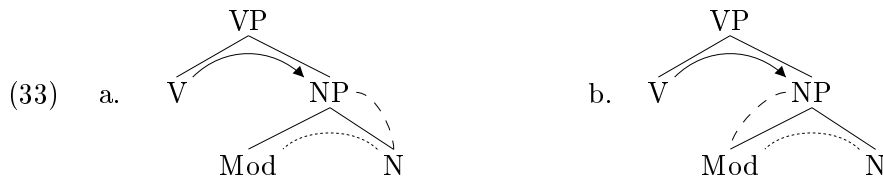


¹⁴There are possible exceptions to this generalization, notably NPs in Slavic languages that include numerals or certain other quantifiers.

This picture, though, is incomplete: an unsyncretized adjective can modify a syncretized noun, and a syncretized adjective can modify an unsyncretized noun:

- (32) a. Er findet die Frauen.
 He finds the.ACC women.NOM/ACC/DAT/GEN.
 b. Ona znaet xoroshego muščinu
 she knows good.ACC/GEN man.ACC

If, as we have thus far assumed, the lexical entries of nouns include the specification of particular values (as opposed to upper bounds on the lattice) for CASE, then the CASE value cannot be shared between adjective and noun. This opens several logical possibilities for the relation of the CASE feature value in the NP structure, including the following (the fine dotted line specifies a yet-unspecified, possibly asymmetric, relation):



Both of these structures are problematic, however, for the following reason. The fact that nouns of a given case c can always be modified by forms syncretized between c and other values, and unsyncretized modifiers with case c can always modify nouns syncretized for c and other values, suggests that the required relation between noun and modifier is one of sharing similar values—equivalent on either the power set lattice or the double set lattice to the two values standing in an ordering relation. If either noun or modifier CASE value is identified with that of the NP, though, the prediction is that when the value identified with the NP's is syncretized, a more weakly-syncretized value on the other daughter may be “protected” from the verbal selection requirement—an accusative/genitive modifier, for example, might modify a genitive noun, even when the NP structure is governed by an accusative-selecting verb. No available evidence is consistent with this prediction, and much evidence suggesting otherwise is available, in German for syncretized nouns:

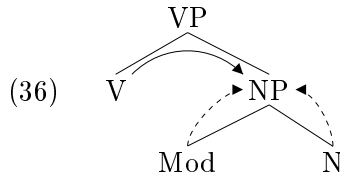
- (34) a. Er findet (die/*der) Frauen.
 He helps (the-ACC/*the-DAT) women.

- b. Er hilft (*die/der) Frauen.
 He helps (*the-ACC/the-DAT) women.
- c. Er findet und hilft (*die/*der) Frauen.
 OBJ.ACC OBJ.DAT *ACC/*DAT
 He finds and helps *the women

and in Polish, for a syncretized adjective:¹⁵

- (35) a. *? Maria kocha a Ewa nienawidzi tego
 Maria loves.OBJ-ACC but Ewa hates.OBJ-GEN this.ACC/GEN
 mężczyzny.
 man.ACC
- b. Maria kocha a Ewa nienawidzi tego faceta.
 Maria loves but Ewa hates this.ACC/GEN guy.ACC/GEN
 (Przepiorkowski, p.c.)

The relation between noun and adjective case is better conceived as a symmetric concord relation, structurally denotable as:



where nouns and adjectives are seen as mutually restricting the formal case value of the NP mother.

The question remains, what is this mutual restriction relation in formal terms? We saw before in Section 6.3 that the the join operator on the double-set lattice, double intersection, gives the proper results for restriction of coordinate mother case values by conjunct daughter noun phrases. We might assume that the mother node in a modifier-N' construction has a CASE value equal to the double intersection of the values of its conjunct daughters. This appears insufficiently restrictive, however. Example (13) shows that the presence in an NP of an adjective of a given case does not

¹⁵Since these examples are in different languages, the evidence I present here is, strictly speaking, still circumstantial. However, there is absolutely no evidence against the multilaterality of NP-internal case concord, and it is only a combination of morphosyntactic facts and apparent grammatical function restrictions on argument sharing that prevents the direct testing of the inverse in each of Polish and German.

prevent conjunction with an NP of different case, given the proper governing verb. However, each adjective must modify a noun of identical case, even in NP objects of a verb allows object case-marking alternation; contrast (13) with the following ungrammatical example:

- (37) *Včera vec' den' on proždal [_{NP} svoej podругu Irinu]
 yesterday all day he awaited self's-GEN girlfriend-ACC Irina.ACC
 i [_{NP} zvonka [_{PP} ot svoego brata Grigorija]]. (cf. (13))
 and call-GEN [from self's brother Gregory]

In this example, the genitive adjective *svoej* cannot appear modifying accusative *podругu*, even though the genitive case can appear in another conjunct NP object.¹⁶ If NP case were constructed using the double intersection operator on modifier and head noun case, this example would be admitted.

Instead, I take advantage of the fact that I have defined CASE values as sets, and model case values in the combination of nouns and modifiers with simple intersection, which is a more restrictive operator than double intersection on the lattice:¹⁷

- (38) The CASE value for the mother of a nominal head daughter and a modifier is the intersection of the CASE values of its daughters.

Reverting to the interpretation of double-set values as statements of logical content, intersection allows a weakening of propositional strength, but it does not permit the introduction of any new disjunctions.

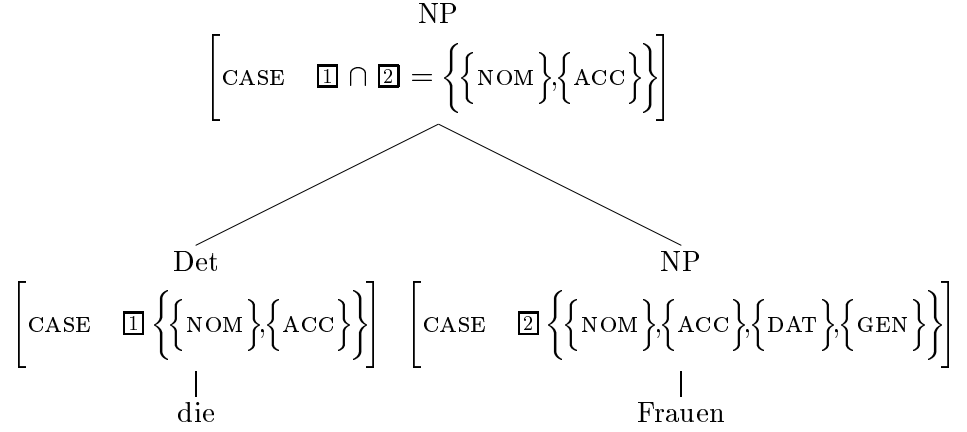
¹⁶The possibility that this is a property of adjectives rather than a property of NP syntax seems doubtful. It presumably would be possible in principle to conjoin unlike-case NPs consisting of adjectives without nouns; but this is in practice difficult to test, because using an adjective in a nounless NP seems to carry a strong connotation of definiteness, to which differential case marking is sensitive.

¹⁷I have considered an approach aiming to derive required concord between nouns and modifiers from *semantic* facts: multiple case values in NPs could only be licensed by verbs with differential case marking, and differential case marking seems always to be associated with differential semantics–definiteness, for example–of the marked NP. If we assume that the DEFINITENESS value must be the same between the adjective and the noun, then the identity of case value seems to follow.

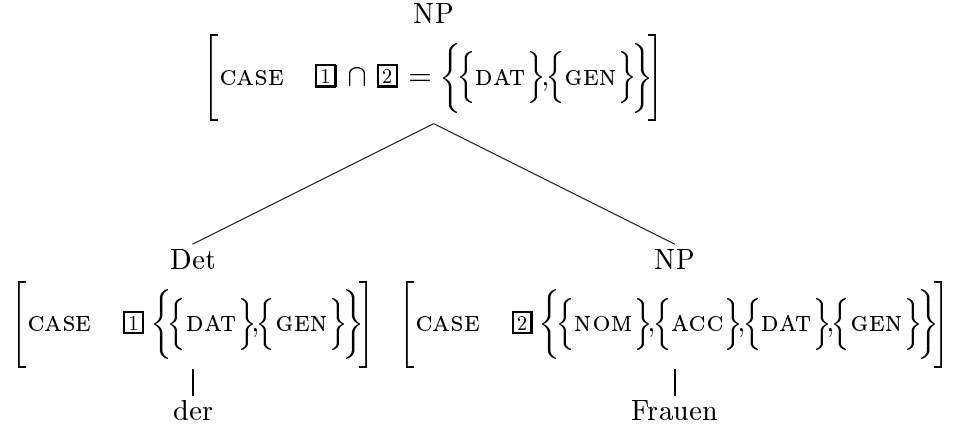
There are two problems with this approach. One is that its formal statement actually depends on a complex theory of correlation between selection on feature values (in this instance, case and definiteness) that is not yet worked out. Another is that, insofar as we are interested in the total well-typing of coordinate structures, the question of what the DEF value for the coordinate mother is, and how the possible values for conjunct daughters are restricted, need to be resolved, and they are fundamentally the same questions as we now face for CASE NP-internally.

We can now return to see why examples (34a) and (34b) are grammatical with one article, but (34c) is ungrammatical with any article.

(39) a.



b.



- c. i. *findet*: $\left[\text{ARG-ST} < \text{subj}, \text{NP}[\text{CASE } \boxed{2}] > \right] \wedge \boxed{1} \geq \left\{ \left\{ \text{ACC} \right\} \right\}$
 ii. *hilft*: $\left[\text{ARG-ST} < \text{subj}, \text{NP}[\text{CASE } \boxed{1}] > \right] \wedge \boxed{1} \geq \left\{ \left\{ \text{DAT} \right\} \right\}$

With these specifications, Example (39a) can function as the object of *findet*, but not as the object of *hilft*. Example (39b), on the other hand, can function as the object of *hilft* but not of *findet*. And neither one suffices for both $\left\{ \left\{ \text{ACC} \right\} \right\}$ and $\left\{ \left\{ \text{DAT} \right\} \right\}$, so (34c) is ungrammatical with either article.¹⁸

¹⁸The proposal here makes the unorthodox prediction that the ungrammaticality of NPs with completely unmatching case values is always a property of external selection, since the intersection of unmatching values will be the empty set, which is not undefined on the lattice. It is unclear, however, whether environments unselected for case exist, making this prediction difficult to test.

In using the standard intersection operator for NP-internal syntax, instead of the double-intersection operator used for coordination, I am claiming that the relation among nouns and their modifiers is symmetric and multilateral, but more restricted than the the relation among conjuncts of a coordinate NP, whose similarity is mandated only by external constraints shared by all conjuncts. In particular, combination within a noun phrase can weaken logical content by eliminating one or more members of a conjunction, but it can never introduce a new disjunction. It might be instructive to translate such a proposition into CG terms used by Morrill (1994): my proposal is equivalent to saying that nouns and their modifiers syntactically combine under similar conditions as occur for coordination; however, during the process of noun-modifier combination, while Meet Elimination is permitted, Join Introduction is never allowed. This is in sharp contrast to the typical CG approach, where modifiers and nominal categories are taken to have the same asymmetric functor/argument relation as nouns and verbs. In the HPSG approach I advance here, it is possible to build up NP-internal semantics treating modifiers as functors in CG style, while allowing multilateral relation among strictly syntactic features.

10 Discussion

The work presented here can be seen as a clarification of the work necessary to fully account for the coordination pattern expressed by (2) within a constraint-based theory such as HPSG, and as the first step toward such an account. It sketches an alternative to the account of coordination in LFG (Kaplan and Maxwell, 1988), where alternative modeling conditions are assumed for coordinate structures, and further developed in Dalrymple and Kaplan (2000), where feature indeterminacy on inherent values is modeled with sets of symbols.

One result of particular significance for HPSG is that the lattice structure required for an account of feature indeterminacy and the coordination of unlikes, as a joint phenomenon, cannot be integrated directly into a sort hierarchy. On the double-set lattice, selecting values and inherent values are ordered with respect to each other, and ordered in opposite directions. As presented here, the double-set lattice is an ordering on atomic values, independent of the sort hierarchy. This preserves the HPSG modeling assumption that linguistic structures are *sort-resolved* (Pollard and Sag, 1994). If the structure of the double-set lattice were to be integrated into the sort hierarchy directly, this modeling assumption could not be maintained.

Although Dalrymple & Kaplan rely essentially on the powerset ordering for treatment of feature indeterminacy, the problem of the coordination of unlike cases appears to be avoided by the distinct mechanisms modeling coordination in LFG, in which a unique coordinate mother functional structure does not exist for a set of conjunct daughter f-structures, but rather constraint satisfaction is determined independently for each daughter. For features such as number and person, which uniquely *resolve* in coordination, on the other hand, D&K permit unique specification in a “hybrid” f-structure consisting of attribute-value pairs and a set of conjunct f-structure daughters. The model I present here can in some sense be seen as an alternative to this approach, rather “precompiling” all information from all conjunct daughters into a unique coordinate mother with similar feature geometry. In principle these two proposals may lead to differing predictions, although it appears that current evidence is neutral.

The problem of case concord within the NP appears previously unaddressed. The account here takes advantage of the fact that intersection remains well-defined on the double-set lattice, and directly encodes the crosslinguistic generalization that case concord is a symmetric, not hierarchical, relation. This appears to be quite troublesome for the Lambek Categorical Grammar approach under which adjectives and similar modifiers are functors of the form N/RN , and the case value visible to the verb will be that presented by the outermost modifier. For example, an adjective that is syncretized for accusative and genitive case cannot license an accusative noun when the governing verb selects for the genitive case, as seen in (35), and it is unclear how an approach such as Bayer (1996) or Bayer and Johnson (1995) might account for this fact, aside from assuming a proliferation of lexical entries for syncretized adjectives. This also appears to be an issue for the LFG approach, although it should be addressable by slightly changing

the lexical specification of case for syncretized nouns and adjectives.¹⁹

Finally, a few words are necessary regarding the syncretization of correlations of feature values. As Dalrymple and Kaplan show, German VPs with nonconstituent-coordinated complements and verbforms ambiguous between third-person singular and second-person plural (such as *kauft*) may be analyzable as cases of feature indeterminacy, which appears to be the correlation of multiple feature values.²⁰ However, they appear to be too hasty in their conclusion that Bayer & Johnson’s LCG account cannot handle such a case. While B&J’s feature system allows for the reassociation of categories with assertions $(A \wedge B) \wedge (C \wedge D)$ to $(A \wedge D) \wedge (C \wedge B)$, the relevant assertion for the German verbform case would be one of form $(A \wedge B) \vee (C \wedge D)$, which does not reassociate. Furthermore, the corresponding problem of reassociation is also present in D&K’s account, since a mechanism to neutralize inherent values is only given for individual features, and not arbitrary correlations of values for multiple features. If a given lexical entry includes both formulae $(\uparrow A = \{w, x\})$ and $(\uparrow B = \{y, z\})$, for example, then any correlation between w and y , for example, is lost.

In terms of the system presented here, the German verbform correlation could be handled by allowing the construction of double-set lattices over the set of totally well-typed, sort-resolved feature structures permissible for a non-atomic-valued feature, such as HPSG’s INDEX, rather than constructing lattices only on the set of values for an atomic feature. If this were done, German verbs such as *kauft* could be specified as setting a lower bound on

¹⁹One specific set of changes that would account for NP-internal concord facts would be to change noun and modifier lexical entries from the form

$$(\uparrow \text{CASE}) = X$$

to the form

$$X \subseteq (\uparrow \text{CASE})$$

with a simple identity requirement on modifier and noun CASE values in f-structure. To avoid the problem of spurious ambiguity, an ordering on the powerset lattice must be imposed, to which the LFG conception of minimal satisfying solution must be extended.

Note that the coordination of unlike-case NP objects follows as a special case of the Kaplan and Maxwell (1988) approach to the coordination of unlikes; the Russian verb *ždat’* would under this approach have the partial lexical entry

$$(\text{ACC} \in (\uparrow \text{OBJ CASE})) \vee (\text{GEN} \in (\uparrow \text{OBJ CASE}))$$

A possible merit to this extension of Dalrymple & Kaplan’s approach is that the constraint of unique case value within non-coordinate NP conjunct daughters falls out automatically from the representation of coordinate structures.

²⁰See Maxwell and Manning (1996) for an LFG model of nonconstituent coordination.

their subject’s INDEX value of:

$$(40) \quad \left\{ \left\{ \begin{array}{l} \text{NUM PL} \\ \text{PER 2} \end{array} \right\}, \left\{ \begin{array}{l} \text{NUM SG} \\ \text{PER 3} \end{array} \right\} \right\}$$

To pursue such an account would have the interesting consequence that feature geometry could be used to encode possible selectional and inherent indeterminacies among correlated values—if, for example, double-set lattices were taken for CASE and INDEX values, but not for the mutually dominating node in feature geometry.²¹

It is unclear whether this putative role for feature geometry is justified, however; there is at least one example that casts doubt on it, but it is an example that casts doubt on the whole family of approaches discussed here. In Zaenen and Karttunen (1984), the following example from Finnish illustrates the apparent indeterminate use of a correlation between number and case marking on nouns:

- (41) He lukivat hänen uusimman ja me hänen parhaat
 They read his newest.SG.GEN and we his best.PL.NOM
 kirjansa.
 books.

As Zaenen & Karttunen discuss, the noun form *kirjansa* is syncretized between singular nominative, singular genitive, and plural nominative. The above example shows that this form can be used simultaneously for the latter two specifications. To treat this sentence syntactically with the tools for coordination and indeterminacy discussed here, the conjunctive specification (NUM SG) \wedge (CASE GEN) must alternate at least with the specification [CASE NOM], in either the sense of alternation as indeterminate inherent value, or in the sense of alternation as a disjunctively-specified selecting value. The latter would seem unnatural for the treatment of case and number on a noun, and the former, under the LCG and LFG proposals reviewed in this paper, would lead—presumably incorrectly—to the reassociatability of plural number with the genitive case.

To demonstrate that this truly is an indicator of the empirical inadequacies of previous proposals regarding indeterminacy and the coordination of

²¹Another possible approach to the correlation of feature values is to assume that the set \mathcal{B} over which the double-set lattice is defined is the set of *paths* to atomic feature values from a given node in feature geometry. This permits the correlation of arbitrary feature clusters beneath that node, but leads to the same problems with correlated indeterminacy as discussed below.

unlikes, further work is necessary to verify that (a) the distribution of this class of coordination in Finnish is broad enough to demand a treatment in syntax; and (b) whether it can be shown conclusively that either number or case in Finnish need be treated as indeterminate for independent reasons (for example, if examples exist analogous to Polish *kogo* (3)). It is possible that the structure of the double-set lattice presented here can be integrated into an HPSG-style feature geometry in a way such that these putative empirical inadequacies can be avoided. Further work will focus on these two issues.

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