

Constituent Coordination in LFG

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(supersedes "The Rudiments of Coordination in LFG")

In this paper I will present an analysis of constituent coordination within the grammatical theory of Lexical-Functional Grammar (LFG) developed in Bresnan (1982). We will see that the principles of LFG provide a reasonable account of many of the basic properties of this kind of coordination, although I will suggest certain modifications of the theory to accommodate the 'Across-the-Board' (ATB) effects that are among the most salient properties of these constructions.

In section 1. I will develop the basic principles that govern coordination of 'complete' constituents (those whose f-structure correspondents are fully determined by the contents of the constituent itself) without ATB effects. In section 2. I will consider coordination of incomplete constituents (such as VP, AP or predicate NP), and develop a basic theory of ATB effects. Finally in 3. I will discuss the problem of extending the theory to accommodate 'constituent control' phenomena.

1. Complete Constituent Coordination: An informal description of the form of a coordinate structure might be that it consists of one or more conjuncts without an overt conjunction, followed by one or more conjuncts with one. With two conjuncts we thus get the pattern of (1); with three, the two of (2); with four, the three of (3):

- (1) Bill and Mary
- (2) a. Bill, Ted and Mary
 - b. Bill and Ted and Mary
- (3) a. Bill, Ted, Mary and Alice
 - b. Bill, Ted and Mary and Alice
 - c. Bill and Ted and Mary and Alice

We can formulate this observation in a pre-theoretical way by writing a coordinate structure rule (4), where subscript 'c' stands for a constituent of type X with a conjunction attached, and subscript '1' indicates one or more occurrences of the subscripted item:

$$(4) \quad X \rightarrow (X)_1 (X_c)_1$$

The fact that a conjunct may itself be a coordinate structure provides for various possibilities beyond those of (1-3), which will be discussed and constrained below.

These slightly asymmetrical constituent structures must be mapped onto f-structures that capture the following essential points: (a) the conjuncts of a coordinate structure are ~~essentially~~ on an equal footing with respect to each other (b) they constitute a unit which may have certain grammatical properties (such as number) distinct from those of any of its members (c) the choice of conjunction determines the semantic operation applied to the readings of the conjuncts to determine the reading of the whole.

To address (c), we wish the conjunction to introduce a PRED, which takes as argument something provided by the conjuncts. (b) will be addressed if each conjunct corresponds in f-structure to a distinct part of the argument (of the PRED of) the conjunction. (a) will be addressed if the argument of the conjunction is a set of f-structures, each member of the set being the f-structure correspondent of one of the c-structure conjuncts.

Since the GF borne by the argument of a conjunction has a number of special properties, we will give it a special name, 'COORD'. We can now produce an f-structure for (1) in accord with the above criteria:

$$(5) \quad \left[\begin{array}{l} \text{PRED} \quad \text{'AND<(\uparrow \text{COORD})>'} \\ \text{COORD} \quad \left\{ \begin{array}{l} [\text{PRED} \text{'Bill'}] \\ [\text{PRED} \text{'Mary'}] \end{array} \right\} \end{array} \right]$$

How can we get such structures by an annotation of something like (4)?

Consider first the conjunctionless conjuncts. These obviously have to be introduced explicitly as members of the COORD, that is, annotated with ' $\downarrow \in (\uparrow \text{COORD})$ '. What then, of those with conjunctions? Since the conjunction is providing the PRED, they must be annotated with ' $\uparrow = \downarrow$ '. Then to introduce the conjunction itself we will need a second schema expanding a category to a conjunction and an instance of the same category, annotated with ' $\downarrow \in (\uparrow \text{COORD})$ '. The required rules may be formulated as in (6):

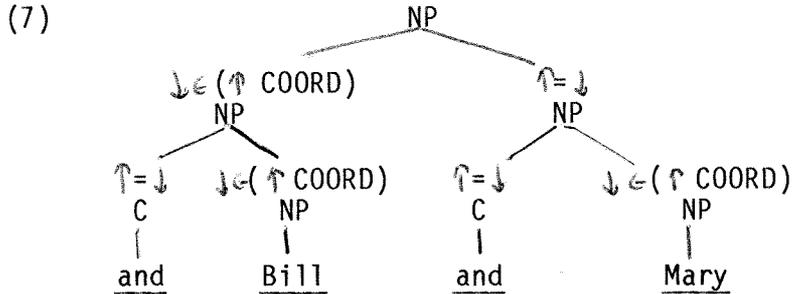
$$(6) \quad \begin{array}{l} \text{a. } X \rightarrow \begin{array}{cc} (X)_1 & (X)_1 \\ \downarrow \in (\uparrow \text{COORD}) & \uparrow = \downarrow \end{array} \\ \text{b. } X \rightarrow \begin{array}{cc} C & X \\ \uparrow = \downarrow & \downarrow \in (\uparrow \text{COORD}) \end{array} \end{array}$$

Without further conditions, these rules will overgenerate grossly. The main problem is that we will be able to introduce an NP (or other constituent type) whose PRED is a conjunction and which as a single member for its COORD, e.g. and Jack in *and Jack left.

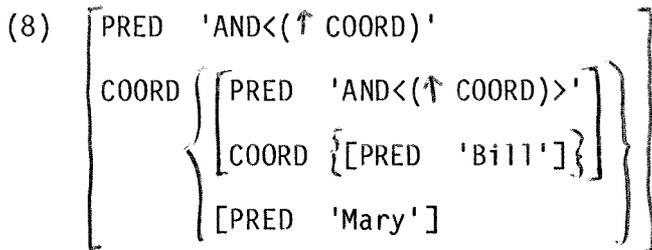
To rule this out, I propose a (rather natural) condition that the argument of a conjunction must be a non-singleton set. This could be treated either as a property of the 'COORD' function, or of the PREDs associated with the conjunctions.

Excluding singleton arguments of conjunctions will rule out most of the overgenerations produced by (6). For example, we will not be able to get *and Bill and Mary by illegitimately expanding both conjuncts with

(6b):



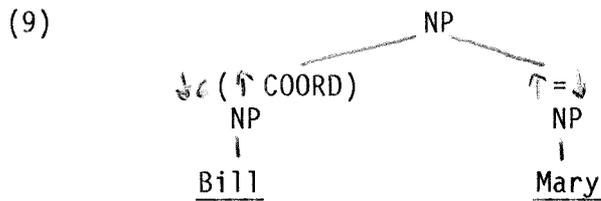
This annotated c-structure will lead to the f-structure (8):



(8) contains a conjunction with a singleton argument, violating the constraint.

Conjuncts introduced by the first component of (6a) cannot thus be expanded by (6b) (though they may themselves be full coordinate structures, as in Tom and Mary, Bill, and Alice). For the same reason, the constituent introduced by (6b) cannot itself be expanded by (6b).

Suppose on the other hand that the NP introduced by the second component of (6a) were not expanded by (6b), as in the ungrammatical *Bill, Mary:



Here we obviously get an f-structure that makes no sense, since there will be no PRED that takes a COORD argument.

A third pathological possibility that is ruled out is that of structures such as *Fred and Bill, Mary, where the last two conjuncts are introduced by the second component of (6a) (annotated with ' $\uparrow = \downarrow$ '), but the last is not expanded by (6b). Here the problem is that we will get an f-structure with two conflicting PREDs; the PRED of the conjunction, and the PRED of Mary.

The role of PRED conflict in excluding bad outputs reveals a minor problem: how can we provide for structures in which the conjunction appears twice (Bill and Ted and Mary). Assuming that each conjunct introduces a PRED, the structure will be incorrectly ruled out by the convention of PRED instantiation (each PRED value, upon introduction, receives a unique index). This convention prevents PREDs from being introduced in two places at once, as is often necessary. In this instance however, it seems that we must allow rather than block multiple introduction of a PRED.

This problem has a straightforward solution: the equations introducing the PRED feature of conjunctions can be interpreted either as defining or as constraining equations:

- (10) a. [and, C, (\uparrow PRED) = $\langle_C \rangle$ 'AND $\langle(\uparrow$ COORD) \rangle ']
 b. [or, C, (\uparrow PRED) = $\langle_C \rangle$ 'OR $\langle(\uparrow$ COORD) \rangle ']

To get a well-formed f-structure from Fred and Susan and Mary we take one of the PRED equations as defining, the other as constraining (it doesn't matter which). Note that in terms of efficient computational

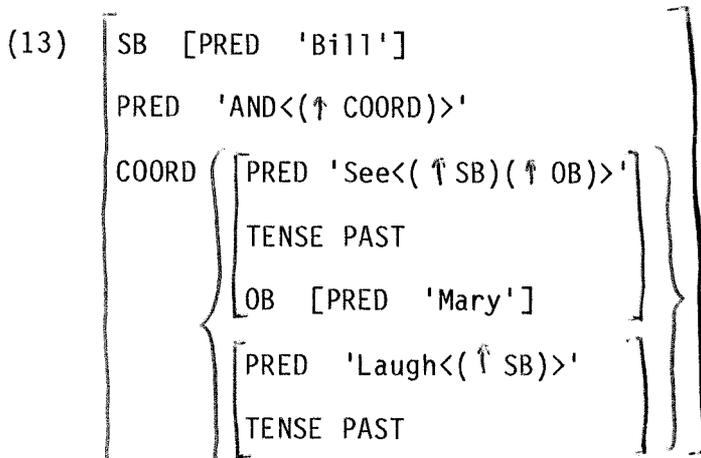
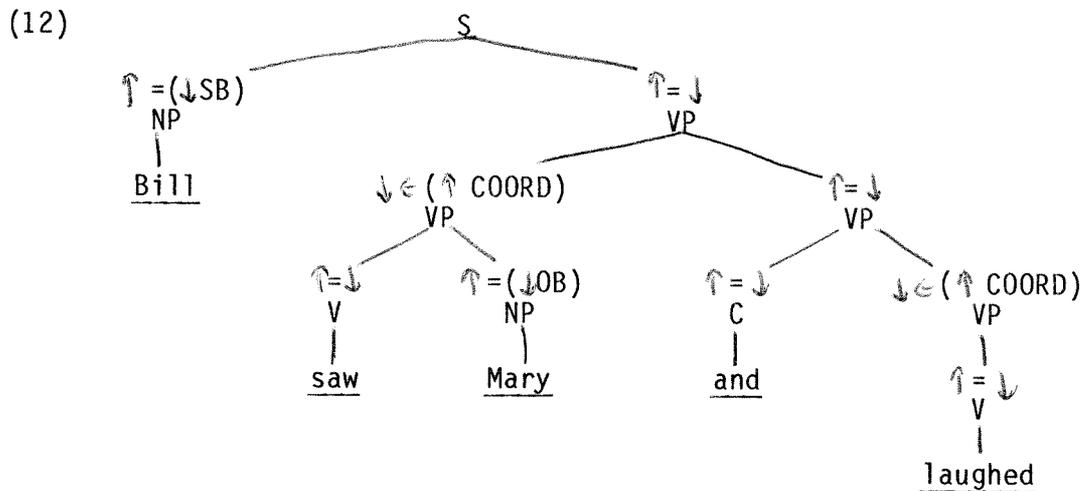
implementation, such defining/constraining equations can be easily processed by treating them as defining, but omitting the PRED index, so that no problem will arise if a defining equation introducing the same PRED is also encountered. The PRED equations of the conjunction enforce the 'agreement' condition that the same conjunction (if any) must be introduced by all the conjuncts of a coordinate structure.

The reader may have to experiment further to convince himself of the fact, but at this point we have accumulated enough machinery to produce more or less correct instances of complete constituent coordination, conforming to the pattern of (4). The main issue I have been silent about is the interpretation of the category symbol 'X' in the phrase-structure rule (6). The usual understanding would be that 'X' represents any combination of category and level features, so that a coordinate structure of a given category and level consists of conjuncts of that category and level. There seems little reason to doubt these claims insofar as levels are concerned, but Peterson (1981) has adduced numerous examples in which it appears that constituents of different categories are being conjoined:

- (11) a. Fred found Mary awake_{Ap} and demanding breakfast_{vp}.
 b. Jack is in his office_{pp} and eager to work_{Ap}.

While I will not attempt to draw any definitive conclusions from these examples at this point, they clearly suggest that the members of a coordinate structure may in fact belong to different major categories.

2. Incomplete Constituent Coordination: Consider now the problem of coordinating 'incomplete' constituents, such as VP or AP, which typically do not contain the c-structure correspondents of all of their functional parts. Consider a simple example such as Bill saw Mary and laughed, assuming that it is an S with a single subject and a conjoined NP. Under our assumptions so far, the annotated c-structure will be (12), the resulting f-structure (13):



(13) is not a well-formed f-structure because it is both Incomplete (the SB does not serve as argument of anything) and Incoherent (the PREDs of the two verbs demand SB's but don't get them).

The cure for this is clearly to make the SB of the whole coordination the SB of each of its conjuncts. One way of formulating this is as a principle of 'functional expansion': after the solution algorithm has solved for the minimal solution to the f-description of the c-structure, suppose that certain principles can apply to add

additional material to the f-structure (but not so as to contradict anything already done). The principle relevant for coordinate structures might be roughly as follows:

(14) ATBP(LFG):

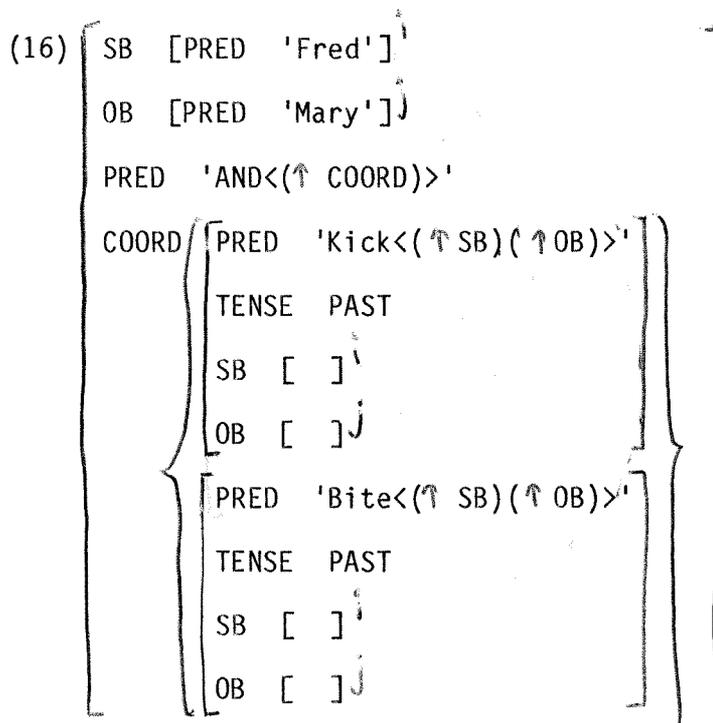
If f has a value for COORD, let $(f \text{ GF}) = (g \text{ GF})$ for all g (f COORD), for certain GF.

We leave unsettled for the moment the question of which GF's are those that obey the principle. Assuming that SB is one of them, the principle will assign the SB of (13) to be the SB of each of the members of the COORD of (13), yielding (15):

(15) $\left[\begin{array}{l} \text{SB [PRED 'Bill']} \\ \text{PRED 'AND<(\uparrow \text{COORD})>'} \\ \text{COORD } \left\{ \begin{array}{l} \text{[PRED 'See<(\uparrow \text{SB})(\uparrow \text{OB})>'} \\ \text{SB []} \\ \text{TENSE PAST} \\ \text{OB [PRED 'Mary']} \end{array} \right\} \\ \left\{ \begin{array}{l} \text{[PRED 'Laugh<(\uparrow \text{SB})>'} \\ \text{SB []} \\ \text{TENSE PAST} \end{array} \right\} \end{array} \right]$

(15) is complete and coherent, and would seem to determine the appropriate semantic interpretation.

The ATBP(LFG), applying to the appropriate grammatical functions, will also permit coordination of transitive verbs, as in Fred kicked and bit Mary, which will receive the f-structure (16):



We now face the problem of determining which grammatical functions are shared between a coordinate structure and its conjuncts.

A coordinate NP will obviously often differ in number from its conjuncts, and likewise in gender, in languages that have grammatical gender. In Icelandic, for example, agreement facts reveal that if a pair of nonhuman NP are coordinated, one of masculine gender, the other of feminine gender, the coordinate NP has neuter gender:

- (17) bíllinn og rútan eru ónýt eftir árekstur
 masc.nom.sg fem.nom.sg p; neut.nom.pl
 the-car the-bus(interurban) are useless after collision
 'The car and the bus are totalled from a collision.'

(for coordination of human NP the gender of the coordinate is determined by the semantic rather than the grammatical gender of the conjuncts). The coordinate NP is also plural, as indicated by agreement on the copula and the adjective.

Case, on the other hand, is shared between a coordinate NP and its conjuncts: both components of the subject of (17) are nominative, which is the case one would expect the entire NP to have.

It would clearly be essentially ad-hoc to try to build into the ATBP some kind of specification of which grammatical functions undergo it and which don't. I will instead propose that as far as the principles of coordination per se are concerned, (14) can apply optionally to any grammatical function. It 'obligatorily' derives (15) from (13) because (13) itself is a ill-formed f-structure. On the other hand, were it to attempt to apply with respect to grammatical gender in the f-structure of the subject of (17), the result would violate the consistency principle, since the two conjuncts differ in grammatical gender.¹ To implement this general idea, we need to propose principles, hopefully independently motivated ones, that will cause the ATBP(LFG) to apply or not as required.

It should be clear that this will work out well for governable functions. Generally speaking, if (14) fails to apply with a governable function, the resulting structure will be Incomplete and Incoherent. There is in fact a strengthening of the Incoherence constraint which helps (14) to exclude certain kinds of bad sentences. Consider an example such as *Mary kicked and laughed Bill. On the ordinary understanding of the Incoherence condition, it might be possible to generate this sentence by treating kicked and laughed as a coordinate V. The ATBP(LFG) would establish Bill as the OB of both the conjuncts. One might propose that the structure should not be rejected by the Incoherence constraint on the basis that the f-structure correspondent of Bill does serve as an argument in the overall f-structure, even though it doesn't in the substructure whose PRED is 'DANCE<(↑SB)>'.¹

We can avoid this problem and exclude the offending sentence by interpreting the Coherence constraint to mean that each substructure of an f-structure must satisfy the Coherence constraint individually. This understanding of the constraint will automatically entail that if any governable GF acquires a value in a coordinate structure, the ATBP(LFG) will have to apply, since the structure will otherwise be Incoherent regardless of circumstances elsewhere in the f-structure of the containing sentence.

Turning to case, the exact means that are used to enforce 'case-agreement' between the members of a coordinate structure will depend on the details of the theory of case-marking we are working with. One possibility (developed from the analysis of Icelandic case given in Andrews (1982)) is that case is introduced by defining equation on nominals, and checked by conditional constraint equations associated with various configurations of grammatical relations. There is furthermore a default condition that if case is not required to appear on an NP by some case-marking principle, case must not appear on that NP, so that the NP appears in the unmarked 'default' case for the language in question.

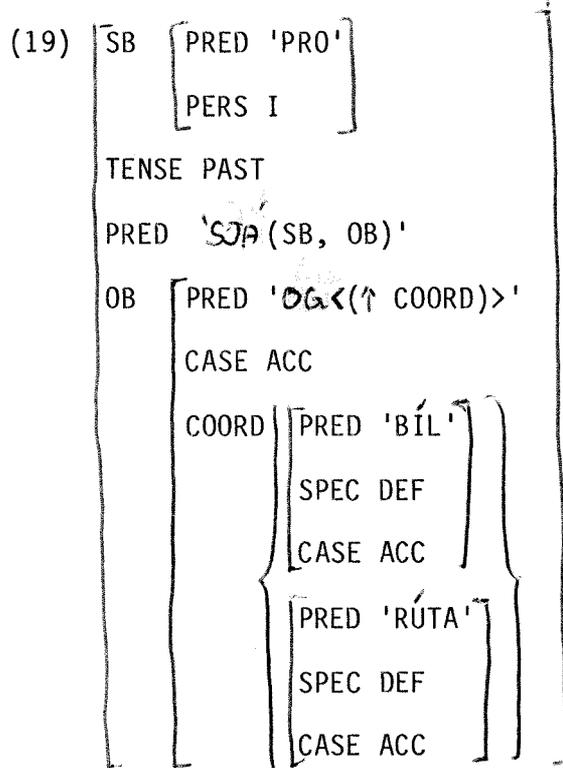
In Icelandic, I argue that nominative is the default case, and that the major case-marking rule is that Objects and Second Objects must be accusative, if the subject satisfies certain conditions, which are irrelevant here. Consider then a sentence such as (18):

(18) *ég* *sá* *bílinn* *og* *rútuna*
 acc acc

I saw the-car and the-bus

Why must the objects of the verb be accusative?

Suppose they weren't. Then there might be no way for the whole coordinate NP to become accusative, and for the case-marking constraint that objects be accusative to then be satisfied. On the other hand, when the two conjuncts are accusative, the ATPB(LFG) can apply, producing an f-structure like (19):



Now consider a sentence like (17), where coordinate NP is subject, an environment that is not explicitly mentioned in any case-marking rule, and which therefore requires the default (nominative) case. If, say, accusative case appeared on both of the conjuncts, and the ATPB(LFG) applied, the sentence would presumably be bad for the same reason that any sentence with an accusative subject would be (excepting sentences with certain verbs that lexically select accusative subject, as discussed at considerable length in Andrews (1982)). But suppose a non-default case appeared on one or both of the conjuncts, and the ATPB did not apply.

The result would still be reasonably taken as bad, since the environment 'conjunct of a coordinate NP' is presumably not mentioned in any specific case-marking rule and therefore might be expected to require the default case. But then why doesn't this principle apply to rule out (18), which also has accusative in this environment?

^ The answer, I suggest, is that in (18) the two accusatives^{symbols} in the 'bad' environments are saved by being merged and 'raised' into the higher structure, where they are in an appropriate case-marking environment. It is clear that the f-structure solution algorithm must record when two bits of f-structure have been declared equal, and distinguish the resulting necessarily equal values for GF's of various bits of f-structure from accidentally equal values (that might arise and exist temporarily in the course of the solution algorithm). There is no reason why the required facility (which might be implemented by retaining one or all placeholders under merger) should not apply to grammatical feature values, and play a role in the operations of constraints such as the proposed conditions on case-marking.

There are of course various other possibilities that one might consider here, some of which might prove more adequate. But his discussion should suffice to show that there is no insuperable difficulty with case in this analysis.

Gender and number pose a rather different set of problems. Although I will not attempt a full solution here, it is worth discussing the main implications of the phenomena. Consider first number.

In every language I have encountered, the number of an coordinate NP with and or an equivalent is determined as the arithmetic sum of the numbers of the constituent conjunct NP. So if a language has singular, dual and plural numbers, and one coordinates two singulars, the result is

dual. On the other hand if a language has only a singular and plural, the result of coordinating two singulars is plural. The principle thus seems to be that number is assigned semantically to a coordinate NP (at least one in and): for the purposes of number agreement, one treats the coordinate NP as if it were a pronoun referring to its referent.

Suppose that this behavior of number agreement is part of universal grammar. Then LFG must contain some mechanism^s for depositing the appropriate grammatical number features on coordinate NP (though I am presently unclear as to what ~~they~~ should be). These principles will furthermore prevent the application of the ATBP in the cases where its application would make a difference: if, for example, the singular number of two singular NP were hoisted up onto the f-structure of the whole coordinate NP, the principle would be violated. Making the ATBP optional allows this not to happen, and heads off a potential contradiction between the ATBP and the number-marking principle.

~~This treatment seems formally reasonable as far as it goes. The missing ingredient, for which I must issue a promissory note, is some mechanism for depositing number features on coordinate NP in accord with the semantics.~~

The treatment of gender is typically more complex. One basic principle is that if the conjunct NP have the same gender, their coordination also has that gender, while if there is a conflict, the coordinate NP is neuter. The latter case is exhibited in (17) above, the former by (20) below:

- (20) rútan og flugvélin eru ónytar eftir árekstur
 fem.nom.sg fem.nom.sg pl fem.nom.pl
 the-bus and the-plane are useless after collision

But there is an additional complexity in that if the NP has human reference, the gender of the coordinate NP is determined by the semantic ('natural') rather than the grammatical (inherent lexical) gender of the conjuncts.

This has noticeable effects in Icelandic because the linkage between grammatical and semantic gender is rather weak in Icelandic: there are a number of grammatically masculine words which can or must refer to women (of which the most flagrant is perhaps kvenmadur 'woman'), and likewise a number of grammatically feminine words that normally refer to males. The grammatical gender is reflected not only in the declension of the nouns in question, but in their behavior under agreement, including predicate adjective agreement:

- (21) a. kvenmadurinn er ólettur
 masc masc
 the-woman is pregnant
- b. löggan er leiddinleg
 fem fem
 the-cop is tiresome

The subject in (21a) must be female, while that in (21b) can (and usually would) be male.

But if human NP are coordinated, it is the semantic rather than the grammatical gender of the conjuncts that determines the gender (as manifested by agreement) of the result:

- (22) a. fulltrúinn og vörubílsstjórinn eru skemmtilegar
 masc masc fem
 the-delegate and the-truckdriver are amusing.
- b. löggan og fyllibyttan eru leidirlegir
 fem fem masc
 the-cop and the-drunk are tiresome

(22a), with a feminine adjective, is what one would say if the delegate and the truckdriver were female, even though both of the conjuncts are grammatically masculine. Likewise, (22b), with a masculine adjective, is what one would say if the cop and the drunk were male, even though the conjuncts in this case are grammatically feminine. Furthermore, if the referents of the conjuncts in either example were of different sex, the predicate adjective would be neuter.

The principles for dealing with gender in coordinate NP are complex, and vary considerably from language to language (see Corbett (XXXX) for a typological review). Although I have not presented a theory of such principles here, the discussion demonstrates three points:

- a) The ATBP may be prevented from clashing with the gender principles by making it optional.
- b) The gender principles may be treated as part of the process of 'functional expansion' discussed above, whereby material is added to an f-structure that is not supplied by the defining equations provided by the c-structures.
- c) Some kind of access to the semantics seems to be involved (as is also the case with number).

As a final observation, I will point out that it may be that we should regard the ATBP as not quite optional, but instead as obligatory unless it produces an output that is bad according to some other principle.

This might be formulated by proposing that an f-structure \underline{f} is blocked from being assigned to a c-structure \underline{c} if there is another well-formed f-structure that is consistent with the f-description of \underline{c} and derived from \underline{f} by the ATBP(LFG). Gender marking of nonhuman coordinate NP in Icelandic would follow entirely from this principle, if masculine and feminine are treated as mutually contradictory values of a gender feature GEND, and neuter is treated as an unmarked value of that feature, represented by the absence of a GEND value in f-structure (see Andrews (198b) for discussion of this analysis).

For the ATBP(LFG) could only apply to a coordinate NP if the conjuncts had the same value for GEND, and then it would have to apply, as seems appropriate. If the conjuncts had different GEND values, the ATBP could not apply, and the coordinate NP would receive no GEND value, and would therefore be neuter. It remains to be seen whether this sort of analysis will be able to be extended profitably to other sorts of systems (the decomposition of grammatical features into binary features, perhaps along the lines of Andrews (1983), would be an essential concomitant of such an extension, I believe).

3. Constituent Control and the ATBP: It has long been known that if one conjunct of a coordinate structure contains an element that is under constituent control from outside the coordinate structure, all conjuncts must contain such an element (with the apparent exception of certain constructions, such as the liquor which John went to the store and bought, which are generally regarded as not being true instances of coordinate structures). Indeed, the term 'across the board' was first used in connection with this effect (Ross, somewhere(?)). It would be desirable to integrate its explanation with that of the f-structural across-the-board effects discussed above.

To see how this might be done, consider the nature of the f-structure of a typical violation of the coordinate-structure constraint, such as Which carton did Cindy open and Jimmy dump the toys onto the floor?. Which carton will become a substructure in the first conjunct, but not of the second. This in and of itself is clearly not enough to rule the sentence out, but it has a further property, that one of its non-shared substructures also bears a GF outside of the conjunct (since which carton is the Q-FOCUS of the whole S. We can rule out this structure with a constraint such as the following:

(23) ATBP(LFG) version II:

Let \underline{x} be a substructure of \underline{y} , for $\underline{y} \in (\underline{z} \text{ COORD})$. If \underline{x} bears a GF to \underline{w} , where \underline{z} is a (not necessarily proper) substructure of \underline{w} , then \underline{x} must be a substructure of \underline{y} for all $\underline{y} \in (\underline{z} \text{ COORD})$.

This admittedly rather complicated condition is to be interpreted as a filter on f-structures.

Observe that it will achieve part of the effects of the earlier formulation (14) of the ATBP(LFG), in that if something comes to bear a GF to a coordinate structure and to one of its conjuncts, it must come to bear that GF to all of the conjuncts (since any f-structure is a (non-proper) substructure of itself). What it will not do is perform the structure-building aspect of (14): it won't make something that bears a GF to a conjunct bear a GF to the containing coordinate structure, or vice versa. I suggest therefore that the process of 'functional expansion' be treated as formally distinct from the ATBP.

Given this interpretation of the ATBP, we can in fact treat functional expansion in coordinate structures as an aspect of c-structure annotation. Suppose that whenever a constituent is introduced with the annotation ' $\downarrow \leftarrow (\uparrow \text{COORD})$ ' we can optionally add the annotation ' $(\uparrow \text{GF}) = (\downarrow \text{GF})$ ', for any GF. This would not have worked previously, because there was nothing to assure that the same GF's be mentioned for each of the conjuncts of a coordinate structure. But our second version of the ATBP will properly constrain this kind of optional annotation.

Although the new version of the ATBP is more complicated than one might hope, it has it to its credit that it seems to reduce the extent to which we need to extend the basic mechanisms of LFG to deal with coordinate structures. I shall therefore rest content with it for the present.