Coordination and constituency

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2 Flexibility

2.1 Introduction

In chapter 1 I have argued that a transformational approach to coordination phenomena is problematic, because transformations should act on constituents. As we have seen, the transformation Right Node Raising is neither a necessary nor a sufficient condition on constituency. In order to account for Right Node Raising and coordination phenomena in general, Zwarts (1986) suggested accounting for coordination phenomena and in general natural language syntax with a categorial grammar.

As we encountered in chapter 1, there is a wide variety of categorial grammars, ranging from the rigid AB-grammar, using only application rules, to the Lambek-calculus, a deduction system in which many other rules can be proved. In chapter 1, I presented proofs of among others the rules for Functional Composition and Type Lifting, as well as Associativity, the Geach Rule, Strong Composition, and Dekker's paradox. The Lambek-calculus is thus an extremely flexible system, in which it can be proved that two arbitrary adjacent expressions form a constituent. This is convenient for the analysis of coordination and especially Right Node Raising. In section 2.2, I will focus on coordination as an argument for flexibility. The examples I present, involve Forward Conjunction Reduction, Right Node Raising, and combinations of these rules. The conclusion is that these phenomena can, to a large extent, be accounted for by Functional Composition, Type Lifting and the Geach Rule. But, as we will see too, some coordinations still cannot be accounted for. The reason for this is the disharmonic structuring of the verbal group. A categorial account of verb clustering in Dutch will at least have to call on Disharmonic Composition, as we have seen in chapter 1.

This is one of the arguments against the flexibility we encounter in the Lambek-calculus. In chapter 1, we mentioned the fact, observed by Moortgat (1988), that adding Disharmonic Composition to grammars that already use Harmonic Composition and Type Lifting leads to permutation closure for all strings greater than two.[30] Of course, for languages with rigid word orders, like Dutch, such grammars are not suitable, and must be rejected. In section 2.3, I address this argument and other arguments to reject flexibility.

At the end of this chapter, I propose to build a grammar for Dutch which doesn't allow for the flexibility of the Lambek-calculus. In chapter 3, I will present a product-based applicative categorial grammar (PACG), which is less flexible where the admissibility of Functional Composition, Type Lifting and the Geach Rule is concerned. This PACG is, however, flexible in the use of Product Rules. We will even show that the universal system I propose is structurally complete. On the other hand, the flexibility induced by the PACG is harmless with respect to the arguments against flexibility, discussed in this chapter. It turns out that the PACG allows for conditions on categorial rules where necessary, for a clear view on constituency in categorial grammar, and for putting a restraint on overgeneration.

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30 Moortgat, however, notes that the permutation closure

> "(...) relies crucially on the validity of the Cut inference, i.e. on the transitivity of the derivability relation '⇒'. (...), the transitivity of '⇒' is a *derived* property of **L**: the Cut inference does not increase the set of provable theorems in the pure directional system, since any proof with cuts can be transformed into a cut-free derivation. Whereas the cut-free implementation of **L** and the alternative version with the Cut inference are extensionally equivalent, we see here that these implementations exhibit different properties when we consider extensions with **LP** theorems (...)"
> Moortgat (1988: 93)

So solutions for the LP collapse could possibly be found in a Cut free calculus, but Moortgat notes furthermore:

> "From a linguistic point of view, it will be clear that we do not want to give up Cut. The Cut inference (...) is the motor behind a bottom-up perspective on categorial derivations; working with a cut-free calculus would make this perspective unavailable."
> Moortgat (1988: 93)

2.2 Coordination as an argument for flexibility

2.2.1 Introduction

In chapter 1 we have seen that there is strong evidence that in phrase structure grammar the transformation Right Node Raising doesn't in general involve constituents. For this reason, the transformational approach was rejected. In this chapter, we will pay attention to an account of coordination phenomena in the Lambek-grammar. As we have discussed in chapter 1, besides the application rules, within the Lambek system the rules for Functional Composition, Type Lifting, and the Geach Rule are provable.

In this section, I will show that the problems that arise in the transformational account of coordination do not play a part in a categorial account of coordination. The reason for this is that categorial grammars, and especially flexible systems, show a more liberal view on constituent structure. In a Lambek-grammar it is even the case that the notion *constituent* has become void, because each two adjacent categories can form a constituent by Functional Composition and Type Lifting, exemplified in (1).

```
1.     a.   A              B                    b.          A              B
            |TL            |TL                              |TL            |TL
           C/(A\C)  (A\C)/(B\(A\C))          ((C/B)/A)\(C/B)  (C/B)\C
           |_______________|RC                          |______________|LC
              C/(B\(A\C))                                ((C/B)/A)\C
```

This is at the same time the strength and the weakness of this flexible approach. By lifting and composing the categories of the relevant expressions, we are able to deal with Right Node Raising examples which we couldn't account for in the transformational approach. At the same time, the flexibility of the system predicts that all sequences of expressions can be coordinated, because they must all be considered constituents. In section 2.3, we will discuss this matter more thoroughly. For the time being we will look on the bright side of life.

Coordination is such a common and general phenomenon, that one is inclined to suppose that all pairs of expressions of the same category are conjoinable. In section 2.2.2, a large variety of conjoinable expressions is presented. In section 2.2.3, we analyze coordination examples, where the conjuncts have a shared right part (the *Right Node Raising* examples). Furthermore, in section 2.2.4 we pay attention to examples where the conjuncts have a shared left part (the *Forward Conjunction Reduction* examples), and finally, in section 2.2.5, we discuss the examples, where the conjuncts have both a shared left part and a shared right part. In these three cases a flexible categorial grammar like the Lambek-calculus appeals to Functional Composition and Type Lifting.

2.2.2 Conjoinable expressions

From the examples below, we can see that many expressions can be coordinated. In example (2), two sentences are coordinated, in (3) two infinitivals, in (4) and (5) two finite verbs, in (6) two NP's, in (7), (8) and (9) a combination of a subject NP and a finite verb. Infinitivals and participles are distinguished by the subscripts (*i* for infinitivals, *p* for participles).

2. [$_{S}$Bobby wint] en [$_{S}$Boris verliest]
   Bobby wins and Boris looses

3. Anatoly kan [$_{VPi}$schaken] en [$_{VPi}$bridgen]
   Anatoly can play chess and play bridge

4. De grootmeester [$_{NPs\backslash(S/NP)}$beschermt] en [$_{NPs\backslash(S/NP)}$verdedigt] zijn koningsstelling
   The grandmaster protects and defends the position of his king

5. Garry [$_{NPs\backslash(S/VPi)}$moet] en [$_{NPs\backslash(S/VPi)}$zal] winnen
   Garry must and will win

6. [$_{NPs}$De grootmeester] en [$_{NPs}$de amateur] hebben de partij geanalyseerd
   The grandmaster and the amateur have analyzed the game

7. [$_{S/VPi}$De grootmeester wil] en [$_{S/VPi}$de amateur zal] de partij analyseren
   The grandmaster wants to and the amateur will analyse the game

8. ? [$_{S/VP_p}$De grootmeester heeft] en [$_{S/VP_p}$de amateur heeft] verloren
The grandmaster has and the amateur has lost

9. [$_{S/VP_p}$De grootmeesters hebben] en [$_{S/VP_p}$de amateur heeft] verloren
The grandmasters have and the amateur has lost

Sentence (8) is less acceptable because of the repetition of *heeft* (has). This repetition doesn't allow the expression to get main stress, while RNR demands that this expression get main stress. If we can replace one of the occurrences of *heeft* by the plural form *hebben* (to have), then the sentence is beyond any doubt grammatical (sentence (9)). That is why we don't have to formulate restrictions on the coordination of expressions of category S/VP_p. Example (9) shows that these restrictions wouldn't be legitimate.

The examples above all involve constituent coordination. By virtue of the categories assigned in the lexicon to the finite verb, sequences consisting of the subject and the finite verb are constituents in main clauses. The backgrounds of this supposition were explained in chapter 1. It differs from the phrase structure approach, in which the subject and the finite verb do not form a constituent. In phrase structure grammars, the finite verb is part of the VP, instead. In the sentences (2) to (9) the coordinated constituents were built up by application only. Application doesn't suffice to account for determiner/adjective combinations (see (10)). We need Functional Composition in this case.

```
10.    De    zwakke en  de    oude schaker   winnen     van  Kasparov
      NPs/N   N/N   |  NPs/N  N/N     N    NPs\(S/PP)  PP/NP    NP
        |______| RC |    |_____| RC   |         |         |______| RA
         NPs/N      |    NPs/N        |         |            PP
            |_______|________| CR     |         |            |
                NPs/N                 |         |            |
                  |___________________| RA      |            |
                           NPs                  |            |
                            |___________________| LA         |
                                   S/PP                      |
                                    |________________________| RA
                                               S
```

'The weak and the old chess player win of Kasparov'
The weak and the old chess player beat Kasparov

In the next section we will examine the machinery needed to account for coordinations consisting of two conjuncts and a joint right part. We will keep on referring to such examples with the transformational notion *Right Node Raising*.

2.2.3 Right Node Raising

To some extent, Right Node Raising is accounted for by application rules, and of course the Coordination Rule. This is the case, when the conjuncts consist of the subject and the tensed verb (see the examples (11), (12) and (13)).

```
11.       Nigel  bedacht    en Boris  vermeed    de  combinatie
           NPs  NPs\(S/NP)  |    NPs  NPs\(S/NP)  NP/N      N
            |_______|LA     |     |_______|LA      |_______|RA
             S/NP           |       S/NP              NP
               |____________|__________|CR            |
                          S/NP                        |
                            |_________________________|RA
                                         S
```

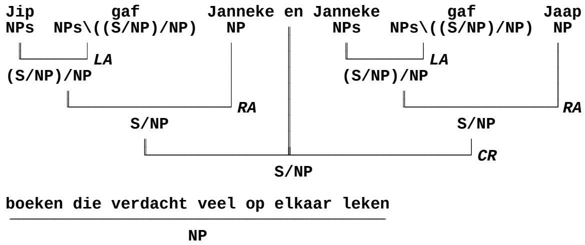
Nigel contrived and Boris avoided the combination

12. Viktor bewondert en Oleg haat briljante tegenstanders
Viktor admires and Oleg hates brilliant opponents

13. Jip floot en Janneke neuriede op dezelfde toonhoogte
Jip whistled and Janneke hummed at equal pitch

When the conjuncts consist of the subject, the tensed verb and the first object of the verb, the coordination is also accounted for by application rules and the Coordination Rule (see example (14)).

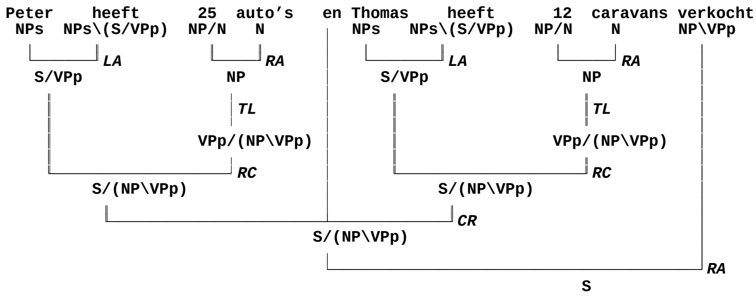
14.



Jip gave Janneke and Janneke gave Jaap books that resembled each other suspiciously

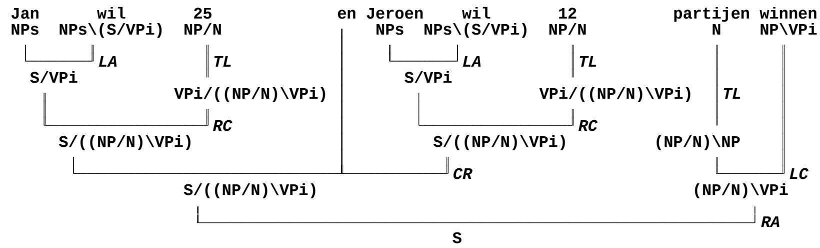
Beside these examples, there are, however, cases in which either the conjuncts or the RNR elements do not involve classical constituents. In section 1.4, we discussed Dowty's and Steedman's view of these non-standard constituents. In categorial grammar, the derivations of the sentences (15) to (19) make use of Type Lifting and Functional Composition.

15.



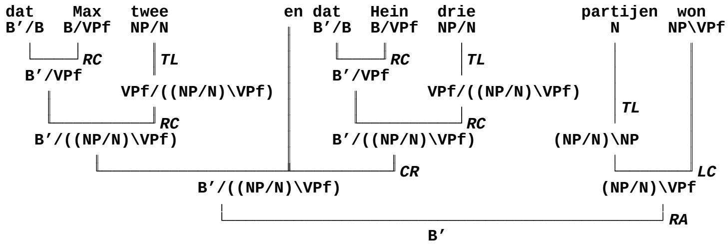
'Peter has 25 cars and Thomas has 12 caravans sold'
Peter has sold 25 cars and Thomas has sold 12 caravans

16.

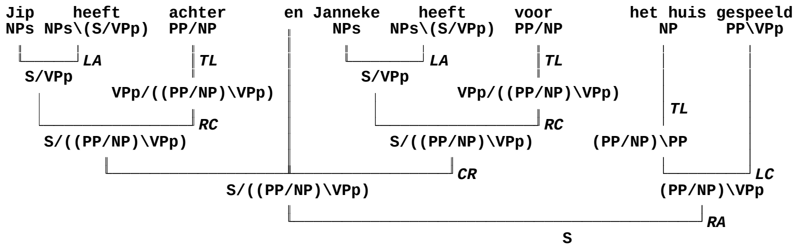


'Jan wants 25 and Jeroen wants 12 games win'
Jan wants to win 25 games and Jeroen wants to win 12 games

17. Friso heeft twee en Joris heeft drie pionnen geofferd
‘Friso has two and Joris has three pawns sacrificed’
Friso has sacrificed two pawns and Joris has sacrificed three pawns

18.


‘that Max two and that Hein three games won’
that Max won two games and that Hein won three games

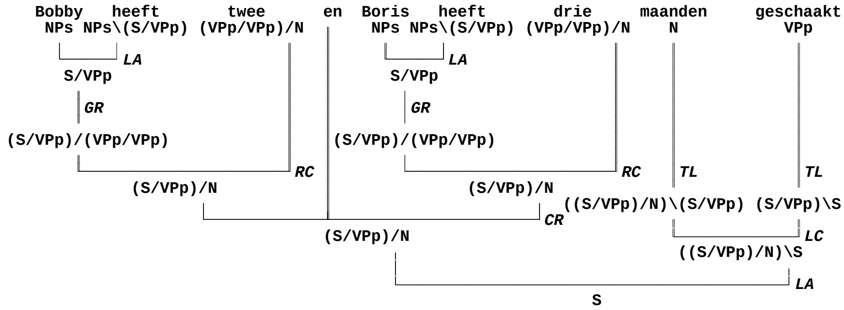
19.


‘Jip has behind and Janneke has before the house played’
Jip has played behind the house and Janneke has played in front of the house

In case the conjuncts consist of part of a verb phrase modifier, there is also the need for the Geach Rule (GR), as presented in chapter 1 and repeated here under (20). The reason for this is that composition of the subject and the tensed verb on the one hand and the VP modifier on the other hand, is not possible, because the denominator of the first function is not identical to the numerator of the second function. By applying the Geach Rule, the two become equal after which the functions can be composed. Examples are presented in (21), (22) and (23).

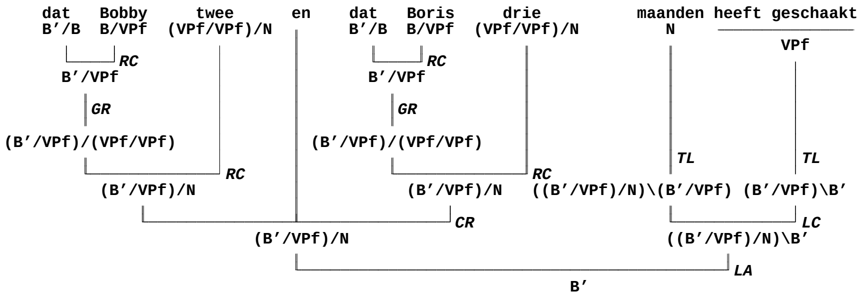
20. **Geach Rule (GR)**
a. X/Y ⇒ (X/Z)/(Y/Z)
b. Y\X ⇒ (Z\Y)\(Z\X)

21.



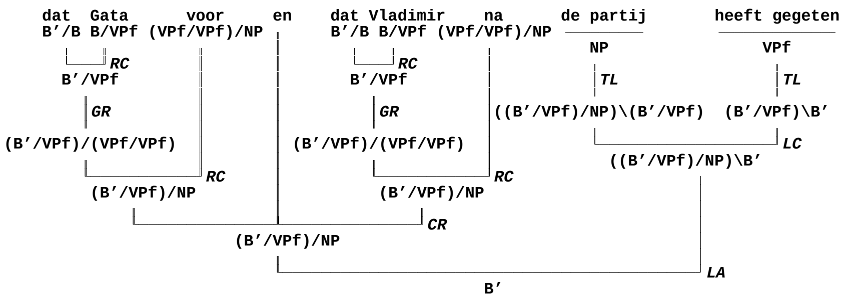
‘Bobby has two and Boris has three months played chess’
Bobby has played chess for two months and Boris has played chess for three months

22.



‘that Bobby two and that Boris three months has played chess’
that Bobby has played chess for two months and that Boris has played chess for three months

23.

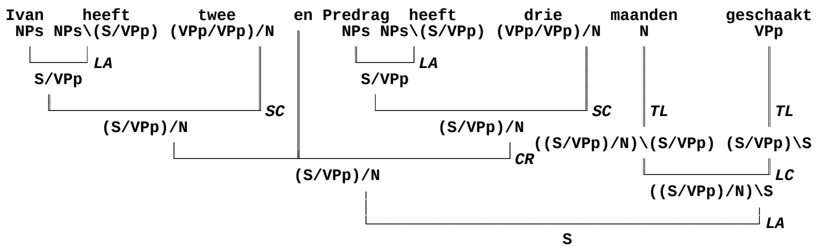


‘that Gata before and that Vladimir after the game has eaten’
that Gata has eaten before and that Vladimir has eaten after the game

As we have seen in chapter 1, the Geach Rule is a provable theorem of the Lambek-calculus. The sentences (21) to (23) are therefore derivable in a Lambek-grammar. Instead of using the Geach Rule, we could also have used the rule Strong Composition (24), which is also provable in the Lambek-calculus. I present the derivation of sentence (21) with Strong Composition, instead of the Geach Rule, in example (25).

24. **Strong Composition (SC)**
X/Y (Y/Z)/U ⇒ (X/Z)/U

25.



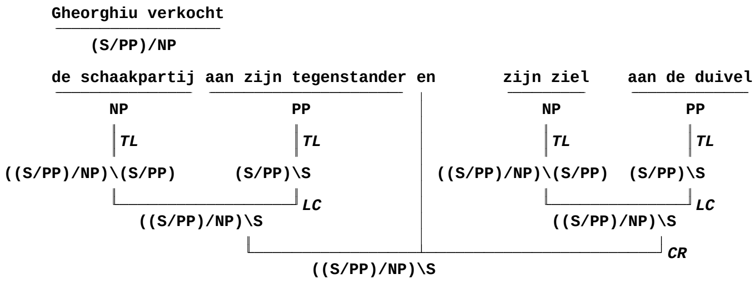
'Ivan has two and Predrag has three months played chess'
Ivan has played chess for two months and Predrag has played chess for three months

In the next section we will examine the rule schemata necessary to account for Forward Conjunction Reduction.

2.2.4 Forward Conjunction Reduction

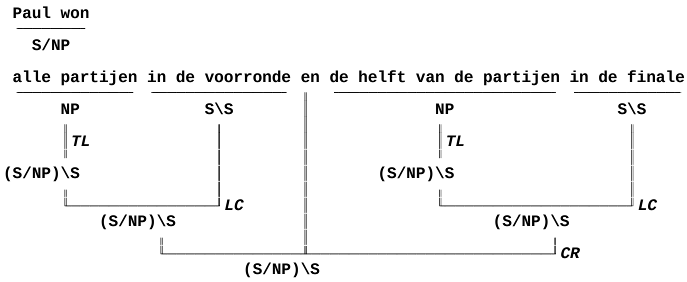
Forward Conjunction Reduction is more restricted than Right Node Raising. As we have seen, many traditional non-constituents can be coordinated in Right Node Raising cases. This means that within a flexible categorial grammar, the grammaticality can be accounted for by Functional Composition, Type Lifting and sometimes the Geach Rule (or Strong Composition). In the Forward Conjunction Reduction cases, there appears to be less liberty in the coordination of non-constituents. This is shown in the examples (29) and (30). Forward Conjunction Reduction is, however, accounted for in case the conjuncts consist of arguments of the verb ((26), (27) and (28)).

26.



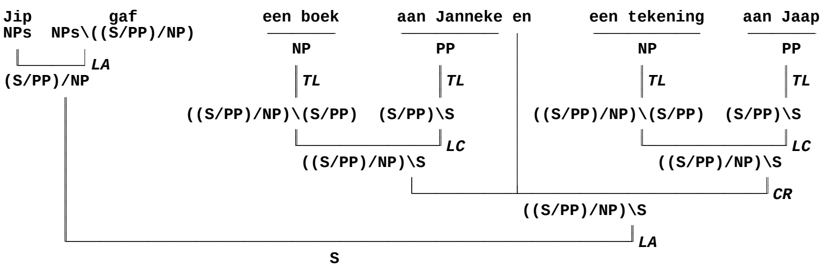
Gheorghiu sold the chess game to his opponent and his soul to the devil

27.



Paul won all games in the qualifying round and half of the games in the final

28.



Jip gave a book to Janneke and a record to Jaap

```
29. *    David heeft twee              en Michael heeft drie
          ──────────                   │   ────────────
            S/VPp    NP/N              │    S/VPp      NP/N
             │         │TL             │     │           │TL
             │       VPp/((NP/N)\VPp)  │     │         VPp/((NP/N)\VPp)
             └─────────┘RC             │     └───────────┘RC
            S/((NP/N)\VPp)             │    S/((NP/N)\VPp)
                 └─────────────────────┴─────────────┘CR
                             S/((NP/N)\VPp)

          pionnen   geofferd en schaakklokken vernield
             N       NP\VPp  │       N        NP\VPp
             │TL       │     │       │TL        │
          (NP/N)\NP    │     │   (NP/N)\NP      │
             └─────────┘LC   │       └──────────┘LC
            (NP/N)\VPp       │      (NP/N)\VPp
                 └───────────┴────────────┘CR
                         (NP/N)\VPp
```

‘David has two and Michael has three pawns sacrificed and chess clocks ruined’
David has sacrificed two pawns and ruined two chess clocks and Michael has sacrificed three pawns and ruined three chess clocks

```
30. *    Jip heeft achter           en  Janneke heeft voor
          ────────                  │   ────────────
           S/VPp   PP/NP            │     S/VPp      PP/NP
            │        │TL            │      │           │TL
            │      VPp/((PP/NP)\VPp)│      │         VPp/((PP/NP)\VPp)
            └────────┘RC            │      └───────────┘RC
          S/((PP/NP)\VPp)           │     S/((PP/NP)\VPp)
                └───────────────────┴──────────────┘CR
                            S/((PP/NP)\VPp)

         het huis gespeeld en de schuur gegeten
          ───────          │ ────────
            NP     PP\VPp  │    NP     PP\VPp
            │TL      │     │    │TL      │
        (PP/NP)\PP   │     │ (PP/NP)\PP  │
            └────────┘LC   │    └────────┘LC
          (PP/NP)\VPp      │   (PP/NP)\VPp
               └───────────┴──────────┘CR
                      (PP/NP)\VPp
```

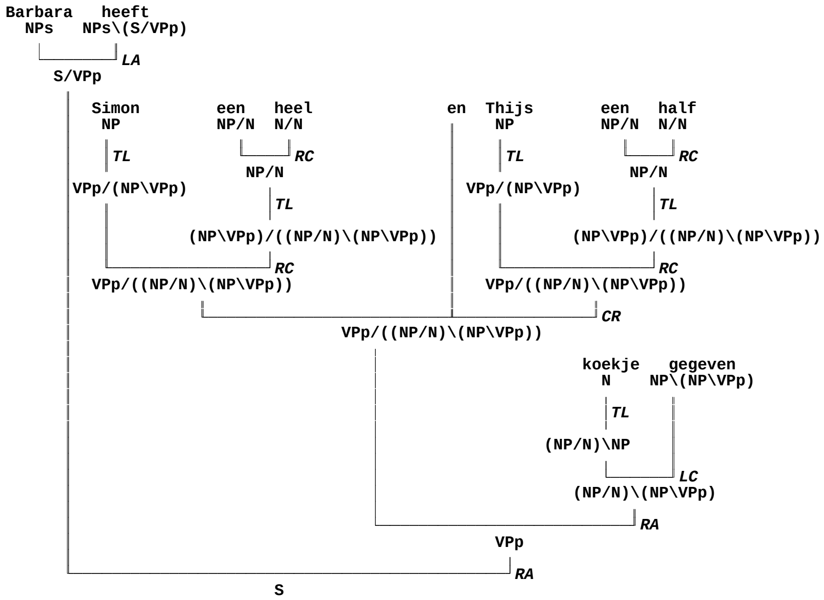
‘Jip has behind and Janneke has in front of the house played and the barn eaten’
Jip has played behind the house and eaten behind the barn and Janneke has played in front of the house and eaten in front of the barn

The coordination possibilities in Forward Conjunction Reduction examples are more restricted than the ones in Right Node Raising sentences. In section 2.3, we will discuss conditions on the Coordination Rule to block just these cases, where the conjuncts are functions over determiners or prepositions.

2.2.5 Right Node Raising and Forward Conjunction Reduction

In this section we look at a conjoined case of Right Node Raising and Forward Conjunction Reduction. Besides the application rules, Functional Composition and Type Lifting account for the derivation of sentence (31).

31.



‘Barbara has Simon a whole and Thijs a half biscuit given’
Barbara has given Simon a whole biscuit and Thijs half a biscuit

The discussion on Right Node Raising, Forward conjunction Reduction and combinations of both rules, shows that within a flexible categorial grammar like the Lambek-calculus, coordinations can be accounted for by Functional Composition, Type Lifting and the Geach Rule. Nevertheless, there are cases in which even those strong devices don’t suffice. As a last example of this section I present sentence (32). The sentence in (32a) is not derivable by means of Functional Composition, Type Lifting and the Geach Rule. the reason for this is that in comparable sentences without coordination (see (32b)), we have to make use of Disharmonic Composition to combine the VP modifier and the transitive verbal group.

```
32. a.  dat de arbiter na de wedstrijd
        ------------------------------
                   B'/VPf

        Bobby met bestraffende en Boris met lovende woorden heeft toegesproken
         NP   ---------------       NP  ----------     N    -----------------
                (VPf/VPf)/N             (VPf/VPf)/N              NP\VPf
```

‘that the arbiter after the match Bobby with punishing and Boris with praising words has spoken to’
that after the match the arbiter has spoken to Bobby in punishing words and to Boris in praising words

```
    b.  dat de arbiter na de wedstrijd
        ------------------------------
                   B'/VPf

        Bobby met bestraffende woorden heeft toegesproken
         NP   ---------------     N    -----------------
         |      (VPf/VPf)/N       |         NP\VPf
         |              |_________| RA        |
         |               VPf/VPf              |
         |                  |_________________| DC
         |                      NP\VPf
         |__________________________| LA
                     VPf
```

Notice that in (32.a) we have to combine part of the VP modifier (N) and the verbal group (NP\VPf). Lifting of the N *woorden* to (NP/N)\NP in (32.a), and subsequent composition with the verbal group of category NP\VPf, wouldn’t yield the correct function/argument structures, because not *woorden* is (part of) the argument of the function *heeft toegesproken*, but *Bobby* and *Boris* are.

2.3 Arguments against flexibility

2.3.1 Introduction

In this section I will provide four arguments against a flexible approach to coordination phenomena. I will argue against the description of coordination within a Lambek categorial grammar. In general coordination is hard to account for in the Lambek-calculus, because for a sequence of categories it isn’t to be proved that it reduces to S or some other specified category, but to a polymorphic category X. The first argument concerns the fact that flexible categorial grammars tend to overgenerate. Together with the grammatical configurations in natural language, the grammar inevitably recognizes many ungrammatical sentences. I will pay attention to this argument in section 2.3.2. I will show that flexible grammars, especially the grammars that are supposed to describe languages with disharmonic structures, tend to overgenerate.

The second argument relates to the notion *constituent*. In categorial grammar every expression that is assigned a category, or for which a category can be computed, is considered a constituent. This implies that in a grammar, based on the Lambek-calculus, the notion *constituent* has lost its meaning. The reason for this is that two arbitrary adjacent categories can always be composed by Type Lifting and Functional Composition, as I showed in example (1) of this chapter. There, nevertheless, seems to be a need for a notion *constituent* of some sort, witness the discussion of Barry and Pickering (1990) I present in chapter 3. In that chapter, I will redefine the notion *constituent*. The reason to delay the discussion to chapter 3 is that we need a thorough introduction to the product-based applicative categorial grammar (PACG) first. I will address constituency briefly in section 2.3.3.

The third argument concerns the fact that not all configurations should be allowed to coordinate. In earlier work,[31] I captured these facts in conditions on the Coordination Rule. Functor categories looking for a determiner or a preposition as argument were excluded from the domain of the Coordination Rule. Although the observations are correct, the solution to the problem was not compatible with a flexible categorial grammar. By means of Type Lifting rules, the categories of the non-conjoinable sequences can be changed, after which the conditions on the Coordination Rule can no longer be applied. This argument against flexibility will be presented in section 2.3.4.

The fourth argument is actually due to Dekker.[32] He proved that within the framework of a Lambek grammar two arbitrary modifying categories X/X and Y/Y can be type-lifted to the same category (Y/(X\Y))/X, after which the modifiers apparently are suitable for coordination. I shall argue that some of the

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31 Houtman (1987a), Houtman (1987b)

32 Dekker (1988)

examples of Dekker do not have to lead to the conclusion that they can be coordinated. But other examples inevitably lead to conjoinability. Dekker's paradox will be used to argue against flexibility in section 2.3.5.

The conclusion of section 2.3 is that a categorial grammar for Dutch should be far less flexible with respect to Functional Composition and Type Lifting than the Lambek-calculus is. In section 2.3.6, I argue that a categorial grammar should be essentially applicative. That is, we exclude the flexibility invoked by Functional Composition and Type Lifting. On the other hand, we need some sort of flexibility in order to account for the coordination examples I presented. This flexibility can be invoked by the Product Rules, to be discussed in chapter 3. The universal part of this grammar turns out to be the parenthesis-free AB-grammar. Parenthesis-free means that the grammar doesn't discriminate between the structures (XY)Z and X(YZ). Nevertheless, we will show that the notion *constituent* can be held upright.

2.3.2 Lambek grammars overgenerate

In this section, I shall argue that the flexibility of Lambek grammars has undesirable consequences for languages that exhibit disharmonic structures. We speak of disharmonic structures, when two functions with opposed directionality are composed. In (33) we see a reduction scheme which is not valid in the Lambek-calculus, but which is called for in languages with disharmonic structures. Dutch is such a language. In particular in the clustering of the verbs, we see that a sequence of words should be treated as a unit, although the last part of the cluster is a left-directed functor and the penultimate constituent is a right directed functor (34). Although, in chapter 1, we discussed a lexical account of verb clustering, we cannot avoid disharmonic structures in syntax. Looking at sentence (34), we can assign the string *heeft willen inlichten* the category NP\VP, but composition of this string with the VP modifier *op tijd* will appeal to Disharmonic Composition in syntax.[33]

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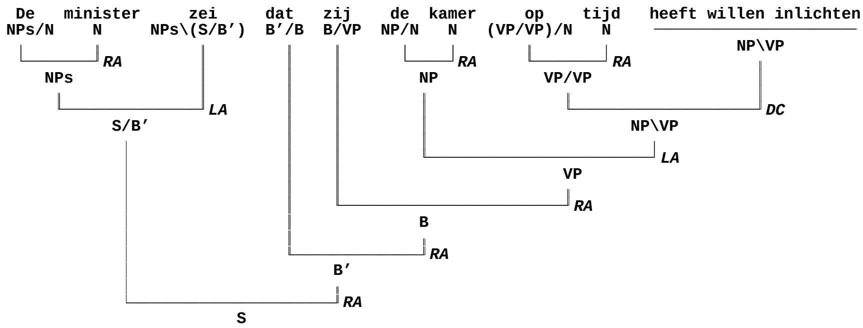
[33] Recently, attempts have been made to avoid Disharmonic Composition by treating VP modifiers as arguments of the verbs. instead of as functions over VP's (see Bouma and Van Noord (1994), and Van Noord and Bouma (1994)).
In this respect, the work of McConnell-Ginet (1982) deserves mention too.

33. **Disharmonic Composition (DC)**

a. X/Y Z\Y ⇒ Z\X

b. Y/Z Y\X ⇒ X/Z

34.



'The minister said that she Parliament on time has wanted to inform'
The minister said that she intended to inform Parliament on time

In the derivation of sentence (34) **NPs** is short for subject-NP, **B** for subordinate clause (*bijzin* in Dutch) and **B'** for subordinate clause with a subordinator.

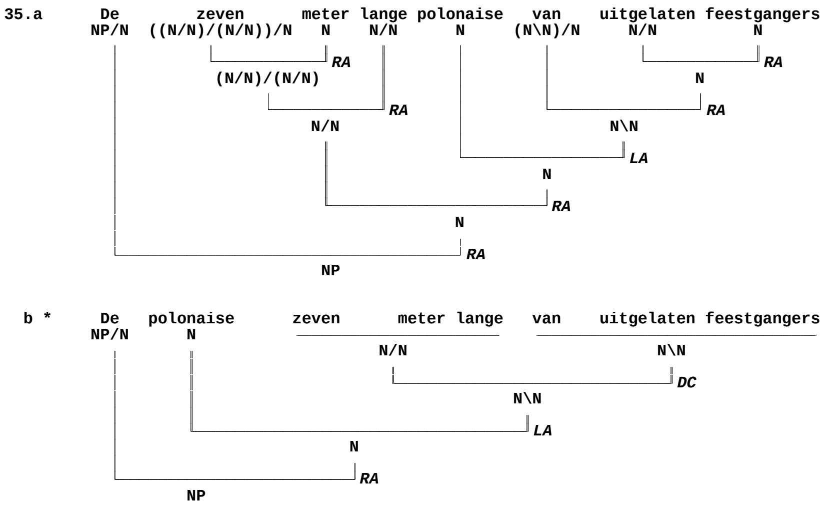
The problem of combining the Lambek-calculus with disharmonic structures is that the grammar will recognize too many structures. Moortgat notes:

> "Again R2' [the disharmonic composition rule, JH] would be valid in the permutation closed calculus LP. But note that the version of Disharmonic Composition needed for the above phenomena is intermediate between the order preserving form R2 [the harmonic composition rule, JH] and the variants in LP that are completely order-insensitive."
> Moortgat (1988b: 88)

> "(...) addition of the disharmonic composition rule [to L, JH] (...) entails LP collapse for sequences of length > 2"
> Moortgat (1988b: 90-91)

This position can be illustrated with the following example. Take a noun phrase with a prenominal adjective and a postnominal adjective phrase. The first one is categorized as N/N and the second as N\N. Were Disharmonic Composition a general rule of syntax, then we could turn all prenominal adjectives into postnominal ones, provided there is at least one postnominal adjective phrase. The

Disharmonic Composition rule would compose the two into a postnominal adjective phrase.



the seven meter long polonaise of elated feasters

The conclusion then is that, if for the description of a natural language we need to appeal to Disharmonic Composition, then we cannot maintain the Lambek-calculus as a proof system to account for the syntax of these natural languages.[34]

2.3.3 Constituents in categorial grammar

As I mentioned in section 2.2.2, the notion *constituent* doesn't play a role in flexible categorial grammars. The reason for this is that two arbitrary adjacent categories can be lifted and accordingly composed. That means that we cannot refer to the notion *constituent* to describe or account for grammatical issues.

---

[34] Recently, in modal variants of the Lambek-calculus new operators have been proposed, which permit limited forms of permutation. That is, by introducing new operators the Lambek-calculus as such is maintained, while permutation is restricted to those expressions that are assigned categories containing these operators, or are composed to categories that contain these operators (see Moortgat and Morrill (to appear)).

Nevertheless, attempts have been made to restore this notion. For example Barry and Pickering (1990) define the notion *dependency constituent* to characterize the class of conjoinable expressions. A string of words is a dependency constituent if the syntactic and semantic representations of the string are not missing a functor. This means that dependency constituents are strings in which one or more arguments can be missing from the syntactic and semantic representations. But when these representations are missing a functor of which the arguments are in the string, then the string is not a dependency constituent. Thus, the bracketed strings in (36) are dependency constituents, according to Barry and Pickering, whereas the bracketed strings in (37) are not.

36. a. [the dog] runs
    b. [John likes] Mary
    c. John [will see] Mary

37. a. the [dog runs]
    b. I think [that Harry] left
    c. I showed [Mary John]

We will discuss this matter thoroughly in chapter 3. There we will also argue that within a product-based applicative categorial grammar (PACG), the notion *constituent* should be associated with applicative structures and not with product structures.

2.3.4 Conditions on the Coordination Rule

In section 2.2, we looked at a large variety of conjoinable expressions. Among them, there were several 'Right Node raising' examples. I repeat part of them here as (38) to (43).

38. [$_{S/VPi}$Jan wil] [$_{NP/N}$25] en [$_{S/VPi}$Jeroen wil] [$_{NP/N}$12] partijen winnen
    'Jan wants 25 and Jeroen wants 12 games win'
    Jan wants to win 25 games and Jeroen wants to win 12 games

39. [$_{S/VPp}$Peter heeft] [$_{NP}$25 auto's] en [$_{S/VPp}$Thomas heeft] [$_{NP}$12 caravans] verkocht
'Peter has 25 cars and Thomas has 12 caravans sold'
Peter has sold 25 cars and Thomas has sold 12 caravans

40. [$_{S/VPp}$Jip heeft] [$_{PP/NP}$achter] en [$_{S/VPp}$Janneke heeft] [$_{PP/NP}$voor] het huis gespeeld
'Jip has behind and Janneke has in front of the house played'
Jip has played behind the house and Janneke has played in front of the house

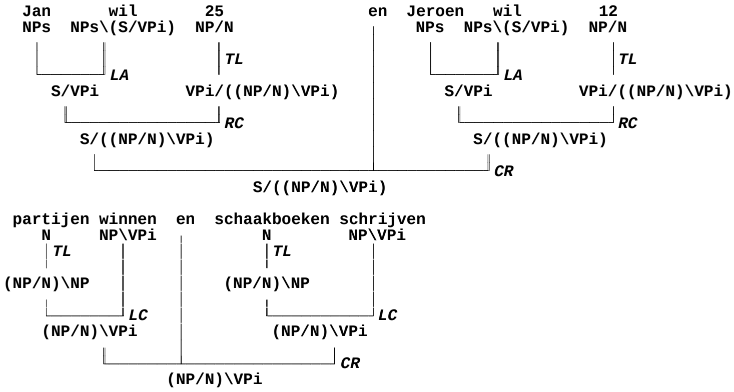
41. ..., [$_{B'/VPf}$dat Gata] [$_{PP/NP}$voor] en [$_{B'/VPf}$dat Vladimir] [$_{PP/NP}$na] de partij heeft gegeten
'... that Gata before and that Vladimir after the game has eaten'
... that Gata has eaten before the game and that Vladimir has eaten after the game

42. [$_{S/VPp}$Bobby heeft] [$_{NP/N}$twee] en [$_{S/VPp}$Boris heeft] [$_{NP/N}$drie] pionnen geofferd
'Bobby has two and Boris has three pawns sacrificed'
Bobby has sacrificed two pawns and Boris has sacrificed three pawns

43. ..., [$_{B'/VPf}$dat Jan] [$_{NP/N}$twee] en [$_{B'/VPf}$dat Anatoly] [$_{NP/N}$drie] partijen won
'... that Bobby two and that Boris three games won'
... that Bobby won two games and that Boris won three games

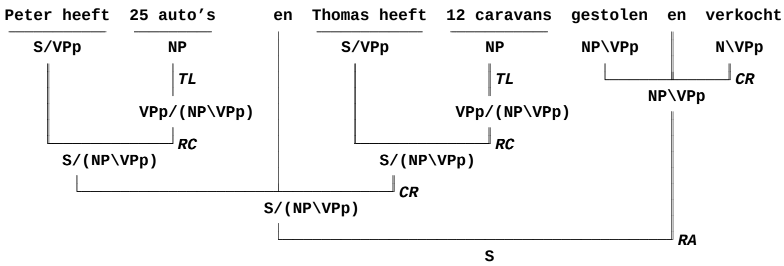
In a grammar based on the Lambek-calculus, these examples call for use of Type Lifting, Functional Composition and the Geach Rule, all discussed in chapter 1. In the examples below, I will show that a categorial grammar incorporating these flexible rules will inevitably accept ungrammatical strings as sentences. In the examples above the coordinated expressions are lifted and composed, before the Coordination Rule is applied. But at the same time the 'Right Node Raised' part of the sentences sometimes must be lifted and composed to a single constituent as well. This doesn't mean, however, that all these RNR-parts are conjoinable. In (44) to (49) I changed the examples (38) to (43) in such a way that the RNR-expressions are part of a coordination.

44. *



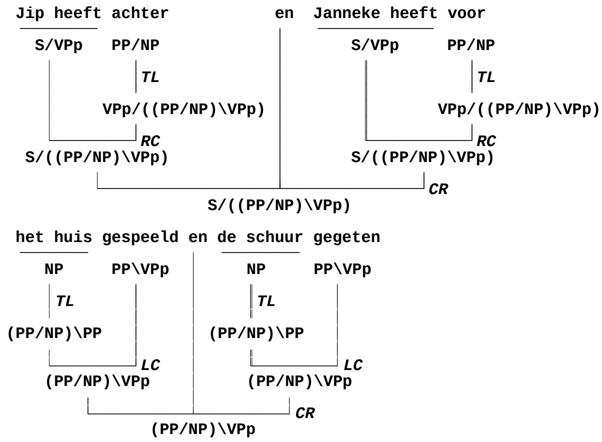
‘Jan wants 25 and Jeroen wants 12 games win en chess books write’
Jan wants to win 25 games and wants to write 25 chess books and Jeroen wants to win 12 games and wants to write 12 chess books

45.



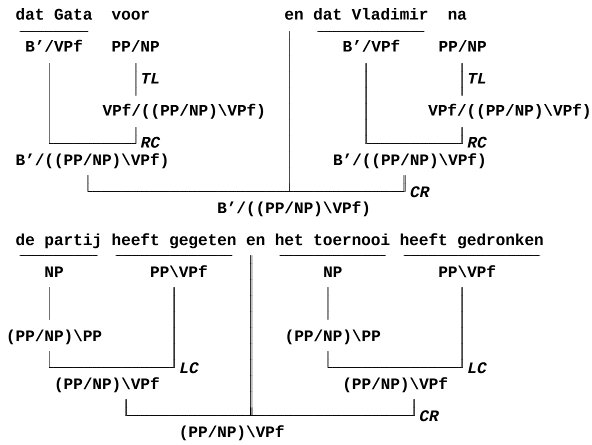
‘Peter has 25 cars and Thomas has 12 caravans stolen and sold’
Peter has stolen and sold 25 cars and Thomas has stolen and sold 12 caravans

46. *



'Jip has behind and Janneke has in front of the house played and the barn eaten'
Jip has played behind the house and eaten behind the barn and Janneke has played in front of the house and eaten in front of the barn

47. *



'... that Gata before and that Vladimir after the game has eaten and the tournament has drunk'
... that Gata has eaten before the game and has drunk before the tournament and that Vladimir has eaten after the game and has drunk after the tournament

```
48. *    Bobby heeft twee                en Boris heeft drie
         ----------------                |    ----------------
            S/VPp     NP/N               |       S/VPp     NP/N
            |          |TL               |       |          |TL
            |        VPp/((NP/N)\VPp)    |       |        VPp/((NP/N)\VPp)
            |__________|RC               |       |__________|RC
         S/((NP/N)\VPp)                  |    S/((NP/N)\VPp)
              |__________________________|_________|CR
                          S/((NP/N)\VPp)

         pionnen   geofferd  en schaakklokken vernield
            N       NP\VPp   |        N        NP\VPp
            |TL       |      |        |TL        |
        (NP/N)\NP     |      |    (NP/N)\NP      |
            |_________|LC    |        |__________|LC
          (NP/N)\VPp         |      (NP/N)\VPp
               |_____________|___________|CR
                        (NP/N)\VPp
```

‘Bobby has two and Boris has three pawns sacrificed and chess clocks ruined’
Bobby has sacrificed two pawns and ruined two chess clocks and Boris has sacrificed three pawns and ruined three chess clocks

```
49. *    dat  Jan  twee               en dat Anatoly drie
         ---------                    |  -----------
         B'/VPf   NP/N                |   B'/VPf    NP/N
           |       |TL                |     |        |TL
           |     VPf/((NP/N)\VPf)     |     |      VPf/((NP/N)\VPf)
           |_______|RC                |     |________|RC
         B'/((NP/N)\VPf)              |  B'/((NP/N)\VPf)
              |_______________________|______|CR
                        B'/((NP/N)\VPf)

         partijen    won    en schaakklokken vernielde
            N       NP\VPf  |        N        NP\VPf
            |TL       |     |        |TL        |
        (NP/N)\NP     |     |    (NP/N)\NP      |
            |_________|LC   |        |__________|LC
          (NP/N)\VPf        |      (NP/N)\VPf
               |____________|___________|CR
                       (NP/N)\VPf
```

‘that Jan two and Anatoly three games won and chess clocks ruined’
that Jan won two games and ruined two chess clocks and Anatoly won three games and ruined three chess clocks

The examples show that some coordinations should not be accepted by the grammar. Example (45) is grammatical. In this case the coordination concerns transitive verbs of category NP\VPp. The other examples all appear to be ungrammatical. If we put restrictions on Functional Composition and Type Lifting, then the derivation of the sentences (38) to (43) is also blocked. The remaining solution would be to constrain the conjoinable expressions in such a way that the categories (NP/N)\VPi (example (44)), (PP/NP)\VPp (example (46)), (PP/NP)\VPf (example (47)), (NP/N)\VPp (example (48)), and (NP/N)\VPf (example 49)) cannot be coordinated. This could be done by restrictions on the Coordination Rule.[35] In earlier work,[36] I proposed to exclude functor categories that are looking for determiners and prepositions as arguments from the Coordination Rule (see (50)).

50. **Coordination Rule**
X *en* X ⇒ X, conditions:
a. X ≠ (NP/N)\Y
b. X ≠ (PP/NP)\Y
c. X and Y are variables over conjoinable types

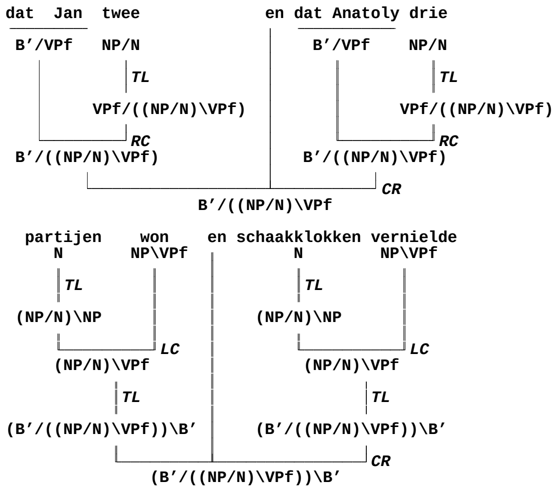
The conditions on coordination, formulated above, constrain the possible conjuncts of coordination. But within a flexible categorial grammar, like the ones based on the Lambek-calculus, the derivation of ungrammatical coordination gets round these conditions by Type Lifting and Functional Composition. In (51) an alternative analysis of the ungrammatical sentence (49) is presented. In (51), the coordination is no longer ruled out by the conditions, mentioned in Coordination Rule (50).

---

35 Conditions to be formulated on categorial rules are the main arguments for modal variants of categorial grammar. In relation to coordination, modal operators have been proposed for Gapping by Morrill and Solias (1993) and by Solias (1993). This proposal is discussed in chapter 3. As for the phenomena discussed in this section, Right Node Raising and Forward Conjunction Reduction, up to now no solutions have been suggested in modal variants of categorial grammar. I will not present a solution in that respect either. My main interest in this section has been to explicate the conditions to be posed on coordination and not how to translate these to modal operators.

36 Houtman (1987a), Houtman (1987b)

51. *



This proves that within a Lambek-grammar the necessary conditions on coordination cannot adequately be formulated. This means we have to look for a grammar that can incorporate these conditions, without inherently evading them. As a consequence, we have to define a less flexible grammar with respect to Functional Composition and Type Lifting. This means, furthermore, that we have to formulate the conditions differently, because the categories to be excluded from the Coordination Rule are based on Functional Composition and Type Lifting themselves. I will return to this matter in chapter 3.

2.3.5 Dekker's paradox

In 1988, Paul Dekker wrote a paper in which he proved that, within a Lambek-grammar, two arbitrary modifying categories X/X and Y/Y can be type-lifted to one and the same category (Y/(X\Y))/X. The proof of this conjecture, Dekker's paradox, is presented in (53). The same naturally holds for the modifying categories X\X and Y\Y, which can be type-lifted to X\((Y/X)\Y). This is proved in (54). In (52), I will first repeat the Lambek-calculus, as presented in chapter 1.

52. **The Lambek-calculus (Gentzen-style)**

Axiom

A $X \Rightarrow X$

Inference rules

I1 $T,Y \Rightarrow X \models T \Rightarrow X/Y$ Introduction

I2 $Y,T \Rightarrow X \models T \Rightarrow Y\backslash X$ Introduction

I3 $T \Rightarrow Y$ en $U,X,V \Rightarrow Z \models U,X/Y,T,V \Rightarrow Z$ Elimination

I4 $T \Rightarrow Y$ en $U,X,V \Rightarrow Z \models U,T,Y\backslash X,V \Rightarrow Z$ Elimination

I5 $U,X,Y,V \Rightarrow Z \models U,X{*}Y,V \Rightarrow Z$ Elimination

I6 $P \Rightarrow X$ en $Q \Rightarrow Y \models P,Q \Rightarrow X{*}Y$ Introduction

Cut

C $T \Rightarrow X$ en $U,X,V \Rightarrow Y \models U,T,V, \Rightarrow Y$ Transitivity of derivations

53. **Dekker's paradox**

Two modifiers of arbitrary categories X/X and Y/Y can be type-lifted to the same category (Y/(X\Y))/X

Proof

$$\dfrac{X \Rightarrow X \qquad \dfrac{X \Rightarrow X \quad Y \Rightarrow Y}{X\ X\backslash Y \Rightarrow Y}\,I4}{\dfrac{X/X\ X\ X\backslash Y \Rightarrow Y}{\dfrac{X/X\ X \Rightarrow Y/(X\backslash Y)}{X/X \Rightarrow (Y/(X\backslash Y))/X}\,I1}\,I1}\,I3$$

$$\dfrac{X \Rightarrow X \qquad \dfrac{Y \Rightarrow Y \quad Y \Rightarrow Y}{Y/Y\ Y \Rightarrow Y}\,I3}{\dfrac{Y/Y\ X\ X\backslash Y \Rightarrow Y}{\dfrac{Y/Y\ X \Rightarrow Y/(X\backslash Y)}{Y/Y \Rightarrow (Y/(X\backslash Y))/X}\,I1}\,I1}\,I4$$

54. **Dekker's paradox (mirror image)**
Two modifiers of arbitrary categories X\X and Y\Y can be type-lifted to the same category X\((Y/X)\Y).

Proof

$$\dfrac{X \Rightarrow X \qquad \dfrac{X \Rightarrow X \quad Y \Rightarrow Y}{Y/X\ X \Rightarrow Y}\ I3}{\dfrac{Y/X\ X\ X\backslash X \Rightarrow Y}{\dfrac{X\ X\backslash X \Rightarrow (Y/X)\backslash Y}{X\backslash X \Rightarrow X\backslash((Y/X)\backslash Y)}\ I2}\ I2}\ I4$$

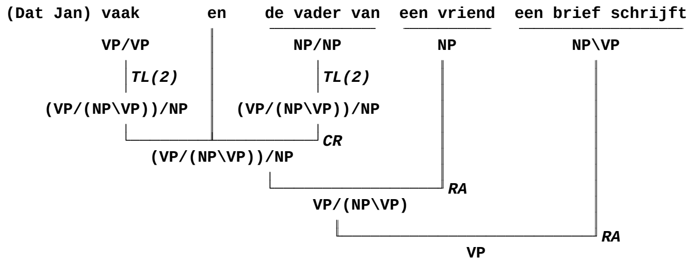
$$\dfrac{X \Rightarrow X \qquad \dfrac{Y \Rightarrow Y \quad Y \Rightarrow Y}{Y\ Y\backslash Y \Rightarrow Y}\ I4}{\dfrac{Y/X\ X\ Y\backslash Y \Rightarrow Y}{\dfrac{X\ Y\backslash Y \Rightarrow (Y/X)\backslash Y}{Y\backslash Y \Rightarrow X\backslash((Y/X)\backslash Y)}\ I2}\ I2}\ I3$$

Type Lifting of this kind is not desirable, witness the examples (55), (56) and (57), due to Dekker (1988).

```
55. *    De broer van  en  Jan gelooft dat Piet slaapt
            NP/NP                S/S         NP    NP\S
              |TL(2)             |TL(2)
       (S/(NP\S))/NP       (S/(NP\S))/NP
              |____________|_____|CR
            (S/(NP\S))/NP
                          |______________|RA
                              S/(NP\S)
                                 |_______________|RA
                                           S
```

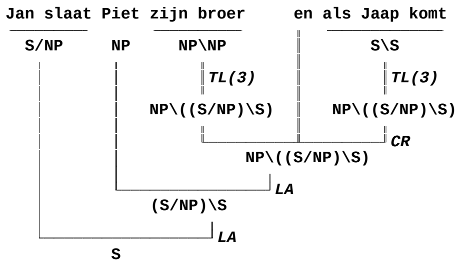
‘The brother of and Jan believes that Piet sleeps’

56. *



'That Jan often and the father of a friend a letter writes'

57. *



'Jan beats Piet his brother and when Jaap comes'

If one distinguishes between main declarative clauses and subordinate clauses, as we do by means of different categorizations for the finite verb in main and subordinate clauses (see chapter 1), then the first example, (55), is no longer subject to the Dekker paradox. This means that the original category assignment influences the possibility of modifiers to be lifted to the same category. In (58), it appears that the derivation of (55) is blocked, if the category assignment corresponds to the assignments of chapter 1. In (58a) the categories of *Piet* and *slaapt* are NP and NPs\S, respectively, as in main clauses. In (58b) the categories of these expressions are B/VP and VP, respectively, as in subordinate clauses.

```
58.a *   De broer van  en  Jan gelooft dat Piet slaapt
            NPs/NP              S/B          NP  NPs\S
  b *    De broer van  en  Jan gelooft dat Piet slaapt
            NPs/NP              S/B        B/VP   VP
```

It is obvious that the category S/B of the sequence *Jan gelooft dat* doesn't fit the Dekker paradox scheme X/X.

The examples (56) and (57), however, are even with the category assignment proposed in this study, subjected to the Dekker paradox. This proves the Lambek-calculus to be too strong, that is grammars based on the Lambek-calculus recognize too many structures as grammatical.

2.3.6 Concluding remarks

In this section, we discussed the arguments against flexibility. I showed that the rules for Functional Composition and Type Lifting result in a grammar system that is too strong to account for Dutch coordination phenomena. Flexible categorial grammars recognize too many structures as sentences of Dutch, that is it overgenerates. Furthermore, I showed that it is impossible to apply a flexible categorial grammar to languages that exhibit disharmonic structures. In addition, we saw that in order to be able to use the notion *constituent* we need a less flexible categorial grammar. Finally, Dekker's paradox implies conjoinability of two arbitrary modifiers.

From this I conclude that flexible categorial grammars are not suitable for Dutch (and possibly for no natural language at all). The grammar for Dutch should be essentially applicative, that is the core grammar should consist of Right Application and Left Application. Furthermore, some kind of flexibility is needed to account for coordination phenomena. The flexibility needed can be taken care of with so called product rules. In chapter 3 we will discuss a product-based applicative categorial grammar (PACG) for Dutch coordination phenomena. The flexibility induced by this grammar is of a different kind than the one invoked by the Lambek-grammar.

In chapter 3 we will show that, although the universal part of the PACG is structurally complete, this doesn't lead to an excessive overgenerating power. Secondly, we will discuss the notion *constituent*, and we will argue that it is possible to regain some of its meaning, even in a categorial grammar. In the third place, a more rigid categorial grammar, like the PACG, allows for conditions on categorial rules. We showed in section 2.3, that conditions on rules are needed to exclude ungrammatical coordinations. Finally, coordinations of arbitrary modifiers are excluded in this more rigid categorial grammar.