



# **Syntax & Semantics WS2019/2020**

Lecture 8: Generalized Phrase Structure Grammar (GPSG)

**18/11/2019, Christian Bentz**



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## **Section 1: Recap of Lecture 7**



# D-Structure

**Deep structure** in GB theory refers to the underlying template or mould that is used to build all grammatical sentences in a given language.

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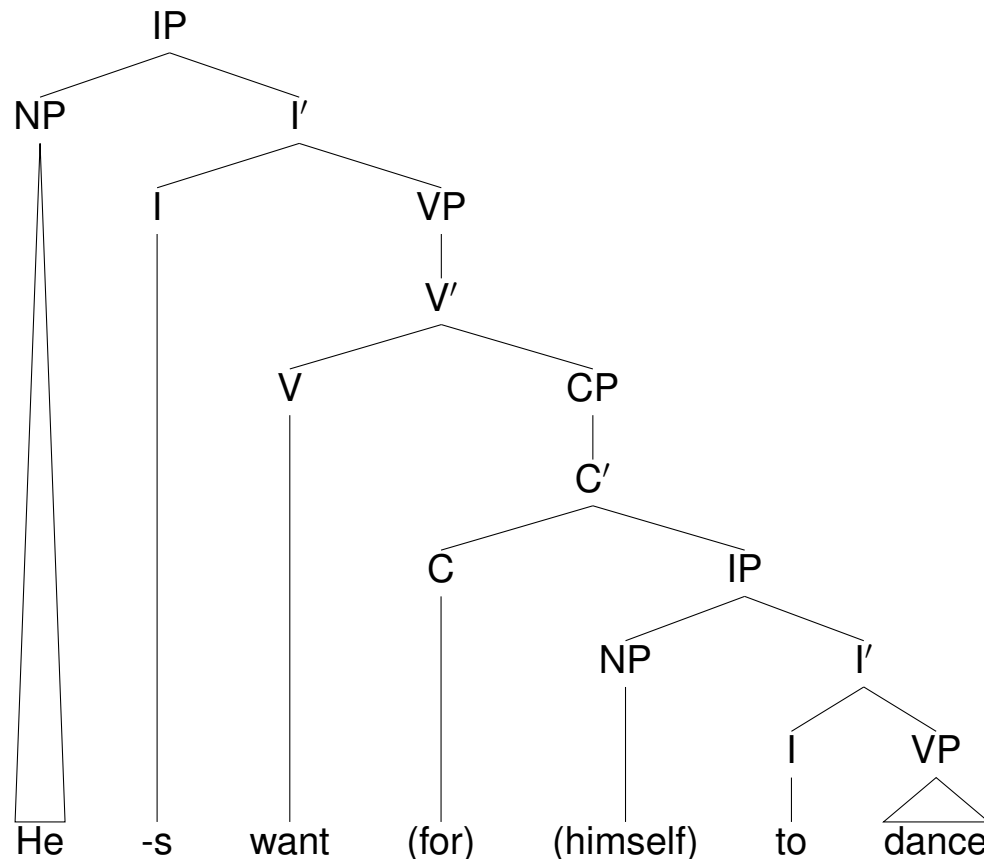
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## Passive

**Passive constructions** are handled in GB with the same underlying deep structure as **active constructions**. Note that this is an important deviation from traditional PSGs. In a traditional PSG you would have to formulate different phrase structure rules for active and passive sentences, while within GB active and passive sentences are connected, i.e. the active sentence is **transformed** into a passive sentence.

Early example of a transformational rule going back to Chomsky (1957):

$$NP_1 V_2 NP_3 \rightarrow 3 [AUX \text{ be}] 2en [PP [P \text{ by}] 1]$$

John sees Mary  $\rightarrow$  Mary [AUX is] seen [PP [P by] John]

Müller (2019). Grammatical theory, p. 85.

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## **Section 2: Historical Notes**



## Historical Perspective

“Generalized Phrase Structure Grammar (GPSG) was developed as an answer to Transformational Grammar at the end of the 1970s. The book by Gazdar, Klein, Pullum & Sag (1985) is the main publication in this framework [...] Analyses in GPSG were so precise that it was possible to use them as the basis for computational implementations.”

Müller (2019). Grammatical theory, p. 181.

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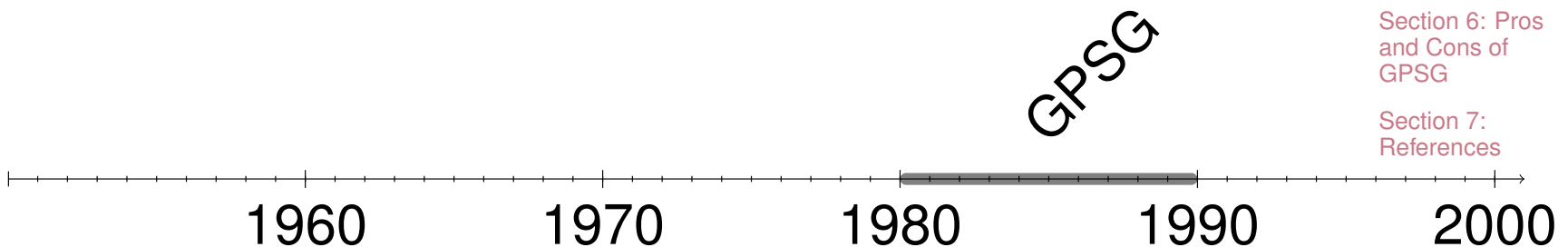
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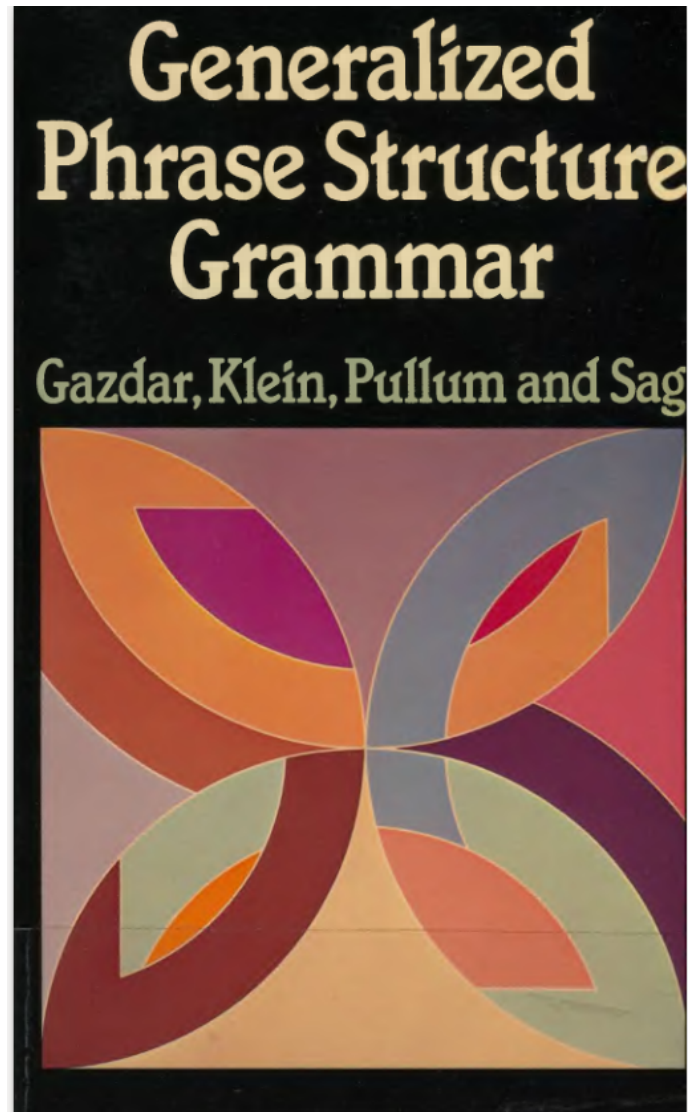
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“This book contains a fairly complete exposition of a general theory of grammar that we have worked out in detail over the past four years. Unlike much theoretical linguistics, it lays considerable stress on detailed specifications both of the theory and of the descriptions of parts of English grammar that we use to illustrate the theory.”

Gazdar et al. (1985). *Generalized Phrase Structure Grammar*, p. ix.



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# Languages analyzed by GPSG

German, English, French, Persian.

According to Müller (2019). Grammatical theory, p. 181.

# Language Families<sup>1</sup>

Indo-European

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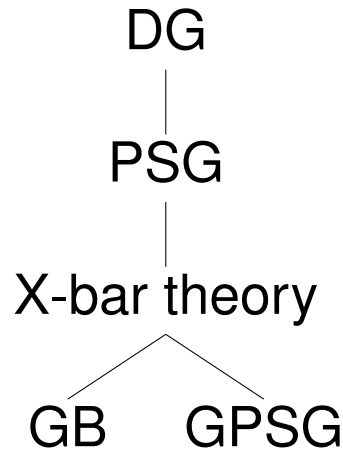
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<sup>1</sup>According to Glottolog 4.0, <https://glottolog.org/>.



# Syntactic frameworks and their (rough) historical relationships



DG: Dependency Grammar  
PSG: Phrase Structure Grammar  
GB: Government & Binding  
GPSG: Generalized Phrase  
Structure Grammar

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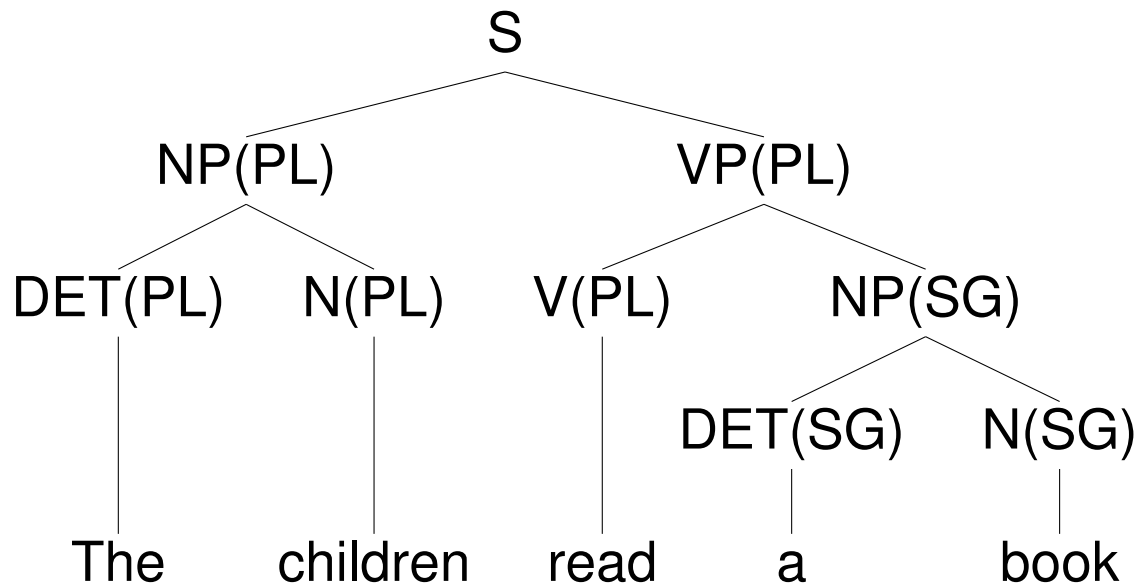
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## **Section 3: Basic Definitions**



## Non-Terminal Symbols with Features

Remember that non-terminal symbols in a classic PSG can be augmented by morphological features in order to model, for example, agreement relationships.



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## Non-Terminal Symbols with Features

In GPSG this is worked out more precisely, such that each non-terminal symbol can be defined by a set of feature value pairs of the form  $\langle \textit{feature}, \textit{feature-value} \rangle$ . For instance, a non-terminal symbol with feature values like NP(3,sg,nom) could be rendered as in (1):

$$\begin{aligned} & \{ \langle \textit{CAT}, \textit{N} \rangle, \\ & \quad \langle \textit{BAR}, \textit{2} \rangle, \\ & \quad \langle \textit{PER}, \textit{3} \rangle, \\ & \quad \langle \textit{NUM}, \textit{SG} \rangle, \\ & \quad \langle \textit{CASE}, \textit{NOM} \rangle \} \end{aligned} \tag{1}$$

Note: The NP is here replaced by the X-bar theoretic representation, i.e.  $\overline{\overline{N}}$ , which is then indicated by  $\langle \textit{BAR}, \textit{2} \rangle$ .

Müller (2019). Grammatical theory, p. 182.

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## Non-Terminal Symbols: Notation

However, the actual notation for non-terminal symbols used by Gazdar et al. (1985) is such that the POS or phrase symbol is given followed by square brackets. The feature value(s)<sup>2</sup> relevant for a particular construction are given inside the square brackets. We would thus typically have the following notation for the example above:

(1) NP[PERS 3, NUM SG, CASE NOM],

or without the feature labels just:

(2) NP[3, SG, NOM].<sup>3</sup>

see Gazdar et al. (1985, p. 20) for further details on notation.

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<sup>2</sup>Sometimes the feature labels might be given to disambiguate in case different features could take the same values.

<sup>3</sup>Gazdar et al. (1985) rather use -PLU for SG.



## Beware the Notational Confusion

A further notational convention within GPSG related publications – which deviates from the traditional PSG notation – is that the projection level of a non-terminal symbol is (sometimes) represented also as an integer (rather than with bars, primes or in the XP notation). We thus have:

$$\begin{aligned}
 XP &\equiv \overline{\overline{X}} \equiv X'' \equiv X2 \equiv X^2, \\
 &\text{and} \\
 \overline{X} &\equiv X' \equiv X1 \equiv X^1, \\
 &\text{and} \\
 X &\equiv X^0
 \end{aligned}$$

These integers indicating projection levels are not to be confused with integers in brackets indicating lexical subcategorization.

We here follow the notation of Müller (2019) i.e. **X2 for the highest projection level, X1 for the intermediate projection level, and X for the lowest projection level (preterminal).**

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# Lexical Subcategorization

**Lexical subcategorization** refers to matching *non-terminal* (*preterminal*) symbols, and the *rewrite rules* they are allowed to occur in. For verbs, for example, this means that an integer specifies which type of verb (in terms of valency) is allowed to occur in a particular rule. Take the rewrite rules below:

$$(3) \quad V2 \rightarrow V[1]$$

$$(4) \quad V2 \rightarrow V[2] N2$$

The integers in square brackets would then be found also in the lexical entry of particular verbs, e.g. in simplified form:

$$(5) \quad \langle \textit{weep}, [\mathbf{SUBCAT 1}], \dots \rangle$$

$$(6) \quad \langle \textit{devour}, [\mathbf{SUBCAT 2}], \dots \rangle$$

Gazdar et al. (1985). Generalized phrase structure grammar, p. 33-34.

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## Lexical Subcategorization

Lexical subcategorization thus ensures the correct usage of lexical items in rewrite rules, and hence licensing of grammatical sentences.

- (7) Peter [V2 [V weeps]].
- (8) \*Peter weeps cheesecake.
- (9) Peter [V2 [V devours][N2 cheesecake]].
- (10) \*Peter devours.

Note: Strictly speaking, we would need intermediate levels, i.e. V1 and N1, here. But this is often skipped in the notation found in the literature, since the rewriting from V1 to V is essentially a unary branch, as seen in X-bar theory.

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## Preterminal Symbols: Verbs

The symbols finally rewritten into terminals are called **preterminal symbols** here.<sup>4</sup> In the square brackets of preterminal symbols of verbs we need to define their SUBCAT value as well as the verb form (VFORM). According to Gazdar et al. (1985, p. 110) VFORM can take (at least) the following values:

FIN: finite

INF: to-infinitive

BSE: bare infinitive

PRP: present participle

PSP: past participle

PAS: passive participle

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<sup>4</sup>Remember that in the lecture on PSGs we distinguished rewrite rules only containing non-terminals, and those also containing terminals. The latter type of rewrite rules is equivalent to rewrite rules that contain preterminals, as every preterminal has to be rewritten into a terminal.



## Preterminal Symbols: Verbs

For the verbs *weep* and *devour* from above, we can thus have the following rewrite rules involving preterminals (i.e. terminal rewrite) below.

V[1, FIN] → weeps  
 V[2, FIN] → devours  
 V[1, INF] → to weep  
 V[2, INF] → to devour  
 V[1, BSE] → weep  
 V[2, BSE] → devour  
 V[1, PRP] → weeping  
 V[2, PRP] → devouring  
 V[1, PSP] → wept  
 V[2, PSP] → devoured  
 etc.

Note: this list is not exhaustive since there is syncretism between different forms of the verbs, such that, for example, there could also be a rule  $V[1, FIN] \rightarrow \text{weep}$ , e.g. *we weep, you weep*, where *weep* is a finite verb. In fact, for the English GPSG fragment by Gazdar et al. (1985) person and number are handled via agreement features with the NP (see below).

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## Preterminal Symbols: Nouns

Similarly, for nouns, we have preterminal symbols with respective feature values rewritten into terminals in agreement with these feature values.

N[3, SG, NOM] → book  
N[3, PL, NOM] → books  
N[3, SG, ACC] → book  
N[3, PL, ACC] → books  
N[1, SG, NOM] → I  
N[2, SG, NOM] → you  
N[3, SG, NOM] → he/she/it  
N[3, SG, ACC] → him/her/it  
N[1, PL, NOM] → we  
etc.

Note: pronouns are here subsumed under nouns. Note that grammatical gender does not play a role in English agreement relations, hence it is not considered a necessary feature. This would be different for gender marking languages.

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# Preterminal Symbols: Adjectives and Prepositions

The other two major POS that Gazdar et al. (1985) take into account are adjectives and prepositions.

A → beautiful  
A → interesting  
A → green  
etc.

P[*for*] → for  
P[*about*] → about  
P[*to*] → to

Note: adjectives do not inflect for person, number and case in English, hence these can be represented just by the symbol A without feature values. Likewise, prepositions are mostly represented with the PFORM feature essentially taking the pronoun itself as its value.

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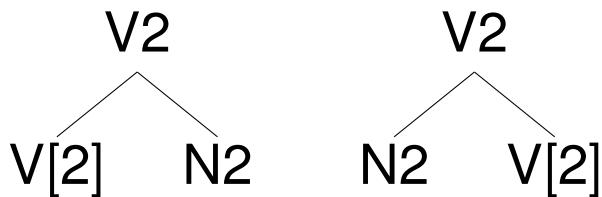


## GPSG Rules: Immediate Dominance (ID)

Notice a further subtle difference: In GPSG rules, a **comma** is put in between the symbols on the right side of the rewrite rule instead of just a blank space. This means that the **order of the symbols is free** to start with. The rule is then called an **Immediate Dominance (ID)** rule, since it only captures which symbol dominates other symbols.

$$V2 \rightarrow V[2], N2 \equiv V2 \rightarrow N2, V[2]$$

Both tree possibilities are licensed:



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## GPSG Rules: Linear Precedence (LP)

If linearization constraints are necessary to license the correct word orders, then they are implemented in so-called **Linear Precedence (LP)** rules.

“Of course, in general we will want a grammar to be able to impose some constraints on the linear precedence relations between sisters. In order to do this, we introduce a relation  $\prec$ , where  $A \prec B$  means that  $A$ s must precede  $B$ s.”

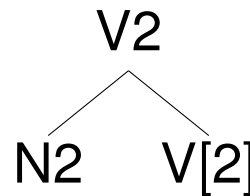
Gazdar et al. (1985). Generalized phrase structure grammar, p. 46.

If we have the rules:

(11)  $V2 \rightarrow V[2], N2$

(12)  $N2 \prec V[2]$

This licenses only:



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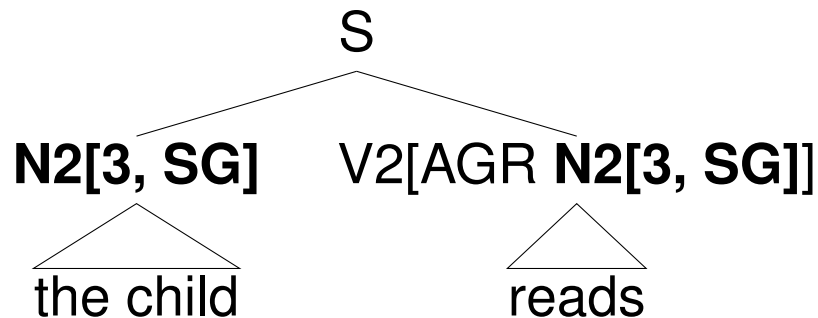
## **Section 4: Important Principles**





# The Control Agreement Principle

In order to model agreement – in the case of English between VPs and NPs – Gazdar et al. (1985, p. 83) introduce the **Control Agreement Principle**. The control relation between the controller and the target is such that the target contains a feature AGR which is then linked to the controller (i.e. filled by the controller). For example, the VP can contain an AGR feature which specifies that it agrees in person and number with the respective NP.



Note: This somewhat contradicts the general idea that the head (i.e. the verb in a verb phrase) assigns agreement features to the subject noun phrase. But note that in practice it does not matter who is the controller and who the target, as long as agreement is guaranteed.

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# Heads

Another important addition in GPSG rules compared to PSG rules is that the **head of a phrase** is explicitly marked by using **upper case H** instead of the original non-terminal symbol. For our two PSG rules above we thus get the following GPSG formulations:

(13)  $V2 \rightarrow H[1]$

(14)  $V2 \rightarrow H[2], N2$

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## Rewrite Rules with Heads

Let us formulate some rewrite rules (immediate dominance rules) for VPs with heads and their subcategorization indices depending on the type of complements taken by the respective verb that heads the phrase. These examples are adopted from Gazdar et al. (1985, p. 110):

- |      |  |                                     |
|------|--|-------------------------------------|
| (15) | $V_2 \rightarrow H[1]$                 | <i>die, eat, sing, read, etc.</i>   |
| (16) | $V_2 \rightarrow H[2], N_2$            | <i>sing, love, cook, read, etc.</i> |
| (17) | $V_2 \rightarrow H[3], N_2, P_2[to]$   | <i>give, sing, throw, etc.</i>      |
| (18) | $V_2 \rightarrow H[4], N_2, P_2[for]$  | <i>buy, cook, reserve, etc.</i>     |
| (19) | $V_2 \rightarrow H[5], N_2, P_2[with]$ | <i>hit, hurt, etc.</i>              |
| (20) | $V_2 \rightarrow H[6], N_2, N_2$       | <i>spare, hand, give, buy, etc.</i> |
| (21) | $VP[+AUX] \rightarrow H[7], XP[+PRD]$  | <i>be</i>                           |

Note, importantly, that the **same verb can be associated with different rewrite rules**, e.g. *give* can be used in both variants of the so-called *dative alternation* (*give her the book, give the book to her*). The +PRD (*i.e. predicate*) feature is necessary to indicate that the XP has to be “predicative” in the sense that a main verb is part of it.

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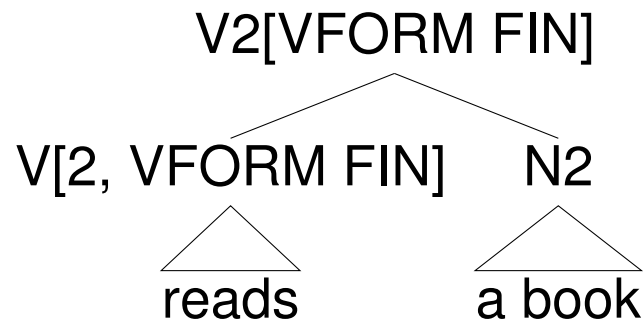


# Head Feature Convention (HFC)

This principle can be roughly summarized as: “The mother node and the head daughter must bear the same head features unless indicated otherwise.”

Müller (2019), p. 182.

Note: this does not include the SUBCAT feature. Subcategorization is here modelled as only becoming relevant at the level below the highest projection.



Note: While in the rewrite rules the H notation is used for the head of the VP phrase, in the tree notation Gazdar et al. (1985) use the POS symbol (i.e. V). We here use the POS symbol with feature specifications in both to show the correspondence.

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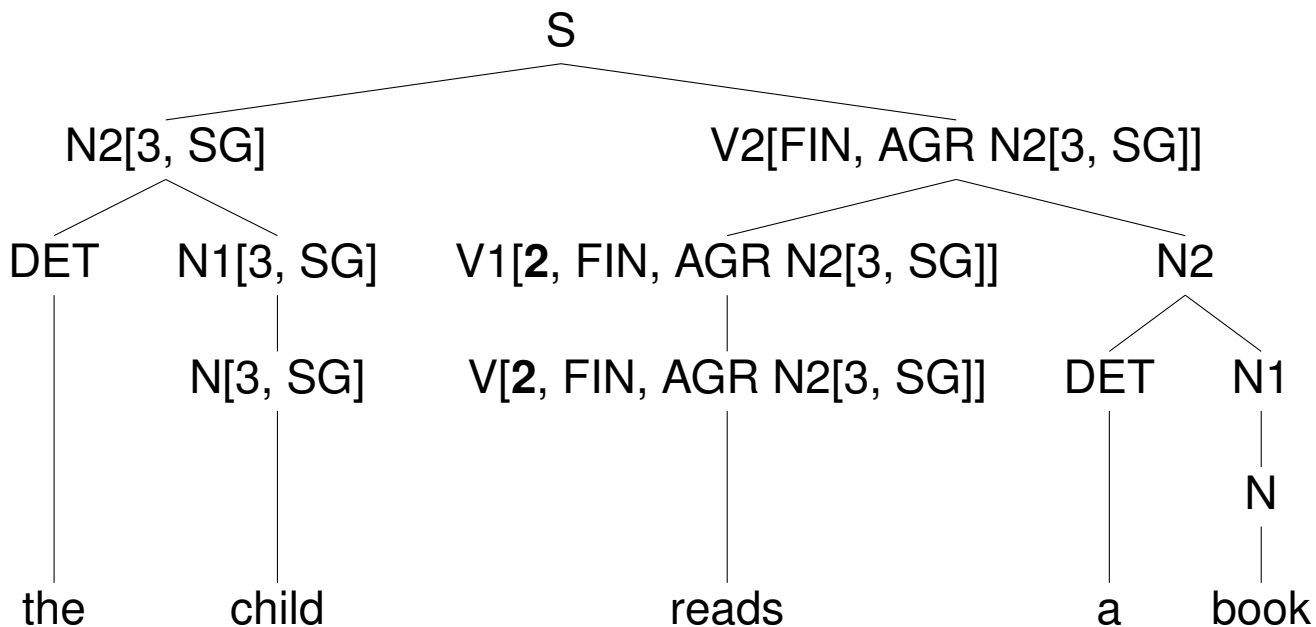
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## Example of Full Declarative Sentence



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### ID rules

- (22)  $S \rightarrow N2[3, SG], V2[FIN, AGR N2[3, SG]]$
- (23)  $N2[3, SG] \rightarrow DET, N1[3, SG]$
- (24)  $V2[FIN, AGR N2[3, SG]] \rightarrow V1[2, FIN, AGR N2[3, SG]], N2$
- (25)  $N2 \rightarrow DET N1$

### LP rules

- (26)  $N2 \prec V2$
- (27)  $DET \prec N1$
- (28)  $V1 \prec N2$



## Some Notes

- ▶ Note that the only difference between the non-terminal symbols for the verb is that the **subcategorization index** (2) does not occur in the square brackets of the highest level projection V2.
- ▶ There is no indication of **case features here**, since in English nouns do not inflect for case (though pronouns do). Case can be assigned by adding a case feature to the rewrite rules: e.g.  
V2 → H[2], N2[ACC]
- ▶ We could also introduce a number feature that needs to agree between the **determiner and the noun** it is headed by, e.g. N2 → DET[SG] N1[SG]. This would help to disallow for example *\*a books*.

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## Important Take-Home-Message

GPSG is construed as a more **explicit and detailed extension of classical PSG**. As such, it takes over some features from X-bar theory (i.e. projection levels). However, it does not follow the GB framework in positing for example a CP and IP, but still follows the classical structure with the S as a starting symbol, mostly rewritten into NPs and VPs.

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# Notation Glossary

A: adjective  
AP: adjective phrase  
Adv: adverb  
AdvP: adverbial phrase  
AGR: agreement feature  
DET: determiner  
H: head  
N: noun  
N1: intermediate projection level  
N2: noun phrase

P: preposition  
P1: intermediate projection level  
P2: prepositional phrase  
PRD: predicative complement phrases  
(after copular)  
V: verb  
V1: intermediate projection level  
V2: verb phrase

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## **Section 5: Syntactic Phenomena**



## Verb Position

Remember from the lecture on classic PSG that verb position can be handled by simply changing the **order of non-terminal symbols on the right side** of the rewrite rules. This is essentially the same in GPSG, with the only difference that the order is now **specified separately in the LP rules**.

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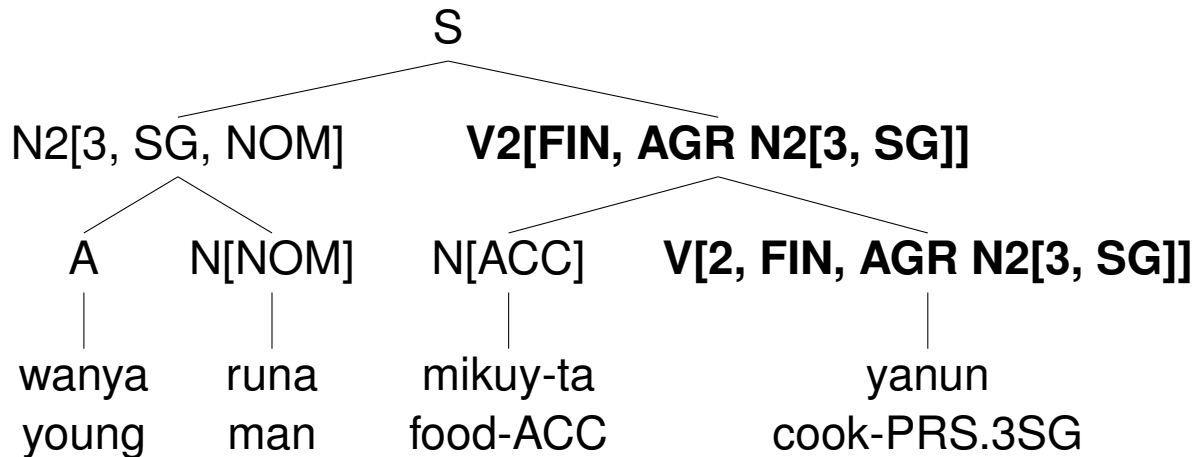
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## Verb-final Position (SOV)

Ayacucho Quechua (quy, Quechuan)



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### ID rules

1.  $S \rightarrow V2[FIN, AGR N2[3, SG]], N2[3, SG, NOM]$
2.  $V2[FIN, AGR N2[3, SG]] \rightarrow V[2, FIN, AGR N2[3, SG]], N[ACC]$
3.  $N2[3, SG, NOM] \rightarrow N[NOM], A$

### LP rules

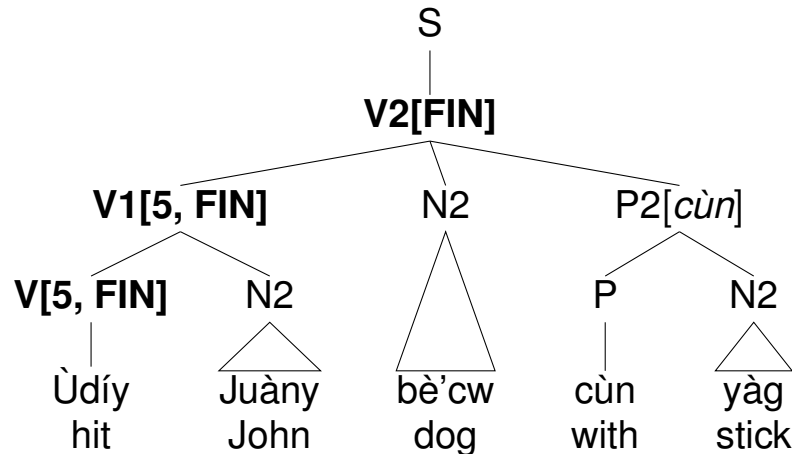
4.  $N2 \prec V2$
5.  $N \prec V$
6.  $A \prec N$

Note: We use the same SUBCAT features here as defined for English above. Also, we need to assign nominative and accusative case in the rules, since this is required for subjects and objects in this construction in Ayacucho Quechua.



## Verb-initial Position (VSO)

Zapototec (Otomanguean)



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### ID rules

$S \rightarrow V2[FIN]$   
 $V2[FIN] \rightarrow V1[5, FIN], N2, P2[cùn]$   
 $V1[5, FIN] \rightarrow V[5, FIN], N2$   
 $P2[cùn] \rightarrow N2, P$

### LP rules

$V1 \prec N2 \prec P2[cùn]$   
 $V \prec N2$   
 $P \prec N2$

Note: We here need first rewrite S into just V2, in order to then use the V1 with SUBCAT 5 defined above for English verbs. Also, In the original example by Hudson (2007, p. 174) there are no further number, person, case assignments specified in the glossings. I'm here assuming that there is still some distinction between finite and non-finite verbs.



## The Passive

Remember that **passive constructions** were one of the reasons why generative grammar accounts moved away from classic PSGs. In a classic PSG, active and passive sentences can be handled by simply having two separate rewrite rules. However, this does not capture the underlying similarity between active and passive constructions. Hence, **transformations** were proposed instead.

Early example of a transformational rule going back to Chomsky (1957):

$$NP_1 V_2 NP_3 \rightarrow 3 [_{AUX} \text{be}] 2en [_{PP} [_{P} \text{by}] 1]$$

John sees Mary  $\rightarrow$  Mary  $[_{AUX} \text{is}]$  seen  $[_{PP} [_{P} \text{by}] \text{John}]$

Müller (2019). Grammatical theory, p. 85.

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## The Passive: Metarules in GPSG

As an alternative to transformations, GPSG proposes to use so-called **metarules**, which allow one, for example, to rewrite an active sentence into a passive sentence – while still keeping the context-free structure of the rules (i.e. only having one non-terminal symbol on the left-hand side).

The general structure of metarules is:

$$\begin{array}{c} \alpha_0 \rightarrow \alpha_1, \dots, \alpha_n \\ \Downarrow \\ \beta_0 \rightarrow \beta_1, \dots, \beta_n \end{array}$$

where  $\alpha_j$  and  $\beta_1$  represent the rewrite symbols. This rule basically states that from a particular rewrite rule, you can regularly derive another particular rewrite rule.

Gazdar et al. (2019), p. 58.

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## The Passive Metarule

The **passive metarule** is then formulated as follows:

$$\begin{array}{c} V2 \rightarrow W, N2 \\ \Downarrow \\ V2[PAS] \rightarrow W, (PP[by]) \end{array}$$

where  $W$  stands in for a multiset of symbols, i.e. could be replaced by whatever symbols are used to form the active sentence.

Gazdar et al. (2019), p. 59.

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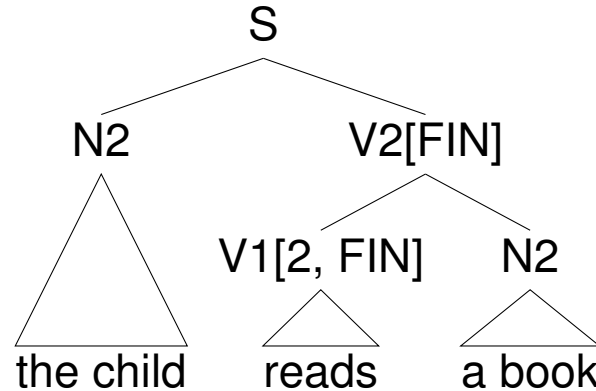
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# Active Sentence



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## ID rules

(29)  $S \rightarrow N2, V2$

(30)  $V2[FIN] \rightarrow V1[2, FIN], N2$

## LP rules

(31)  $N2 \prec V2$

(32)  $V1 \prec N2$

Note: We here considerably simplify the full tree structure from the earlier example by using triangles and by dropping all the agreement features (except the VFORM feature).





## The Passive Metarule

The **passive metarule** is then formulated as follows:

$$\begin{array}{c} V2 \rightarrow W, N2 \\ \Downarrow \\ V2[PAS] \rightarrow W, (PP[by]) \end{array}$$

where  $W$  stands in for a multiset of symbols, i.e. could be replaced by whatever symbols are used to form the active sentence.

Gazdar et al. (2019), p. 59.

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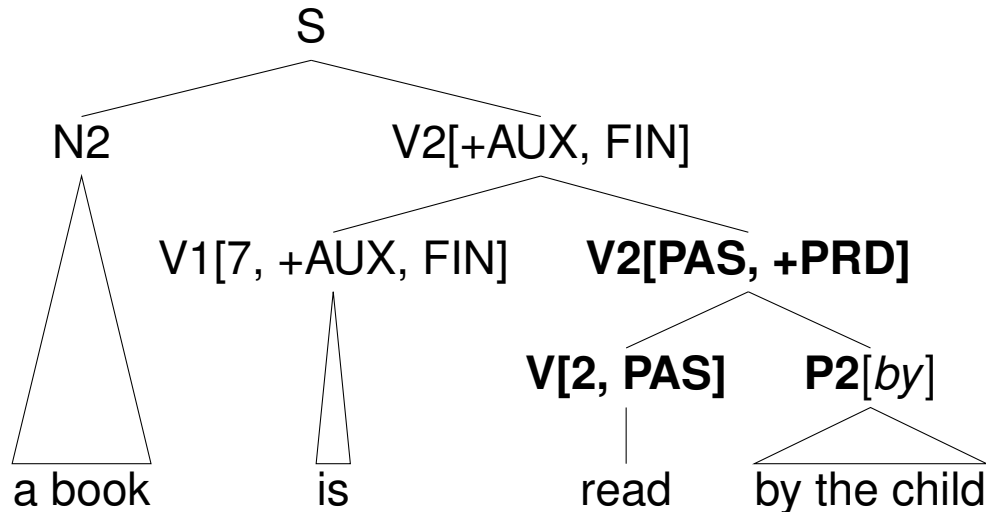
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# Passive Sentence



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## ID rules

- (33)  $S \rightarrow N2, V2[+AUX, FIN]$   
 (34)  $V2[+AUX] \rightarrow V1[7, +AUX, FIN], V2[PAS, +PRD]$   
 (35)  $V2[FIN] \rightarrow V1[2, FIN], N2$   
 $\Downarrow$   
 (36)  $V2[PAS, +PRD] \rightarrow V1[2, PAS], P2[by]$

## LP rules

- (37)  $N2 \prec V2$   
 (38)  $V1 \prec V2$   
 (39)  $V \prec P2$



## Notes on the Passive Sentence

- ▶ The passive metarule is applied to rule (35) which is the same as rule (30) in the active sentence above. Note that this changes only the part of the tree which contains the main verb (read).
- ▶ The auxiliary verb (is) – which is needed for the passive construction – is not derived by the passive rule, but is external to it. It has to be added by first using the rule  $V2[+AUX] \rightarrow H[7]$   $XP[+PRD]$ , where  $H[7]$  represents forms of *be*, and  $+PRD$  indicates a predicative clause following the copula.

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# Long-Distance Dependencies

Remember from the lecture on Dependency Grammar that **long-distance dependencies** can get us into trouble, for example, in terms of crossing dependencies, which might be hard to model and explain within any given grammatical framework.

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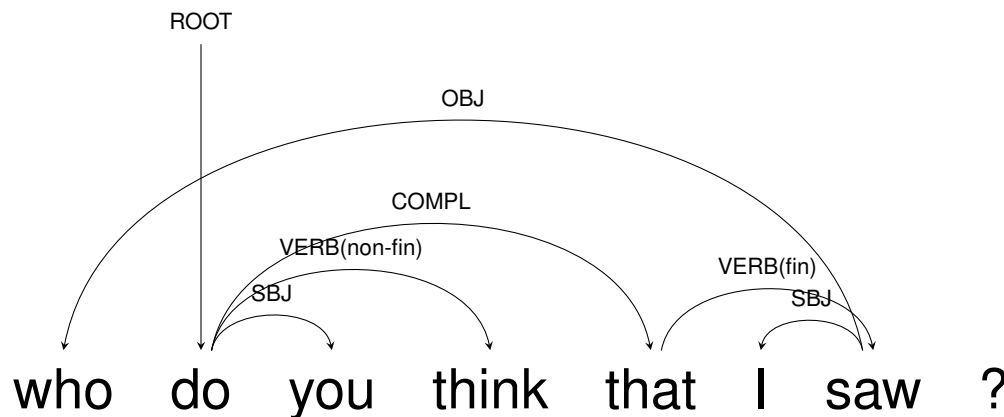
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## Long-Distance Dependencies

“One of the main innovations of GPSG is its treatment of **long-distance dependencies as a sequence of local dependencies** [...] For this, the metarule [below] has to be used. This metarule removes an arbitrary category  $X$  from the set of categories on the right-hand side of the rule and represents it on the left-hand side with a slash ( $/$ ).”

(40)  $V2 \rightarrow W, X$

$\Downarrow$

(41)  $V2/X \rightarrow W$

Müller (2019). Grammatical theory, p. 195.

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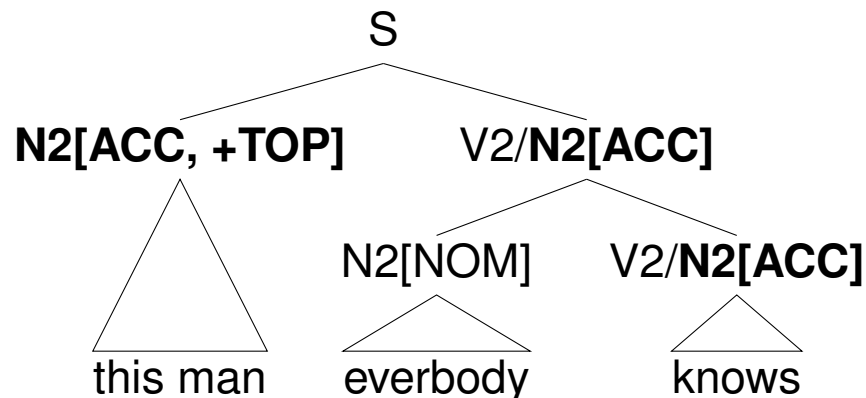
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# Long-Distance Dependencies

This metarule allows for non-terminals being “percolated” up the tree to higher positions where they can then combine with other non-terminals. This helps to model long distance dependencies while maintaining the *context-freeness* of the rewrite rules. Also, note that this is a so-called *trace-less* analysis, as it is assumed that only the features move up the tree, rather than the words themselves.

Müller (2019). Grammatical theory, p. 198.



Note: The +TOP value is here needed to indicate that this is not the regular order of phrases in the language, but an order due to topicalization.

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## **Section 6: Pros and Cons of GPSG**



## Pros (Advantages)

- ▶ Works out explicitly the details of feature representations and rewrite rules which were left open by classic PSGs and GB theory
- ▶ This makes it implementable for computational applications
- ▶ It can handle a range of syntactic phenomena (e.g. the passive) without reference to rewrite rules that go beyond context-free grammars (psycholinguistically more plausible?)
- ▶ While not discussed in this lecture, semantics (of the Montague type) is also firmly integrated into this framework

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## Cons (Disadvantages)

- ▶ Due to all details being explicitly worked out, the notation is complex, and cumbersome for manual analyses (maybe a reason why many syntacticians rather stuck with X-bar theoretic and GB notations and analyses)
- ▶ The context-free nature of rewrite rules might also be seen as a disadvantage, if structures/languages need to be analyzed which require context-sensitive grammars

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## Section 7: References



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# Thank You.

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