EBERHARD KARLS
UNIVERSITÄT
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Faculty of Philosophy
General Linguistics

Syntax & Semantics WiSe 2020/2021

Lecture 9: $\overline{\text{X}}$ Theory

08/12/2020, Christian Bentz

Overview

Tutorial Week 2

> *Could it be that the verb "eat" is polysemous? I.e. there are two sub-entries in its lexical entry – one that says "consume a [particular] meal" and one that says "consume any item of food". An example for the former is the use of the verb in "Oh, no thank you, I ate already." This is a valid use of the verb. It is intransitive. An example for the verb in its second meaning would be "He is eating cheese", where the verb is transitive. [...]*

Yes, this is a valid observation. Even within the same language, the valency of a particular verb might change in different sentential contexts. So we have to decide for a particular sentence if it is grammatical/ungrammatical given the presence/lack of arguments and adjuncts.

Tutorial Week 3

> *Why do we not count the root when calculating average dependency lengths?*

We could count roots with a dependency length of 0. But note that this wouldn't change our results when we compare two sentences in terms of average dependency lengths. It would just amount to adding 1 to the denominator for both.

Tutorial Week 3

> *In your new dependency structure of the Swiss German sentence "(dass) mer d'chind em Hans es huus lönd hälfe aanstriiche", both "Hans" and "children" now depend on two different heads: "Hans" depends on "paint" as a subject, but also on "help" as an object, "children" depends on "help" as a subject, but also on "let" as an object. In my understanding of dependency grammar up to now, each word in a sentence usually depends on exactly one head [...] Did I understand that wrong?*

It is correct that "usually" we have just one head per word. But in this particular structure, we have the unusual situation with two heads (subject-head and object-head). At least this is the analysis which the UD team (for English) also gives (see next slide).

Example of UD 2.7 (English Corpus)

sent_id = email-enronsent00_02-0028
text = Can you help me interpret this statement […]

1	Can	can	AUX	MD	VerbForm=Fin	3 aux	3:aux
2	you	you	PRON	PRP	Case=Nom|Person=2|PronType=Prs	3 nsubj	3:nsubj
3	help	help	VERB	VB	VerbForm=Inf	0 root	0:root
4	me	I	PRON	PRP	Case=Acc|Number=Sing|Person=1|PronType=Prs	3 obj	3:obj|5:nsubj:xsubj|9:nsubj:xsubj
5	interpret	interpret	VERB	VB	VerbForm=Inf	3 xcomp	3:xcomp
6	this	this	DET	DT	Number=Sing|PronType=Dem	7 det	7:det
7	statement	statement	NOUN	NN	Number=Sing	5 obj	5:obj

Tutorial Week 3

> *What irked me at first sight of the new solution [subject and object heads for "Hans" and "the children"] is that nouns that are not in the nominative case are marked as subjects. (Both "Hans" and "the children", I believe, are glossed as being in the dative case.)*
>
> *[...] I believe a distinction needs to be made between metaphysical subject, i.e. the entity which in reality performs the action [...] and the epistemological subject, i.e. the sentence subject, i.e. the entity at the center of the thought being put into words by the sentence [...]*
>
> *My point, in a short-hand way, could be made as "but datives oughtn't be subjects, right?"*

It is true that at least in Standard German nominative case can be seen as a strict requirement for subjects (see Müller 2019, p. 36). However, for other languages (e.g. Icelandic) it has been argued that subjects can be in dative case as well (see Müller 2019, p. 37). In fact, in the English example sentence from the UD corpus, an accusative/dative subject is attested in the exact parallel construction to the Swiss German one (see next slide).

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Example of UD 2.7 (English Corpus)

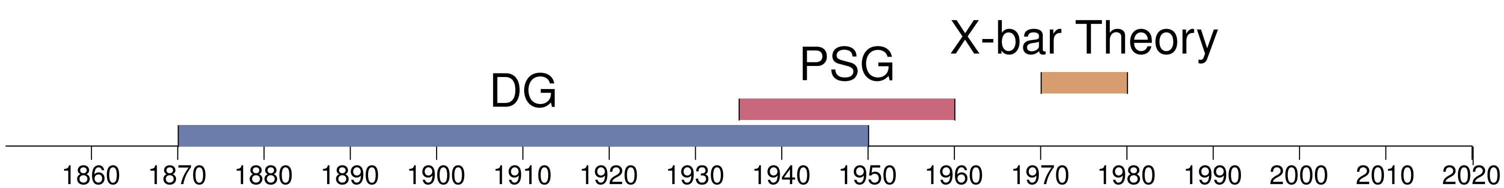
# sent_id = email-enronsent00_02-0028						
# text = Can you help me interpret this statement […]						
1	Can	can	VerbForm=Fin	3	aux	3:aux
2	you	you	Case=Nom|Person=2|PronType=Prs	3	nsubj	3:nsubj
3	help	help	VerbForm=Inf	0	root	0:root
4	**me**	I	**Case=Acc**|Number=Sing|Person=1|PronType=Prs	3	obj	3:obj|**5:nsubj**:xsubj|9:nsubj:xsubj
5	**interpret**	interpret	VerbForm=Inf	3	xcomp	3:xcomp
6	this	this	Number=Sing|PronType=Dem	7	det	7:det
7	statement	statement	Number=Sing	5	obj	5:obj

Section 2: Historical Notes

Historical Perspective

"[...] so-called $\overline{X}$ theory (or X-bar theory, the term *bar* refers to the line above the symbol), which was developed by Chomsky (1970) and refined by Jackendoff (1977). This form of abstract rules plays an important role in many different theories. For example: Government & Binding (Chapter 3), Generalized Phrase Structure Grammar (Chapter 5) and Lexical Functional Grammar (Chapter 7)."

Müller (2019). Grammatical theory, p. 75.



Note: The chronology bars indicate the rough time period where the first and foundational works relating to a framework were published. All of the theories discussed here still have repercussions also in current syntactic research.

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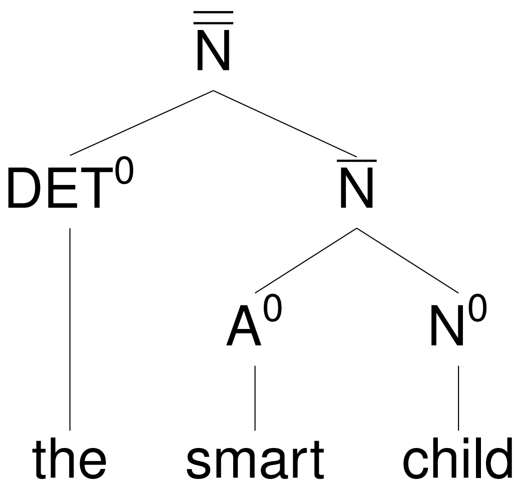
Section 3: Basic Definitions

The bar(s) in X-bar theory

The bar is simply a notational convention to indicate the **level or position of a symbol** in the phrase structure tree – in relation to the level of the symbol that it is dominated by.



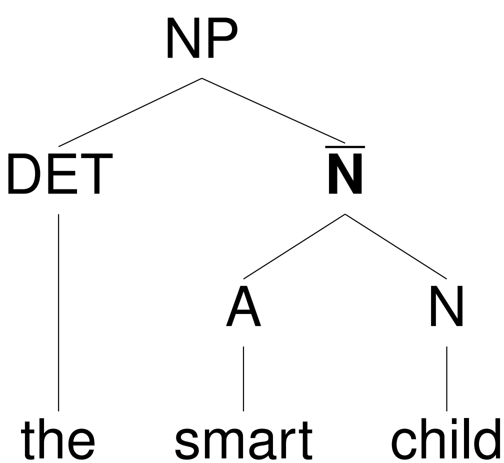
Equivalent Notations:

$\overline{\overline{N}}$ = NP
$\overline{N}$ = NP or N
N^0 = N (of terminal rewrite)

Note: The bars represent so-called *projection levels*. Level 0 (no bar), level 1 (one bar), level 2 (two bars).

Beware the Notational Confusion

In Müller (2019) – and other publications working on this framework – the most frequent convention is to only use bars for the symbols in between the highest level phrase and the symbols leading to the terminals. For highest level phrases the phrase notation is used (e.g. NP), and for the terminal level the zero is dropped. We will adopt this notation in this lecture as well.



Equivalent Notations:

$\overline{\overline{N}}$ = NP

$\overline{N}$ = NP or N

N^0 = N (of terminal rewrite)

Why do we need bars in the first place?

Natural languages are arguably **infinite in their productive potential**. To capture this productivity, we need some structure in our rewrite rules that allows for infinite productivity. For example, we could use the so-called wild card <*>.

Sentences:	**Rule:**	**Creates:**
(1) a child	NP $\rightarrow$ DET N	(1)
(2) a smart child	NP $\rightarrow$ DET A N	(2)
(3) a smart, diligent child	NP $\rightarrow$ DET A A N	(3)
(4) a smart, diligent, quiet, etc. child	NP $\rightarrow$ DET A* N	(1), (2), (3), (4)[1]

[1] The wild card allows for anything from 0 to ∞ realizations of A.

Why do we need bars in the first place?

However, the problem with the rewrite rule involving the wild card[1] is that the adjective-noun combination is not a constituent by itself, since the determiner is required by the rewrite rule. This rewrite rule hence excludes coordination involving adjective-noun phrases without the determiner.[2]

Sentences:	**Rule:**
(5) all [[the smart children] and [the diligent people]]	NP $\rightarrow$ [DET A* N]
(6) all [[smart children] and [diligent people]]	NP $\rightarrow$ DET [A* N]

[1]Some theories would also consider it a problem that the rule does not adhere to the binarization constraint.

[2]The problem could also be sloved by allowing empty determiners, i.e. *DET* $\rightarrow \epsilon$, but then we would always have to posit an empty determiner when only adjective-noun combinations are used.

Why do we need bars in the first place?

The solution to capture all the noun phrases discussed above is a set of rewrite rules using the bar notation:[3]

1. NP $\rightarrow$ DET $\overline{\text{N}}$
2. $\overline{\text{N}}$ $\rightarrow$ A $\overline{\text{N}}$
3. $\overline{\text{N}}$ $\rightarrow$ N

"These rules state the following: a noun phrase consists of a determiner and a nominal element ($\overline{\text{N}}$). This nominal element can consist of an adjective and a nominal element, or just a noun. Since $\overline{\text{N}}$ is also on the right-hand side of the rule, we can apply this rule multiple times and therefore account for noun phrases with multiple adjectives [...]"

Müller (2019). Grammatical theory, p. 64.

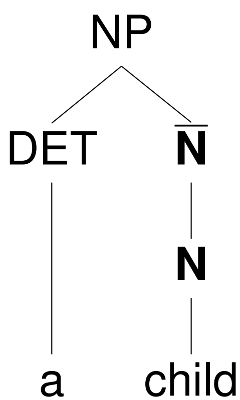
[3] These rewrite rules also adhere to the binarization constraint but they wouldn't have to.

Important Take-Home-Message

The element that is marked by the bar (e.g. $\overline{\text{N}}$) can be either another phrase (NP) or a symbol directly leading to a terminal (N). The rewrite rule where this flexible symbol occurs on both sides is the core part of the set of rewrite rules which allows for **infinite recursive application**:

$$\overline{\text{N}} \rightarrow \text{A}\ \overline{\text{N}}$$

Noun Phrase Examples



Rewrite Notation

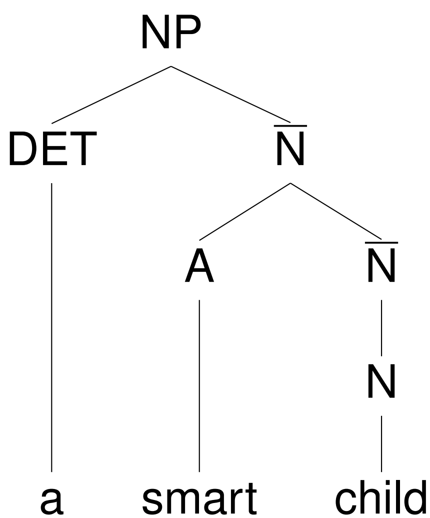
NP
DET $\overline{\mathbf{N}}$
DET **N**

---

a N
a child

Note: Compared to the earlier notation without bars we have an increase in so-called *unary branches*, since we always need to rewrite the element with a bar into an element without the bar.

Noun Phrase Examples



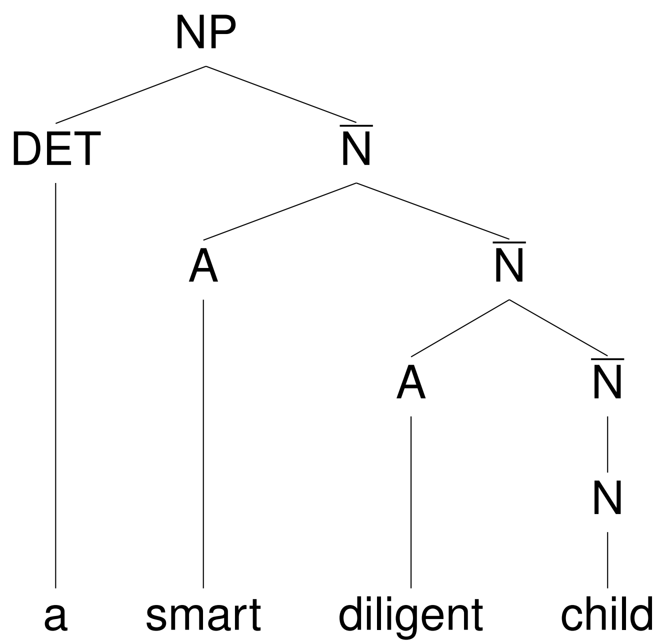
Rewrite Notation

NP
DET $\overline{N}$
DET A $\overline{N}$
DET A N

---

a A N
a smart N
a smart child

Noun Phrase Examples



Rewrite Notation

NP
DET $\overline{N}$
DET A $\overline{N}$
DET A A $\overline{N}$
DET A A N

---

a A A N
a smart A N
a smart diligent N
a smart diligent child

Other Adjuncts (PPs and Relative Clauses)

"Thus far, we have discussed how we can ideally integrate adjectives into our rules for the structure of noun phrases. Other adjuncts such as **prepositional phrases** or **relative clauses** can be combined with N in an analogous way to adjectives [...]"

4. $\overline{\text{N}} \rightarrow \overline{\text{N}}$ PP (e.g. the woman from Stuttgart)
5. $\overline{\text{N}} \rightarrow$ N PP (e.g. father of Peter)
6. $\overline{\text{N}} \rightarrow \overline{\text{N}}$ REL (e.g. the woman who ...)

Müller (2019). Grammatical theory, p. 66.

Note: Rule 5. is a special rule for so-called *relational nouns* (e.g. *father (of)*, *son (of)*, *picture (of)*). Here, the PP is considered a direct complement of the noun (i.e. a possessive construction would be incomplete without it).

Prepositional Phrases

"PPs normally consist of a preposition and a noun phrase whose case is determined by that preposition. We can capture this with the following rule:"

7. PP $\rightarrow$ P NP

Müller (2019). Grammatical theory, p. 71.

However, we also need to cover the following examples:

(7) [PP [**NP one step**] [P before [NP the abyss]]]

(8) [PP [**A shortly**] [P after [NP the take.off]]]

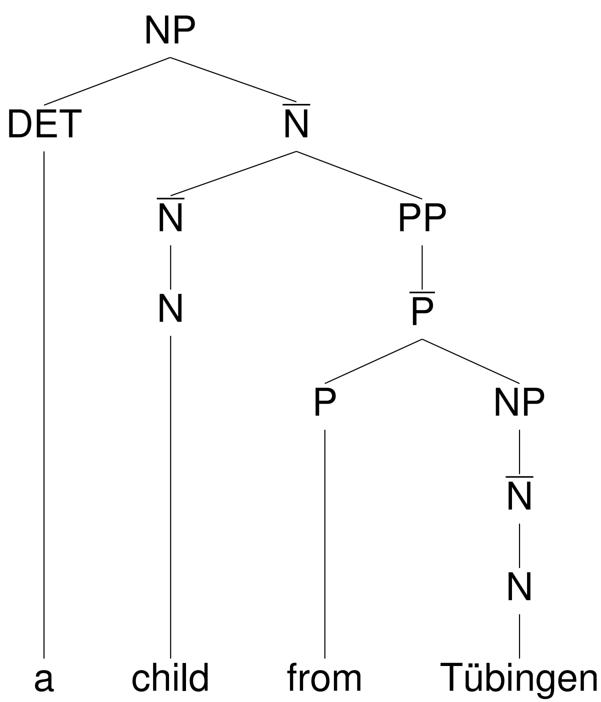
Prepositional Phrases

In order to cover such examples including an indication of measurement (e.g. *shortly*, *one step*) we can choose the following set of X-bar rules:

8. PP $\rightarrow$ NP $\overline{\text{P}}$
9. PP $\rightarrow$ AP $\overline{\text{P}}$
10. PP $\rightarrow$ $\overline{\text{P}}$
11. $\overline{\text{P}}$ $\rightarrow$ P NP

Müller (2019). Grammatical theory, p. 72.

Prepositional Phrase Example



Rewrite Notation

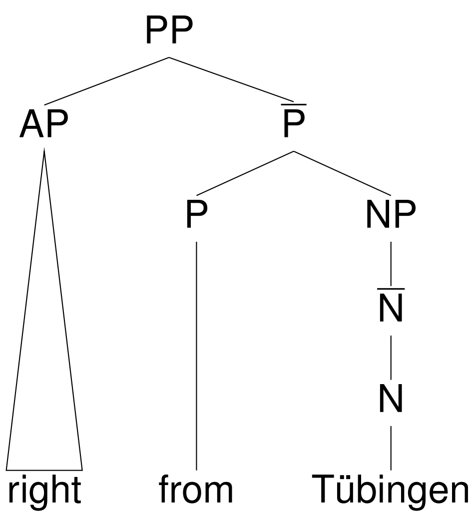
NP
DET $\overline{N}$
DET $\overline{N}$ PP
DET N $\overline{P}$
DET N P NP
DET N P $\overline{N}$
DET N P N

---

a N P N
a child P N
etc.

Note: There is an inflation of non-terminal rewritings due to the fact that X-bar elements have to be rewritten into elements without the bar before being rewritten into the terminals.

Prepositional Phrase Example (with Adjective)



Rewrite Notation

PP
AP $\overline{P}$
AP P NP
AP P $\overline{N}$
AP P N

---

right P N
right from N
right from Tübingen

Note: We haven't defined the structure of adjective phrases (AP) according to X-bar rules yet. Hence, the AP is directly connected to the terminal word *right* by a triangle, which is a placeholder for the actual branching structure.

Adjective Phrases

Müller (2019), p. 74 gives the following examples of adjective phrases that need to be covered by corresponding X-bar rules:

(9) proud

(10) very proud

(11) proud of his son

(12) very proud of his son

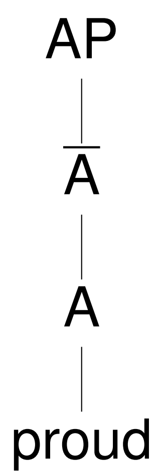
Adjective Phrases

Therefore, he proposes the following rules:

12. AP $\rightarrow \overline{\text{A}}$
13. AP $\rightarrow$ AdvP $\overline{\text{A}}$
14. $\overline{\text{A}} \rightarrow$ A PP
15. $\overline{\text{A}} \rightarrow$ A

Müller (2019). Grammatical theory, p. 74.

Adjective Phrase Examples

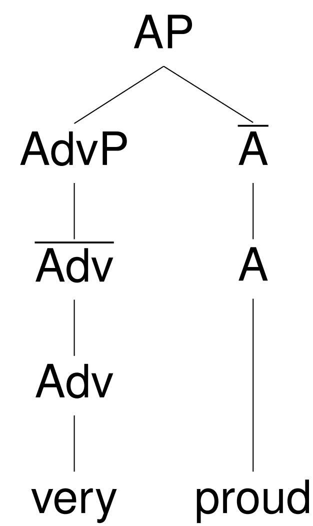


Rewrite Notation

AP
$\overline{A}$
A

---

proud



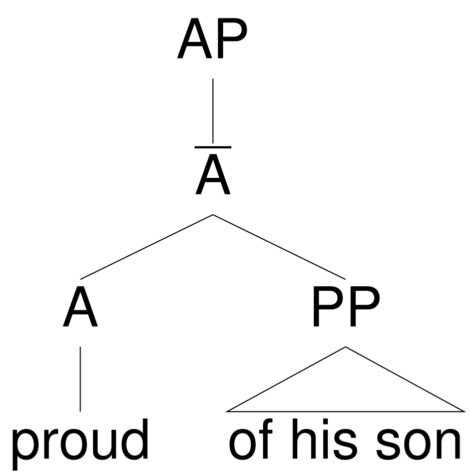
Rewrite Notation

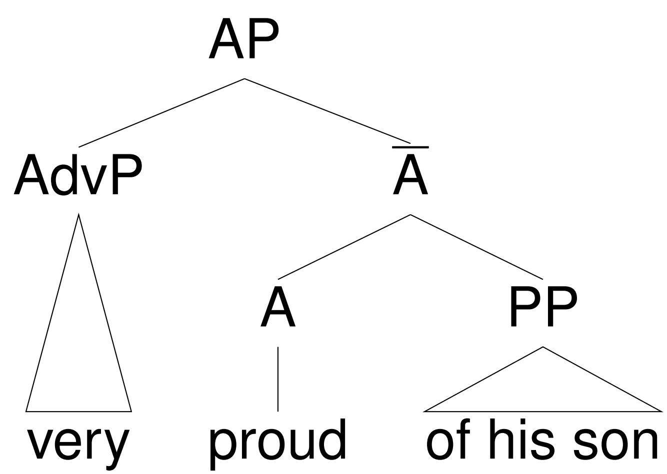
AP
AdvP $\overline{A}$
AdvP A

---

very A
very proud

Adjective Phrase Examples





Rewrite Notation

AP
$\overline{A}$
A PP

---

proud PP
etc.

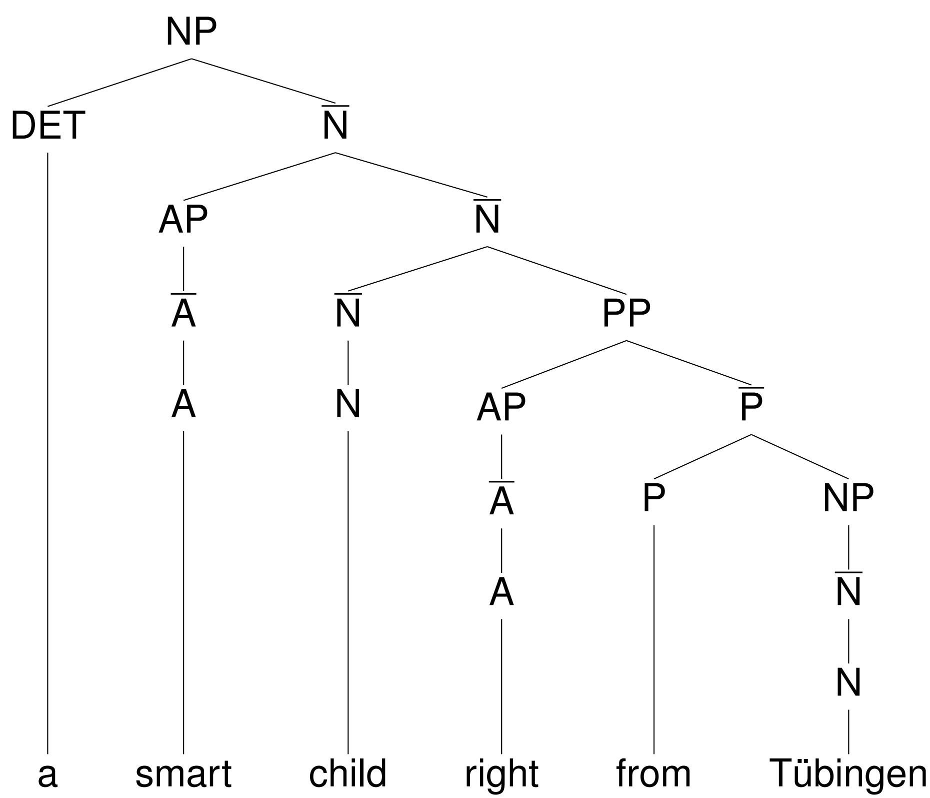
Rewrite Notation

AP
AdvP $\overline{A}$
AdvP A PP

---

very A PP
etc.

Full Example



Rewrite Rules

1. NP → DET $\overline{\text{N}}$
2. $\overline{\text{N}}$ → AP $\overline{\text{N}}$
3. $\overline{\text{N}}$ → N
4. $\overline{\text{N}}$ → $\overline{\text{N}}$ PP
5. $\overline{\text{N}}$ → N PP
6. $\overline{\text{N}}$ → $\overline{\text{N}}$ REL
8. PP → NP $\overline{\text{P}}$
9. PP → AP $\overline{\text{P}}$
10. PP → $\overline{\text{P}}$
11. $\overline{\text{P}}$ → P NP
12. AP → $\overline{\text{A}}$
13. AP → AdvP $\overline{\text{A}}$
14. $\overline{\text{A}}$ → A PP
15. $\overline{\text{A}}$ → A

Notes: The rule number two was modified (A → AP). Rule number seven is not included here as it was replaced by other rules of the X-bar notation.

Notation Glossary

A: adjective
AP: adjective phrase
Adv: adverb
AdvP: adverbial phrase
COMPL: complementizer (i.e. *that*)
DET: determiner
N: noun
NP: noun phrase
P: preposition
PP: prepositional phrase
PRON: pronoun
REL: relative clause
V: verb
VP: verb phrase

Section 4: $\overline{\text{X}}$ Theory

$\overline{\text{X}}$ rules

Grammarians (mostly working with English) realized that different phrase structure rules have structural similarities and can hence be capture in more abstract form by using **X as a placeholder** for other non-terminal symbols.

See also discussion in Müller (2019), p. 75.

$$\overline{\overline{\text{X}}} \equiv \text{XP} \rightarrow \text{NP, VP, AP, PP, etc.}$$

$$\overline{\text{X}} \rightarrow \overline{\text{N}}, \overline{\text{V}}, \overline{\text{A}}, \overline{\text{P}}, \text{etc.}$$

$$\text{X} \rightarrow \text{N, V, A, P, etc.}$$

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Examples of $\bar{X}$ rules

Rewrite Rules

1. **NP** $\rightarrow$ **DET** $\bar{\mathbf{N}}$
2. $\bar{N} \rightarrow$ AP $\bar{N}$
3. $\bar{N} \rightarrow$ N
4. $\bar{N} \rightarrow \bar{N}$ PP
5. $\bar{N} \rightarrow$ N PP
6. $\bar{N} \rightarrow \bar{N}$ REL
8. **PP** $\rightarrow$ **NP** $\bar{\mathbf{P}}$
9. **PP** $\rightarrow$ **AP** $\bar{\mathbf{P}}$
10. PP $\rightarrow \bar{P}$
11. $\bar{P} \rightarrow$ P NP
12. AP $\rightarrow \bar{A}$
13. **AP** $\rightarrow$ **AdvP** $\bar{\mathbf{A}}$
14. $\bar{A} \rightarrow$ A PP
15. $\bar{A} \rightarrow$ A

Bar-notation:

1. $\bar{\bar{N}} \rightarrow \bar{\bar{DET}}^{1}\ \bar{N}$

8. $\bar{\bar{P}} \rightarrow \bar{\bar{N}}\ \bar{P}$

9. $\bar{\bar{P}} \rightarrow \bar{\bar{A}}\ \bar{P}$

13. $\bar{\bar{A}} \rightarrow \bar{\bar{Adv}}\ \bar{A}$

X-bar rule:

$$\bar{\bar{\mathbf{X}}} \rightarrow \bar{\bar{\textbf{specifier}}}\ \bar{\mathbf{X}}$$

[1] Note that this means we need two more re-write rules, and hence have several unary branches for determiners: e.g. DP ($\bar{\bar{DET}}$) $\rightarrow \bar{DET} \rightarrow$ DET $\rightarrow$ the.

Examples of $\overline{\text{X}}$ rules

Rewrite Rules

1. NP $\rightarrow$ DET $\overline{\text{N}}$
2. $\overline{\mathbf{N}} \rightarrow$ **AP** $\overline{\mathbf{N}}$
3. $\overline{\text{N}} \rightarrow$ N
4. $\overline{\mathbf{N}} \rightarrow \overline{\mathbf{N}}$ **PP**
5. $\overline{\text{N}} \rightarrow$ N PP
6. $\overline{\mathbf{N}} \rightarrow \overline{\mathbf{N}}$ **REL**
8. PP $\rightarrow$ NP $\overline{\text{P}}$
9. PP $\rightarrow$ AP $\overline{\text{P}}$
10. PP $\rightarrow \overline{\text{P}}$
11. $\overline{\text{P}} \rightarrow$ P NP
12. AP $\rightarrow \overline{\text{A}}$
13. AP $\rightarrow$ AdvP $\overline{\text{A}}$
14. $\overline{\text{A}} \rightarrow$ A PP
15. $\overline{\text{A}} \rightarrow$ A

Bar-notation:

2. $\overline{\text{N}} \rightarrow \overline{\overline{\text{A}}}\ \overline{\text{N}}$

4. $\overline{\text{N}} \rightarrow \overline{\text{N}}\ \overline{\overline{\text{PP}}}$

6. $\overline{\text{N}} \rightarrow \overline{\text{N}}\ \overline{\overline{\text{REL}}}$

X-bar rule:

$\overline{\mathbf{X}} \rightarrow \overline{\overline{\textbf{adjunct}}}\ \overline{\mathbf{X}}$

or

$\overline{\mathbf{X}} \rightarrow \overline{\mathbf{X}}\ \overline{\overline{\textbf{adjunct}}}$

Examples of $\overline{X}$ rules

Rewrite Rules[1]

[...]
5. $\mathbf{\overline{N} \rightarrow N\ PP}$
[...]
16. $\mathbf{\overline{V} \rightarrow V\ NP}$
17. $\mathbf{\overline{V} \rightarrow V\ NP\ NP}$
18. $VP \rightarrow \overline{V}$
19. $\overline{V} \rightarrow NP\ V$
etc.

Bar-notation:

5. $\overline{N} \rightarrow N\ \overline{\overline{P}}$
16. $\overline{V} \rightarrow V\ \overline{\overline{N}}$
17. $\overline{V} \rightarrow V\ \overline{\overline{N}}\ \overline{\overline{N}}$

X-bar rule:

$$\overline{X} \rightarrow X\ \overline{\overline{\text{complement}^*}}$$

[1] We haven't introduced VPs and their X-bar structure in this lecture, but here are two possible rewrite rules involving verbs and their complements as proposed within the Government & Binding framework.

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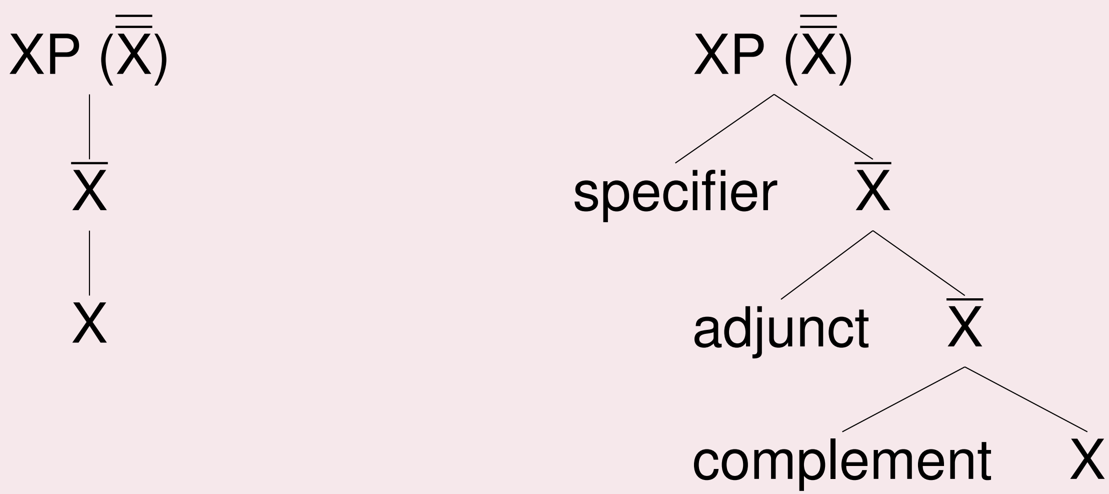
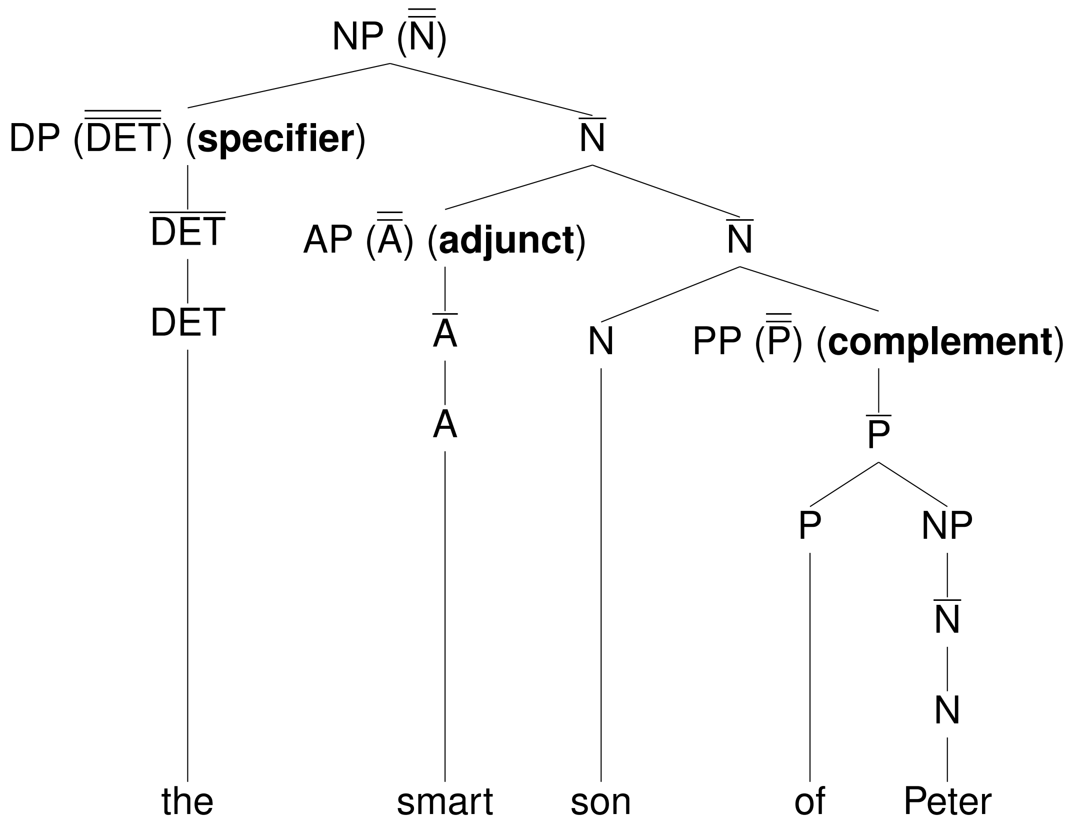
Maximal and Minimal $\overline{X}$ phrases

Given all the generalized $\overline{X}$ rules above we get to the **minimal** and **maximal phrase structure** possible within $\overline{X}$ theory:



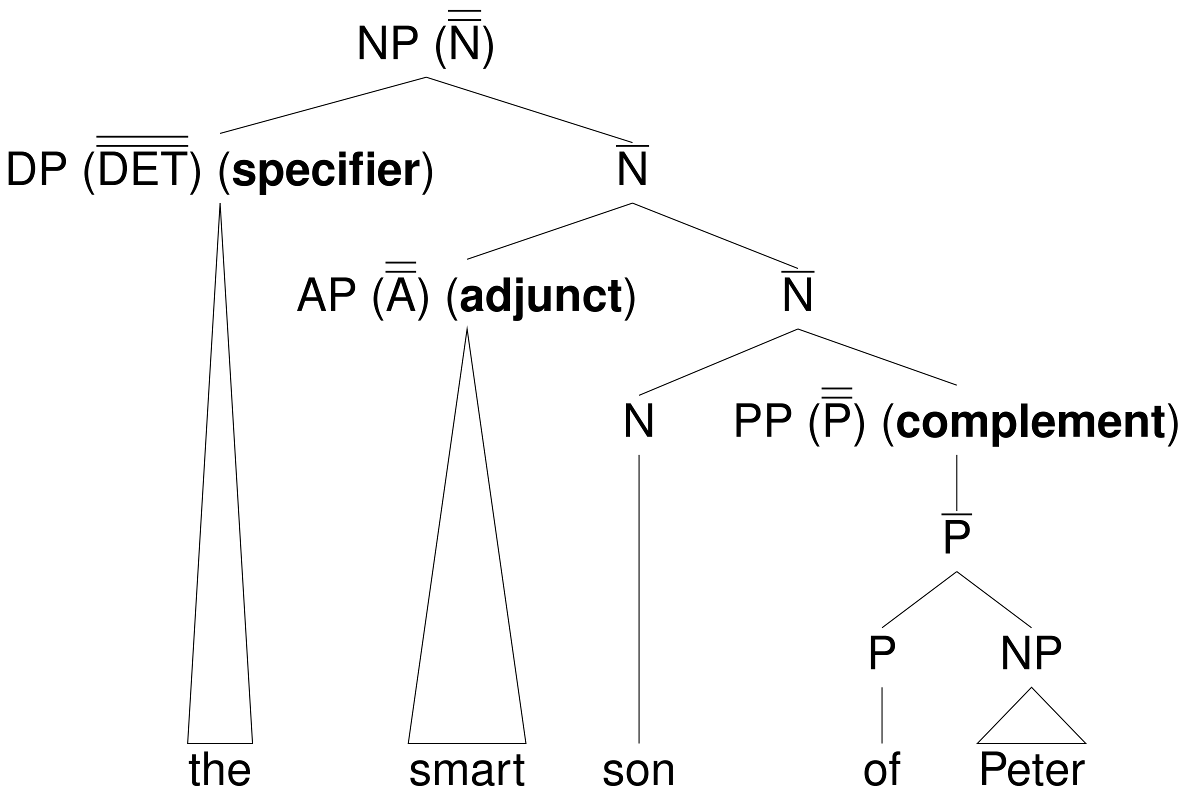
Müller (2019). Grammatical theory, p. 76.

Example of Maximal $\bar{X}$-Phrase



Note: *son* is here a *relational noun*. With the example above (the smart child from Tübingen) the analysis is slightly different. Namely, the PP *from Tübingen* would not be considered a complement, but an adjunct.

Example of Maximal $\overline{X}$-Phrase (with triangles)



Note: *son* is here a *relational noun*. With the example above (the smart child from Tübingen) the analysis is slightly different. Namely, the PP *from Tübingen* would not be considered a complement, but an adjunct.

Section 5: Pros and Cons of $\overline{\text{X}}$ theory

Pros (Advantages)

- Explicitely models the productiveness of natural language by recursively applying rules (though note that recursive application is also possible in classical PSGs)
- Abstracts away from ideosyncrasies of particular phrase types and formulates more general rules (X-bar rules)
- While we haven't discussed morphological features in this lecture, these can be implemented (similar to PSG)

Cons (Disadvantages)

- The bar-notation leads to an inflation of unary branches, and, more generally, makes the analyses of even relatively simple sentences quite daunting.

Section 6: Current Research

A Language Without Recursion?

PLOS | ONE

RESEARCH ARTICLE

A Corpus Investigation of Syntactic Embedding in Pirahã

Richard Futrell[1]*, Laura Stearns[1], Daniel L. Everett[2], Steven T. Piantadosi[3☯], Edward Gibson[1☯]

1 Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA, United States of America, **2** Dean of Arts and Sciences, Bentley University, Waltham, MA, United States of America, **3** Department of Brain and Cognitive Sciences, University of Rochester, Rochester, NY, United States of America

A Language Without Recursion?

- Embedded possessives: *[[[the woman]'s sister]'s husband]*
- Reported Speech: *He said [that she said [that . . .]]*
- Sentential complements: *I dreamed that the Brazilian woman was there last night*
- Adverbials: *because x, x*
- Relative clauses: *the food that the man devoured*
- Coordination: *John and Mary and Bill and ...*

Futrell at al. (2016). A corpus investigation of syntactic embedding in Pirahã.

A Language Without Recursion?

"Our analysis has failed to find strong support for syntactically embedded structures in Pirahã. We emphasize that any conclusions that can be drawn from this corpus evidence must be highly tentative, due to the difficulty of working with a language whose speakers are so difficult to access, as well as the computational challenges of characterizing linguistic complexity."

Futrell at al. (2016). A corpus investigation of syntactic embedding in Pirahã.

A Language Without Recursion?

“We found no unambiguous evidence for sentential or NP embedding in Pirahã in our corpus. The corpus is consistent with the hypothesis that Pirahã is a regular language; [...] In order to flesh out our claim that the corpus is consistent with a regular grammar, we give here a regular expression (technically an egrep expression) which is consistent with the corpus. The symbol `S` matches all sentences in the corpus:

```
S = NPtopic? NPtopic? NPvoc? NPsubj NPsubj? NPsubj? NPtmp? NPloc? NPiobj? (JJobj | NPobj NPobj?)? NPiobj? V JJobj? NPvoc? NPtopic?
```

where `X?` means optional `X` , `(X|Y)` means `X` or `Y`, and each of the symbols above expand into other regular expressions (ignoring morphology and null nouns/verbs) [...]”

Futrell at al. (2016). A corpus investigation of syntactic embedding in Pirahã, p. 17.

Section 7: References

References

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Thank You.

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