Government & Binding

Reading: Chap 2, Siddiqui & Tiwari

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Natural Language Processing

Topics

Language Modelling

Grammar-based language modelling

Government & Binding

X-bar theory

C-command & Governs

Binding

Theta theory & criterion

Extended Projection Principle – EPP

Movement

Language Modelling

- Language modelling : processing the natural language – a complex entity – through a computer program
- Two approaches:
  - Grammar based
  - Statistics based

Language Modelling

- Grammar-based LM
  - Uses the grammar of a language to create its model
  - Grammar – hand-coded rules defining the structure and ordering of constituents appearing in linguistic unit
  - Represents the syntactic structure of language
- Statistics LM
  - Model created by training from a corpus
  - To capture the regularity of a language – large corpus
  - Example: n-gram model

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Grammar-based LM

- Various computational grammars are:
- Transformational grammar
- Lexical Functional Grammar
- Government and Binding
- Generalized phrase structure grammar
- Dependency grammar
- Paninian grammar
- Tree-adjoining grammar

Generative grammar

- Generative grammar – work by Noam Chomsky.
- Focused on modelling the syntactic component – that deals with the combination of words into phrases, clauses and sentences.
- A complete set of rules that can generate all possible sentences in a language

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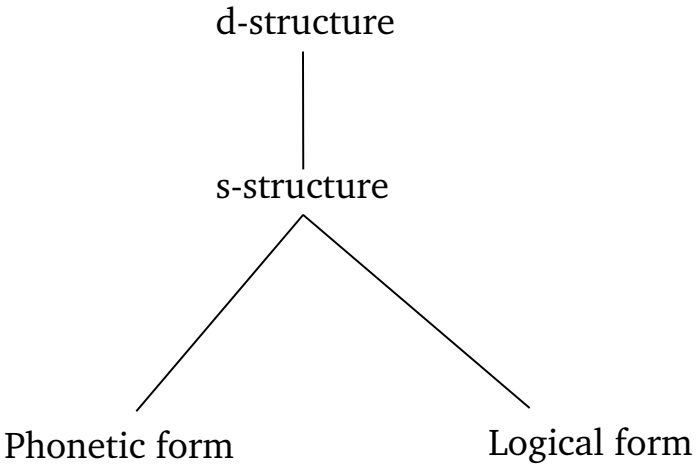
Government and Binding

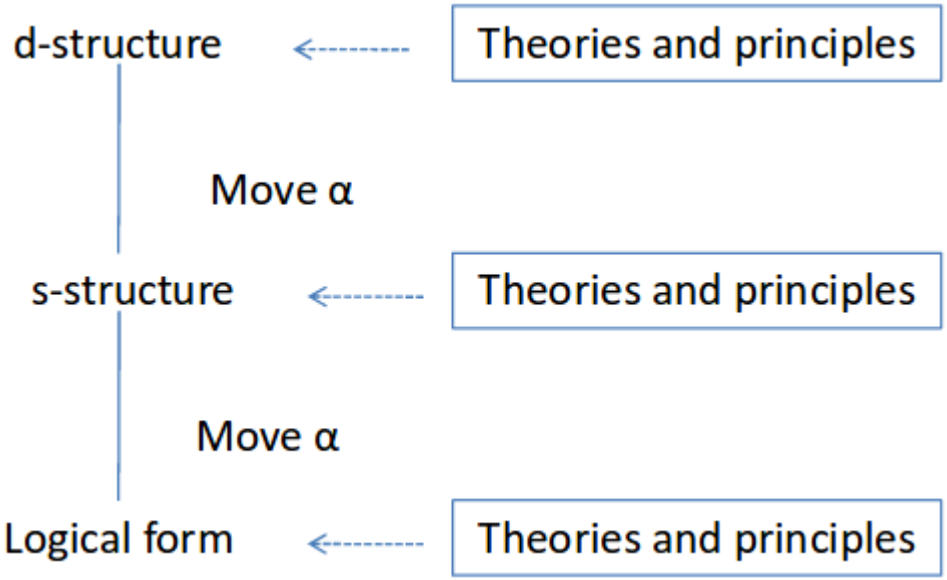
- Two levels in Transformational grammar: surface level and deep root level
- GB added two more level: phonetic and logical form.



Government and Binding

- Transformational grammar issue:
  - Hundreds of rewriting rules
  - Language-specific and construct-specific
  - Generation of complete set of rules – not possible!
- GB idea:
  - Define rules for structural units at deep level
  - Deep-level structures are common to all languages
  - Comprises a set of theories that map the structures from d-structure to s-structure and to logical form

Components of GB



Government and Binding

- Move alpha – a transformational rule
- Move the constituents at any place if it does not violate the constraints put by theories and principles.
- GB contain various constraints and principles:
  - X-bar theory
  - Projection principle
  - θ–theory and θ-criterion
  - C-command and government
  - Case theory
  - Binding theory
  - Empty category principle (ECP)

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X-bar theory

- One of the central concepts in GB
- Defines the phrase structure and sentence structure as maximal projections of some head.
- Thus NP, VP, AP, PP are maximal projections of N, V, A, P
- In X-bar theory, specifiers, head words, complements and adjuncts together form phrases.

X-bar terminology

- X-bar contains
- the head, which projects the whole structure
- the complement (or comp), that complements the head
- the adjunct (or adjt), that modifies the head
- and the specifier (or spec), that determines the head

- The heads are the main class of words like noun(N), verb (V), adjective (J), adverb (A), etc.,

Specifier

- Specifiers further qualify the category of the head in the phrase
- Specifiers are non-recursive unlike complements and adjuncts
- Example:
  - For noun phrases; *determiners* such as the, a, this *quantifiers* such as no, some, every *possessives* such as John's and my son's, which can precede noun phrases.
  - Verb phrases can be preceded by *quantifiers* such as each, and all.
  - Adjective phrases and adverbial phrases can be preceded by *degree* words such as very, extremely, rather and quite.

Specifier

- Examples:
  - For noun phrases;

    determiners – this book

    quantifiers – some money

    possessives – Ram's bow
  - Verb phrases

    quantifiers – every work, often remember
  - Adjective phrases and adverbial phrases

    degree words – great food (JJ), extremely slow (AD)

Complement

- Complement is a word, phrase or clause that is necessary to complete the meaning of a given expression.

  He wiped the counter. – the counter is the object complement of the verb wiped.

  She scoured the tub. – the tub is the object complement of the verb scoured.

- The noun phrases (NPs) – *the counter* and *the tub* – are necessary to complete the meaning of the verbs *wiped* and *scoured*, respectively;

Complement

- Complements always follow the head of the phrase.
- Examples:

1. this book about unicorns

   PP complement follows NP.

2. very late to class

   PP complement follows AP.

3. often forgets his hat

   NP complement follows VP.

4. almost in the basket

   NP complement follows PP.

Adjuncts

- An adjunct is an optional, or structurally dispensable, part of a sentence, clause, or phrase.
- If adjuncts are removed or discarded, will not otherwise affect the remainder of the sentence.
- An adjunct can be a single word, a phrase, or an entire clause.

Single word

She will leave *tomorrow*.

Phrase

She will leave *in the morning*.

Clause

She will leave *after she has had breakfast*.

X-bar theory

- In X-bar theory, specifiers, head words, complements and adjuncts together form phrases.
- There are three "syntax assembly" rules which form the basis of X-bar theory.

  1. An X Phrase consists of an optional specifier and an X-bar, in any order:

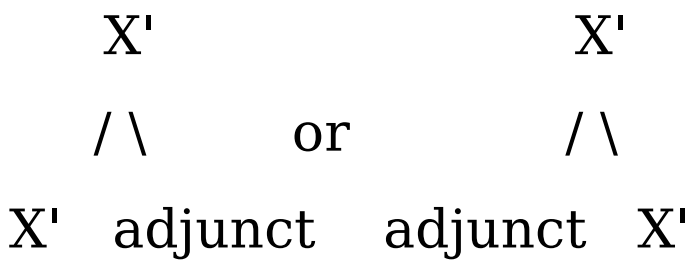
XP → (specifier), X′

```
      XP              XP
      /  \     or     /  \
spec    X'          X'  spec
```

X-bar theory

2. One kind of X-bar consists of an X-bar and an adjunct, in either order:

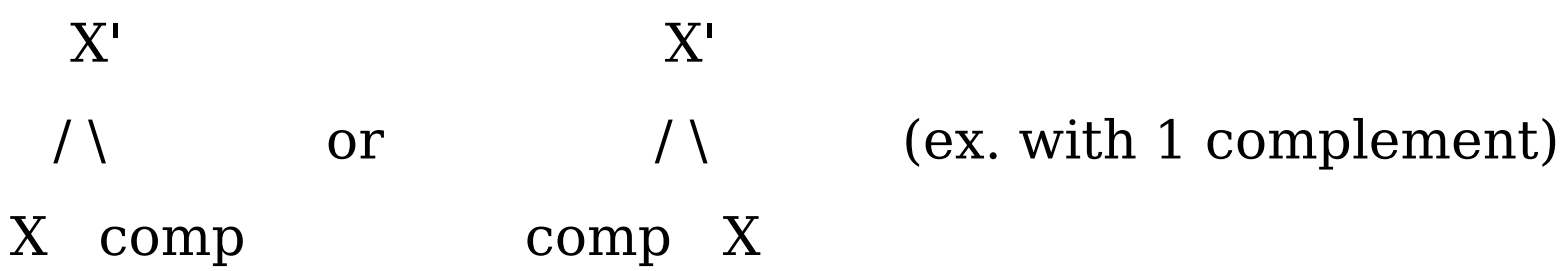
(X′ → X′, adjunct) – optional, recursive



X-bar theory

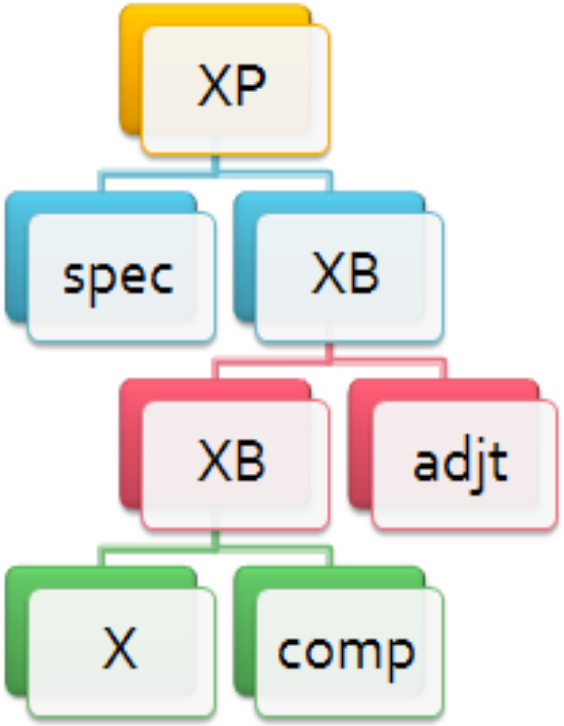
3. Another kind of X-bar consists of an X (the head of the phrase) and any number of complements (possibly zero), in any order:

X′ → X, (complement…)



X-bar structure

X-bar structure



- Where:
  - XP = maximal projection
  - XB = intermediate projections
  - spec = specifier
  - adjt = adjunct
  - comp = complement
  - X = head
    - N (noun)
    - V (verb)
    - J (adjective)
    - A (adverb)
    - D (determiner)
    - P (preposition)
    - C (conjunction)

X-bar structure

X is the head, the X may become an N for noun, a V for verb, an J for adjective, a P for preposition, etc.

comp (i.e., complement) is an *internal argument*, i.e., a word, phrase or clause which is necessary to the head to complete its meaning

adjt (i.e., adjunct) is a word, phrase or clause which modifies the head but which is not syntactically required by it

spec (i.e., specifier) is an *external argument*, i.e., a word, phrase or clause which qualifies (determines) the head

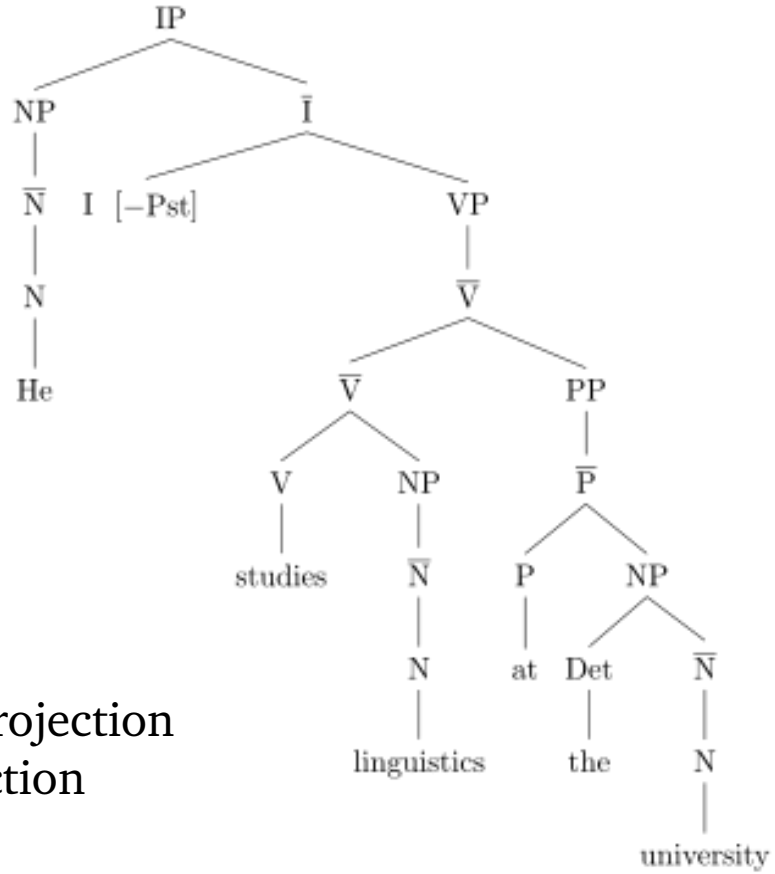
XB (X-bar) is the intermediate projections derived from X

XP (X-bar-bar, X-double-bar, X-phrase) is the maximal projection of X.

Phrase structure

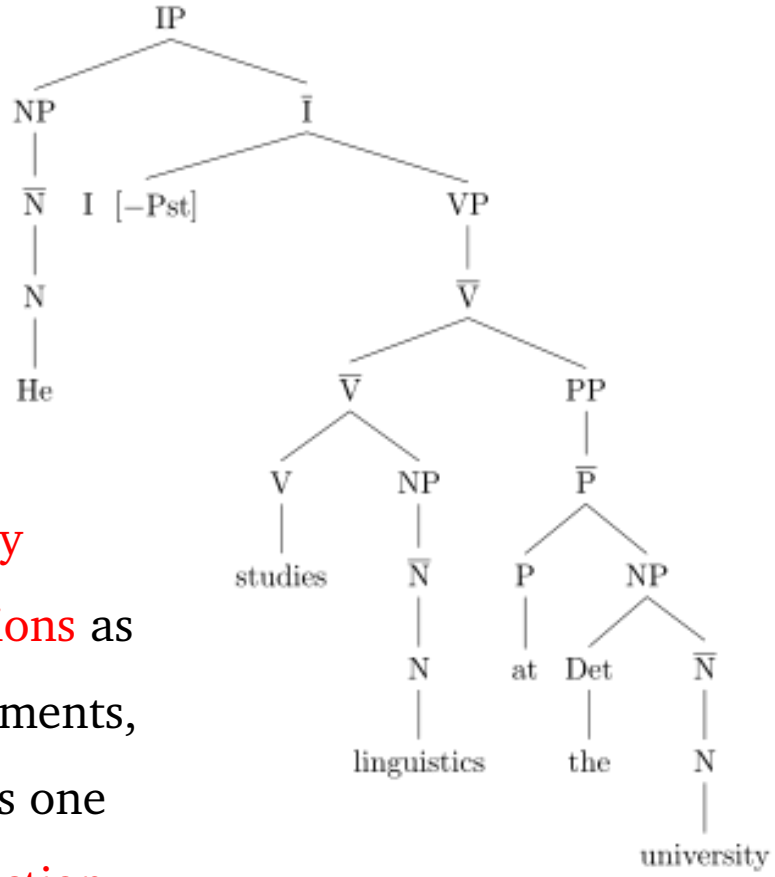
PHRASE	STRUCTURE			
	XP			
	SPEC	XB		
		XB		ADJT
		HEAD	COMP	
NP	DP	N	PP	JP, PP
VP	NP	V	NP, PP	PP, JP, AP
JP	AP	J	PP	AP, JP, PP
AP	AP	A	PP	PP, AP
PP	AP	P	NP, JP, VP	AP
DP	DP	D	-	AP
IP	NP	I	VP	AP
CP	AP	C	IP	AP

X-bar – Example



XB is intermediate projection
XP is maximal projection

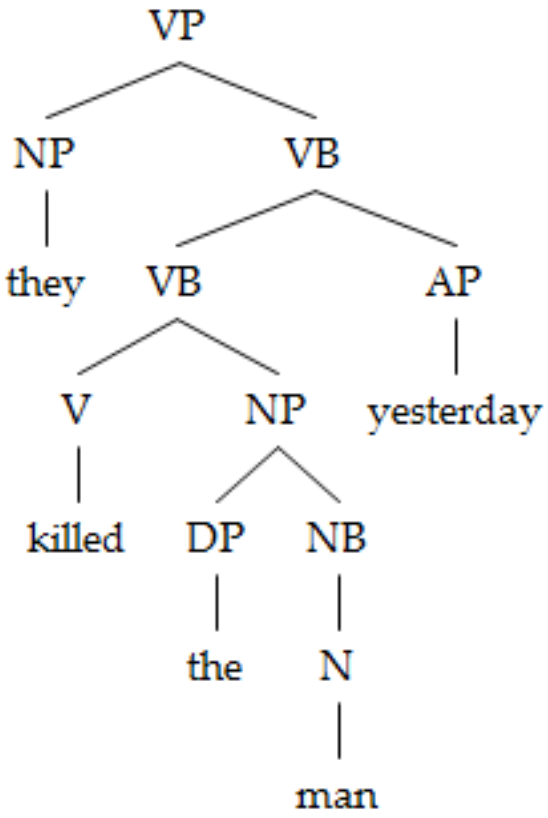
X-bar – Example



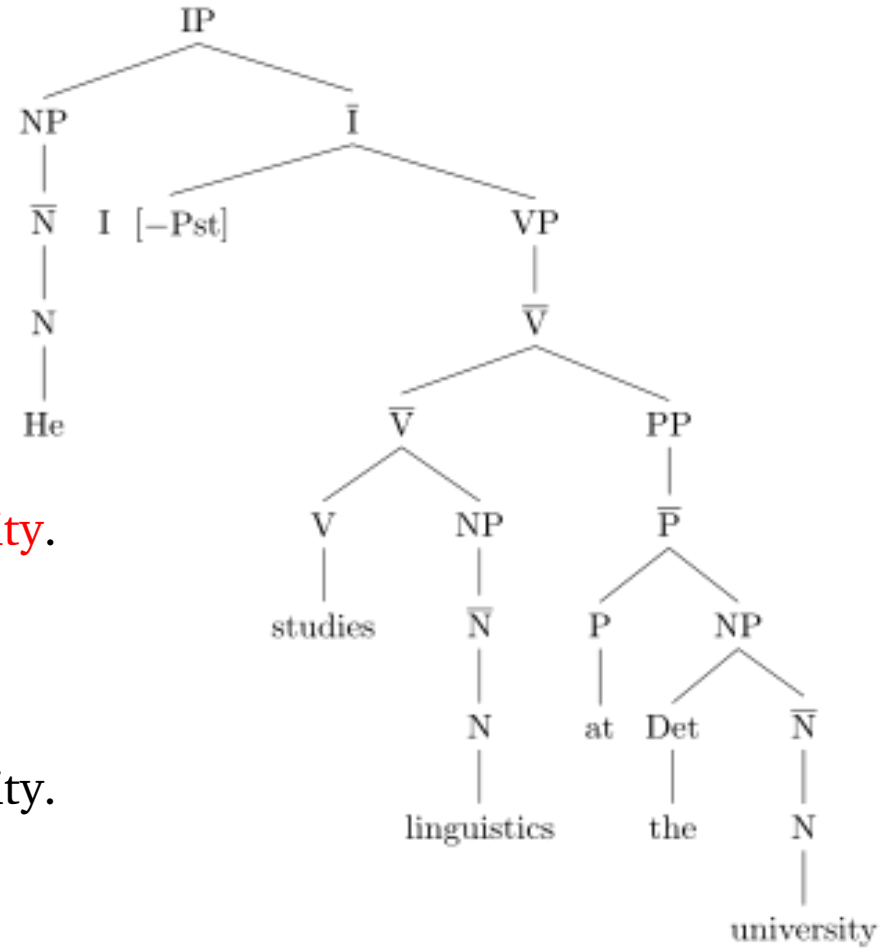
There can be as many intermediate projections as adjuncts and complements, but any head projects one single maximal projection.

X-bar – Example

Find the maximal and intermediate projections



X-bar – Substitution test



P1: He studies linguistics at the university.

P2: She does, also.

P1: He studies linguistics at the university.

P2: And she does at an Institute.

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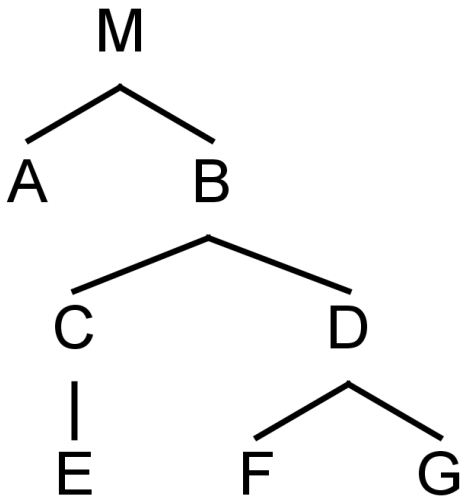
C-command

- C-command (constituent command) is a relationship between the nodes of grammatical parse trees
- Informally, a node in a tree c-commands its sibling node(s) and all of its siblings' descendants.
- A node without siblings c-commands everything that its parent c-commands.



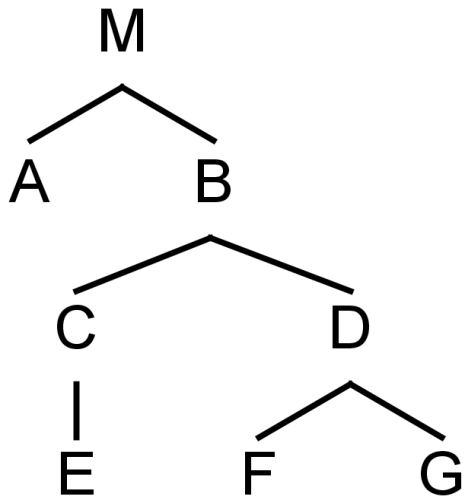
C-command

- Node A *dominates* node B if and only if A is higher up in the tree than B and if you can trace a line from A to B going only downwards.
- A **c-commands** node B if and only

  (i) if A does not dominate B and B does not dominate A;

  (ii) And the first branching node dominating A also dominates B.

Find the c-command nodes for each node in the tree.



Government

- The element which governs is called the *governor*.
- The element that is governed is called the *governee*.
- A **governs** B if and only if

  A is a governor and

  A c-commands B and

  no barrier intervenes between A and B.
- Governors are heads of the lexical categories (V, N, A, P) and tensed.

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Binding

- The binding theory identifies the syntactic relationship that can or must hold between a given pronoun or noun and its antecedent (or postcedent)
- This theory distinguishes between three types of nominals (nouns and pronouns).
- Based on these three types, three binding conditions a formulated, conditions A, B, and C.
- The theory classifies nominals according to two features, [±anaphor] and [±pronominal], which are binary.

Binding

- The binding characteristics of a nominal are determined by the values of these features, either plus or minus.
- A nominal that is [-anaphor, -pronominal] – R-expression (referring expression).

  Ex: common noun or a proper name
- A nominal that is [-anaphor, +pronominal] – Pronoun

  Ex: *he* or *they*
- A nominal that is [+anaphor, -pronominal] - Reflexive pronoun

  Ex: *himself* or *themselves*

Binding

- Condition A

  An anaphor (reflexive) must have a local (nearby) antecedent.

- Example:

  Mukesh$_i$ knows himself$_i$

  α β

  here, anaphor (himself$_i$) is bound in its governing category

  (ie) α c-commands β

Binding

- Condition B

  A pronoun can have an antecedent as long as the antecedent is not local or does not c-command the pronoun.

- A pronoun is free in its governing category.

  Example:

  Mukesh$_i$ believes that Amrita knows him$_i$

  here, Mukesh$_i$ is antecedent of pronoun (him$_i$) and it does not governs the pronoun.

Binding

- Condition C

  An R-expression cannot have an antecedent that c-commands it.

- An R-expression is free.

  Example:

  Mukesh$_i$ believes that Amrita$_j$ knows Ramesh$_k$

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Theta theory (θ thoery)

- These relations between verbs and their arguments are referred to in terms of thematic roles or theta roles (θ-roles)
- Example: Rama killed Ravana.

  kill: verb; 1 2

  NP NP
- The verb *kill* takes two arguments to which it assigns a θ role:
  - it assigns the role AGENT to the subject argument
  - and the role PATIENT to the object argument
- Predicates in general have a thematic structure.
- Thematic structure determines the number and types of arguments which the predicate takes.

Theta theory

- The component of the grammar that regulates the *assignment of thematic roles* is called theta theory .
- Some of the thematic roles are:

  AGENT/ACTOR: the one who *intentionally initiates* the action expressed by the predicate.

  PATIENT: the person or thing *undergoing the action* expressed by the predicate.
- Example: Rama killed Ravana

  AGENT Pred PATIENT

Theta theory

- Example: Rama killed Ravana

  AGENT Pred PATIENT

- Theta grid:

  kill: verb

AGENT NP	PATIENT NP

- An NP refers to an individual or an object and is identified by the referential index.

Theta theory

- An NP refers to an individual or an object and is identified by the referential index.
- Example: Rama$_i$ killed Ravana$_j$

  AGENT Pred PATIENT

- Theta grid:

  kill: verb

AGENT NP	PATIENT NP
i	j

- Each thematic role of a predicate must be assigned

Theta criterion

- Example: Rama$_i$ killed Ravana$_j$ in the battlefield$_k$

  AGENT Pred PATIENT

- Theta grid:

  kill: verb

AGENT NP	PATIENT NP	
i	j	k?

- Theta criterion:
  - Each argument is assigned one and only one theta role.
  - Each theta role is assigned to one and only one argument.

Extended Projection Principle

- **It** is a general property of sentences that they must have subjects.
- This property is stated in the extended projection principle (EPP)

  S → NP – AUX – VP
- In order to satisfy the EPP, so-called *expletives* may have to be inserted in the subject position of a sentence.
- Expletives are pronouns such as *it* and *there* in English which are not assigned a thematic role.

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Movement

- Head-to-head movement
- Wh-movement
- A-movement
- V-movement
- NP-movement
- Adjunct movement

Head Movement

- Movement from one head position to another one is called head-to-head movement
- Example:

  a. Poirot will abandon the investigation after lunch.

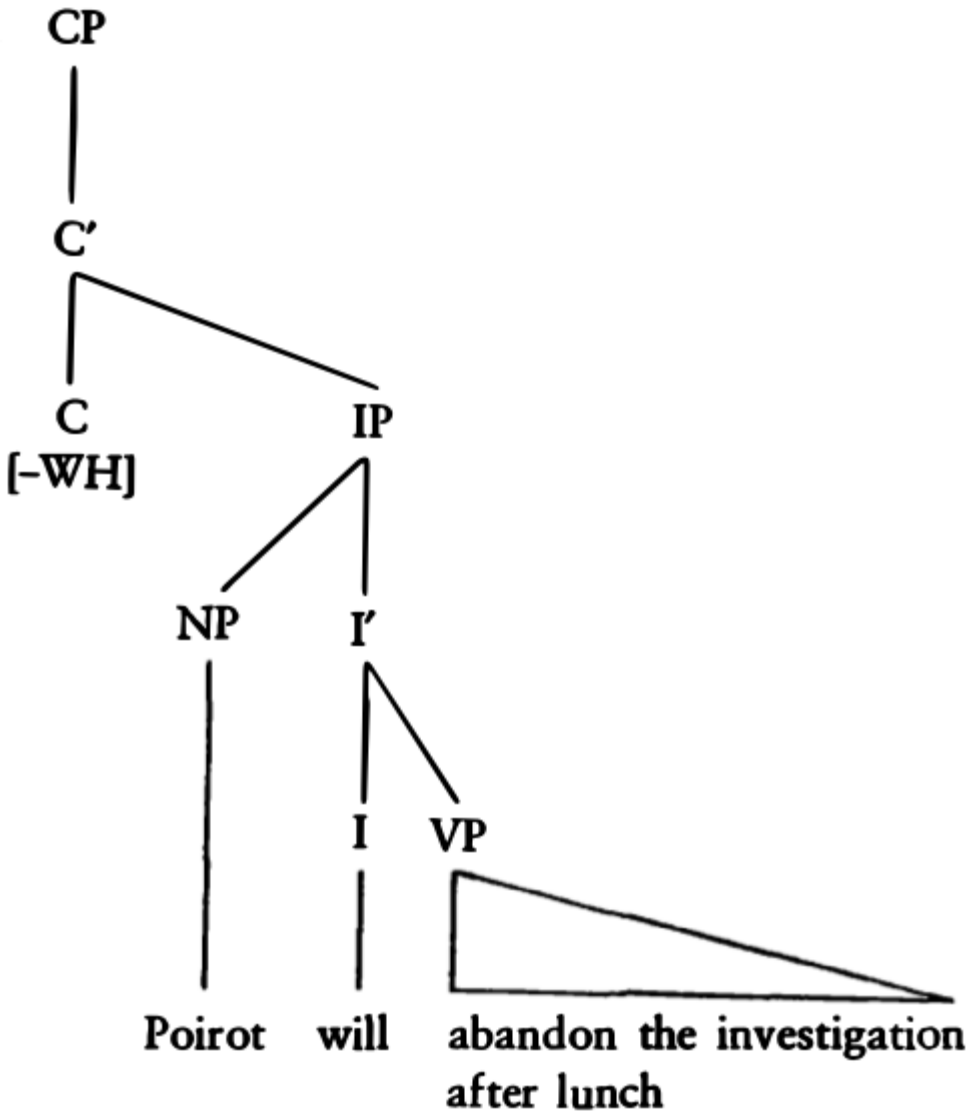
  b. Will Poirot abandon the investigation after lunch?

  c. When will Poirot abandon the investigation?

Head Movement

- No complementizer, assume head of CP has feature [WH]
- Example:

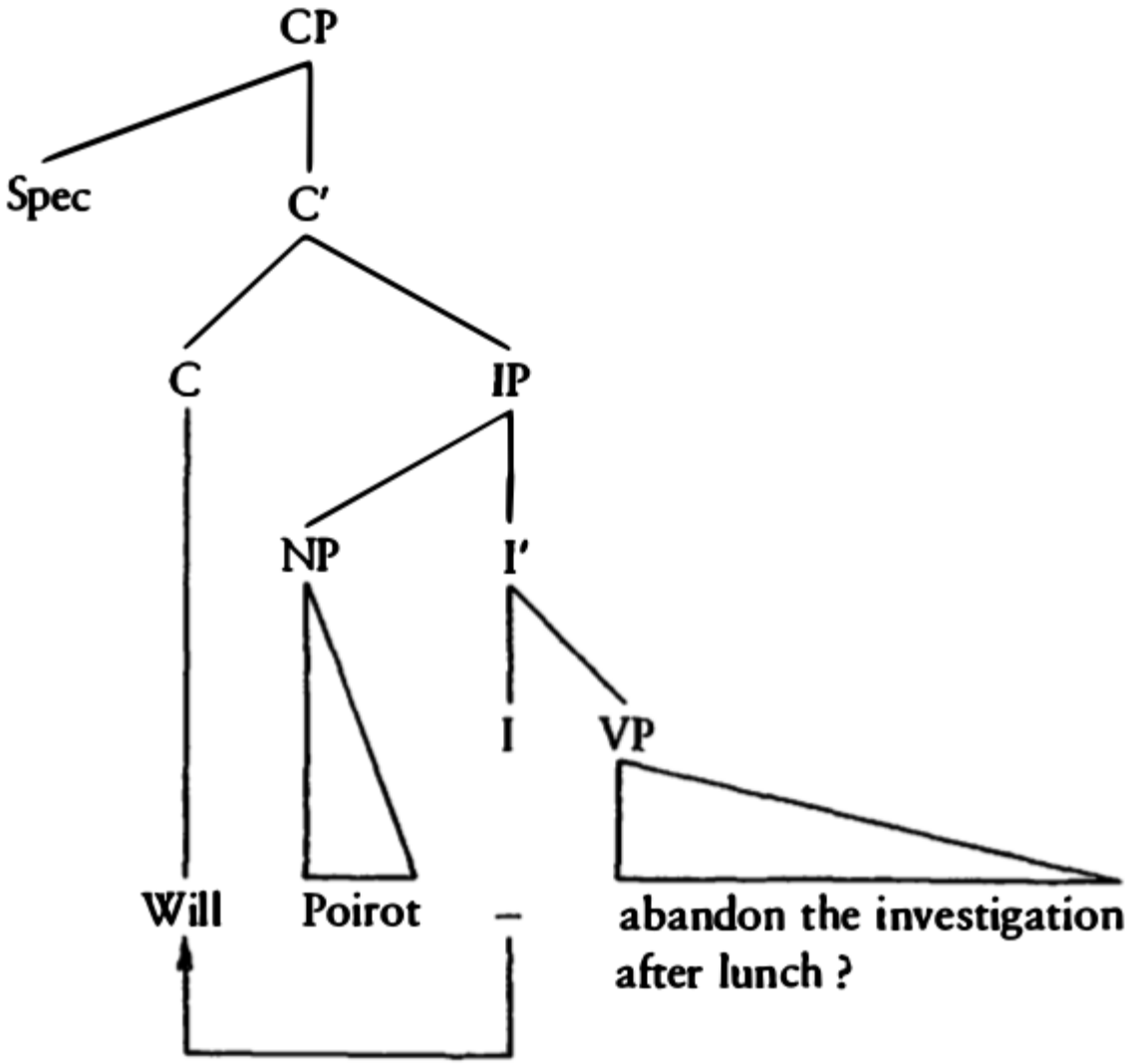
  a. *Poirot will abandon the investigation after lunch.*



Head Movement

- Auxiliary *will* moves from its position I to the position C
- Example:

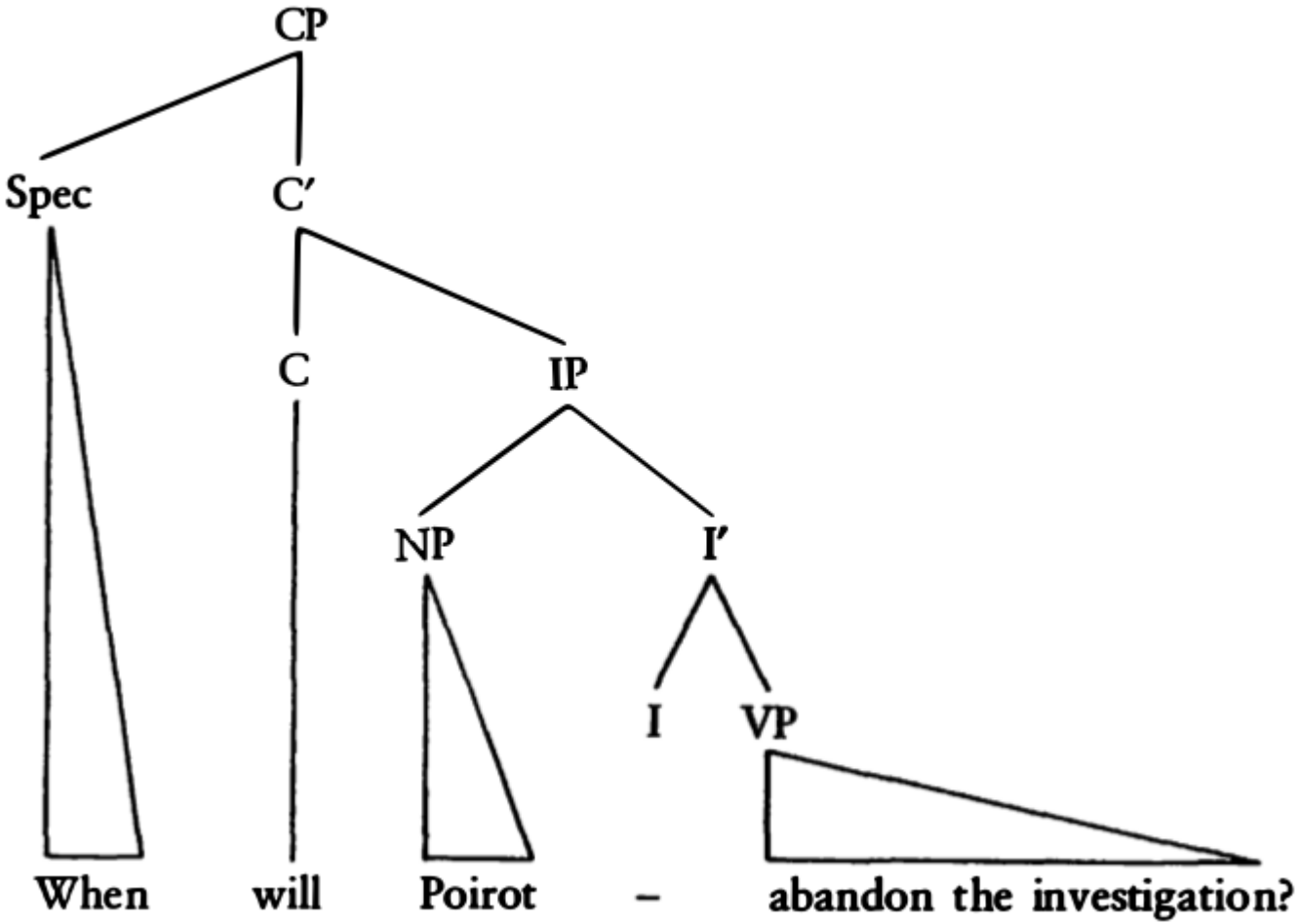
  b. *Will Poirot abandon the investigation after lunch?*



Head Movement

- *When* is moved from time-adjuncts to position preceding C
- Example:

c. *When will Poirot abandon the investigation*



Thank You

References:

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2. Introduction to Government and Binding Theory, Liliane Haegeman, Blackwell Publishers