Syntax in Language Production:

An Approach Using Tree-Adjoining Grammars

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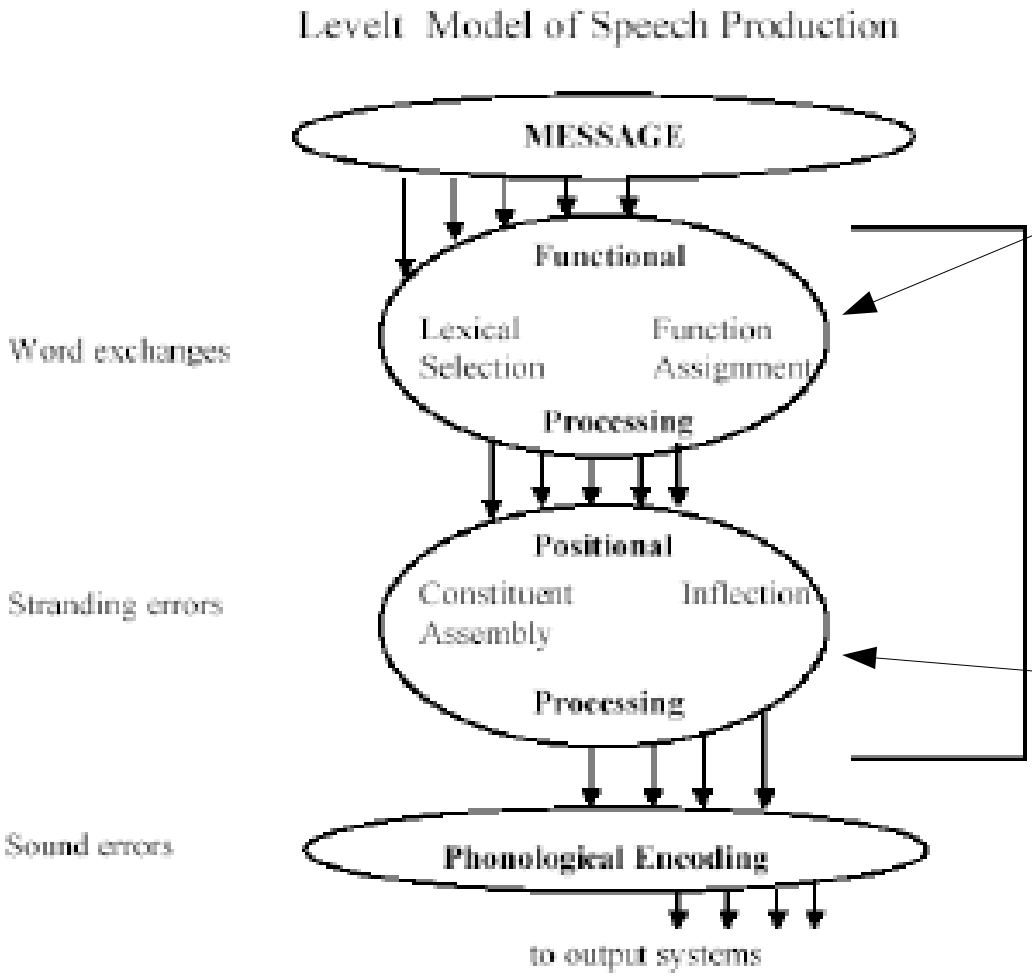
Outline

- Introduction
  - Production of Language and Syntax
- Tree-Adjoining Grammar
  - Elementary trees and operations
- Aspects of Syntactic Production – captured with TAG
- Model of Syntactic Production – based on TAG
  - Implications for incrementality

Introduction



Lemmas are retrieved and assigned grammatical functions (subject, object, ...)

Serial order of phrases

Order of elements within any given phrase

Inflectional processing

Incrementality is assumed!

Simone was eating tuna yesterday.

- Decisions about word order
- Constraints:
  - *Eating*: requires appropriate subject and object
  - Subject before and object after verb
  - *Yesterday*: beginning or end of the sentence
  - *Tuna*: object or subject (requires passive)

- Syntactic information for these decisions:

  consulted **quickly** and **efficiently**

How is this speed and efficiency accomplished?

- Why active form rather than passive?
- How to manage agreement between *to be* and *Simone*?

How are these decisions made?

How do speakers make syntactic decisions?

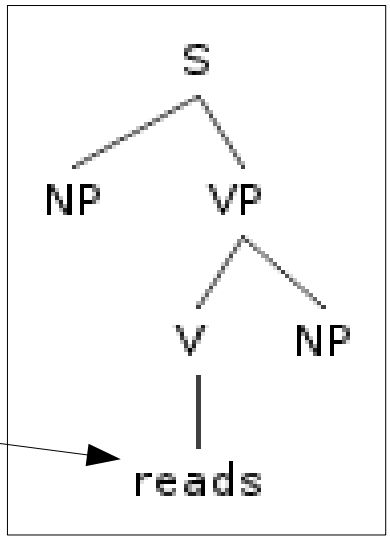
- Considering
  psychological **mechanisms**
  underlying the **ability to combine words**
  to **form appropriate sentences**

➔ Approach: Tree-Adjoining Grammar (TAG)

Tree-Adjoining Grammar

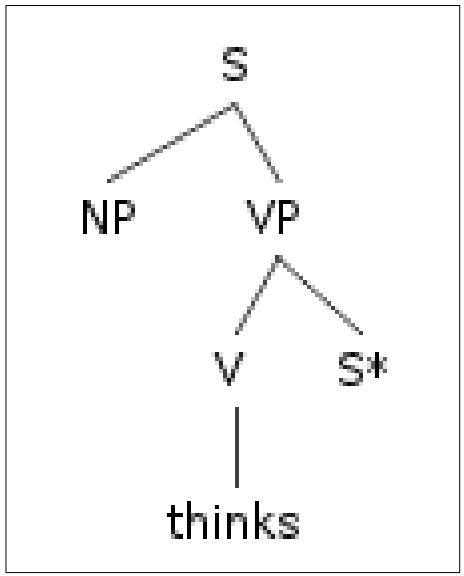
- Grammar:
  - set of **objects**
  - set of **operations** for object manipulation

- Objects: *elementary trees*
  - Primitive **syntactic units** consisting of
    - Lexical **head**
    - **argument(s)** licensed by the head



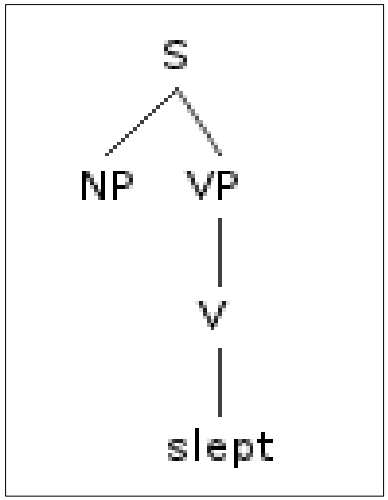
TAG – Types of Trees (1)

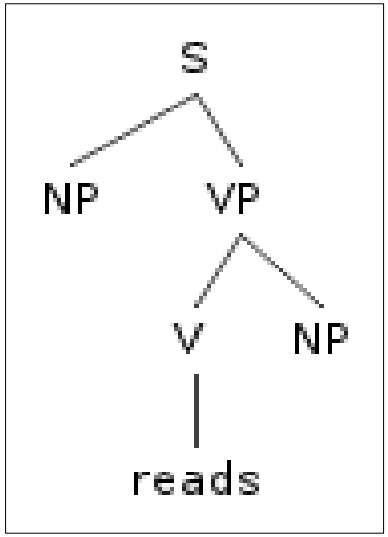
- Two types of elementary trees:
  - **Auxiliary** tree:
    - Root node **identical** to one of the non-terminal nodes
    - → **Recursion**



TAG – Types of Trees (2)

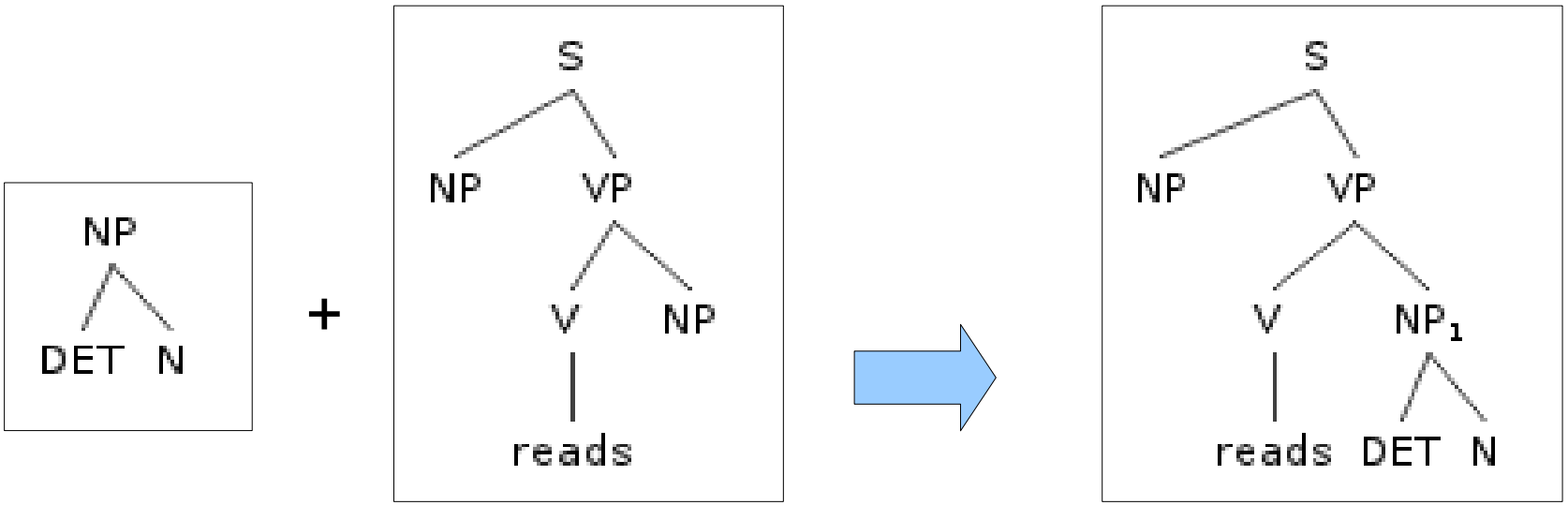
- Two types of elementary trees:
  - **Initial** trees:
    - All elementary trees that are **not auxiliaries**
    - Do **not permit recursion**





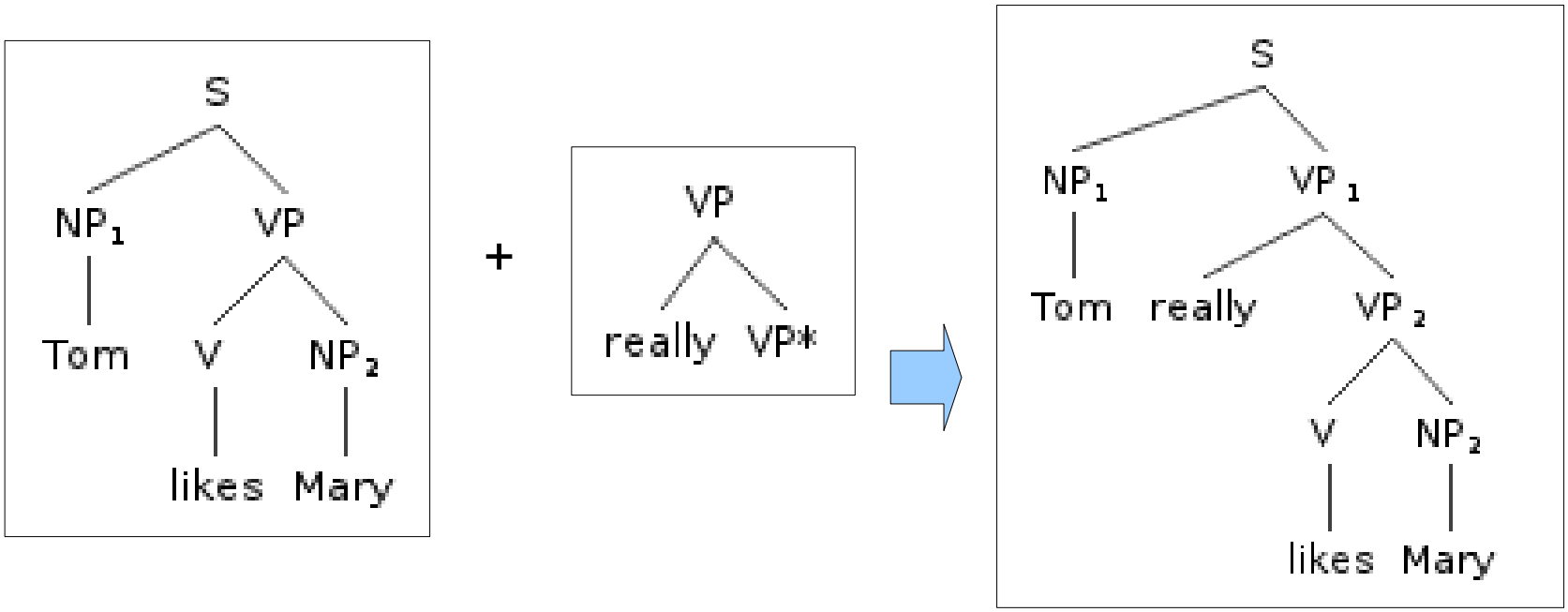
TAG – Operations (1)

- Substitution
  - **attaching** one elementary tree to **bottom node** of another one
  - Restriction: root node **matches** bottom node



TAG – Operations (2)

- Adjoining:
  - inserting elementary tree **inside** another one



TAG - Summary

- Primitive syntactic objects (*elementary trees*)
  - retrieved as single chunk
  - Containing all **dependency** relations
    e.g., relation between **head** as verb and its **arguments**
  - Information about **sorts** of further **syntactic entities**
    e.g., NP needed for subject position
- Operations: *substitution* and *adjoining*

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  - Implications for incrementality

Syntactic Production

- Using TAG to describe syntactic production
  - Lexical influences on syntactic form
  - Syntactic priming
  - Subject-verb agreement
  - Implications for the assumption of the **incrementality** of language production

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Syntactic Production - Lexical Influences

Tom quoted Mary.
Mary was quoted by Tom.

➔ Same idea, expressed differently

What **factors** influence the **decision**
to choose **one of these structures**
during the on-line production?

Syntactic Production - Lexical Influences

- Syntactic form influenced by **availability*** of concepts
  - **More available** concepts tend to be **subject**
  - Rest of the structure is **adjusted appropriately**

→ *quote*: if agent (*Tom*) is **more available** than the patient *(Mary)*, **agent** is in **subject** position

(*) ”available”: concepts that are more **prototypical**, more **concrete**, more **animate**, generally more **activated**

Syntactic Production - Lexical Influences

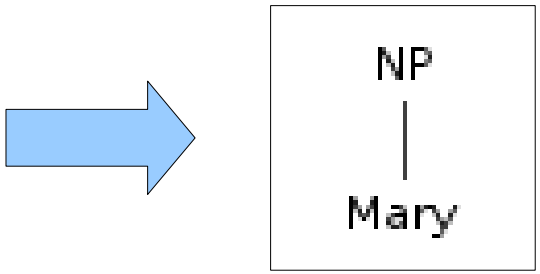
- Example:
  - **Patient**: highly **available** (topic)
  - Production system begins working on it
    - Principle of **incrementality**!
  - Grammatical encoder:
    first thing it can do: **entity = subject**
  - Few options for encoding the rest:
    subject – verb – object
  - Patient = Subject → overall structure **passive**:
    → *Mary was quoted by Tom.*

Can TAG describe this more precisely?

- Propositional representation of the idea:

quote(Tom: agent, Mary: patient, PAST)

  - Assuming **MARY** as **highly available**,
    it can **immediately** be syntactically **encoded**

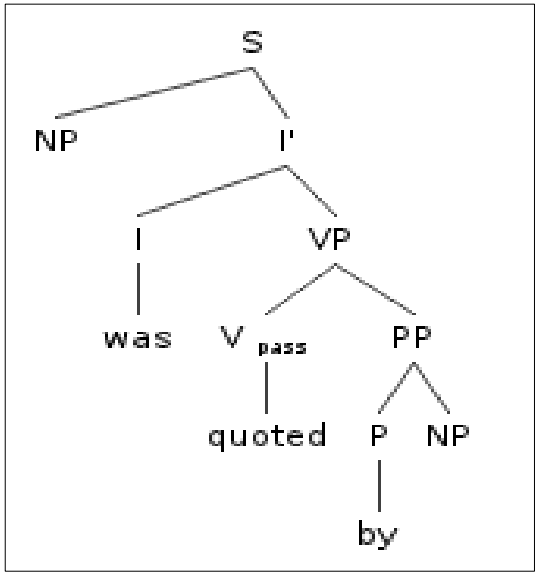


Lexical Influences - TAG

- Concept **QUOTE** constrains encoder to select
  - an **elementary tree** headed by *quote*

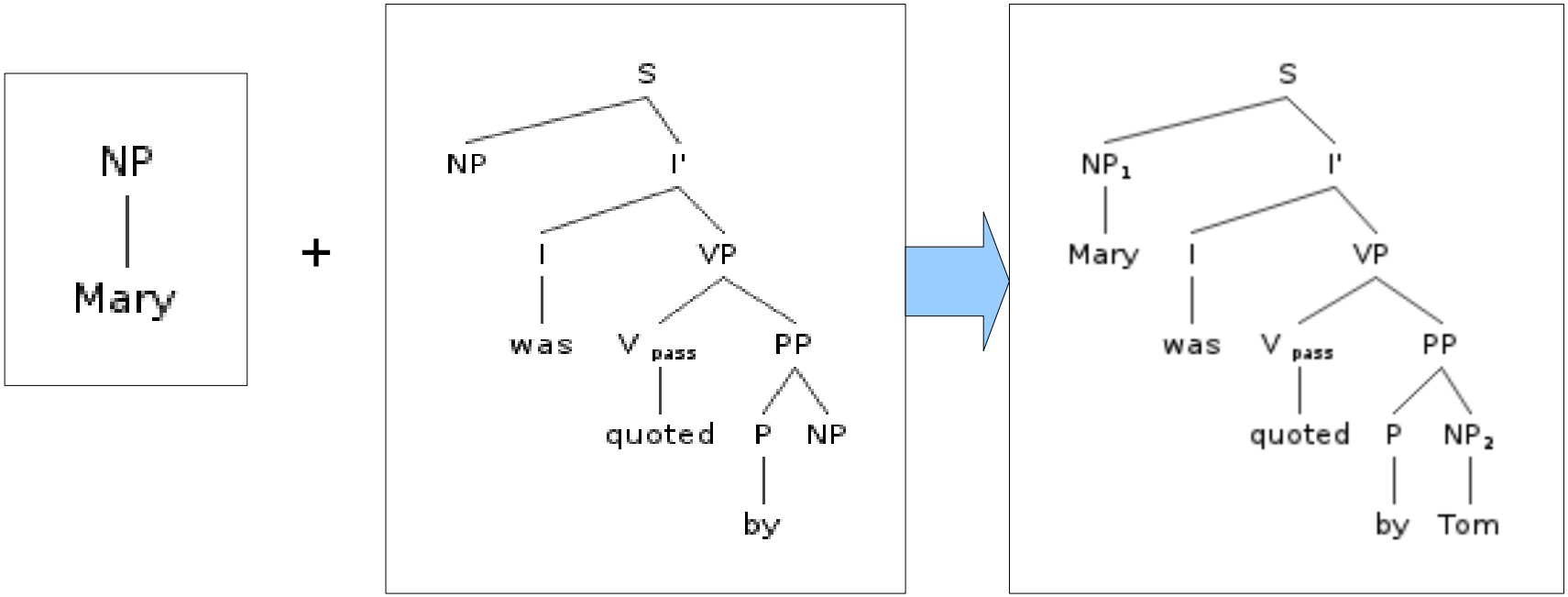
and

  - the information that patient ***Mary*** has already been **encoded** as **subject** and **requires passive**



Lexical Influences - TAG

- Substitution:



→ Principle of **incrementality**: substitution at **earliest position possible** → subject position

Lexical Influences - TAG

- Principle of incrementality:
  - Insertion of NP *Mary:*
    phonological encoder begins to work,
    converting syntactic structure into suitable output
  - **Syntactic** encoder still works on the **remaining parts**
  - **Syntactic** representation **done**:
    phonological representation is **nearly complete**

Syntactic Production

- Using TAG to describe syntactic production
  - Lexical influences on syntactic form
  - Syntactic priming
  - Subject-verb agreement
  - Implications for the assumption of the **incrementality** of language production

Syntactic Production - Syntactic Priming

- Tendency to repeat a particular syntactic form

- Example:

  Speaker just described a **transitive action** using **passive**

  - **Subsequent** transitive event is likely to be **passive** too (Bock, 1986):

The referee was punched by one of the fans.

The church is bring struck by lightning.

Syntactic Production - Syntactic Priming

- Implications of these results:
  - **Challenging extreme forms** of incremental production
  - **Point** during **production**
    where the **entire syntactic form** of a sentence
    can be **influenced** by its **prior presentation**

→ If a **syntactic structure** is simply built up **in little bits**,
immediately converted into **phonological units**:

when is a **syntactic** representation **available** to be primed?

Syntactic Priming - TAG

- Assumption because of syntactic priming effect:

  - **Point** in **syntactic encoding** where a **large chunk** of syntactic structure is **simultaneously available**

- Explanation with a model based on TAG

Syntactic Priming - TAG

- **Availability** of **verb**
  → **availability** of entire clause's **overall syntactic form**
    - active/passive, preposition/double-object dative, …

- Syntactic Priming **independent** of **semantic** content
    - Expected on model:
      elementary **tree headed by verb** may **not include internal content** of any **arguments** in the tree

    - Only thing that may be primed:
      number, configuration, max. projection labels of verb's arguments

Syntactic Priming - TAG

- TAG-based model provides an account of SP effect:
  - **Elementary trees** can be **primed**

- Prediction:

  not just **clausal trees** (i.e., trees headed by verbs) may be **primed**, but **other structures** as well
  - e.g., ADJ before N

    (testing not possible in English: strict word order)

  - Surface order, tested in Dutch (picture description task):

    A ball is on the table. vs. *On the table is a ball.*

    → Expected by TAG: each order with own elementary tree (although both headed by *is*)

Syntactic Priming - TAG

- Further concept in TAG: “families”
  - **Clusters** of related elementary trees, i.e.:
    - **ditransitive** elementary trees including **NP + PP** as post-verbal arguments: *He gave a ball to the cat.*
    - **Variations** on the same basic tree headed by the same lemma (i.e., same verb with different tenses, aspects)

→ Priming would occur across similar trees

→ Similarity relations captured with “families”

Syntactic Production

- Using TAG to describe syntactic production
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Subject-Verb Agreement

- Agreement between *Subject* and *Verb*, e.g.
  - *The report* and *to have* or *to be* (number)

- Agreement errors in sentence completing experiments:
  - More errors with phrases like

    The report *of the destructive fires* (PP)

  - as with phrases like

    The report *that they controlled the fires* (relative clause)

Subject-Verb Agreement - TAG

The report of the destructive fires

- *report* takes PP as argument
- elementary tree for NP includes the PP
- *fires* part of same elementary tree headed by *report*

The report that they controlled the fires

- relative clause merely modifier of *report*
- not in the same elementary tree
- *fires* in different elementary tree (head: *control*)
- inserted by substitution

Subject-Verb Agreement - TAG

- More agreement errors with the PP-construction
  - e.g., *The report of the fires <u>are</u> ...*
  - Head and local noun part of the same structure
  - → Simultaneously available
    (in contrast to the relative clause construction!)
  - → Plural feature of *fires* could end up on head noun
  - → Explanation for more agreement errors

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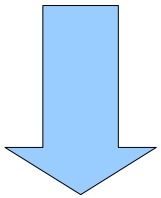
Production of Syntax – based on TAG

- Critical assumptions of the TAG model:
  - **Syntactic structure** built up by **primitive syntactic templates**
  - Each template **based** on a **single lexical item**
  - Templates **retrieved** when its **head** is **activated**
  - Head: template's **only** primitive lexical **content**
  - Other material: inserted by a **operation**
  - Other lexical items: **bound** to **appropriate** syntactic **positions**
  - **Incrementality**: insertion at the **earliest** possible **point**

Production of Syntax – based on TAG

- Example:

The dog bit a flower.

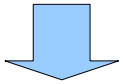


Propositional representation

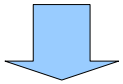
event: BITE(def/1/agent/topic: DOG;
indef/1/patient: FLOWER;
past)

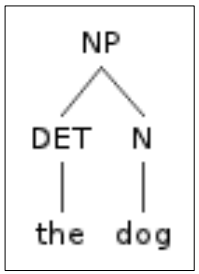
Syntactic Production based on TAG - Example

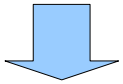
Activated first: DOG (topic)



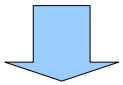
Retrieval of lemma for DOG (sg/def)







Agent: checked off as grammatically encoded

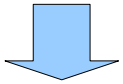


NP placed in syntactic buffer,
awaiting retrieval of clausal tree

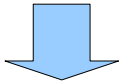
event: BITE(DOG, FLOWER)

Syntactic Production based on TAG - Example

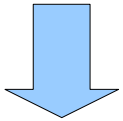
Assumed as next activated: verb

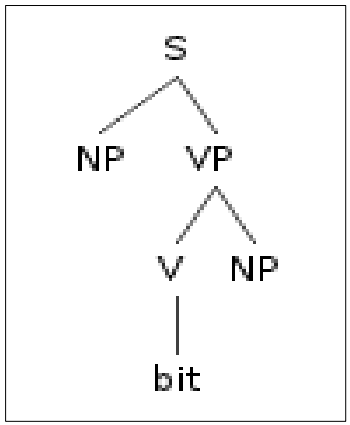


Retrieval of BITE (past)



Active form: agent has been already encoded

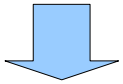




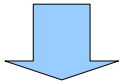
event: BITE(DOG, FLOWER)

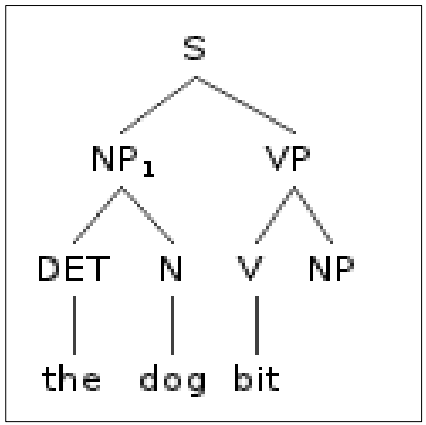
Syntactic Production based on TAG - Example

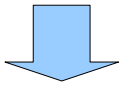
NP (*the dog*) in syntactic buffer



Incrementality: NP in the leftmost NP slot





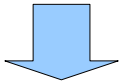


The dog encoded as subject

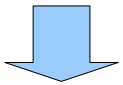
event: BITE(DOG, FLOWER)

Syntactic Production based on TAG - Example

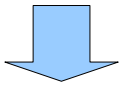
First entity of sentence encoded



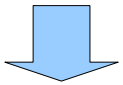
Piece of utterance (S+V)
sent for phonological encoding



Retrieval of lemma for FLOWER
(sg/indef)



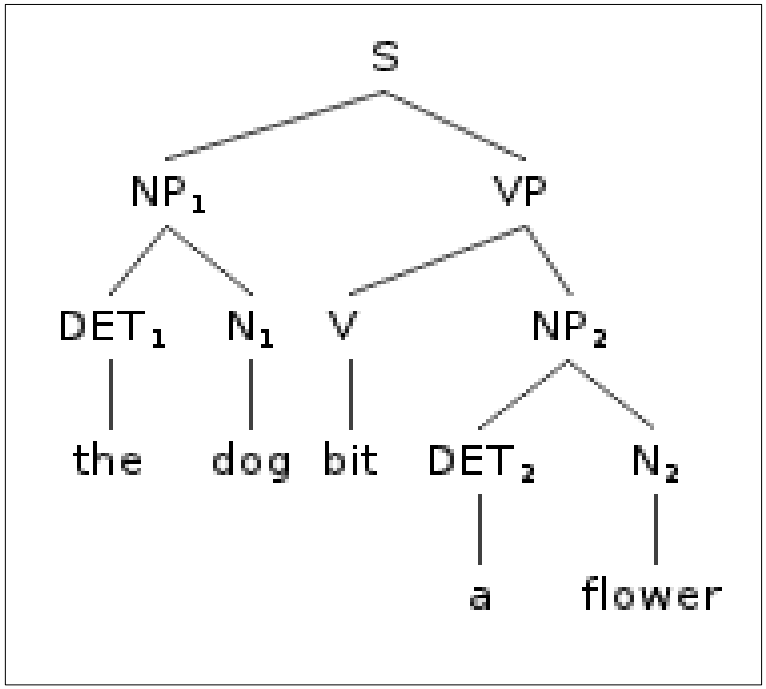
Indefinite NP structure



Inserted in the last remaining NP slot

event: BITE(DOG, FLOWER)

Syntactic Production based on TAG - Example



Grammatical encoding of the sentence is complete!

event: BITE(DOG, FLOWER)

Syntactic Production based on TAG – Example 2

- Another example:
  - advantages of assuming only a **moderate degree** of incrementality

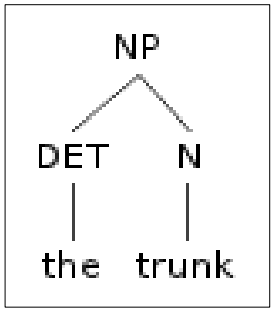
event: PUT (def/1/agent: MAN; def/1/theme: BODY; def/1/location/topic: TRUNK;
Past)

Idea:

“a particular trunk was the location in which a singular male placed a body”

Syntactic Production based on TAG – Example 2

Available first: TRUNK (topic)



LOCATION checked off as encoded

NP placed in syntactic buffer

event: PUT(MAN, BODY, TRUNK)

Syntactic Production based on TAG – Example 2

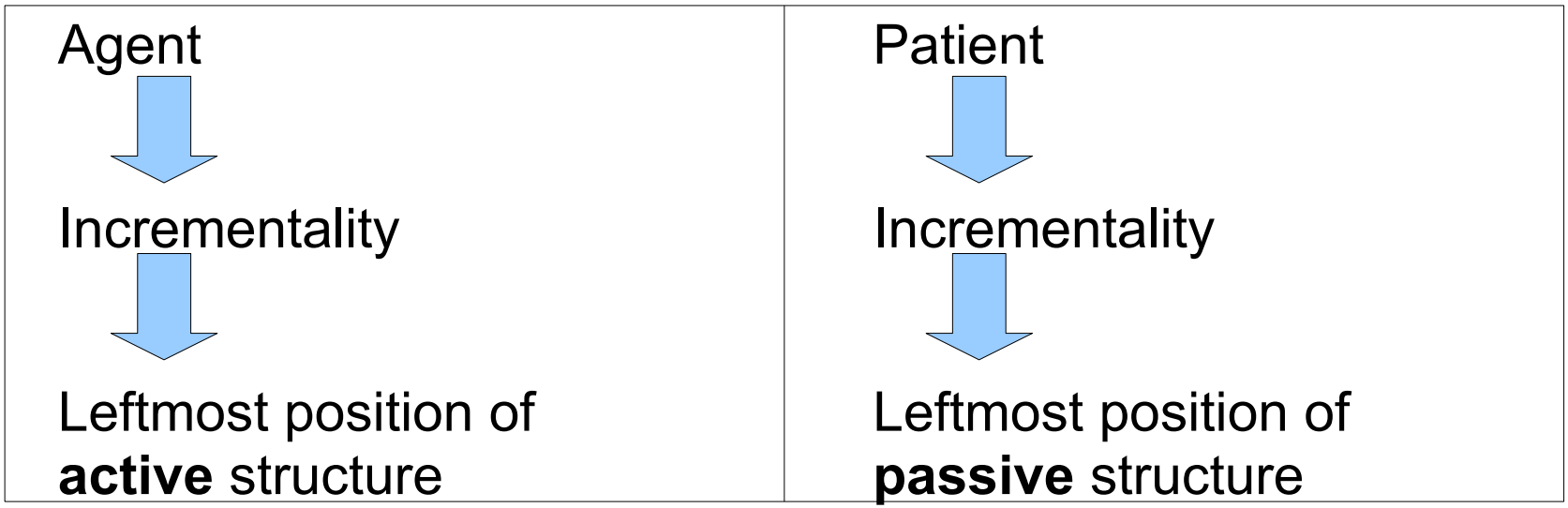
- Assumption: lemma for PUT becomes available
- LOCATION encoded first:
  - Retrieval of two lemmas (and trees) for PUT
  - Active and passive!
  - Lexical semantics of *put*:
    LOCATION is not allowed to be subject

(N.B.: *contain* allows this: *The trunk contains the body.*)

event: PUT(MAN, BODY, TRUNK)

Syntactic Production based on TAG – Example 2

- Two trees **available in parallel**
- Wait for another argument to be encoded



- The structure that is not chosen **loses its activation**

event: PUT(MAN, BODY, TRUNK)

Syntactic Production based on TAG – Example 2

- Example 2: moderate degree of incrementality

- With extreme degree of incrementality:

  - System would not wait for the verb
  - **Nominal** entities **immediately** made into **subjects**

  → **Ungrammatical** utterances, e.g.
  **The trunk was put the body by the man*

event: PUT(MAN, BODY, TRUNK)

Syntactic Production based on TAG

- Syntactic encoding not necessarily a serial process
  - All **structures compatible** with a **lemma** are **activated at one time**
  - As more **information available**: competing **lemmas drop out** until **one structure is left** when encoding is complete
  - **Two nominal** lemmas **equally** available: speaker might be **disfluent**

Syntactic Production based on TAG - Conclusion

- Utterances: generated from **propositional representations**
- Concepts: **differentially** activated
  - Topic: **most available** concept
    - ➔ Most affinity for **subject** position
  - Verb:
    - ➔ determines verb **lemma** (active/passive, dative, …) and
    - ➔ retrieval of **elementary tree(s)**

Syntactic Production based on TAG - Conclusion

- As grammatical encoding enfolds:
  - **Remaining of one** activated clausal elementary **tree**
    - Determines **form** of the sentence
  - Elementary **trees others** than **clausal trees**:
    - **Must be inserted** into clausal tree
    - Order: determined by **availability**

Conclusion

- Tree-Adjoining Grammar
- TAG for capturing aspects of Syntactic Production
- Model for Syntactic Production based on TAG
  - Incrementality
  - Propositional representations
  - Different activations of concepts
  - Simultaneously available trees

References

- Fernanda Ferreira (2000). Syntax in Language Production: An Approach Using Tree-Adjoining Grammars

- Fernanda Ferreira and Paul Engelhardt (2006). Syntax and Production