



# Language acquisition, perception and production

*Lecture 2 - Sentence comprehension*

# Sentence comprehension

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- How do we understand sentences?
  1. John, Mary, chases
  2. John chases Mary
- Word-order carries additional meaning
  - Who is doing the chasing
  - Who is being chased
    - Thematic roles

# Syntax

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- **Syntax**
  - The information that describes the relationship between word-order and meaning
  
- **Syntax**
  - knowledge of the permissible word-orders in your language

# Sentence comprehension

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- **In order to correctly understand a sentence**
  - Know the meaning of words
  - Know syntactic information
- **How is this syntactic information used?**
- **Parsing**
  - Computing the syntactic structure of a sentence

# Parsing

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- **Parsing**
  - 1. Assign syntactic category to each word (noun, verb, etc)**
  - 2. Combine into phrases (structure)**

# Parsing

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- **Some questions about parsing:**
- **Why some sentences more difficult to parse than others?**
- **What if multiple parses are possible?**
- **What kind of information influences parsing?**

# Models

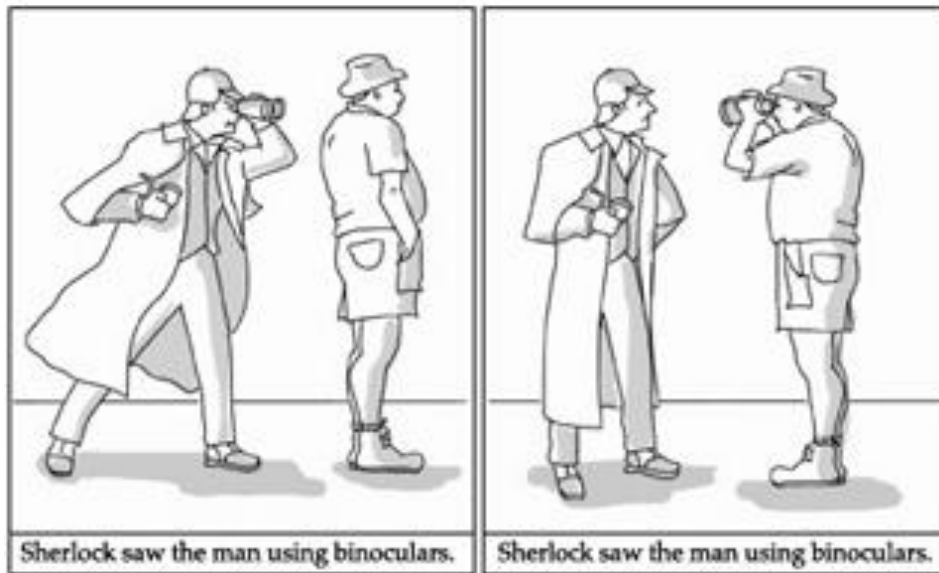
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- **Two models of parsing**
  - **Autonomous**
    - First syntactic stage
    - Second semantic stage
  - **Interactive, one or two stage models**
    - Syntactic stage is directly influenced by semantic information

# Ambiguity

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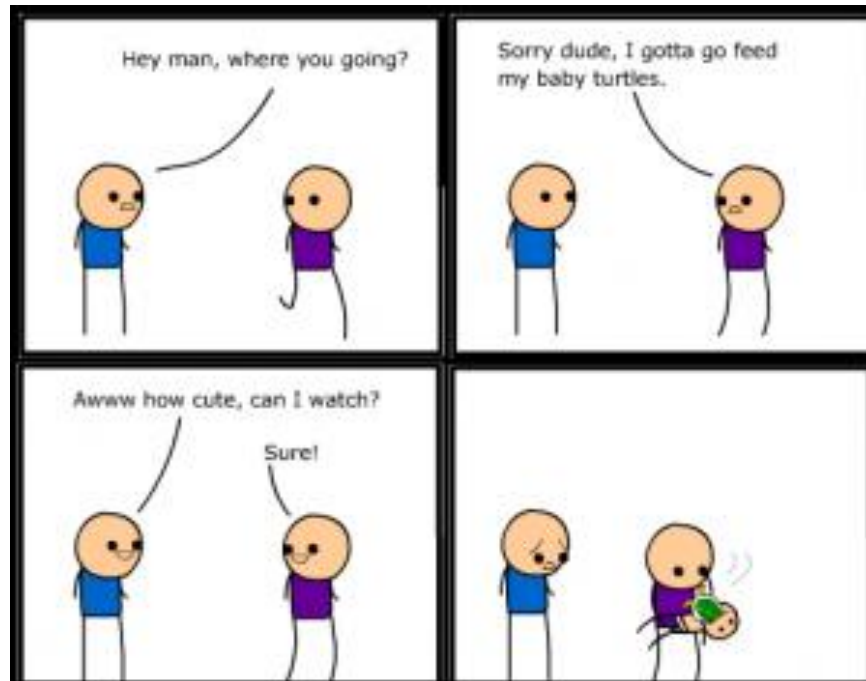
- "Sherlock saw the man using binoculars"





# Ambiguity

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# Ambiguity

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Let's eat Grandpa!  
Let's eat, Grandpa!

COMMAS

They save lives!

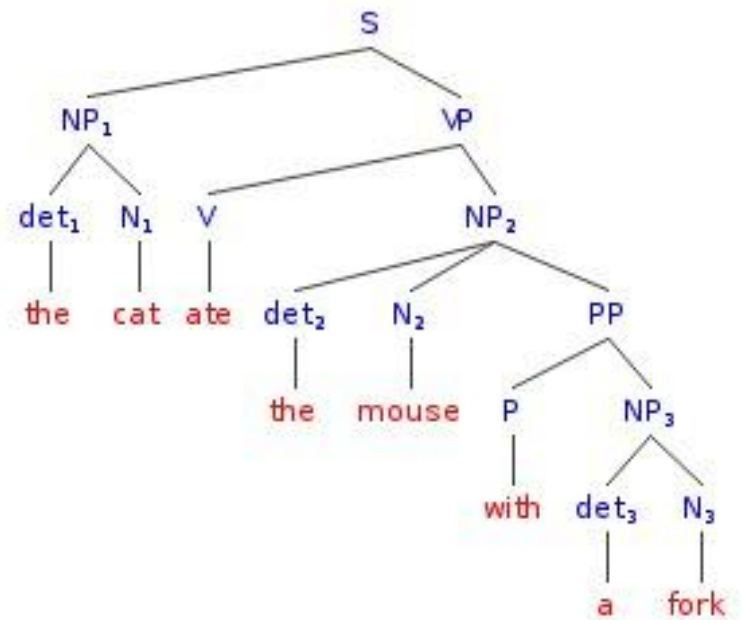
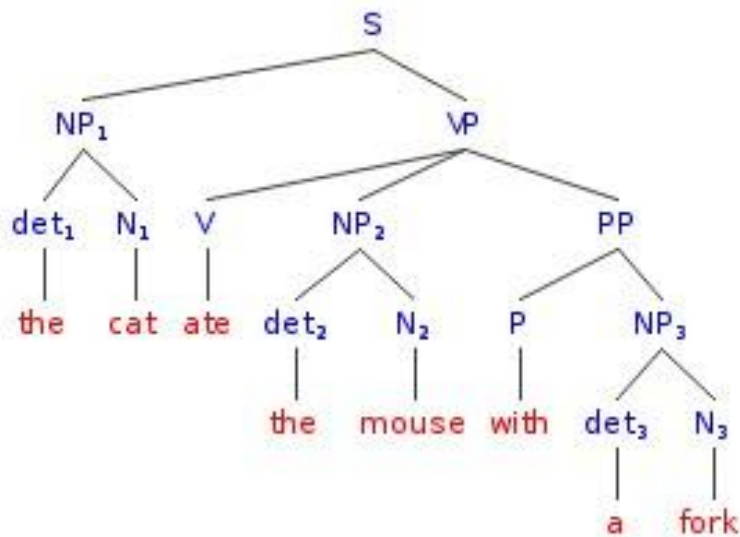
# Ambiguity

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- **Why ambiguity?**
  - **Studying syntactic ambiguity is an excellent way of discovering how sentence processing works**

# Syntactic ambiguity

- "The cat ate the mouse with a fork"



# Models

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- **"I saw the Teide flying to Germany"**
- **There are two possible syntactic parses possible**
  - **Serial autonomous model**
    - Construct one parse, see if it makes sense, if not go back to construct new parse
  - **Parallel autonomous model**
    - Construct all possible parses, use semantic information to pick one
  - **Interactive model**
    - Use semantic information to guide most plausible parse

# Garden path sentences

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- **"The horse raced past the barn fell"**
  - **"There were two horses, right? And we were racing them around, testing their endurance. We raced one horse through the corral and back, the other we raced past the barn and back. So I can't remember their names, but one we raced past the barn, and one through the corral, right? And anyway, my point is, the horse raced past the barn fell. The other horse never did fall, but the one raced past the barn did. Poor horse."**

# Garden path sentences

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- **The log floated past the bridge sank**
- **The ship sailed round the cape sank**
- **The old man the boats**

# Garden path sentences

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- **Local ambiguity**
- **Parse sentence and then go back**
  - Evidence for serial autonomous model?



# Incremental parsing

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- **We analyze sentences on a word-by-word basis**
  - **Do not wait for analysis to start until sentence is finished**

# Kamide, Altmann & Haywood (2003)

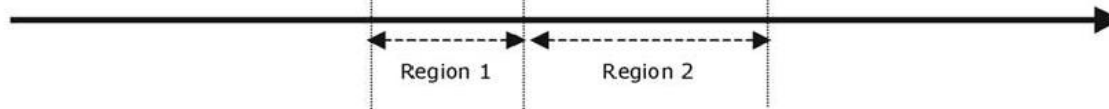
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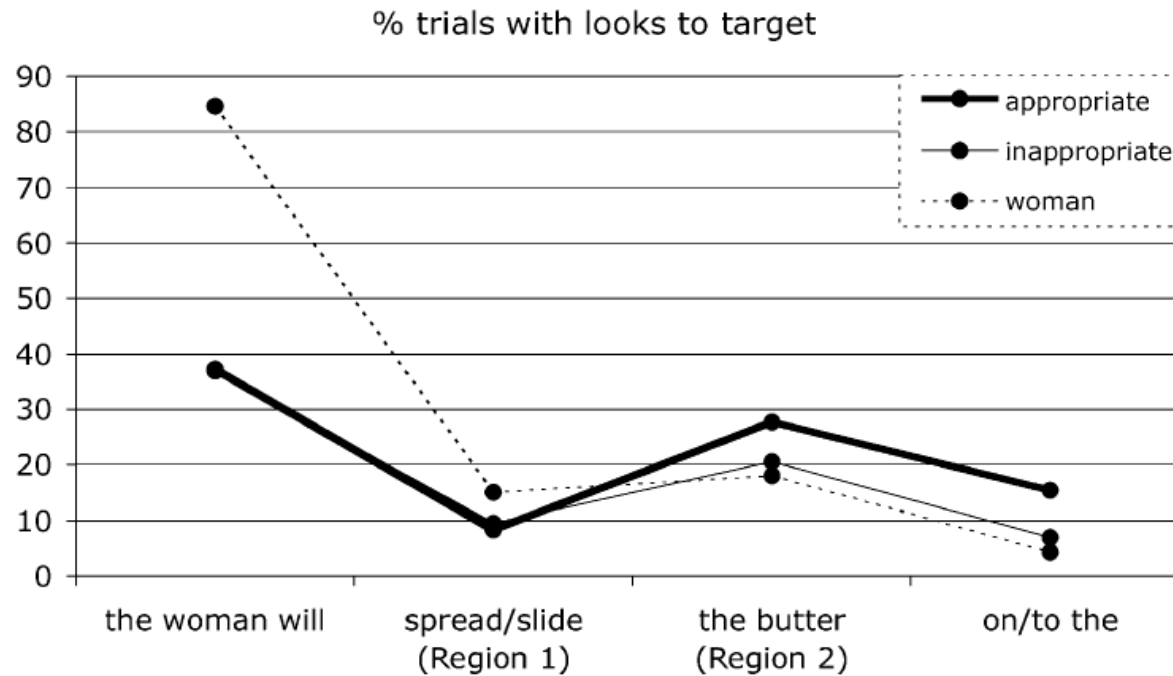
B

The woman will spread the butter on the bread.  
The woman will slide the butter to the man.



# Results

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- Parsing is incremental

# Models of parsing

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- **Garden path model (e.g., Frazier, 1987)**
  - **Serial autonomous model**
    - **Two stages, semantic / syntax**
- **Constraint-based model (e.g., MacDonald, 1994)**
  - **Interactive model**
    - **One stage**

# Garden path model

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- Only use *syntactic criteria* to guide parse:
  - Minimal attachment
    - Parsimony – create syntactic structure that has the fewest number of nodes
  - Late closure
    - Incoming material attached to current node

# Late closure

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- "John said he would leave yesterday"
  - John said (he would leave yesterday)
  - John said he would leave (yesterday)

# Minimal attachment

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- **When building a syntactic parse, use the minimum amount of nodes necessary to attach new words or phrases**

# Constraint-based model

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- **When hearing sentences**
  - Use multiple sources of information (syntax, semantics, world knowledge, frequency of structures)
  - These are called constraints
  - Construction that is most supported by these constraints is most activated
  - Less supported constructions are also activated



# Predictions

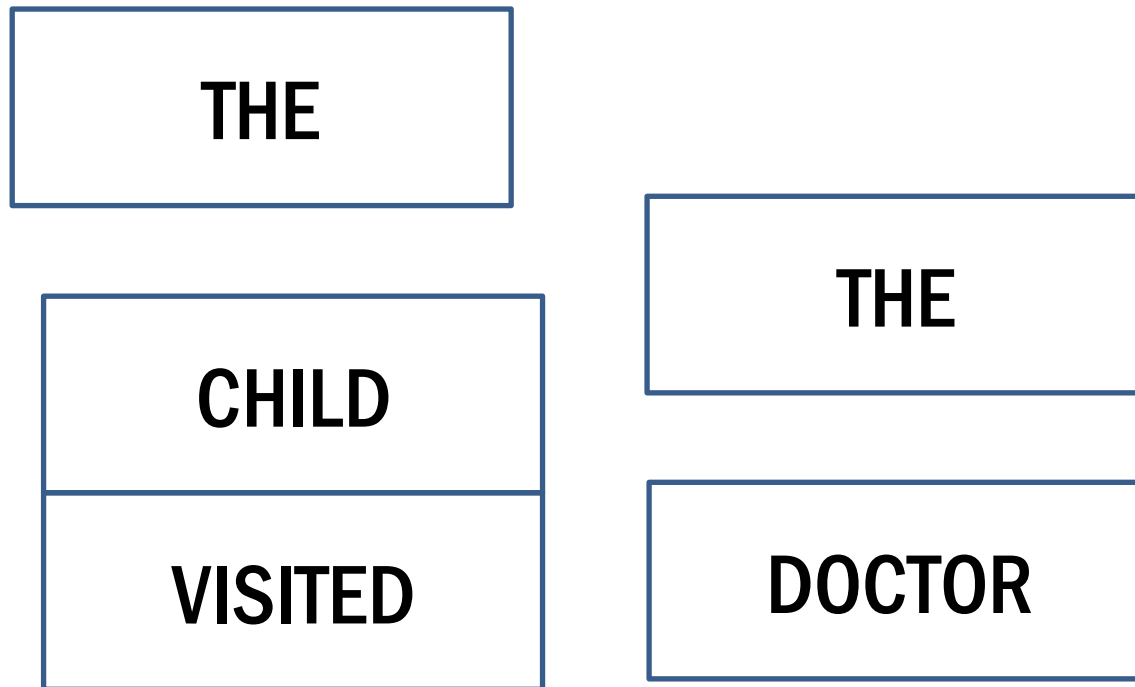
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- **Does semantic information influence the syntactic parse?**
  - **Graden path model: NO**
  - **Constraint-based model: YES**

# Mitchell (1987)

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- Self-paced reading task



# Mitchell (1987)

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- **Materials - different verb types**
- **Transitive verbs**
  - **Require direct object**
    - He opened the door, she visited the doctor
- **Intransitive verbs**
  - **No not requitre direct object**
    - I smiled, he sneezed

# Mitchell (1987)

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- **Example sentences**
- **After the child had visited the doctor prescribed a course of injections**
- **After the child had sneezed the doctor prescribed a course of injections**

# Mitchell (1987)

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- If meaning plays no role, then both sentences should be difficult due to late closure
- If meaning plays a role, sentence with “sneezed” should be easy

# Mitchell (1987)

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- **Results showed longer reading times on “the doctor” for both transitive and intransitive verbs**
- **Meaning does not play a role initially**
- **Only syntactic information is used initially**
- **Consistent with garden path model**

# Milne (1982)

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- **Semantic factors influence parsing:**
- **The table rocks during the earthquake**
- **The granite rocks were by the seashore**
- **The granite rocks during the earthquake**
- **Evidence for constraint-based model**

# Trueswell & Tanenhaus (1994)

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- “The archeologist examined ...”
- “The fossil examined ...”
- How to continue these fragments?
  - Examined as a verb likes an animate AGENT
- Semantics influences parsing



# Cuetos & Mitchell (1988)

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- **Cross-linguistic differences**
- **Late closure in English**
  - “The journalist interviewed the daughter of the colonel who had the accident”
- **Who had the accident?**
  - English speakers: “The colonel”

# Cuetos & Mitchell (1988)

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- **Spanish speakers**
  - “El periodista entrevistó a la hija del coronel que tuvo el accidente”
- **Who had the accident?**
  - Spanish speakers: “la hija”

# Cuetos & Mitchell (1988)

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- **Speakers of different languages resolve ambiguity in different ways**
- **Late closure does not seem like a general strategy that applies to all languages**
- **Instead, parsing strategies are more dependent on language-specific preferences**

# Neuroscience of parsing

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- **Broca's aphasia**
  - Problem in speech production (agrammatism)
  - Problem in speech comprehension
- **Problem understanding reversible sentences**
  - “The dog was chased by the cat” vs
  - “The flowers were watered by the girl”

# Broca's aphasia

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- Is Broca's aphasia a problem in parsing?
- Linebarger and colleagues
  - Four Broca's aphasics
  - Asked to judge grammaticality of sentences
  - Good performance
- Linebarger's conclusion: Broca's aphasics can compute syntactic structure, but cannot map it onto meaning

# Broca's aphasia

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- **Broca's aphasia due to general memory problems**
- **Increase task demands for normal subjects**
  - **Fast presentation of words (Miyake et al., 1994)**
  - **Carry out dual task during grammaticality judgments (Blackwell & Bates, 1995)**
- **Normal subjects behave like Broca's aphasics**

# Summary

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- **Two models of parsing**
  - Garden path model
  - Constraint-based model
- **Semantics influences syntactic processing?**
- **The debate continues...**