Sentence Processing I

LIGN 170, Lecture 6

Putting words together

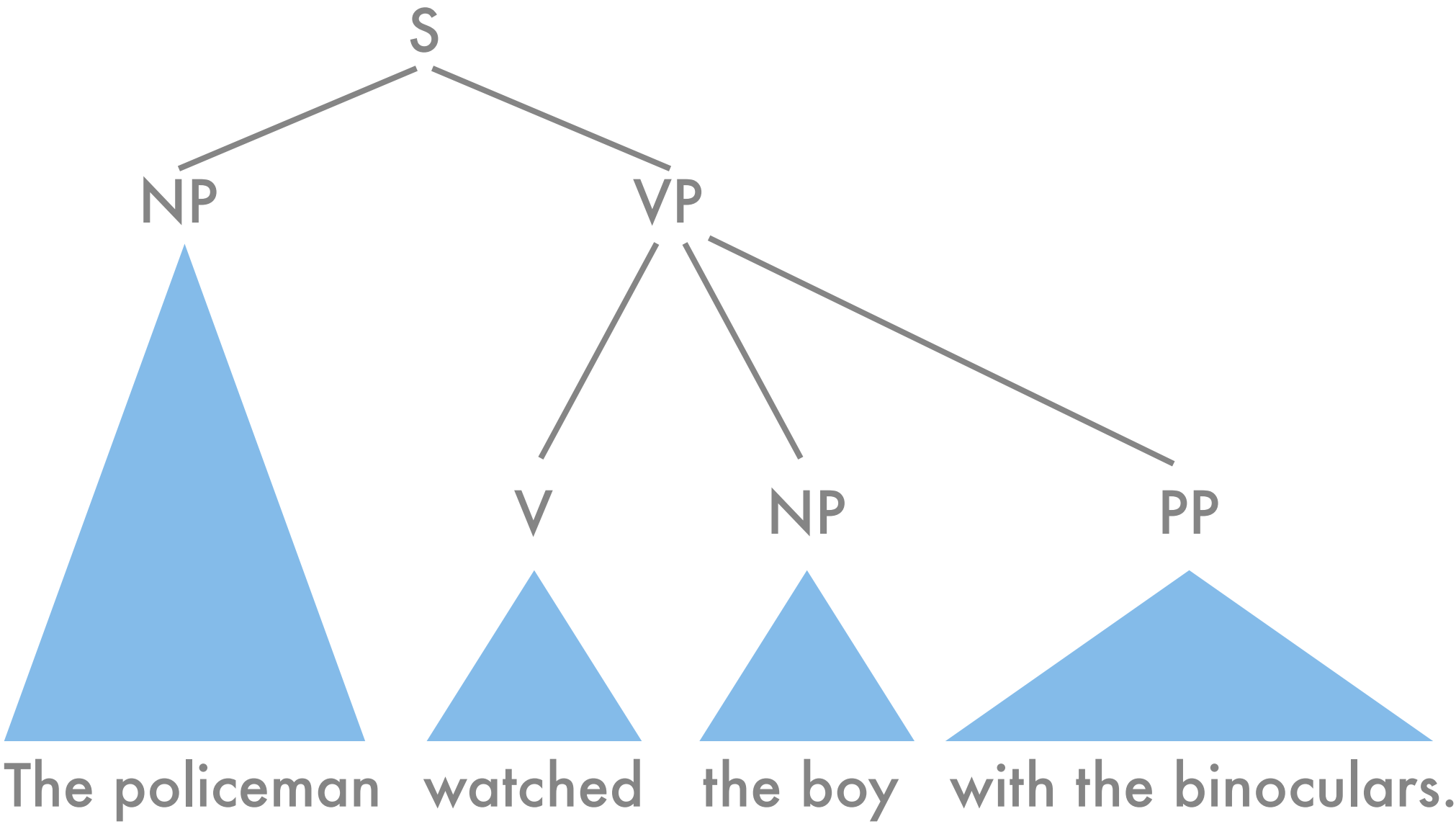
- Standard transmission of language is flat
  - Stream of sounds

- Goal for the hearer: Get meaning!

The benefits of structure

- Language is not flat
  - Words are organized hierarchically
    - Grouped into phrases
    - Phrases grouped into larger phrases

*Who did the policeman watch the ___ with the binoculars?



The benefits of structure

- Language is not flat
  - Words are organized hierarchically

- How do comprehenders fit words together to get meaning?

Parsing sentences

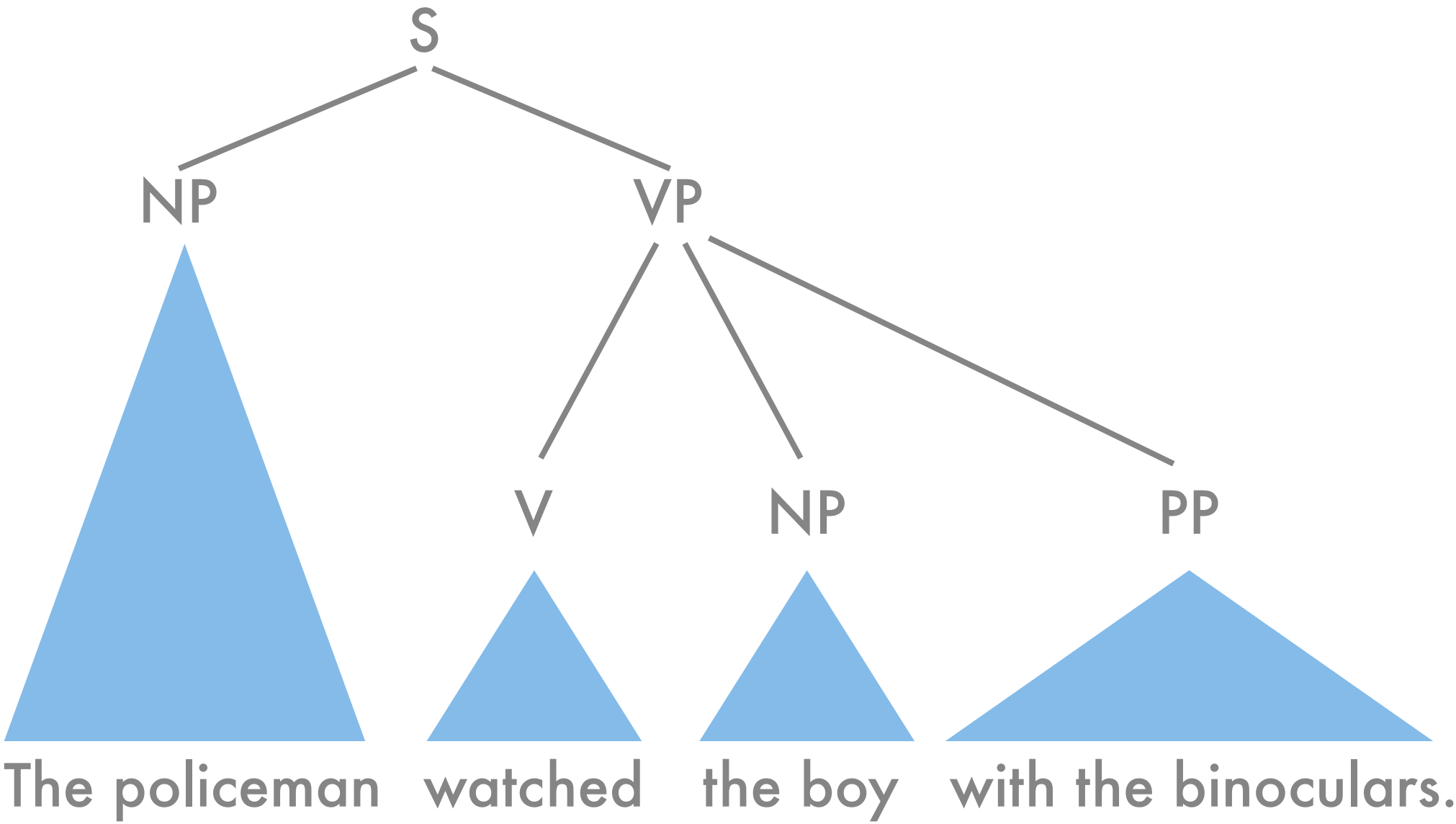
- Parsing sentences involves:
  - Assigning words to grammatical categories
  - Building up tree-like relations within the sentence
- Sentence processing is highly incremental
  - We usually do this parsing without the benefit of seeing what comes next

- Some critical steps for comprehending sentences:
  - Identify parts of speech (noun, verb, determiner, etc)
  - Group into phrases

    Noun Phrases (NPs): “the boy”, “the policeman”, “the binoculars”

    Prepositional Phrases (PPs): “with the binoculars”

    Verb Phrases (VPs): “watched the boy with the binoculars”


S
NP
VP
V
NP
PP
The policeman
watched
the boy
with the binoculars.

- Some critical steps for comprehending sentences:
  - Semantic/Thematic structure:
    We figure out who did what to whom
    - Verb: look (past tense)
    - Agent: the policeman
    - Theme: the boy
    - Instrument: binoculars

- Some critical steps for comprehending sentences:
  - Pragmatic/Real-world knowledge:
    We integrate this information into a larger context
    - Do we know the boy? the policeman?
    - Why would the policeman watch the boy?
    - What just happened?

- Three big topics in sentence processing
  - The problem of finite resources
    - *Displaced elements in sentences*
  - The problem of ambiguity
    - *Incremental processing*
  - The problem of speed
    - *Rapid intake of information*

Today

The problem of finite resources

- Hierarchical structure means that linear order itself doesn't matter
  - Information can be reordered in many ways

- The policeman watched the boy.
- The boy was watched by the policeman.
- It was the boy that the policeman watched.
- Who did the policeman watch?
- I know the policeman that watched the boy.

- Russian “My daughter drew this picture.”
- Moja doč’ narisovala ètu kartinku.
  My.NOM daughter.NOM drew this.ACC picture.ACC
- Étu kartinku narisovala moja doč’.
- Narisovala étu kartinku moja doč’.

The problem of finite resources

- Hierarchical structure means that linear order itself doesn't matter
  - Information can be reordered in many ways

The problem of finite resources

- Hierarchical structure means that linear order itself doesn't matter
  - Information can be reordered in many ways
  - When elements are out of canonical order, displaced, or otherwise separated - this places a greater burden on working memory until relationships between the elements can be resolved.

The problem of finite resources

- This is the nurse that called the pharmacy that served the woman who kissed the man.
  - Left-branching (easier)

- This is the pharmacy the nurse called.
- This is the pharmacy the nurse the woman asked called.
  - Center-embedded (harder)

The problem of finite resources

- This is the nurse that called the pharmacy that served the woman who kissed the man who raised the girl who bought the leash that held the dog that chased the cat that ate the rat that lived in the big blue house.
- This is the nurse the pharmacy the woman the man the girl the dog the cat the rat hid from scratched bit loved kissed asked called.

The problem of finite resources

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The problem of finite resources

- Typical cases of displaced elements:
  - Filler-gap dependencies
    - Wh-questions
      - Who did the cat eat ___ ?
    - Relative Clauses
      - I know the rat that the cat ate ___.

The problem of ambiguity

- Standing ambiguities
  - The old magazines and books were on the shelf.
  - Visiting relatives can be a drag.
- Local ambiguities
  - Garden paths
    - The woman realized her goals were impossible.

The need for speed

- Language processing must be rapid
  - We cannot take a step back and consider the sentence as a whole when we engage in regular, real-world use of language, we must make sense of sentences on-the-fly
- How do we achieve this speed?
  - Autonomous *vs.* interactive approaches

Online/Offline methods

- Online: When a task is able to capture the processing of language in real time
  - Typical online measures: Event-related brain potentials (ERPs) & eye-tracking
- Offline: When a task captures the processing of language after processing has taken place
  - Typical offline measure: Grammaticality judgments

Influence of prior context

- Semantic context plays a role in sentence processing – but when?
  - Semantic/contextual information is available at least 300-400 msec after the onset of a word

A

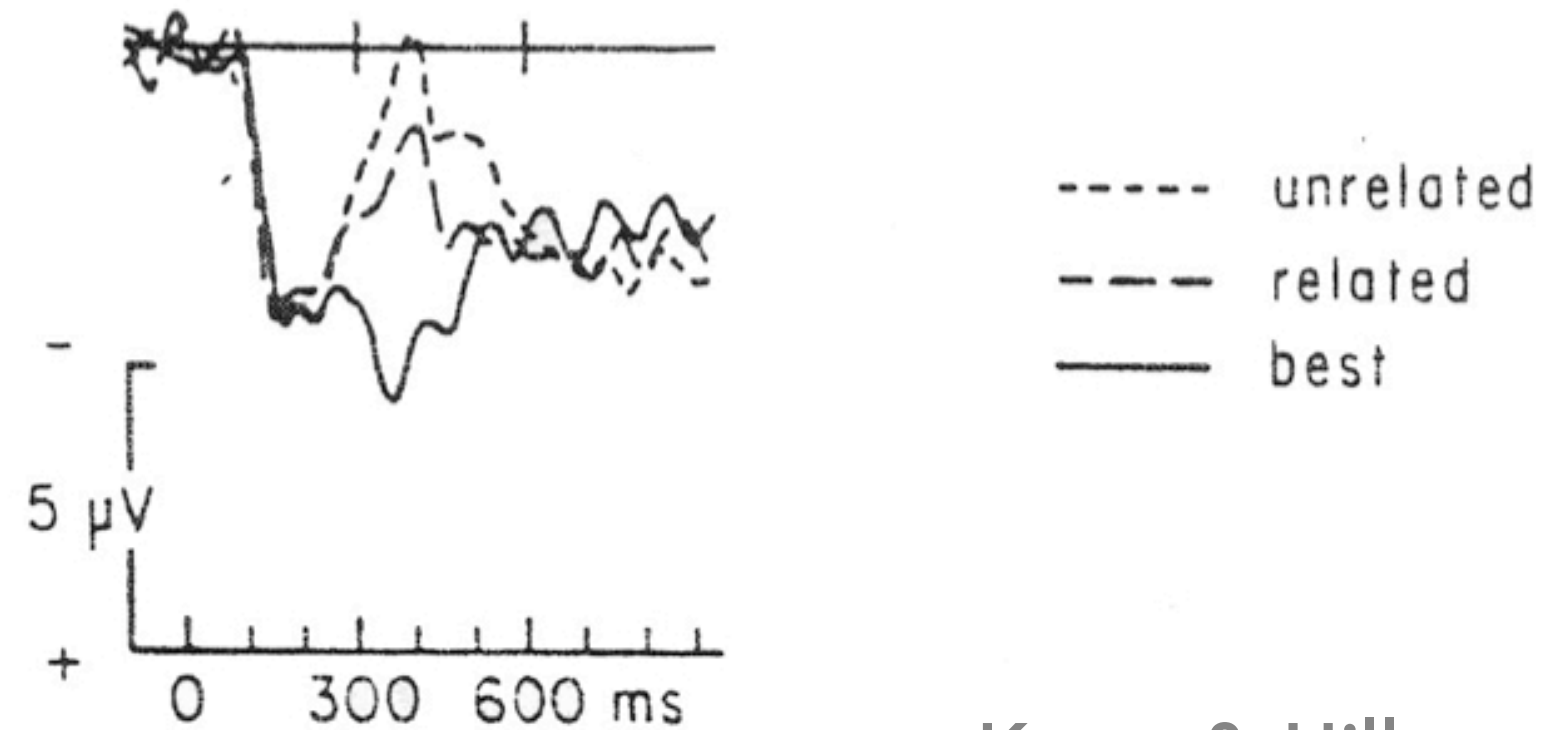
(best) Don't touch the wet paint.

(unrelated) Don't touch the wet dog.

(best) He liked lemon and sugar in his tea.

(related) He liked lemon and sugar in his coffee.

B



Kutas & Hillyard, 1984

Influence of prior context

- Semantic context plays a role in sentence processing – but when?
  - Semantic/contextual information is available at least 300-400 msec after the onset of a word

- The question is: what happens in that first 300 milliseconds?

Autonomous models

- Fastest with initial parse of syntactic information only (and then worry about meaning)
- Logic: We would only be slowed down by additional information that would need to be processed to take context into effect
  - So, those first 300 msec are dedicated to grammatical parsing

Autonomous models

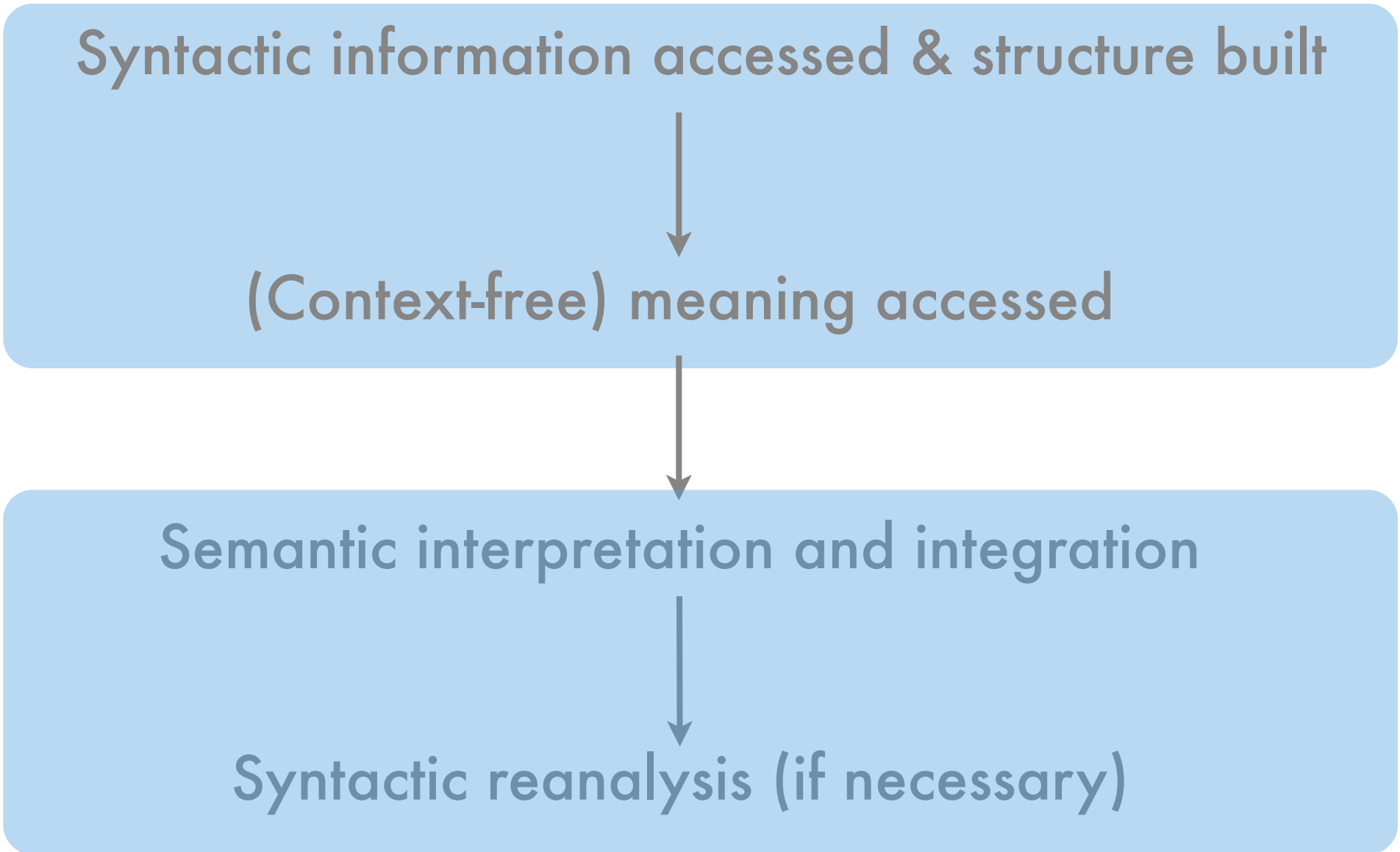
Syntactic information accessed & structure built

(Context-free) meaning accessed

Semantic interpretation and integration

Syntactic reanalysis (if necessary)

Autonomous models



Autonomous models

- Evidence:
  - Some ERP studies show that violations of word category and other morpho-syntactic violations give an ERP response at early as 150msec
    - But, these findings are still contested

Autonomous models

- Evidence
  - Speed of lexical activation is influenced by a number of factors, but all meanings of ambiguous words are initially activated to some degree
  - Initial stages at least somewhat resistant to contextual influence

Interactive Models

- Processing will be fastest if non-grammatical information is allowed to facilitate

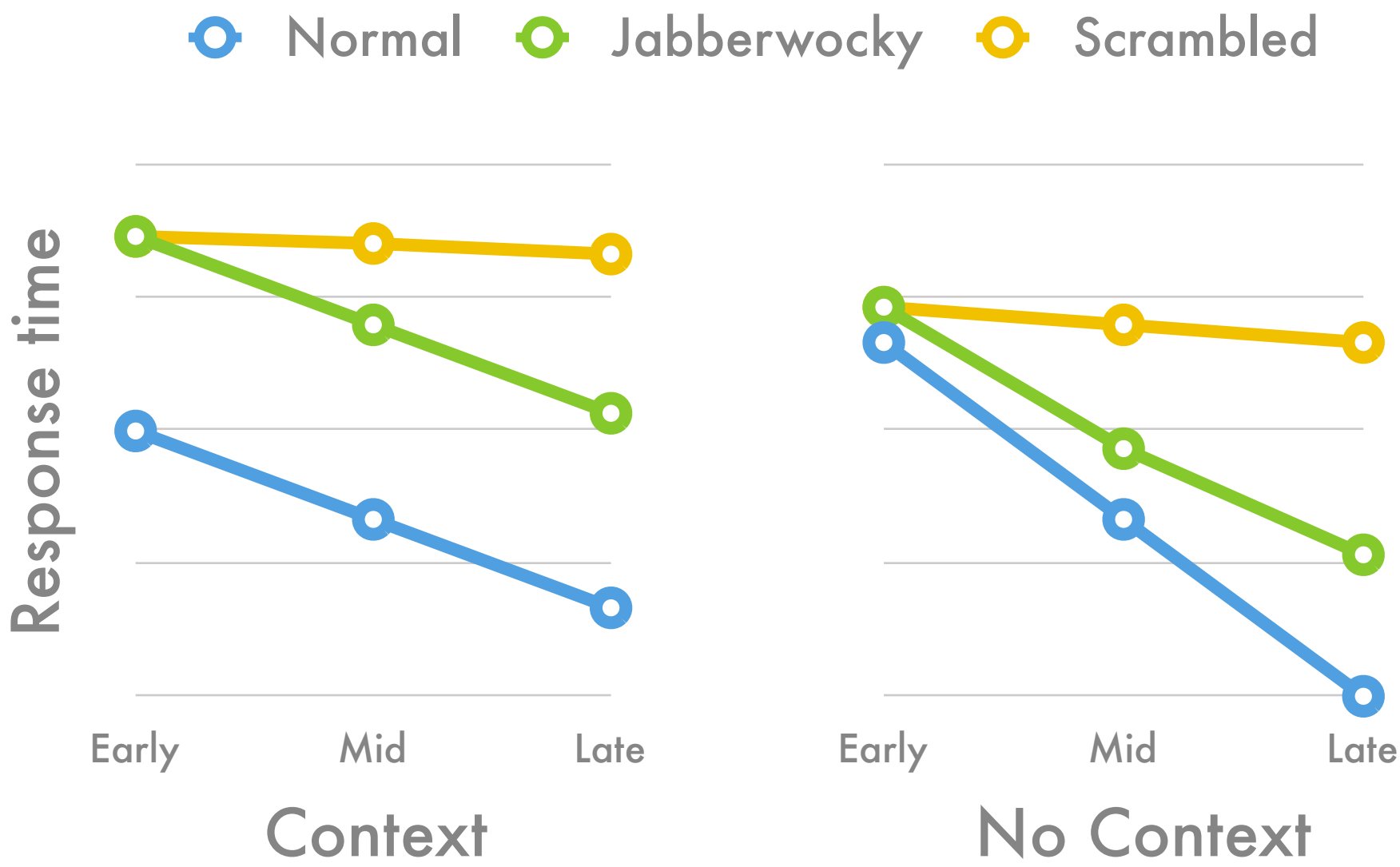
Interactive Models

- Evidence:
- Word-Monitoring Task (Marslen-Wilson & Tyler, 1980)
  - Subjects press a button when they see a pre-established target word

Materials

Late Example	Context	No Context
Normal	The church was broken into last night. Some thieves stole most of the lead off the roof.	Some thieves stole most of the lead off the roof.
Jabberwocky	The power was located in great water. No buns puzzle some in the lead off the text	No buns puzzle some in the lead off the text.
Scrambled	In was power water the great located. Some the no puzzle buns in lead text the off.	Some the no puzzle buns in lead text the off.

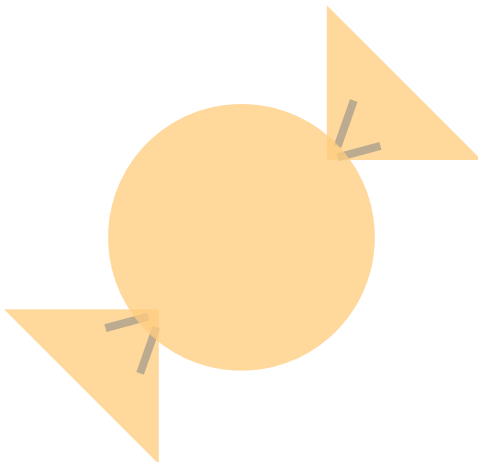
Results


Normal
Jabberwocky
Scrambled
Response time
Early
Mid
Late
Context
Early
Mid
Late
No Context

Results

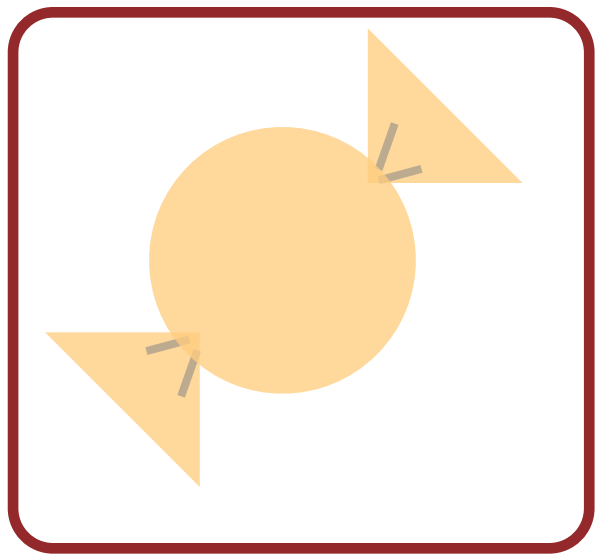
- Syntax helps: Normal and Jabberwocky get better as more syntactic context is given
- But syntax is not alone:
  - Discourse context aids Normal
  - Normal is always better than Jabberwocky
- So, syntactic and semantic context influences word identification

Eye tracking evidence



(e.g. Tanenhaus et al.,1995)

Eye tracking evidence



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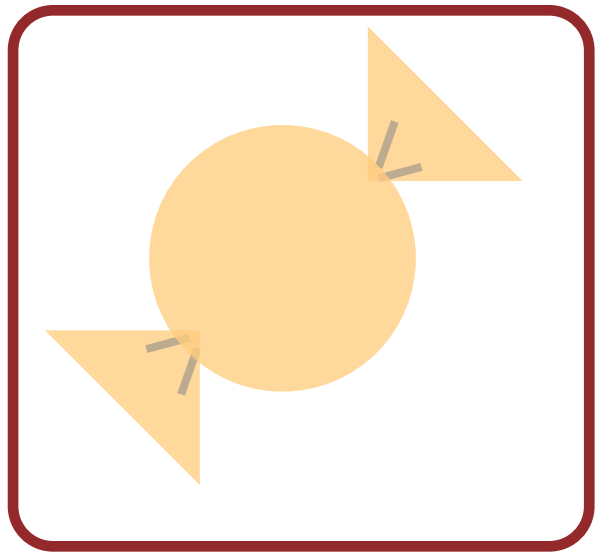
Eye tracking evidence



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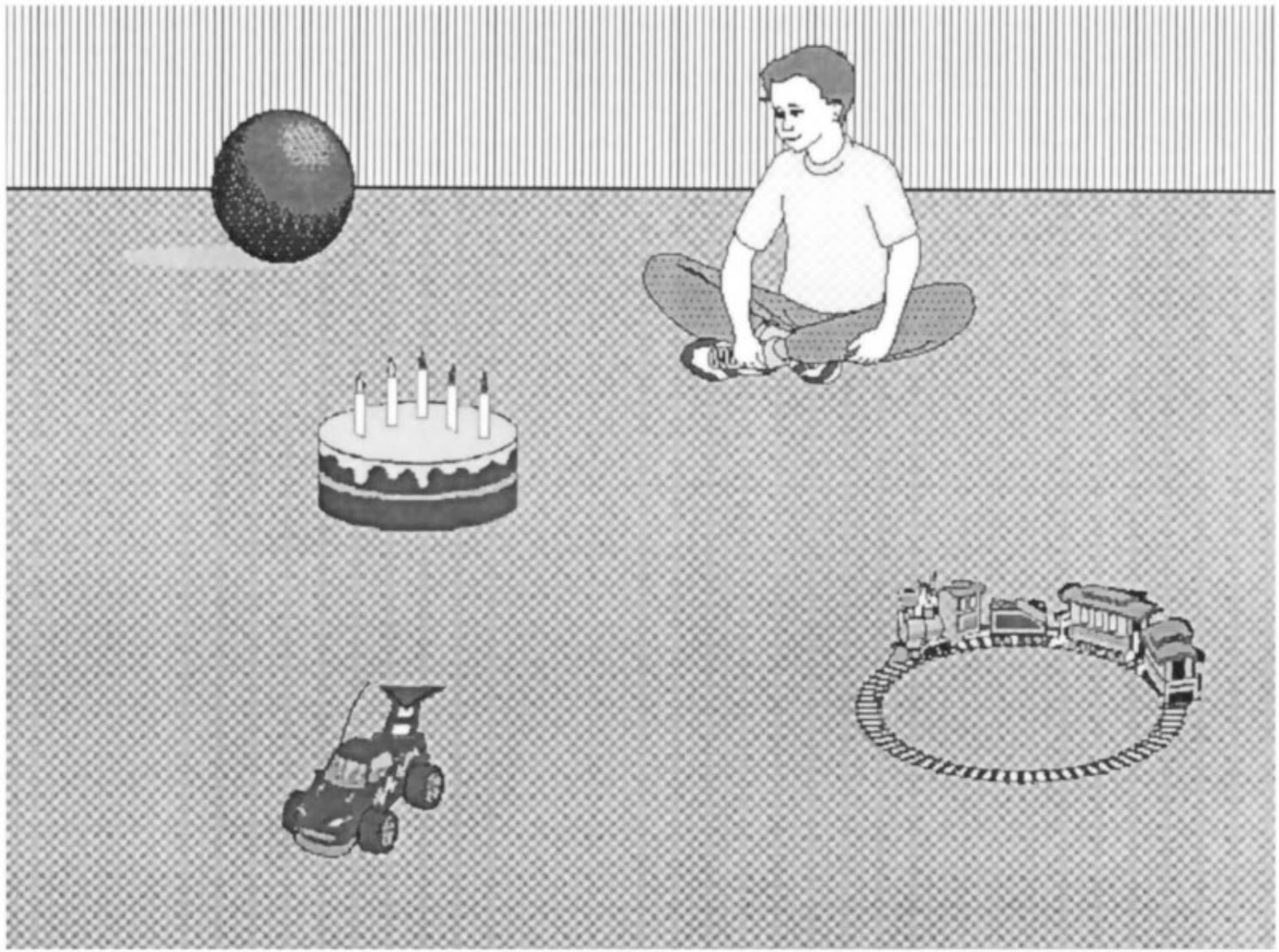
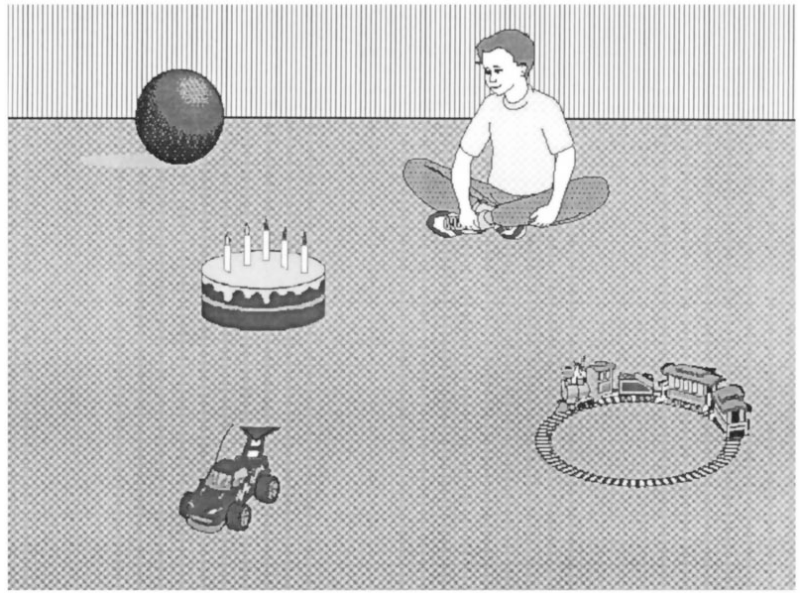
(e.g. Tanenhaus et al.,1995)

Altmann & Kamide (1999)



Altmann & Kamide (1999)

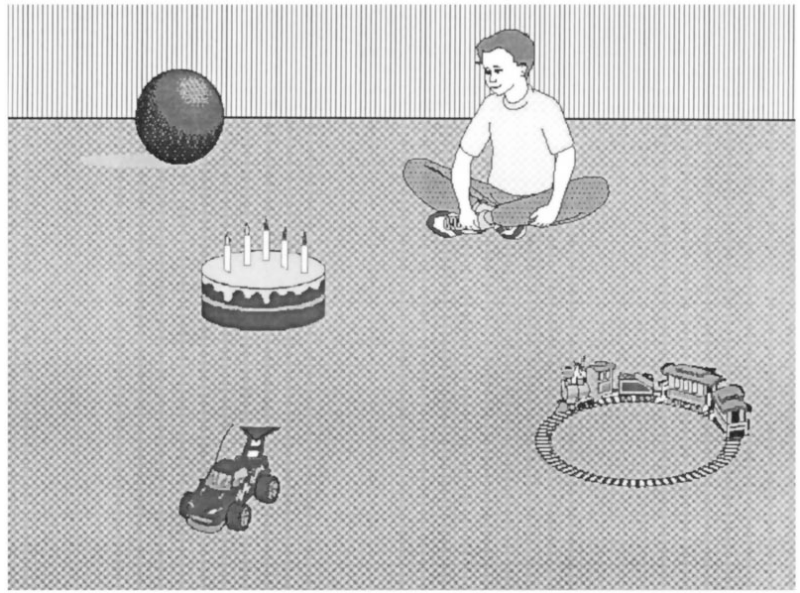
- The boy will eat the ...
- The boy will move the ...



- Will information from the verb influence what the next argument is expected to be?

Altmann & Kamide (1999)

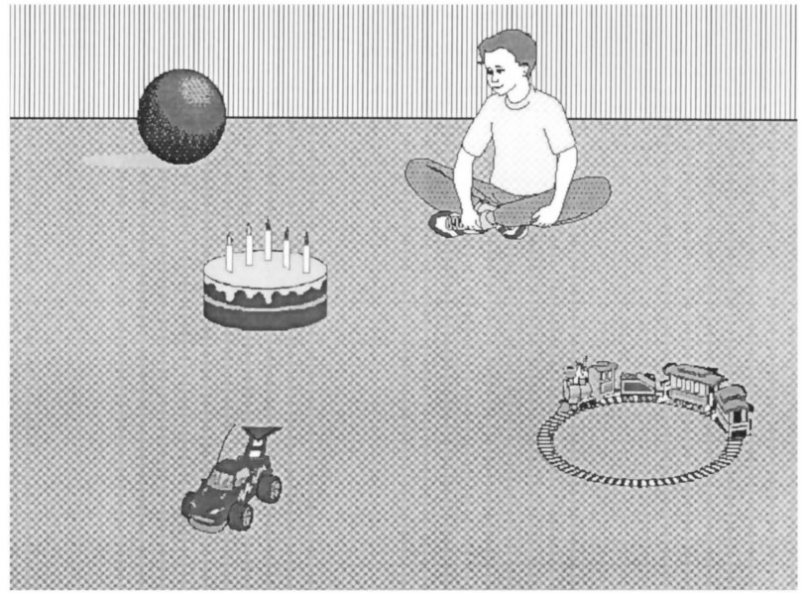
- Logic:
  - Both “eat” and “move” take grammatical objects
    - eat the cake ; move the cake



  - Only “eat” has selectional (semantic) restrictions that apply in this picture
    - #eat the ball ; move the ball

Altmann & Kamide (1999)

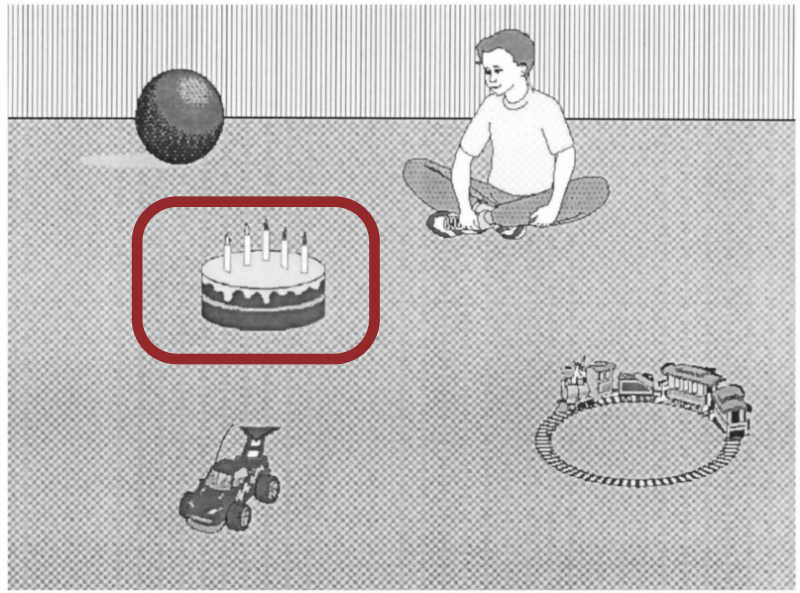
- Logic con't:
  - So, if only syntactic information is used, then there should be no difference between cake and the other objects



  - However, if semantic (restrictional) information is used, the cake should be preferred in the "eat" condition

Altmann & Kamide (1999)

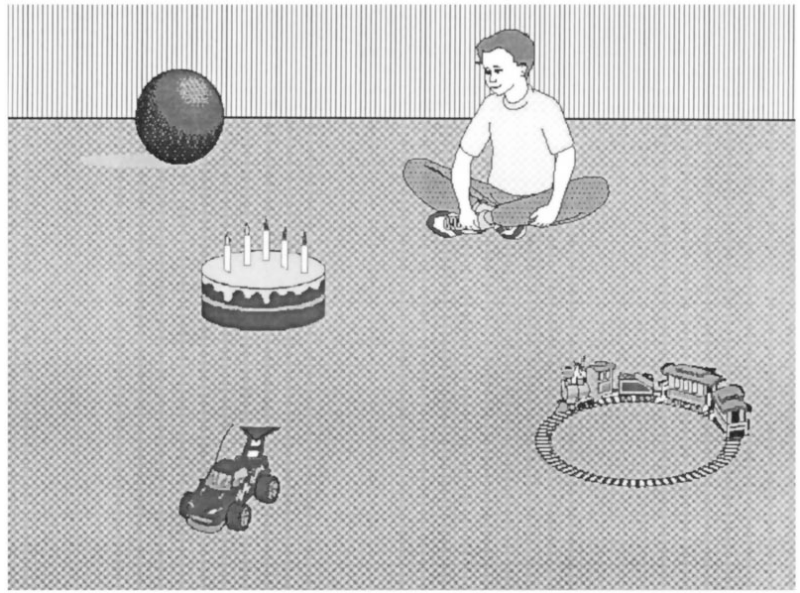
- Results:
  - More looks to cake in the "eat" condition than "move" at the offset of the verb



  - The boy will eat ...

Altmann & Kamide (1999)

- Conclusion:
  - Semantic information from the verb is used to anticipate the next argument in the sentence



  - Top-down information is used during sentence processing even before a word is encountered

Recent ERP evidence

- Kim et al. (2005)

  (1) The meal was devoured ...

  (2) The meal was devouring ...

  - (2) treated as grammatical violation, even though the sentence is perfectly well-formed
  - Semantics influencing syntactic interpretation