Prediction in Incremental Sentence Processing

EVIDENCE FROM
EYE TRACKING EXPERIMENTS
CONDUCTED BY

KAMIDE, ALTMANN AND HAYWOOD, 2003
STAUB AND CLIFTON, 2006

presented by Melanie Reiplinger

Outline

- Why and how to look at eye movements
  - previous findings
  - method of eye movement tracking
- Kamide et al. (2003)– anticipatory thematic role assignment
  - immediate usage of information to anticipate arguments
    - semantic
    - real-world
    - syntactic
- Staub & Clifton (2006)– prediction of syntactic structure
  - “either“ facilitates processing of coordination structures

Why to look at eye movements

- take anticipatory eye movements as indicator of predictive processing
  - visual world paradigm
  - fixations on target objects as function of linguistic input

PREVIOUS FINDINGS:

- a human processor anticipates the Theme role in monotransitive constructions (Altmann & Kamide, 1999)

  "The boy will eat… - the cake" vs. "The boy will move… - the cake"

How to look at eye movements

HTTP://WWW.YOUTUBE.COM/WATCH?V=MRP3TKXAXQC&FEATURE=RELATED

Kamide et al. Exploring Anticipatory Thematic Role Assignment

DOES LINGUISTIC INPUT PROVIDE BASIS FOR ANTICIPATION OF UPCOMING INPUT ?

- What kind of information enables prediction?

ROLE ASSIGNMENT BY MEANS OF

- verb-related information, i.e.
  - meaning
  - selectional restrictions
  - role slots
  - syntactic constituents
- contextual information, i.e. entities available from
  - preceding discourse
  - visual availability

Kamide et al.

3 Experiments on Anticipatory Assignment of Thematic Roles

- Experiment 1

  3-place verbs:
  anticipation of GOAL ?

- Experiment 2

  2-place verbs:
  combinatory effects from verb + subject ?

- Experiment 3

  3-place verbs in Japanese (verb-final):
  effect of morpho-syntactic info from the first 2 pre-verbal arguments ?

Kamide et al.

Experiment 1:

Anticipation of a thematic goal

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

Region 1 Region 2

Kamide et al.

Experiment 1:

Anticipation of a thematic goal

object

- animate (man)
- inanimate (bread)

verb

- slide
- spread

Object labeling:

appropriate vs. inappropriate:

- ‘bread‘ for inanimate condition

  vs.
- ‘man‘ for inanimate condition

Kamide et al.

Experiment 1:

Anticipation of a thematic goal

Hypothesis:

Appropriate goals should be fixated on more often

Consequences:

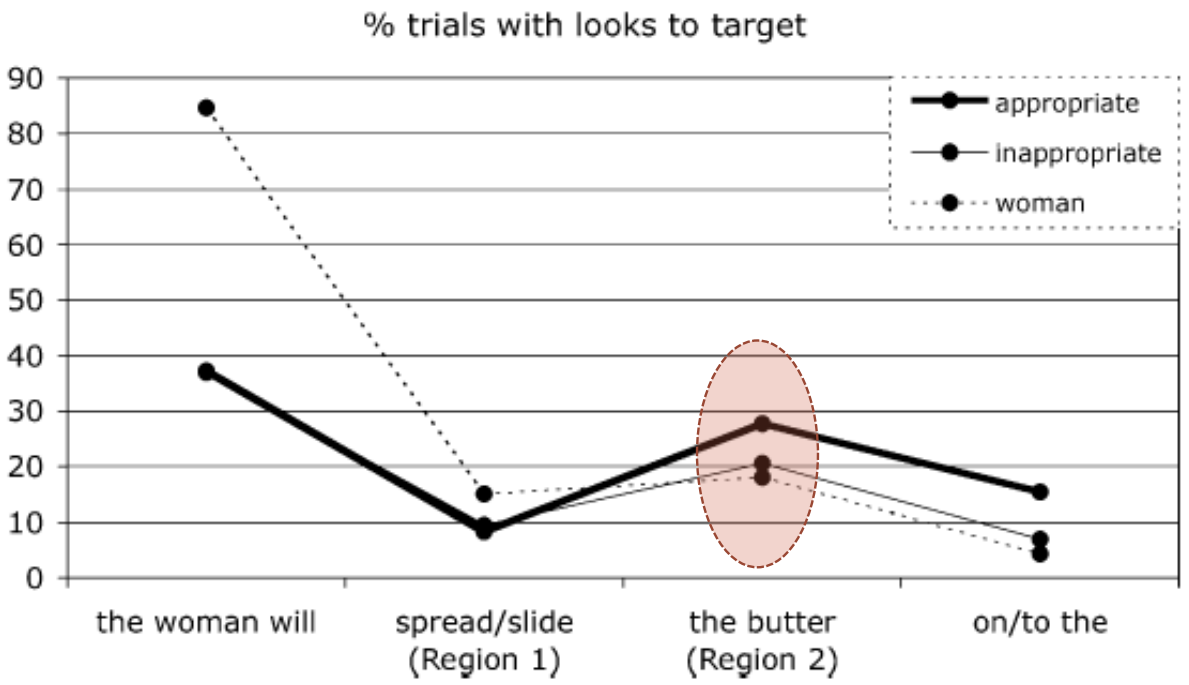
- verb effects: semantic restrictions remain effective
- purely linguistic behaviour
- effects in Region 2: anticipatory eye movements while another entity is being referred to

Results

Kamide et al.

Experiment 1:

Anticipation of a thematic goal



Kamide et al.

Experiment 1:

Anticipation of a thematic goal

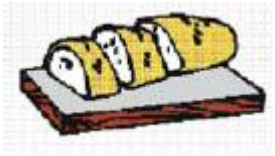
Results

24.3% • “slide“

16.8% • “spread“

24.3% • “slide“

27.4% • “spread“



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

Region 1 Region 2

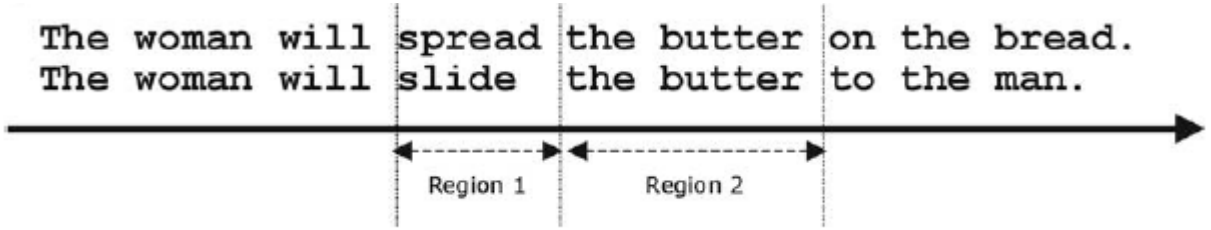
Kamide et al.

Experiment 1:

Anticipation of a thematic goal

Conclusions

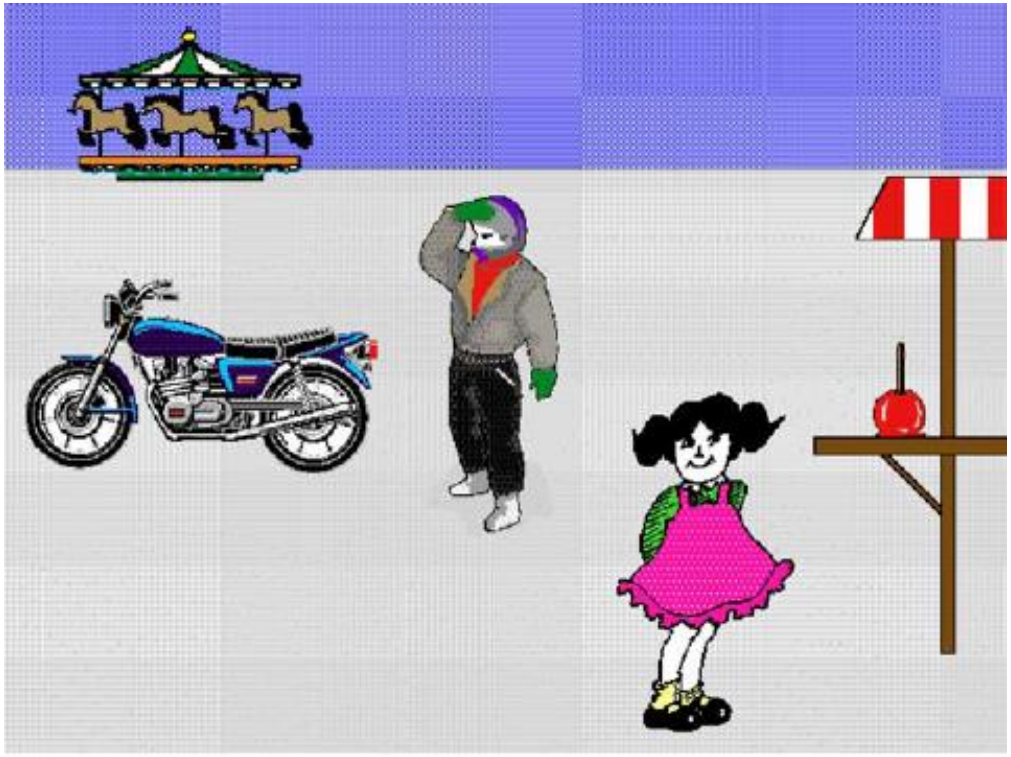
- the processor can anticipate a Goal argument
- during reference to some other object in the scene
- in a ‘look-and-listen‘ task



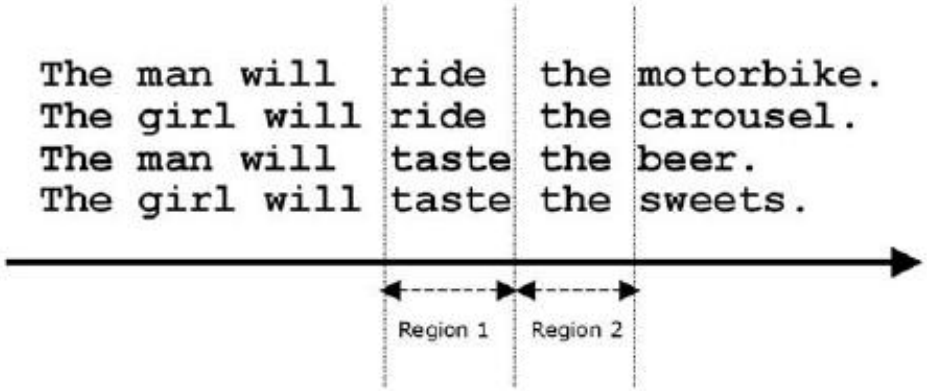
Kamide et al.

Experiment 2:

Combinatory effects from verb + subject



The man will	ride	the	motorbike.
The girl will	ride	the	carousel.
The man will	taste	the	beer.
The girl will	taste	the	sweets.



Kamide et al.

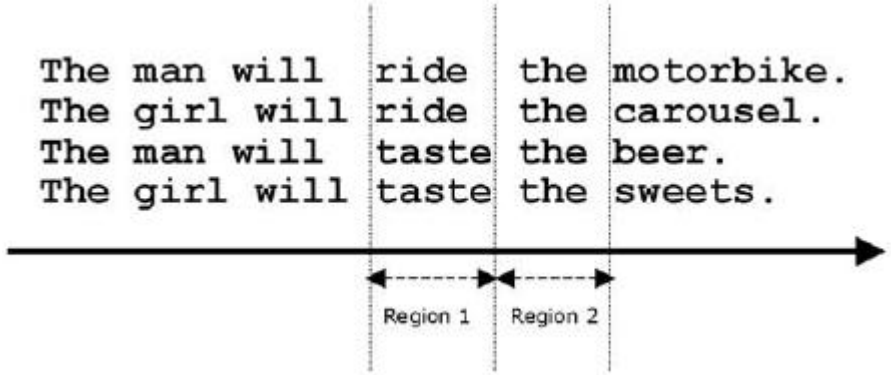
Experiment 2:

Combinatory effects from verb + subject

Hypotheses:

- combination of info (verb + agent) will facilitate looks towards the appropriate object

- no independent influences from verb or agent



Kamide et al.

Experiment 2:

Combinatory effects from verb + subject

IF

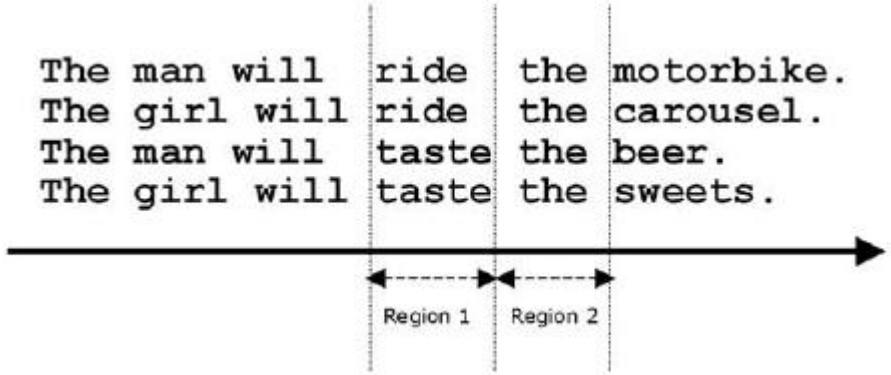
- only verb has influence:

  The man/girl will RIDE… → no difference
  The girl will RIDE/TASTE… → difference

- only agent has influence:

  The MAN will ride/taste → no difference
  The MAN/GIRL will taste → difference

… in looks to ‘motorbike‘

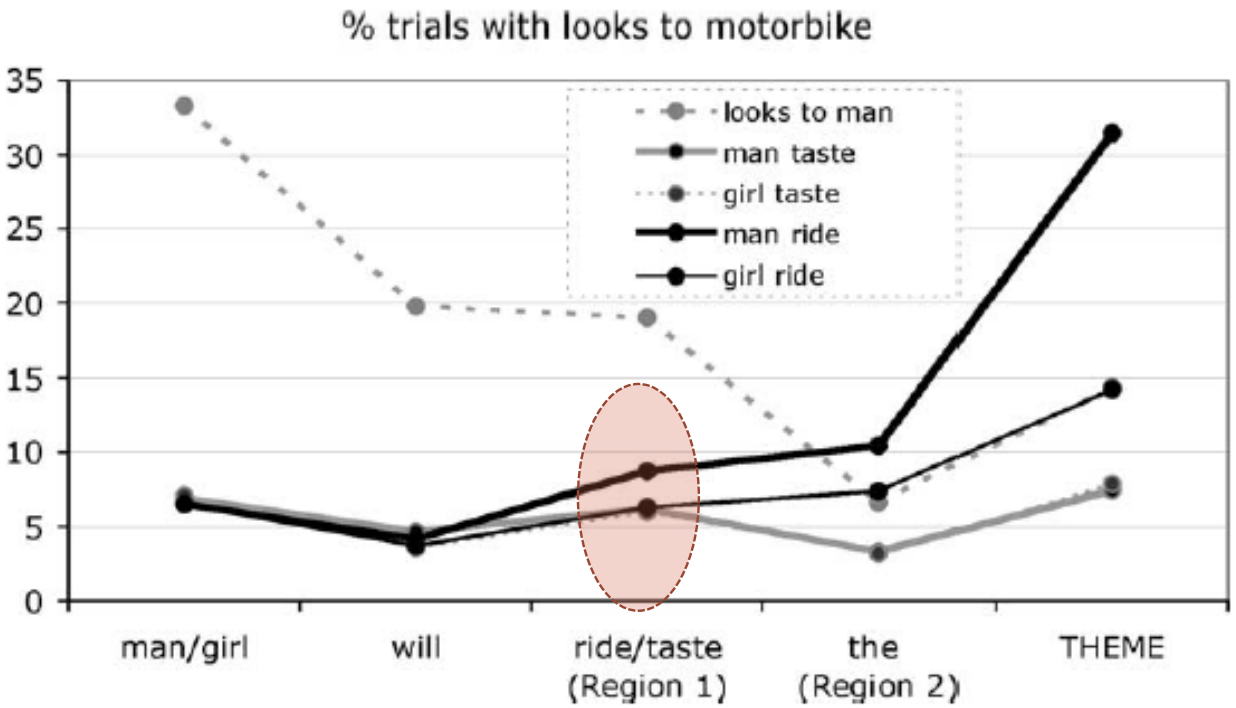


Results

Kamide et al.

Experiment 2:

Combinatory effects from verb + subject

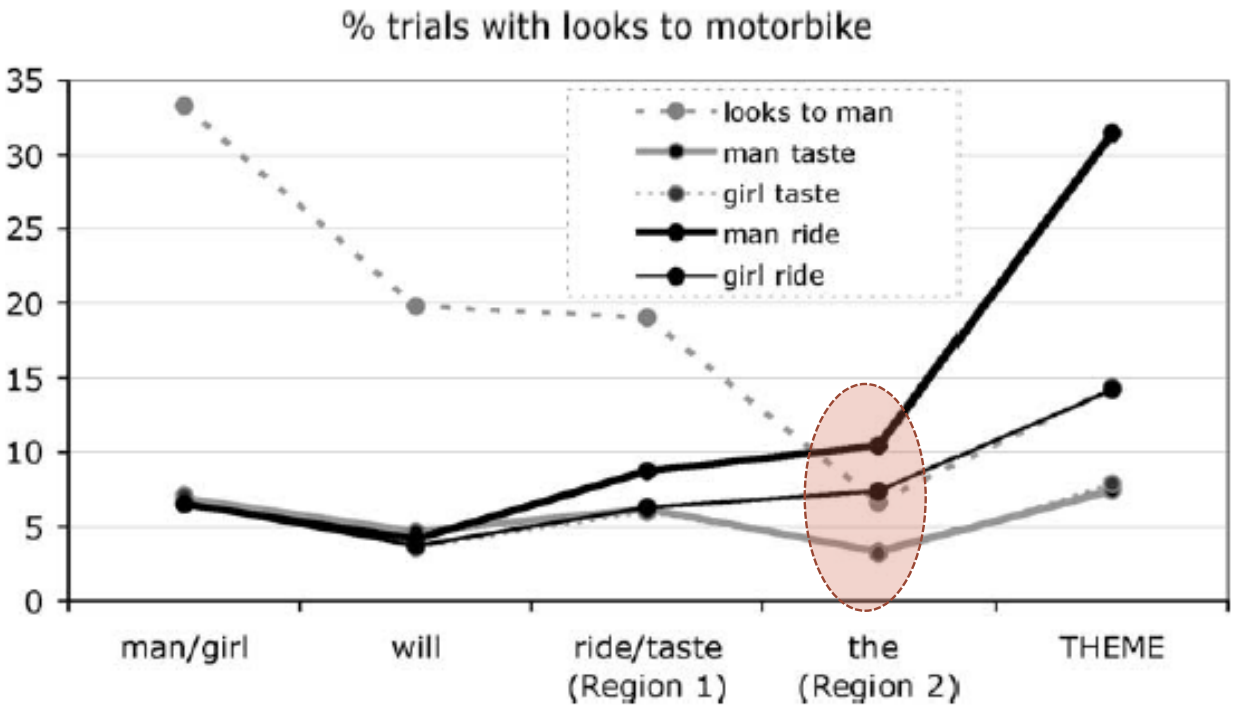


Results

Kamide et al.

Experiment 2:

Combinatory effects from verb + subject



Kamide et al.

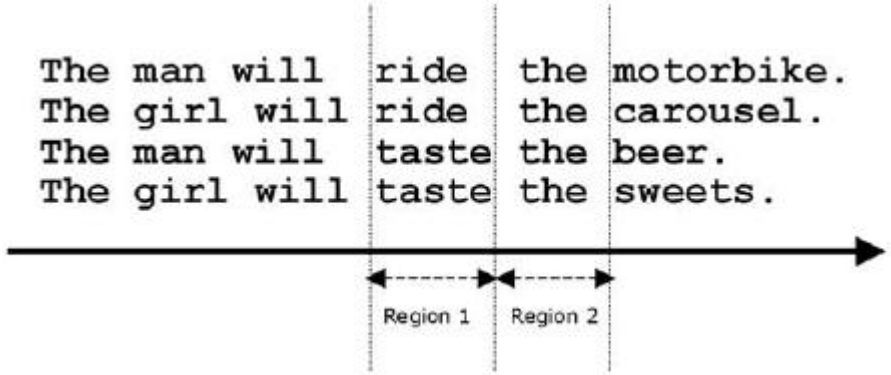
Experiment 2:

Combinatory effects from verb + subject

Conclusions

- the human processor is able to anticipate the Theme on the basis of combinatory info
  (verb + subject)

- very rapid integration of lexical info and world-knowledge



Kamide et al.

Experiment 3:

effect of morpho-syntactic info

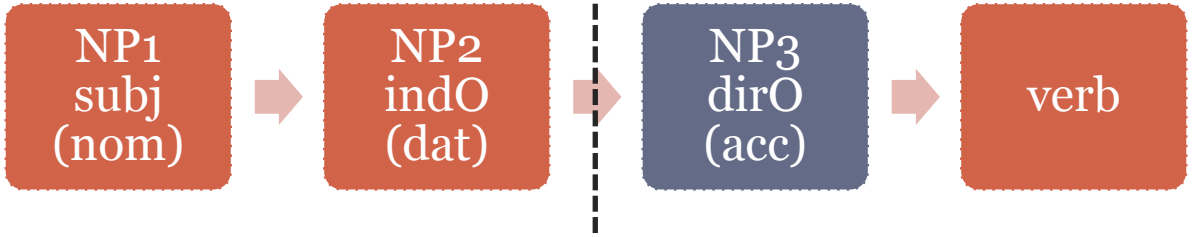
waitress-nom customer-dat	merrily	hamburger-acc bring.
ウェイトレスが 客に	楽し気に	ハンバーガーを 運ぶ。
ウェイトレスが 客を	楽し気に	からかう。
waitress-nom customer-acc	merrily	tease.

Kamide et al.

Experiment 3:

effect of morpho-syntactic info

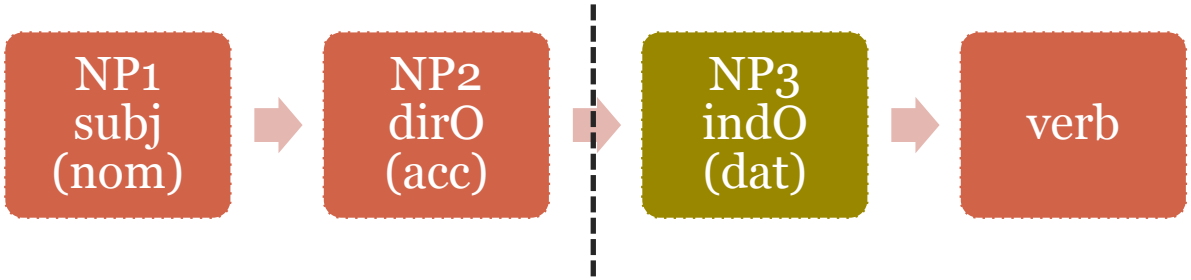
Dative-condition:



Sources of information:

- frequency of structure
- real-world knowledge

Accusative-condition:



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Experiment 3:

effect of morpho-syntactic info

Hypothesis

Syntactic dependencies do influence prediction

→processor anticipates the one plausible object to be the Theme

(more looks towards ‘hamburger‘ in the Dative-condition)

Results

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Experiment 3:

effect of morpho-syntactic info

NP1 subj (nom) → NP2 indO (dat) 38.1%

NP1 subj (nom) → NP2 dirO (acc) 23.9%

waitress-nom customer-dat	merrily	hamburger-acc bring.
ウエイトレスが 客に	楽し気に	ハンバーガーを 運ぶ。
ウエイトレスが 客を	楽し気に	からかう。
waitress-nom customer-acc	merrily	tease.

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Experiment 3:

effect of morpho-syntactic info

Conclusions

- prediction of arguments in absence of the verb
- prediction on basis of morpho-syntactic info
- ➢ structural sensitivity

Staub & Clifton
Prediction of Syntactic Structure

EVIDENCE THAT:

- top-down prediction of constituents facilitates lexical decision tasks (Wright&Garret, 1984)
- preference for low-attachment can be eliminated if context focusses attention on the higher predicate (Altmann et al. 1998)

- top-down storage cost (Chen, Gibson, Wolf, 2005)

Staub & Clifton
Prediction of Syntactic Structure

DOES THE PRESENCE OF "EITHER"…

- facilitate processing of coordination structures ?

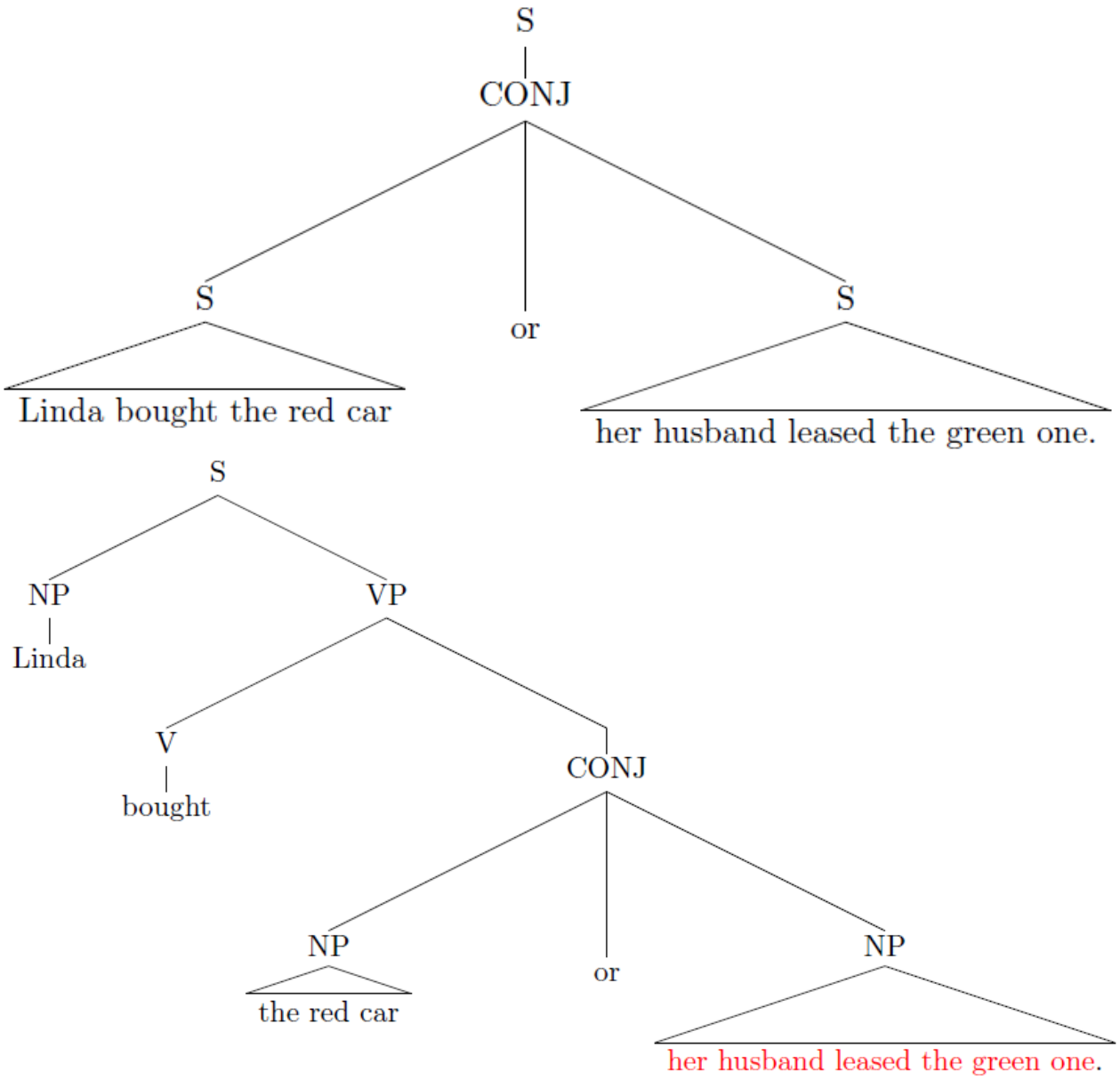
- eliminate garden-pathing in S-coordination sentences ?

Staub & Clifton

S-coordination

vs.

NP-coordination



Staub & Clifton

Experimental items

(a) (Either) Linda bought the red car or her husband leased the green one

(b) The team took (either) the train or the subway to get to the game.

+ yes-no-questions to check comprehension

Staub & Clifton

3 Regions were analyzed

(1) object-NP-region

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

3 Regions were analyzed

(1) object-NP-region

(2) or-NP-region

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

3 Regions were analyzed

(1) object-NP-region

(2) or-NP-region

(3) spillover

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

Results

Object-NP-region:

- **no significant effects of “either“**

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

Results

Object-NP-region:

- no significant effects of “either“

Or-NP-region:

- **eyes could leave the region sooner in the presence of “either“**

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

Results

Object-NP-region:

- no significant effects of “either“

Or-NP-region:

- Eyes could leave the region sooner in the presence of “either“

Spillover-region:

- **first-fixation time reduced with “either“**
  - **facilitatory effect of “either“**
- **more regressive eye movements in ‘no-either-S‘**
- **longer re-reading times in ‘no-either-S‘**

(Either) Linda bought the red car or her husband leased the green one.

Staub & Clifton

Explanation

→ “either“ facilitates reading material from “or“ in both sentence types

Explanation:

- parser is able to build coordination structure predictively
- garden-pathing avoided

Either Linda bought the red car or her husband leased the green one.

Overall Conclusions

Kamide et al.

Exp1:
- post-verbal Goals can be predicted

Exp2:
- post-verbal Themes can be predicted combining semantic info from distinct lexical items

Exp3:
- pre-verbal Themes can be predicted on basis of preceding arguments‘ case-marking

➢ Incremental processor uses
  - syntactic structure
  - semantic constraints
  - real-world knowledge

Staub & Clifton

- parser is able to use available info on syntactic structure for anticipation

➢ maximize incremental comprehension

more general:
- parser is able to activate linguistic representations in advance