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&FEATURERELATED
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
• **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.
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
Results

Kamide et al.

Experiment 1:
Anticipation of a thematic goal

- 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.
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
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’
Kamidé et al.

Experiment 2:

Combinatory effects from verb + subject

Results
Kamide et al.

Experiment 2:

Combinatory effects from verb + subject
Conclusions

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

- very rapid integration of lexical info and world-knowledge
Kamide et al.

Experiment 3:

effect of morpho-syntactic info
Kamide et al.

Experiment 3:
effect of morpho-syntactic info

Sources of information:
- frequency of structure
- real-world knowledge

Dative-condition:

NP1 subj (nom) → NP2 indO (dat) → NP3 dirO (acc) → verb

Accusative-condition:

NP1 subj (nom) → NP2 dirO (acc) → NP3 indO (dat) → verb
Kamidé et al.

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)

<table>
<thead>
<tr>
<th>waitress-nom customer-dat</th>
<th>merrily</th>
<th>hamburger-acc bring.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ウェイトレスが客に笑顔にハンバーガーを運ぶ。</td>
<td></td>
<td></td>
</tr>
<tr>
<td>waitress-nom customer-acc</td>
<td>merrily</td>
<td>tease.</td>
</tr>
<tr>
<td>ウェイトレスが客を笑顔にからかう。</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Kamide et al.

Experiment 3: effect of morpho-syntactic info

Results

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.)
Conclusions

- prediction of arguments in absence of the verb

- prediction on basis of morpho-syntactic info

➤ structural sensitivity
EVIDENCE THAT:

- top-down prediction of constituents facilitates lexical decision tasks (Wright & Garret, 1984)
- preference for low-attachment can be eliminated if context focuses attention on the higher predicate (Altmann et al. 1998)
- top-down storage cost (Chen, Gibson, Wolf, 2005)
DOES THE PRESENCE OF “EITHER“...

- facilitate processing of coordination structures?

- eliminate garden-pathing in S-coordination sentences?
Staub & Clifton

S-coordination vs. NP-coordination

Linda bought the red car

or

her husband leased the green one.

Linda

bought

the red car

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

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.

Object-NP-region:

- no significant effects of “either”
(Either) Linda bought the red car or her husband leased the green one.

Object-NP-region:
- no significant effects of “either“

Or-NP-region:
- eyes could leave the region sooner in the presence of “either“
Staub & Clifton

Results

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

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.

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

Explanation:

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