Theories of sentence comprehension

Psycholinguistic theories of sentence comprehension
♂ Have largely been informed by findings from reading studies
♂ Account for influence of linguistic and world knowledge
  e.g., Frazier & Clifton, 1996; MacDonald et al., 1994, Townsend & Bever, 2001; Tanenhaus & Trueswell, 1994

Little consideration of
♂ The role of immediate scenes for theory formation
♂ The integration of scene, linguistic/world knowledge, and utterance

For comprehension of scene-related utterances
♂ Characterizing the online interplay between language comprehension, the use of linguistic and world knowledge, and scene processing

Overview

PART I
♂ Situated spoken sentence comprehension
♂ Evidence from eye-tracking

PART II
♂ The Coordinated Interplay Account (CIA)
♂ Computational modelling of the eye-tracking findings

Eye tracking in scenes

Attention to objects in the scene is closely time-locked to comprehension
♂ Makes it possible to use eye-tracking in scenes during utterance presentation to investigate spoken comprehension
♂ Permits us to examine use of scene information for comprehension
Tanenhaus et al., 1995, *Science*

Visual referential context effects on the resolution of local structural ambiguity

- Put the apple on the towel in the box.

No referential contrast

Reference contrast

- Put the apple on the towel in the box.

Incremental semantic interpretation

More visual referential ambiguity

- Influence of visual contexts on
  - determination of reference to entities
  - Properties of objects (small, tall)

Sedivy et al., 1999

Pick up the tall glass and put it below the pitcher.

- More rapid looks to the tall glass before hearing “glass” in the contrastive than non-contrastive condition

Anticipatory eye-movements

- Anticipatory eye-movements: eye-movements to an object in a scene before it has been named

- Do verb selectional restrictions allow anticipation of as yet unmentioned postverbal argument/ its referent in the scene
  - Verb selectional restrictions: eat can take only edible objects as arguments

- What is anticipated?

- Why is an object anticipated?

- “The boy will move the cake.”
  - train, ball, toy car and cake can be moved

- “The boy will eat the cake.”
  - highly restrictive: only the cake is edible
Summary visual world studies

- Which kinds of information may influence spoken sentence comprehension?
- Incremental use of
  - Linguistic knowledge
    - Verb selectional restrictions
    - Scalar adjectives
    - Case-marking + verb plausibility
  - Visual scene information
    - Properties of objects (size, shape, texture)
    - Referential contrast between objects
    - ...?... well, how about events?
- What comprehension processes do the various types of information influence?
  - Referential visual contrast: structural disambiguation
  - Adjectives: incremental semantic interpretation
  - Case-marking & verb plausibility: thematic role-assignment

The role of enriched scenes

- Influence of other types of information in scenes
  - E.g., depicted events?
- Use of depicted events for comprehension
  - Rapid and incremental?
Depicted events

- German SVO/OVS sentences
  - Initial structural and role ambiguity

<table>
<thead>
<tr>
<th>SVO</th>
<th>OVS</th>
</tr>
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<tbody>
<tr>
<td>Die Prinzessin wäscht offensichtlich den Piraten.</td>
<td>Die Prinzessin malt offensichtlich der Fechter.</td>
</tr>
<tr>
<td>The princess (amb.) washes apparently the pirate (obj).</td>
<td>The princess (amb.) paints apparently the fencer (subj).</td>
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</table>

Time-course of scene influence

 Shortly after the verb

What we measure

- Eye movements to entities in the scene as the utterance unfolds
- Colour bitmaps to map X/Y coordinates of fixations onto entities
- Entities are coded for their role (ambiguous, agent, patient)
Summary depicted events

- Influence of other types of information in scenes
  - Depicted events
- Time-course of scene influence on comprehension
  - Rapid and verb-mediated

Discussion

Influence of structure in visual contexts on structural disambiguation

In previous studies scenes only contained things

- Contrast between things
  - Tanenhaus et al., 1995

In our studies scenes contained events

- Depicted actions & role relations

Depicted events versus thematic knowledge

- Importance of scene information (depicted events)
  - Relative to linguistic and world knowledge

Previous research

- world knowledge & case-marking => anticipation of thematic roles
  - Kamide et al., 2003; Scheepers et al., 2003

- Depicted events
- Rapid and verb-mediated

Role information from the immediate scene
- Incremental thematic role assignment
Storing thematic knowledge or depicted

- Each agent (detective, wizard) is uniquely identified
  - Depicted: Den Piloten verköstigt gleich der Detektiv.
    - The pilot (obj) serves-food to the detective (subj).
  - Stored: Den Piloten verzaubert gleich der Zauberer.
    - The pilot (obj) jinxes soon the wizard (subj).

Storing thematic knowledge versus depicted

- Both agents (detective, wizard) identified by the verb
  - Depicted: Den Piloten bespitzelt gleich der Zauberer.
    - The pilot (obj) spies-on soon the wizard (subj).
  - Stored: Den Piloten bespitzelt gleich der Detektiv.
    - The pilot (obj) spies-on soon the detective (subj).

Shortly after the verb

- Depicted Target: Den Piloten (patient) verköstigt gleich ...
  - The pilot (patient) serves-food to soon ...
- Stereotypical Target: Den Piloten (patient) verzaubert gleich ...
  - The pilot (patient) jinxes soon ...

- Depicted Target: Den Piloten (patient) bespitzelt gleich ...
  - The pilot (patient) spies-on soon ...
- Stereotypical Target: Den Piloten (patient) bespitzelt gleich ...
  - The pilot (patient) spies-on soon ...
Conclusions and interim summary of findings

- Rapid use of visual referential context for disambiguation
- Rapid use of contrastive properties of same-type objects for semantic interpretation
- Rapid use of verb selectional restrictions
- Rapid use of case-marking, verb meaning, and world knowledge
- Verb-mediated use of depicted events for thematic role assignment and structural disambiguation
- Greater relative priority of non-stereotypical depicted events over stereotypical thematic role knowledge

Predictions of the CIA

- Temporal-coordination hypothesis
  - For early versus late identification of relevant scene events, we would expect a temporal difference in disambiguation
- The priority of depicted events
  - When scenes are not immediately present
  - When events are absent, but characters (and their affordances) are present

Coordinated Interplay Account (CIA)

- Two key steps in situated utterance comprehension
  - Utterance comprehension guides attention in the scene
    - Establishing reference to objects and events
    - Anticipating likely referents
    - Once the utterance has identified the most likely object or event, and attention has shifted to it, the attended scene information then rapidly influences utterance comprehension
  - Strategy of first checking the scene
  - Greater relative priority of immediately depicted events

Experiment 4

- Ambiguous SVO versus OVS sentences

Knoeferle, accepted
Experiment 4

- Unambiguous SVO versus OVS sentences

SVO: Der Herr Orange tritt in diesem Moment den Sir Zwiebel.
The Mr Orange (amb.) kicks currently the Sir Onion (object).

OVS: Den Herrn Orange schlägt in diesem Moment den Sir Apfel.
The Mr Onion (object) hits currently the Sir Apple (subject).

Verb region

Initially ambiguous
Unambiguous - early influence

Experiment 4: Temporal-coordination hypothesis
⇒ For early versus late identification of relevant scene events, we would expect a temporal difference in disambiguation

Experiments 5 and 6: The priority of depicted events
⇒ Experiment 5: Scenes are not immediately present
⇒ Experiment 6: Events are absent, but characters (and their affordances) are present

Shortly after the verb

Initially ambiguous
Unambiguous

### Experiment 5 - blank screen

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![Diagram showing predictions of the CIA](image)

### Predictions of the CIA

- **Experiment 4: Temporal-coordination hypothesis**
  - For early versus late identification of relevant scene events, we would expect a temporal difference in disambiguation

- **Experiments 5 and 6: The priority of depicted events**
  - **Experiment 5:** Scenes are not immediately present
  - **Experiment 6:** Events are absent, but characters (and their affordances) are present

### Results - blank screen

- **Unique conditions**
  - Unique Target
  - Depicted Target

- **Ambiguous conditions**
  - Ambiguous Target
  - Depicted Target

![Graph showing results of experiments](image)

### Experiment 6 - disappearing events

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![Diagram showing experiment 6](image)
Results - disappearing events

- Unique conditions
- Ambiguous conditions

Depicted events with event-related potentials

- No scenes, written presentation
  - Initially ambiguous German SVO versus OVS: P600
  - Initially unambiguous German SVO versus OVS: no P600 e.g., Matzke et al., 2002

- With scenes, auditory presentation
  - SVO
    - Der Musiker
    - Der Fechter
  - OVS
    - Den Musiker
    - Der Fechter

Summary ERPs

- Depicted events enable structural disambiguation of initially structurally ambiguous SVO/OVS utterances
  - Corroborates eye-tracking findings on depicted events
  - Implications for theories of sentence comprehension
    - Immediate syntactic revision through information from depicted events