The Linguistic and Behavioral Reality of Event Structure

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What kinds of info do we use in the earliest stages of language comprehension?

SYNTAX (grammatical structure)

SEMANTICS (meaning)

CONTEXT, WORLD KNOWLEDGE

The cat chased the mouse
3 comprehension models

- **No syntax model:** all types of info (probabilistic) used interactively
- **Syntax first model:** syntax early, semantics (& all else) later
- **Integrated model:** includes both structural and probabilistic information
- Predicate event structure info is both semantic and syntactic.
- This talk presents evidence that event structure is used by the processor during on-line comprehension.
TELICITY
(the semantics: having an endpoint)

Mary is writing a book.  TELIC

Mary has not written a book.  Mary has written a book.

Mary is dancing.  ATELIC

Mary has danced.
Event Types

• Mary pushed the cart (#in/for an hour) (#at 2:00). **ACTIVITY (atelic)**

• Mary melted the chocolate (in/#for an hour) (#at 2:00). **ACCOMPLISHMENT (telic)**

• Mary crossed the finish line (in/#for an hour) (at 2:00). **ACHIEVEMENT (telic)**

# = semantic infelicity  (Vendler, 1957)
All **telic** verbs have an **internal argument**.

Transitive

```
IP
  Mary
  VP
  wrote
    a book
```

Intransitive Unaccusative (inherently **telic**)

```
IP
  VP
  arrived
    Mary
```

Intransitive Unergative

```
IP
  Mary
  VP
  slept
```

(Tenny, 1987)
Theoretical proposals on the syntax of event structure

• An event has subparts:
  – **process** (cross the finish line vs melt the chocolate)
  – **endpoint** (push the cart vs melt the chocolate)
  – **result state** (hit the tennis ball vs melt the chocolate)

• Each of these event subparts is represented by a specific bit of phrase structure.

• Taken together, these bits of phrase structure make up the predicate’s event structure.

(Pustejovsky, 1988; many others)
Telic Functional Projection

...
1. Why might verb telicity be relevant to early stages of sentence comprehension?

2. Experiments
The Garden Path Effect

Temporary syntactic ambiguity:

*The artist sketched by the child laughed.*

The amount of difficulty depends on the degree of commitment to the erroneous analysis of the initial NP (*the artist*) as agent.

Which factors affect this degree of commitment and thus the amount of difficulty?
Optional vs obligatory transitivity

The ruthless dictator fought in the coup
was hated.

↑

hard!

The ruthless dictator captured in the coup
was hated.

↑

easier!

(predicted by Pritchett, 1992; experiment by MacDonald, 1994)
These apparent effects of **transitivity** might really be effects of **telicity**.

15 of MacDonald’s 18 **obligatorily transitive** verbs were **telic**.

15 of MacDonald’s 18 **optionally transitive** verbs were **atelic**.
Telic predicate

Reanalysis is easier
Atelic predicate

Reanalysis is harder
Note that telicity & transitivity can be manipulated independently.

- **Atelic, Intransitive**: dance
- **Atelic, Transitive**: push
- **Telic, Intransitive**: arrive
- **Telic, Transitive**: notice
Event Structure Processing (ESP) Hypothesis

Speakers possess & use knowledge of event structure, specifically an event’s telicity, in on-line sentence comprehension.

Because a telic verb requires an internal argument / theme, the processor will leave open the possibility that the initial noun phrase may be the needed theme.
Prediction of ESP hypothesis

Smaller garden path effect in reduced relatives with **telic** verbs than in those with **atelic** verbs.

The actress **sketched** by the writer left in a hurry.

The actress **tripped** by the writer left in a hurry.
1. Why might verb telicity be relevant to early stages of sentence comprehension?

2. Experiments
Examples of experimental sentences

- **Atelic, Optionally-trans**: The actress (that was) *sketched* by the writer left in a hurry.

- **Atelic, Oblig-trans**: The actress (that was) *escorted* by the writer left in a hurry.

- **Telic, Optionally-trans**: The actress (that was) *tripped* by the writer left in a hurry.

- **Telic, Oblig-trans**: The actress (that was) *noticed* by the writer left in a hurry.
How we categorized predicates as telic or atelic for the experiments

- The 1st 3 authors (O’Bryan, Folli, Harley) agreed upon the categorization.
- These categorizations were verified by untrained native speaker judgments in a questionnaire study designed in collaboration with Selene Gardner.
The girl danced in an hour. The girl danced for an hour.

(Which is more natural, the one on the left or the one on the right?)

Predictions: telic -> in an hour  
atelic -> for an hour

(based on Vendler, 1957)
Questionnaire Results

• Significantly more “in an hour” choices for telic predicates than atelic (p<.05)
• All telic predicates received more “in an hour” choices than all atelic predicates
• The results confirm our categorizations.
Experiment 1
Self-paced reading

• Post-hoc reanalyses of 3 prior self-paced reading studies
• Analyses included a total of 136 subjects & 92 items

Tabossi, Spivey-Knowlton, McRae, & Tanenhaus 1994
McRae, Spivey-Knowlton, & Tanenhaus 1998
Clarke, Townsend, & Bever 2000
The Dependent Variable: Garden Path Effect

depends on commitment to erroneous analysis of initial NP as agent

GPE = processing difficulty (reaction time) for ambiguous sentence minus for unambiguous

**Ambiguous** The actress sketched by the writer left in a hurry.

**Unambiguous** The actress that was sketched by the writer left in a hurry.
Predictions

• The actress sketched by the writer left in a hurry.

Early disambiguation point

Later disambiguation point

• Difficulty resulting from garden path (mis-analysis):
  • telic < atelic
  • obligatorily-transitive < optionally-transitive
Re-analyses of 3 prior self-paced reading studies

Atelic, Optionally-Trans: The N sketched by the N was...

Atelic, Oblig-Trans: The N escorted by the N was...

Telic, Optionally-Trans: The N awakened by the N was...

Telic, Oblig-Trans: The N noticed by the N was...

RRE (Reduced - Unreduced) in milliseconds
Telicity & transitivity effects both in predicted direction

Sig in 2 of the 3 studies. 3rd study shows trend in same direction.
Discussion of self-paced reading results

- Less processing difficulty in critical region when initial verb is **telic** compared to **atelic**

- *The actress tripped by the writer left in a hurry.*
- *The actress sketched by the writer left in a hurry.*

- Preliminary support for hypothesis that event structure is used during on-line comprehension

- Now for a balanced, controlled experiment…
Experiment 2
Voice change monitoring

- Press a key when a word or part of a word is spoken by a female voice.

(Sentence spoken by male voice except for underlined syllable, spoken by female voice.)

*The prisoner examined by the *agent* tried to escape.*

Example 1

Example 2

(Townsend & Bever 1991)
Examples of experimental sentences

• Atelic, Optionally-trans: *The actress (that was) sketched* by the writer left in a hurry.

• Atelic, Oblig-trans: *The actress (that was) escorted* by the writer left in a hurry.

• Telic, Optionally-trans: *The actress (that was) tripped* by the writer left in a hurry.

• Telic, Oblig-trans: *The actress (that was) noticed* by the writer left in a hurry.
The Dependent Variable: Garden Path Effect

depends on commitment to erroneous analysis of initial NP as agent

GPE = processing difficulty (in detection errors) for ambiguous sentence minus for unambiguous

**Ambiguous** The actress sketched by the writer left in a hurry.

**Unambiguous** The actress *that was* sketched by the writer left in a hurry.
Participants: 40 monolingual English speakers

- The actress sketched by the writer left in a hurry.

Predictions:
- Difficulty resulting from garden path (mis-analysis):
  - telic < atelic
  - obligatorily-transitive < optionally-transitive
Significant main effect of **telicity**, $p < .05$

*Transitivity is not significant*, $F = 1.4$, $p > .10$
Atelic minus Telic | Optionally Transitive minus Obligatorily Transitive
---|---
Difference in RRE as % of detection errors

* As predicted
not sig.

Opposite of transitivity prediction
Discussion of voice change monitoring results

• Less processing difficulty in critical region when initial verb is *telic* compared to *atelic*

• The actress *tripped* by the writer left in a hurry.

• The actress *sketched* by the writer left in a hurry.

• Supports hypothesis that event structure is used during on-line comprehension

• Weakness: probed difficulty at only one point in the sentence
Experiment 3
Eye tracking during reading

• 40 monolingual English speaking subjects
• Subjects read sentences silently while eye fixations were measured in 6 regions:

The actress # tripped # by the writer # left # in a hurry.
The actress # that was # tripped # by the writer # left # in a hurry.

1 2 3 4 5 6
Examples of experimental sentences

- **Atelic, Optionally-trans**: The actress (that was) *sketched* by the writer left in a hurry.
- **Atelic, Oblig-trans**: The actress (that was) *escorted* by the writer left in a hurry.
- **Telic, Optionally-trans**: The actress (that was) *tripped* by the writer left in a hurry.
- **Telic, Oblig-trans**: The actress (that was) *noticed* by the writer left in a hurry.
The Dependent Variable: Garden Path Effect

depends on commitment to erroneous analysis of initial NP as agent

GPE = processing difficulty (reaction time) for ambiguous sentence minus for unambiguous

**Ambiguous** The actress sketched by the writer left in a hurry.

**Unambiguous** The actress *that was* sketched by the writer left in a hurry.
Predictions

• *The actress sketched by the writer left in a hurry.*

  Early disambiguation point

  Later disambiguation point

• Difficulty resulting from garden path (mis-analysis):
  • telic < atelic
  • obligatorily-transitive < optionally-transitive
First pass reading times measured as “go past” time per word

![Graph showing first pass reading times measured as “go past” time per word. The graph includes lines for Atelic Oblig-Trans, Telic Oblig-Trans, Atelic Option-Trans, and Telic Option-Trans, with markers for verb’ed, by the writer, left, and in a hurry.]
First pass reading times measured as “go past” time on main verb

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telicity</td>
<td>5.257</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Transitivity</td>
<td>5.019</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Tel x Trans</td>
<td>1.058</td>
<td>.31 (not sig)</td>
</tr>
</tbody>
</table>
Discussion of eye tracking results

- Less processing difficulty in critical region when initial verb is **telic** compared to **atelic**

- The actress *tripped* by the writer left in a hurry.
- The actress *sketched* by the writer left in a hurry.

- Consistent with results of the other experiments

- Supports hypothesis that event structure is used during on-line comprehension
Discussion of results from all 3 experiments

- Less processing difficulty in critical region when initial verb is **telic** compared to **atelic**

- *The actress tripped* by the writer left in a hurry.

- *The actress sketched* by the writer left in a hurry.

- Taken together, the results support the hypothesis that event structure is used during on-line comprehension
3 comprehension models

- **No syntax model:** all types of info (probabilistic) used interactively
- **Syntax first model:** syntax early, semantics (& all else) later
- **Integrated model:** includes both structural and probabilistic information
No syntax model

Simple main clause analysis

Reduced relative clause analysis

Competing for activation

Frequency of verb in passive versus active structures

How frequently verb occurs w/ direct object

Plausibility of initial noun as agent of verb

Other constraints...

“The actress sketched…”
No syntax model

- Can easily include semantics
- But as probabilistic, not structural info
- Could account for our results (very powerful)
Syntax first model

- Parse first, understand later
- Predicts that semantics affects comprehension relatively late
- Thus, does NOT account for our results
- Our experiments show early effects of telicity, a kind of semantic info.

(e.g., F. Ferreira & Clifton, 1986; Frazier & Clifton, 1996)
Arguments for a structural account

- Structural differences between reduced relative clause & erroneous main clause analysis appear to affect difficulty
- Reduced relative clause structure & telic predicate structure are similar
Telic predicate

Reanalysis is easier
Atelic predicate

Reanalysis is harder
• The body of evidence on sentence comprehension suggests that both structural & probabilistic info are involved.

• Calls for a model that integrates both: “Analysis by synthesis” framework (Townsend & Bever, 2001)
analysis by synthesis comprehension model (LAST)  
(Townsend & Bever 2001)

input utterance → short term memory storage of utterance → Are synthesized & stored strings identical? → syntactic derivation → output meaning

Sentence templates like NV(N), phrase segregation, lexically specified info
What kinds of info do we use in the earliest stages of language comprehension?

The evidence suggests that we use syntactic information, as well as **syntactically relevant semantic information**, during the earliest stages of sentence comprehension.
Conclusions

• Evidence from 3 different experimental paradigms suggests that verb telicity information affects the degree of processing difficulty encountered during the comprehension of garden path sentences.

• The evidence is in accord with the Event Structure Processing hypothesis: speakers use knowledge of event structure in on-line sentence comprehension.

• The evidence is consistent with a model that utilizes both structural and probabilistic info.