Processing filled gaps in coordinated wh-questions

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LSA 2013
Coordinated-\textit{wh} questions

What and when will we eat?
One-to-many interpretive dependencies

(1) What and when will we eat?

(2) Mary bought and John ate the cake.

(3) What did Mary buy and John eat?
Why should you care?

Theoretical challenge:
• Generally, there is an isomorphism between syntactic structure and semantic composition.
• Here, the isomorphism is superficially broken.

2 options:
– Preserve the transparent mapping between interpretation and structure
– Allow some divergence between interpretation and structure
Why should you care?

• Syntax-semantics interface in processing: Mismatches between structure and interpretation allow us to tease apart the role of parsing mechanisms at different levels.
Our claims

1) Coordinated-\textit{wh} questions involve a dependency with no instantiation at the syntactic level

\textbf{What and when will we eat?}
Our claims

2) These non-syntactic dependencies are processed differently in real-time comprehension.
   – They do not trigger “active gap-filling”

What and when will we eat?
Outline

• Syntactic analysis of coordinated-\textit{wh} questions
  – Theoretical considerations
  – Evidence from judgment studies
• Processing \textit{wh}-questions: Active gap-filling
• Experiment: Filled gap effects
• Conclusion
Syntactic Analysis

The two wh-words cannot have moved separately:

What$_i$ and when$_j$ did Ivy eat $t_i$ $t_j$?
Syntactic Analysis

Nor can it be the case that the wh-words form a single constituent and single dependency:

\[ \text{What and when}\_i \text{ did Ivy eat } t_i? \]
\[ \text{What and who}\_i \text{ did you see } t_i? \]
Previous accounts

• Backwards ellipsis

• Multidominance
Syntactic Analysis

What and when did Ivan eat?
Syntactic Analysis

What$_i$ and when$_j$ did Ivan eat-$_{xi}$ t$_j$?
Some optionally-transitive verbs like eat allow null variables as internal arguments:

John ate $x$

These variables generally give rise to an existential reading:

$\exists x \text{ John ate } x = \text{ ‘John ate something’}$
Syntactic Analysis

• **Obligatorily-transitive verbs** like *fix* do not allow null variables in the same way:

  *John fixed x*

• It will not be possible for the internal argument of *fix* to enter into a non-syntactic dependency
Syntactic Analysis

• We assume that there are also optional null time, place, etc. variables:

John ran time-x place-x

• Such variables can be bound by their relevant adjunct wh-words
Predictions

*Eat-type verbs:* wh-word order should not matter

- When an argument wh-word (e.g. *what*) is first, it finds a variable
  
  $\text{What}_i$ and when did Ivan eat-$x_i$?

- When an adjunct wh-word (e.g. *when*) is first, it finds a null adjunct variable
  
  $\text{When}_i$ and what did Ivan eat *time-$x_i$*?
Predictions

**Fix-type verbs:** *wh*-word order *should* matter

- When the argument *wh*-word is first, it finds no null variable

  *What* and when did Ivan fix?

- When the adjunct *wh*-word is first, it still finds a null adjunct variable

  ✓*When* and what did Ivan fix *time*-\(x_i\)?
Predictions

In short:

<table>
<thead>
<tr>
<th></th>
<th>Eat-type</th>
<th>Fix-type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Argument-first</strong></td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><strong>Adjunct-first</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
A judgment study

Argument-first

Optionally transitive

VerbType: Eat

VerbType: Fix

Adjunct-first

Obligatory transitive

WhOrder: ArgFirst

WhOrder: AdFirst
Another judgment study
Outline

• Syntactic analysis of coordinated-\textit{wh} questions
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Our theoretical claim

Coordinated-\textit{wh} questions involve a dependency with no instantiation at the syntactic level.

\textbf{What and when will we eat?}
Question

Are purely semantic wh-dependencies processed differently from standard syntactic/semantic dependencies?
Active gap-filling

Who will the professor eat lunch with?

Implausibility effects: e.g. Tanenhaus et al. (1989), Boland et al. (1995), Traxler & Pickering (1996), Phillips et al. (2006)

Filled gap effects: e.g. Stowe (1986), Tanenhaus et al. (1989)
Question, refined

Does the active gap-filling mechanism operate at the syntactic or semantic level?

• If syntactic, there should be no active gap-filling for purely semantic wh-dependencies.

• If semantic, there should be active gap-filling for all wh-dependencies.
Outline

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• \textbf{Experiment: filled gap effects}
• Conclusion
Experiment

Do filled gap effects arise for wh-dependencies without a syntactic component?

*What and when will we eat something?
Experiment

When is the unacceptability of *fix*-type verbs detected?

• Immediate detection could suggest a predictive mechanism.
• Delayed detection could suggest a slower mechanism for building semantic dependencies.
Experiment: Design

• Self-paced reading

• Design:
  – Verb Type: optionally vs. obligatorily transitive
  – What-Gap: filled (‘something’) vs. empty
  – WH type: ‘what’ vs. ‘when’ vs. ‘what and when’

• 42 participants
Experiment: Design

Optionally-transitive verbs
The diplomat had to make a schedule of...

Empty gaps
✓ what his lazy assistant would translate
✓ when his lazy assistant would translate
✓ what and when his lazy assistant would translate

Filled gaps
× what his lazy assistant would translate something
✓ when his lazy assistant would translate something
× what and when his lazy assistant would translate something

...during the work week.
Results:
Optionally-transitive, empty gap
Results:
Optionally-transitive, filled gap
Summary: Optionally-transitive verbs

• No cost for filled gap for purely semantic \textit{wh}-dependency.

→ The active gap-filling mechanism is only sensitive to syntactically-mediated dependencies
Experiment: Design

**Obligatorily-transitive verbs**

The busy executive was especially worried about…

| Empty gaps     | ✓ what his lazy assistant would overlook |
|               | ✗ when his lazy assistant would overlook |
|               | ✗ what and when his lazy assistant would overlook |

| Filled gaps    | ✗ what his lazy assistant would overlook something |
|               | ✓ when his lazy assistant would overlook something |
|               | ✗ what and when his lazy assistant would overlook something |

…during the important deal.
Results:
Obligatorily-transitive, empty gap
Results:
Obligatory-transitive, filled gaps

Graph: Obligatory transitive verbs, Filled gaps

Mean RT (ms)

Region

Aux | Verb | Filler | End1 | End2 | End3

WhType
- What and when
- What
- When
Summary: Obligatorily-transitive verbs

- Delayed detection of ungrammaticality in ‘what and when’ sentences with empty gap
  → The verb type is not predicted.
  → The dependency must be attempted before it can be rejected.
Summary: Obligatorily-transitive verbs

• Immediate detection of ungrammaticality in ‘what and when’ sentences with filled gap, but cost is short-lived

2 possible explanations:
  → Earlier detection of unacceptability of fix-type verb
  → Short-lived filled-gap effect
Summary: Obligatory-transitive verbs

- Immediate detection of ungrammaticality in ‘what and when’ sentences with filled gap, but cost is short-lived

→ Short-lived filled-gap effect?
  - ‘what and when’ suggests semantic dependency
  - ‘fix’ suggests syntactic dependency
Conclusions

1) Coordinated-\textit{wh} questions involve a dependency with no instantiation at the syntactic level

2) Active gap-filling is a mechanism for building syntactic dependencies, not semantic dependencies.
Future directions

• Prediction and revision early in the sentence

• Filled gap effects vs. implausibility effects

• Interpretation of “acceptable” filled gap sentences
Acknowledgments

Thanks to the Cognitive Neuroscience of Language Lab for suggestions and feedback, in particular Norbert Hornstein, Colin Phillips, Wing Yee Chow, Sol Lago, and Ewan Dunbar.

This work was supported by NSF IGERT grant DGE-0801465 awarded to Colin Phillips.