Processing filled gaps in coordinated wh-questions

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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”
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\textsubscript{i} and when\textsubscript{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:

\[
\times [\text{What and when}]_i \text{ did Ivy eat } t_i?
\]

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

• Backwards ellipsis

• Multidominance
Syntactic Analysis

What and when did Ivan eat?

Given this structure, the shared material 'the book' is c-commanded by elements from both conjuncts. This can easily be tested empirically. Elements from both conjuncts should show the effects of c-commanding the shared material. This turns out not to be the case.

Shown in this section, only elements from the second conjunct show c-command effects while elements in the first conjunct do not.

12

(32)

What and when did Ivana repair?

This extends to multiple wh-fronting languages generally (33) a. Mit kinek adtál?

(Serbo-Croatian) b. Mit és hol javítottál meg?

(Hungarian, from Liptak)

what and who gave.indef.2sg

‘What and to whom did you give?’

This suggests that both wh-words are actually undergoing movement (34)

What and when does Igor repair it?

But in Germanic, we seem to have this sort of pattern

Verb-Order: Arg first

<table>
<thead>
<tr>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wh-Order: Arg first</td>
<td>Good</td>
</tr>
<tr>
<td>Wh-Order: Adj first</td>
<td>Good</td>
</tr>
</tbody>
</table>

This is best accounted for with an analysis like the following:

(35)
Syntactic Analysis

What$_i$ and when$_j$ did Ivan eat-$x_i$ $t_j$?
Syntactic Analysis

• 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

- **Obligatory-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
  
  »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
  
  »When$_i$ and what did Ivan eat *time*-x$_i$?
Predictions

\textbf{Fix-type verbs:} wh-word order \textbf{should} matter

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

\*\textbf{What} and when did Ivan fix?

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

✓\textbf{When} and what did Ivan fix \textit{time-}x_i?
Predictions

In short:

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

Argument-first

Adjunct-first

Optionally transitive

Obligatory transitive
Another judgment study
Outline

• Syntactic analysis of coordinated-\textit{wh} questions
  – Theoretical considerations
  – Evidence from judgment studies

• \textbf{Processing \textit{wh}-questions: Active gap-filling}

• Experiment: Filled gap effects

• Conclusion
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

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

![Graph showing mean RT (ms) for different WhTypes across regions.](image-url)
Results:
Obligatorily-transitive, filled gaps
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 ungrammaticalinity 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

3) 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

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Syntactic Analysis

Derivation Sketch

\[ [_{TP} \text{i}vy \text{ ate when}] \rightarrow [_{CP} \text{when} \ [\text{i}vy \text{ ate } t] \]

\[ [_{CP} \text{what } C^0] \quad \& \quad [_{CP} \text{when} \ [\text{i}vy \text{ ate } t] \]

\[ [_{CP} [_{CP} \text{what } C^0] \ [\&P \ & \ [_{CP} \text{when} \ [\text{i}vy \text{ ate } t]])] \]
Filled-gap examples 1

- Now I know what and when to eat the correct food combinations.
- What and when was something done to stop this from happening?
- It allows you to basically pick what and when you want something to be inactive on your hard drive.
- They begin calling and emailing my friends and wanting to know what and when they told me something.
- I have always depended on God’s Holy Spirit to let me know what and when God desires something done by me.
- ...you need to tune in to what and how something is said and be alert for what is left unsaid.
- The projected shortfall could alter what and when things are built.
- ...serving up an array of information that lets women choose what and when they want financial advice.
Filled-gap examples 2

• The AAAS benchmarks provide guidance for what and when we teach certain content areas...
• You must stay on top of what and when seminars are offered.
• … the garage is no longer there and not sure who and when it was removed.
• … a number of questions that now have to be answered in terms of who and when they are going to turn over Elia Gonzalez to his father.
• The team will develop a plan … to include … who and when behaviors will be measured...
• What and where would this monitoring take place?
• … it will specifically give the motorist the power to choose when, who, and where their car will be repaired
• ... In international affairs, what, when, and how you say something is important.
Possible analyses

*Haida and Repp 2009: CWh is RNR*

2) Jo bought ___ and Mary read ___ [the book]

3) What ___ and when ___ [did Mary read]?
Possible analyses

_Haida and Repp 2009: CWh is RNR_

Movement
Ellipsis
Multidomiance
Something else entirely…
Movement

4) What and when did Ivy eat?

5) What $t_i$ and when $t_i [_{C_i} \text{ did Ivy eat}]$
Movement

4) What and when did Ivy eat?

5) What $t_i$ and when $t_i$ did Ivy eat? $[c_i$ did Ivy eat$]_i$

Non-identical, non-maximal projections
Backwards Ellipsis

6) What and when did Ivy eat?

7) What *did Ivy eat* and when did Ivy eat?
Backwards Ellipsis

Problems:
8) When and what did Ivy fix?

9) *When did Ivy fix and what did Ivy fix?

And it can’t mean:
10) When did Ivy fix something and what did Ivy fix?
Backwards Ellipsis

Problems:
CWHs do not allow swiping (Gracanin-Yuksek 2007):

14) John was dancing, but I don’t know who with

15) *Who with were you dancing?

16) *Who with and when were you dancing?
Backwards Ellipsis

Problems:
CWHs do not allow overt indefinites like regular sluices do.

Ivy ate something and I know what Ivy ate

*What did Ivy eat and when did Ivy eat something?
Multidominance

Gracanin-Yuksek 2007
## Multidominance

### Predictions

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Multidominance

Only optionally transitive verbs should be allowed.
Offline acceptability study: Materials

Context: Jim was trying to lose weight. But he gave in and ate a doughnut at midnight last night.

*Argument-first: What and when did Jim eat?*
*Adjunct-first: When and what did Jim eat?*

Context: Rodney is a young mechanic. He fixed a limousine for the first time last week.

*Argument-first: What and when did Rodney fix?*
*Adjunct-first: When and what did Rodney fix?*
Speeded acceptability judgment

- Speeded acceptability judgment

Design:
- **Verb Type**: optionally vs. obligatorily transitive
- **WH Order**: argument-first vs. adjunct-first
- **What-Gap**: filled ('something') vs. unfilled

- 24 participants (recruited on Mechanical Turk)
Speeded acceptability judgment: Filled gaps

Sentences with filled gaps:

• **Optionally-transitive verbs:**
  argument-first better than adjunct-first

  ✗ …what and where he could eat something…
  ✗ …where and what he could eat something…

• **Obligatorily-transitive verbs:**
  bad regardless of WH Order

  ✗ …what and when you might find something…
  ✗ …when and what you might find something…
Speeded acceptability: Filled gaps

- Optionally-transitive verbs: argument-first better than adjunct-first
- Obligatorily-transitive verbs: smaller difference between argument-first and adjunct-first
Speeded acceptability: Filled gaps

- Asymmetry in filled gap effects based on order of WH words.
  - ? What and when will we eat something?
  - * When and what will we eat something?

- Suggests that the gap-filling mechanism is sensitive to whether a dependency is syntactically-mediated.
Speeded acceptability: filler types

The diplomat had to make a schedule of {what and when | when and what | when} his lazy assistant would translate {something | the documents} during the week.
Speeded acceptability: filler types

• NO differences between filler types

• With filled gaps, ‘what and when’ accepted more often (55%) than ‘when and what’ (27%)
Local coherence account?