The what and when of processing coordinated-wh questions

Dave Kush
Shevaun Lewis
Bradley Larson

WCCFL 2013
What and when will we eat?

Coordinated-\textit{wh} questions
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

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
• Processing \textit{wh}-questions: Active gap-filling
• Experiment 1: Filled gap effects
• Experiment 2: Types of filler
• Conclusion
Syntactic Analysis

What and when did Ivan eat?

$\textbf{What}_i$ and $\textbf{when}_j$ did Ivan eat-$x_i$ $t_j$?
Syntactic Analysis

There are two ways to get the right type of variable for the rightward wh-word

1) Some verbs introduce variables that correspond to internal arguments
2) All verbs introduce variables as adjuncts

- John ate-\textit{x}
- \textit{*}John fixed-\textit{x}
- John ate something \textit{time-\textit{x}}
- John fixed something \textit{time-\textit{x}}
Predictions

*Argument-wh first*: Only verbs that can introduce internal argument variables should be OK

✓ What$_i$ and when did Ivan eat-$x_i$ ?

• When a verb that does not allow such variables is used, the result is unacceptable

* What$_i$ and when did Ivan fix ?
Predictions

**Adjunct-wh first:** Any type of verb should be licit as there are freely null adjunct variables

✓ When$_i$ and what did Ivan eat $time-x_i$?
✓ When$_i$ 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>Argument-first</td>
<td>✔️</td>
<td>❌</td>
</tr>
<tr>
<td>Adjunct-first</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>
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

!! – Filled gap effects

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?
Self-paced reading

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

*What and when will we eat something?
Self-paced reading

When is the unacceptability of \textit{fix}-type verbs detected?

- Immediate detection could suggest a predictive mechanism.
- Delayed detection could suggest a slower mechanism for building semantic dependencies.
Self-paced reading: 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
Self-paced reading: 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

[Graph showing optionally transitive verbs with unfilled gap]
Results:
Optionally-transitive, filled gap
Summary: Optionally-transitive verbs

• No cost of the filled gap for purely semantic *wh*-dependency.

→ The active gap-filling mechanism is only sensitive to syntactically-mediated dependencies
Self-paced reading: 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:
Obligatory-transitive, empty gap
Summary: Obligatory-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.
Results:
Obligatorily-transitive, filled gaps
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
Why the grammaticality illusion?

- There is virtually no recognition of ungrammaticality of filled-gap optionally transitive verbs
Why the grammaticality illusion?

- There dependency is fine. It is semantically mediated by the verb and the complement does not matter.
But the sentence is still unacceptable offline

• The verb can only take one internal argument (syntactically, lexically, etc.)

• *What and when did John eat something?
Why the persistence of grammaticality illusion?

- The sentence is not grammatical. Why isn’t this eventually noticed?
Why the persistence of grammaticality illusion?

• There must be a way to salvage the sentence by somehow treating the two internal arguments as one

• How might this be done?
Why the persistence of the grammaticality illusion?

**Option 1:** The wh-word actually binds the overt indefinite. The indefinite *something* is basically the overt version of the null variable.

‘John ate’ = ‘John ate something’

**Option 2:** The rightward wh-word serves to restrict the specificity of the filler

-- *Now I know what and when to eat the correct food combinations.*

-- *You must stay on top of what and when seminars are offered.*
Why the persistence of the grammaticality illusion?

**Indefinite**
1) What and when did John eat something?

**Plural Definite**
2) What and when did John eat the cakes?

**Singular Definite**
3) What and when did John eat the cake?
Why the persistence of the grammaticality illusion?

*Indefinite*
1) What and when did John eat something?

*Plural Definite*
2) What and when did John eat the cakes?

*Singular Definite*
3) What and when did John eat the cake?
Speeded acceptability judgment

- Speeded acceptability judgment, optionally transitive verbs.

- Design:
  - **WH-type**: argument-first vs. adjunct-first vs. solely adjunct
  - **Filler-type**: indefinite (‘something’) vs. plural definite (‘the cookies’)

- 27 participants (recruited on Mechanical Turk)
Speeded acceptability judgment

- **Adjunct wh-word:**
  good independent of filler type
  
  The pastry chef tried to make clear when the new assistant should stir {something/the ingredients} into the batter.

  **Argument first:**
  Filler type may play a role here
  ? ...what and when the new assistant should stir {something/the ingredients}...

- **Adjunct first:**
  bad, independent of filler type
  
  ✗ ...when and what the new assistant should stir {something/the ingredients}...
Different filler type

Effects of filler type

Proportion accepted

Filler Type
- Blue: Definite NP
- Gray: 'something'

Wh Type
- When
- What & When
- When & What
Discussion

The same sort of illusory acceptability that we saw before can be discerned with definite fillers

- This suggests that the illusion is not due to the binding of the overt indefinite *something*

- Instead, it suggests that the repair is done via some other mechanism
Next experiment

• Does the ability of the filler to be further specified determine the possibility of grammatical illusion?

• What and when did John eat the cakes?

• What and when did John eat the cake?
Conclusions

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

3) Filled gap effects are the result of building syntactic dependencies, not semantic dependencies.
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.
Syntactic Analysis

Derivation Sketch

\[ [\text{TP} \text{ Ivy ate when}] \rightarrow [\text{CP} \text{ when } [\text{Ivy ate } t]] \]

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

\[ [\text{CP} [\text{CP} \text{ what } C^0] [\& \& \text{CP} \text{ when } [\text{Ivy ate } t]]]] \]
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 $t_i \left[ c, \text{did Ivy eat}\right]_i$
Movement

4) What and when did Ivy eat?

5) What $t_i$ and when $t_i [c, \text{ did Ivy eat}]_i$

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

<table>
<thead>
<tr>
<th></th>
<th>Verb-type <em>eat</em></th>
<th>Verb-type <em>fix</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Argument first</td>
<td>good</td>
<td>bad</td>
</tr>
<tr>
<td>Adjunct first</td>
<td>good</td>
<td>bad</td>
</tr>
</tbody>
</table>
Multidominance

Only optionally transitive verbs should be allowed.

T°

eat

what

when
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: 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%)
A judgment study

Argument-first

Adjunct-first

Optionally transitive

Obligatory transitive
Another judgment study

[Bar chart showing proportion accepted by Verb Type and WH Order]
Speeded acceptability: Filled gaps

- **Optionally-transitive verbs**: argument-first better than adjunct-first
- **Obligatory-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 type

• In the first experiment, the indefinite *something* was used as the filler.

• This is rather similar to the posited null element.

• We tested same sentences with more contentful fillers like *the cookies*.